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IITA's Social Science and Agribusiness Research for Development:

Compendium of Research Highlights 1967–2022

**Victor Manyong,
Shiferaw Feleke, and
Tahirou Abdoulaye**



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IITA is the lead research partner facilitating agricultural solutions for hunger and poverty in the tropics. It is a member of the CGIAR Consortium, a global research partnership that unites organizations engaged in research for sustainable development for a food secure future.

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Abbreviations and acronyms

A4NH	Agriculture for Nutrition and Health
AIP	Agricultural Information Platforms
AIS	Agricultural Innovation Systems
CGE	Computable General Equilibrium
CGIAR	(formerly) Consultative Group on International Agricultural Research
CRP	Consortium of Research Programs
CSM	Cropping system model
DSSAT	Decision Support System for Agrotechnology Transfer
ESI	Extrapolation Suitability Index
FAO	Food and Agriculture Organization
GPS	Global Positioning System
HPLC	High-performance liquid chromatography
IBSTI	Impact-Based Spatial Targeting Index
IITA	International Institute of Tropical Agriculture
ILO	International Labor Organization
LC-MS	Liquid chromatography-mass spectrometry
MSP	Multi-Stakeholder Platform
NGO	Non-governmental organization
P4D	Partnership for Delivery
PE	Partial Equilibrium
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
R4D	Research for Development
RAAIS	Rapid Appraisal of Agricultural Innovation Systems
SALSA	Search, Appraisal, Synthesis, and Analysis
SDG	Sustainable Development Goal
SRD	Sustainable Recommendation Domain
SSA	Sub-Saharan Africa
WFP	World Food Programme
WTP	Willingness To Pay

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Executive summary

Background

The social science and agribusiness research program at the International Institute of Tropical Agriculture (IITA) has supported the Institute's research and delivery efforts since 1967. This Compendium highlights the main achievements of IITA's social science and agribusiness research over the 55 years from 1967 to 2022.

Methodology

The Compendium is a product of a systematic review conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Grant & Booth 2009), following the Search, Appraisal, Synthesis, and Analysis (SALSA) framework (Moher et al. 2010). This involved four stages: search (keyword identification and database search); appraisal (paper selection through the PRISMA statement); synthesis (data extraction and categorization); and analysis (data analysis, comparison of results, and conclusion).

The online search for IITA's social science and agribusiness research publications in the CGSpace repository of agricultural research outputs yielded 5,755 publications comprising 4,836 journal articles and 919 books and book chapters. Applying the screening and eligibility criteria based on the PRISMA guidelines finally resulted in 597 publications used for data synthesis (data extraction and categorization). Of the 597 documents reviewed, 584 were peer-reviewed journal articles, and 13 were book and book chapters. The synthesis was based on seven variables of interest. These include research themes; research crops; research methods; name of journal; year of publication; country of study; and research findings. The extracted data were then analyzed to assess the achievements of the 55 years of research efforts.

Summary of achievements

The achievements of IITA's social science and agribusiness research program were measured using five indicators: number of research themes; number of research crops; innovativeness of research methods; quality of science (disaggregated by journal type, temporal, and spatial distribution); and research findings.

IITA's social science and agribusiness research program covered nine thematic areas: adoption and impact assessment; food safety and nutrition; innovation platforms and policy advocacy; value chain analysis; research priority setting; situation and context analysis; gender analysis; consumer acceptance; and youth initiatives. We retained the above typology to minimize the overlap of publications, although some of the publications in each group could also fall under another group. That is particularly the case for publications in the two groups on research priority setting and situation and context analysis. However, the authors kept these groups separate because some articles are better suited to

one group than the other.

Adoption and impact studies account for the highest proportion of publications (40%), followed by food safety and nutrition (14%). Consumer acceptance and youth studies account for the lowest number of publications.

The program has covered IITA's six mandate crops: banana and plantain, cassava, cowpea, maize, soybean, and yam. Other non-mandate crops of regional importance, such as legumes, oil crops, coffee, cereals, and tree crops, were also included.

This program has applied innovative research methods in data collection and analysis. The innovative methods in data collection are DNA fingerprinting for variety adoption, Global Positioning Systems (GPS) for plot area measurement, and e-surveys for socioeconomic data. The methodological achievements in data analysis are the adaptation of advanced econometric models. These models were adapted to estimate counterfactual income distributions, and the number of poor Africans lifted out of poverty due to the adoption of technologies developed by IITA and its national and international research partners. In addition, achievements in research priority setting included applying partial equilibrium economic surplus models and poverty impact simulations. Advances in research targeting entailed the development of an extrapolation suitability index (ESI) and impact-based spatial targeting index (IBSTI) using geospatial analysis to delineate sustainable recommendation domains (SRDs) and identify priority areas within each SRD.

In terms of quality of science, the program published over 597 journal articles, books, and book chapters from 1967 to 2022, with most of them published from 2011 to 2022, the period of IITA's refreshed strategy of 2012–2020, during which the Institute committed to demonstrating the impacts of its research. They were published in 14 economic journals with an average impact factor of 2.585, with 22 publications in Agricultural Economics accounting for the highest number. Regarding geographic distribution, nearly half of the published studies were conducted in West Africa. This is not surprising because, with its headquarters in Nigeria, IITA concentrated most of its activities in West Africa for more than four decades before expanding its operations into Eastern, Central, and Southern Africa.

Below are highlights of new knowledge generated along the nine research themes.

Adoption and impact (over 40% of qualified publications)

- Adoption and impact evidence for improved varieties of cassava, heat- and drought-tolerant maize, soybean, cowpea, and sustainable agricultural practices in different countries: Nigeria, Tanzania, Malawi, Democratic Republic of the Congo (DRC), Zambia, Sierra Leone
- Adoption and impact evidence for policies (e.g., subsidy) in Nigeria and Uganda

Food safety and nutrition (14% of publications)

- Understanding of food safety issues, particularly farmers' awareness about aflatoxin

contamination and its control through the use of Aflasafe

- Understanding of nutrient-dense products such as biofortified yellow-flesh and white-flesh cassava variants
- Identification of potential areas of research on edible insects in Africa, and review of available knowledge on post-harvest processes (processing, packaging, and storage) for edible insects in Africa

Situation and context analysis (10% of publications)

- Determination of the potential negative impacts of climate change on food security
- Identification of promising climate change adaptation strategies (e.g., moisture stress- and heat-tolerant crop varieties)
- Identification of constraints to the effectiveness of policies (e.g., policy instability, inconsistency in policies, narrow base of policy formulation, poor implementation, and weak institutional framework for policy coordination)
- Identification of structural and agricultural transformation drivers

Value chain analysis (10% of publications)

- Identification of the drivers of commodity value chain performance
- Identification of the determinants of value chain innovations
- Identification of the determinants of smallholder farmers' participation in agricultural markets
- Determination of economic efficiency
- Determination of the potential social, economic, and environmental impacts of value chain activities
- Determination of post-harvest food losses in different cropping systems
- Identification of promising post-harvest management technologies

Innovation platforms and policy advocacy (9% of publications)

- An understanding of systems approaches to agricultural research and development as innovation development and scaling out mechanisms: agricultural innovation systems (AIS) and agricultural information platforms (AIP)
- Identification of institutional arrangements and policy options about technology, markets, and finance using a Rapid Appraisal of Agricultural Innovation Systems (RAAIS)
- Identification of opportunities for increased commercialization and investment in Nigeria's agriculture, improving the targeting of agricultural research and the resulting innovations through geographic and social scaling

Gender analysis (6% of publications)

- Identification of factors hindering women's participation in the value chain (e.g., low level

of education; poor market infrastructure; access to extension, credits, and improved agricultural technology)

- Identification of the social, economic, institutional, infrastructural, gender, and policy factors promoting or hindering the uptake of agricultural innovations
- Understanding of the role of post-harvest processing, product development, and other demand-creating interventions in stimulating technology uptake
- Understanding of the effects of gender differentials in livelihood assets and technology preferences; and access to services on adoption, yields, and income

Research priority setting (5% of publications)

- Identification of cassava research priorities in Africa, Latin America, the Caribbean, and Asia based on an ex-ante evaluation of the potential economic and poverty reduction impacts of alternative cassava technological options
- Identification of commodity research priorities in Nigeria based on potential economic and poverty reduction impacts
- Delineation of sustainable recommendation domains (SRDs) for scaling improved maize technologies in Tanzania and identification of priority areas within each SRD
- Determination of the social capital dimensions of household food security interventions in Uganda
- Identification of soybean investment priorities in Africa

Youth initiatives (4% of publications)

- Identification of factors influencing youth participation in agricultural value chains
- Understanding of African rural youth engagement in agribusiness
- Understanding of agribusiness's contribution to reducing youth unemployment

Consumer acceptance (3% of publications)

- Identification of the factors determining willingness to pay for agricultural technologies (e.g., access to information from extension centers, farmers' perceptions of attributes such as color, texture, and nutrition), market prices, and availability of products
- Identification of factors that stimulate agricultural innovation and adoption of agricultural technologies
- Understanding of consumer preferences for improved technologies
- Understanding of the range of variety trait preferences among farmers and a range of nutritional, sensory, processing, and product properties that could be used in setting future breeding priorities

The Way Forward

This systematic review shows the richness of topics and the rigor of science applied in the past 50+ years of research in the social sciences and agribusiness at IITA. The review has also uncovered that limited attention has been given to the following topics: technologies outside of genetic improvement; general equilibrium effects models; multidimensional poverty analysis; qualitative analysis; sex-disaggregated data; priority setting; and research targeting.

Therefore, as we advance, it will be important to expand the scope of the impact research in the following ways:

- from single crop varieties to agronomic technologies, multiple and integrated value chain technologies, institutional and policy innovations, mechanical technologies, digital technologies, crop protection, natural resource management, and genetic resources conservation
- from farm production to post-production stages – processing, storage, trade, marketing, and consumption
- from productivity, food security, nutrition, income, and poverty analysis to environmental and health impacts of technologies
- from household models to general equilibrium effects models
- from quantitative analysis to mixed methods
- from inter-household to intra-household analysis of income, nutrition, and health outcomes using sex-disaggregated data
- from a single value chain approach to a food systems approach.

Other areas that have received limited attention are related to partnerships for delivery. For example, youth research has only taken off in recent years.

In thematic areas where research on social science and agribusiness has made noticeable progress, there is still a need to refine the existing methods of impact assessment to demonstrate impacts at different levels; strengthen research priority setting (foresight modeling); and strengthen research targeting through geospatial analysis for identification of recommendation domains and priority areas within each domain.



Youth agripreneurs doing training on food processing for fellow youth. Photo by IITA.

Introduction

The agricultural sector of sub-Saharan Africa (SSA) has been fraught with challenges, including low agricultural productivity, climate variability, land degradation, post-harvest food loss, food insecurity, poverty, youth unemployment, and gender inequalities (Bjornlund et al. 2020). The region's agricultural productivity remains the lowest in the world, undermining its food security and competitiveness in the global market. Climate variability and land degradation pose major challenges to the region's long-term agricultural productivity and the sustainability of its agricultural production due to weather extremes, nutrient mining, deforestation, and loss of biodiversity. Sixty-five percent of Africa's agricultural land had been degraded for several decades (FAO & ITPS 2015). Post-harvest food loss in the region is also unacceptably high, amounting to about US\$4 billion (World Bank 2011). Youth unemployment is also the highest, reaching as high as 60% of total unemployment in the continent (ILO 2011). In the face of these challenges, there is a growing threat of food insecurity. Poverty remains deep and widespread in many African countries.

Agricultural research has long been considered a crucial mechanism to address these challenges. The history of international agricultural research in the region goes back to the 1960s. However, success in technology development and delivery did not come to the region quickly. It took at least two decades for research benefits to be felt in the region. SSA had only modest agricultural production per capita growth from the early 1960s to the 1970s, and occasional short periods of growth in the mid-1970s and 1980s (Bjornlund et al. 2020). For example, IITA's research impact has been felt only since the 1980s with breakthroughs in crop genetic improvement, crop management practices, crop protection, and processing technologies. IITA's research has been organized around four core competencies: biotechnology and genetic improvement; natural resource management; plant protection and health; and social science and agribusiness. These research programs reduce rural poverty, increase food security, mitigate undernutrition, and promote more sustainable management of natural resources.

Over the past five decades, social science and agribusiness research has aimed at achieving six strategic objectives: define agricultural research priorities; better understand the socioeconomic dynamics, determinants of rural livelihood strategies, and pathways out of poverty; better understand gender-differentiated, end-user preferences and the extent, determinants, and pathways of adoption of technological innovations; identify and advocate for alternative institutional arrangements and policy options on technology delivery, input supply, and output markets; better target agricultural research and the resulting innovations through geographic and social scaling; and develop and adapt new methods of ex-post impact assessment as well as documenting the effectiveness, poverty reduction, nutrition, food security, and environmental impacts of research investment for accountability and learning. What has social science and agribusiness contributed to the objectives of IITA? This Compendium attempts to address this question. Through a literature review it highlights the achievements of IITA's social science and agribusiness research from 1967 to 2022.

Chapter 2 presents the review's methodology, and Chapter 3 presents and discusses the achievements of the social science and agribusiness program. We conclude with lessons and implications for future research in Chapter 4.



Empowering women and youth through knowledge sharing using digital means. Photo by IITA.

Methodology

The review is guided by three research questions:

- What has been achieved in terms of the diversity of social science and agribusiness research themes, the types of commodities studied, and the quality of the science?
- What specific research problems are addressed?
- What new findings or knowledge have been generated to address these research problems?

Literature search and analysis methods

A systematic literature search and analysis of all IITA's social science and agribusiness publications in CGSpace (<https://cgspace.cgiar.org/handle/10568/68616>) was carried out according to the Search, Appraisal, Synthesis, and Analysis (SALSA) framework (Table 1). The SALSA framework is one of the most suitable tools for identifying, evaluating, and systematizing literature (Grant & Booth, 2009). The accuracy and completeness of the review were ensured by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Moher et al. 2010).

Table 1. The SALSA framework for systematic literature search and review

Stages	Key actions
Search	Keyword identification; search database Research scope: IITA studies under six strategic objectives
Appraisal	Paper selection through the PRISMA statement
Synthesis	Data extraction and categorization
Analysis	Analysis of data, results in comparison, and conclusion

Source: Grant & Booth (2009) for a typology of reviews

Search strategy

A standardized search strategy was developed to include words or phrases relating to the six strategic objectives of the social science and agribusiness research: agricultural research priorities; socioeconomic dynamics, determinants of rural livelihood strategies, and pathways out of poverty; gender-differentiated, end-user preferences and extent, determinants, and pathways of adoption; institutional arrangements and policy options; research targeting through geographic and social scaling; and ex-post impact assessment.

In addition, subject heading terms were explored to capture the broadest range of publications. Agreed search terms were: ‘ex-ante evaluation’, ‘research targeting’, ‘adoption and diffusion’, ‘value chain’, ‘post-harvest’, ‘consumer preference’, ‘food safety and nutrition’, ‘situation and context analysis’, ‘innovation platform and policy advocacy’, ‘youth’, ‘gender inclusiveness’, ‘willingness to pay’, ‘agricultural technology’, ‘agro-ecologies’, ‘youth agribusiness’, ‘priority setting’, ‘food quality’, ‘effectiveness of programs’, ‘innovation’, ‘nutrition’ and ‘IITA’.

The search strategy was applied to the IITA publication database in CGSpace (<https://cgspace.cgiar.org/handle/10568/68616>). The publications were extracted using the ZOTERO free, open-source reference management software to manage bibliographic data and related research materials.

Appraisal

The appraisal involved identifying and selecting publications and applying inclusion and exclusion criteria to screen the relevant publications for content analysis. As the review focused on published materials, we started with journal articles, books, and book chapters. The appraisal was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement, which comprises four phases: identification, screening, eligibility, and inclusion of documents for further analysis.

The initial search of the IITA publications database in CGSpace yielded a total of 4,836 journal articles and 919 books/book chapters, in addition to other publication types (Figure 1).

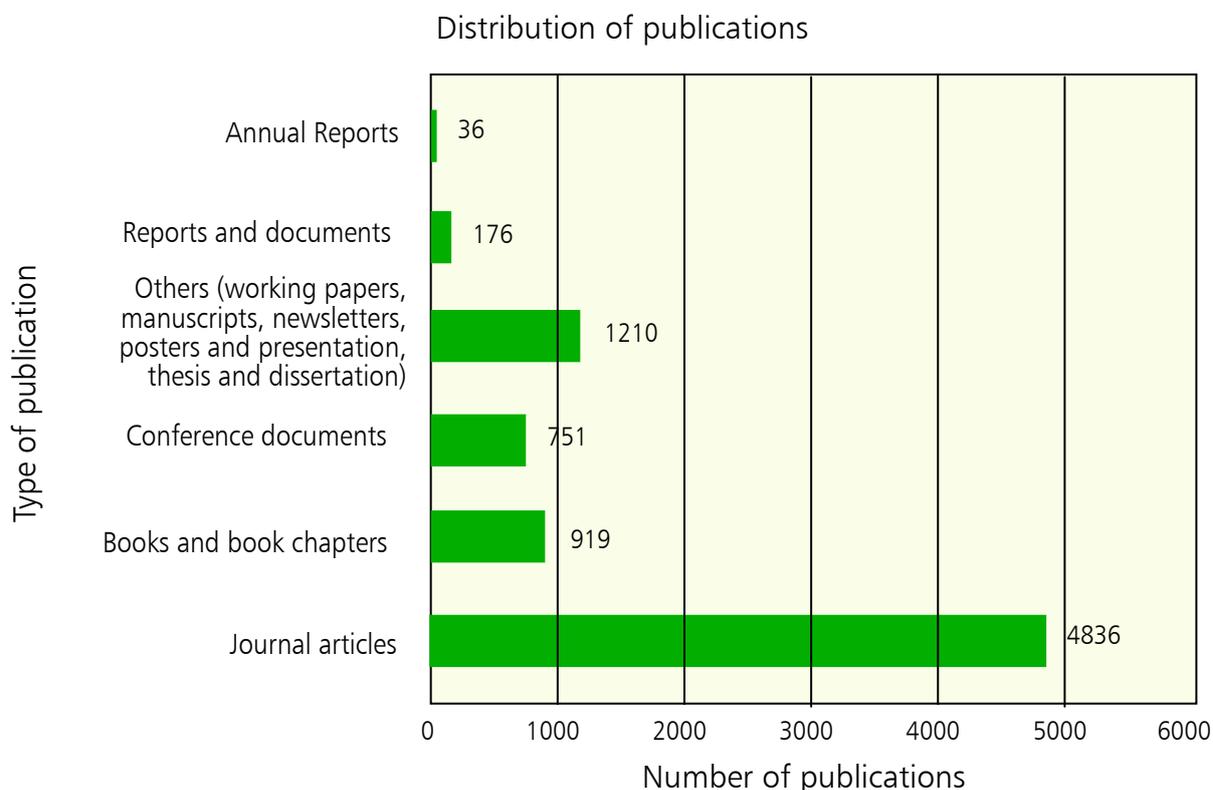


Figure 1. Distribution of publications from the initial search (December 2022). Source: Authors’ analysis

PowerPoint presentations and blogs, among other publication types, were excluded from the list of outputs. Those publications that focused on the identified strategic objective areas, or at least carried out social science and agribusiness-related analysis from 1967 to 2022, were included for further analysis.

On this basis, we excluded 4245 journal articles, 906 books and book sections, 751 conference papers, 176 reports and documents, 36 annual reports, and 1,210 other publications. Many publications were excluded during the screening stage because the key search terms used for identification led to the inclusion of several IITA's biophysical science publications.

We retained 591 journal articles and 13 books and book chapters for the eligibility test (Figure 2). During the eligibility test, we excluded seven other journal articles as we could not find the abstracts or text. We treat them as missing data. Although most publications were written in English, four non-English articles were in the final listing. No restriction was set on the language used in the publications. The number of peer-reviewed publications included in the final listing was 597 papers (584 journal articles and 13 books and book chapters). Figure 2 describes the selection process showing the exclusions of publications in different phases of the PRISMA statement flow of information.

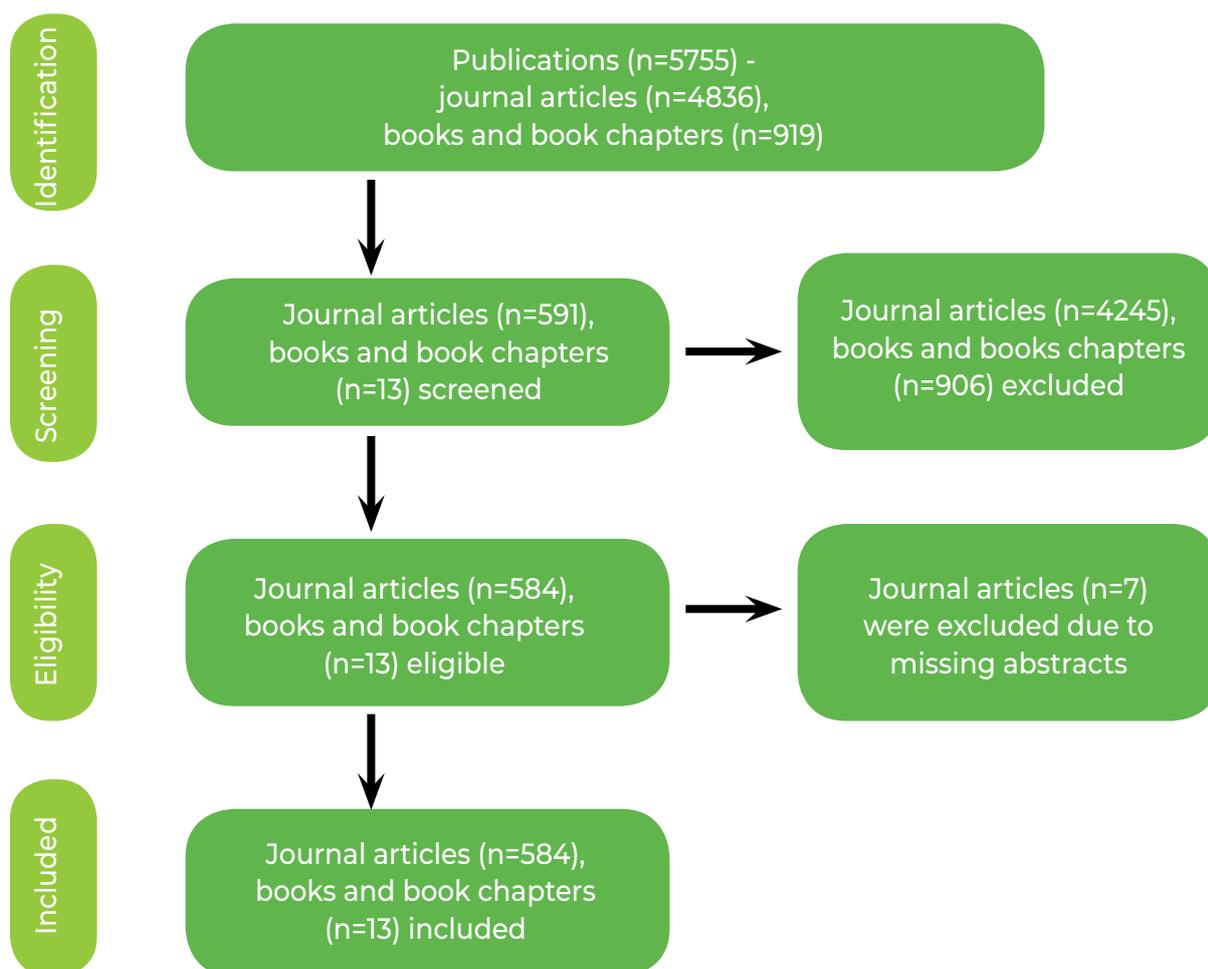


Figure 2. Flow of information in the selection process of qualified articles according to PRISMA.
Source: Authors' analysis

Synthesis

The selection of the 597 publications in the appraisal step was followed by identifying, extracting, and categorizing relevant data based on seven variables of interest: research themes, research crops, research methods, name of journal, year of publication, country of study, and research findings. Data were extracted from the 597 publications and entered into an Excel spreadsheet for analysis.

Analysis

Quantitative and qualitative analyses were applied to the extracted data. The quantitative analysis was applied to answer the research question:

- What has been achieved in terms of the diversity of social science and agribusiness research themes, the types of commodities studied, and the quality of science?

The qualitative analysis was applied to the following research questions:

- What specific research problems have been addressed?
- What research methods have been applied?
- What new knowledge has been generated to address these research problems?

This analysis focuses on the research findings, identifying gaps, and suggesting future areas of investigation. The quantitative results (e.g., the number of publications by year) are summarized using bar charts, while the qualitative results (e.g., advances in research methods) are summarized in tables in Chapter 3.



*Farmers appreciating good performance of legume technologies at one of N2Africa sites in Gairo district, Tanzania.
Photo by IITA.*

Achievements

The achievements of IITA's social science and agribusiness research were measured by five indicators: number of research themes; number of research crops; innovativeness of research methods; quality of science (disaggregated by journal type, temporal and spatial distribution); and research findings.

Research themes

The publications reviewed covered nine thematic areas. Figure 3 presents the percentage distribution of the publications by theme. Studies on adoption and impact assessment were documented in 239 publications from 1967 to 2022, accounting for the highest proportion of publications (40%), followed by food safety and nutrition (14%). Consumer acceptance (3%) and youth studies (4%) account for the lowest number of publications. This finding was not unexpected, given that the focus of the social science and agribusiness strategy over the past decade was adoption and impact assessment. Gender studies accounted for about 6% of the total publications. Most of these articles were published in the past few years when IITA started putting concerted efforts into integrating gender into research for development. IITA currently ensures that all its research programs are gendered so that all technologies generated can benefit men, women, youth, and vulnerable groups/people.

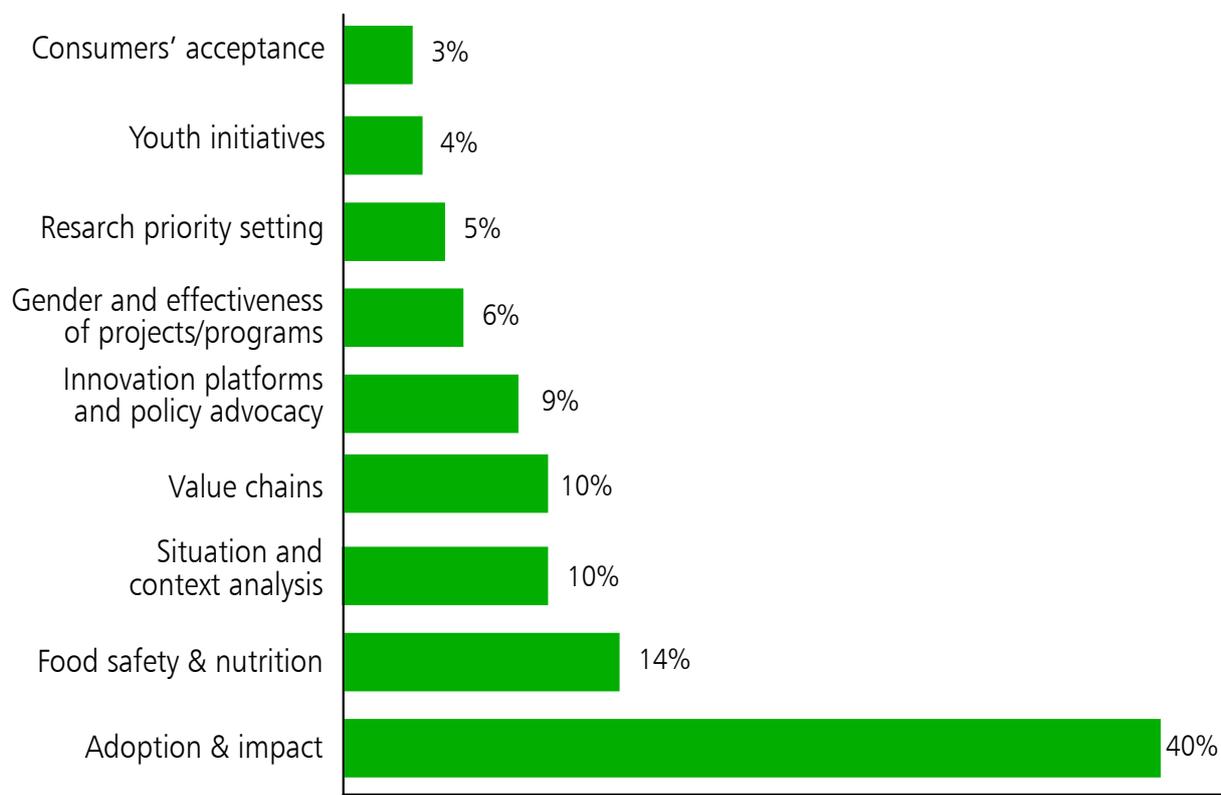


Figure 3. Percentage distribution of reviewed publications by theme. Source: Authors' analysis

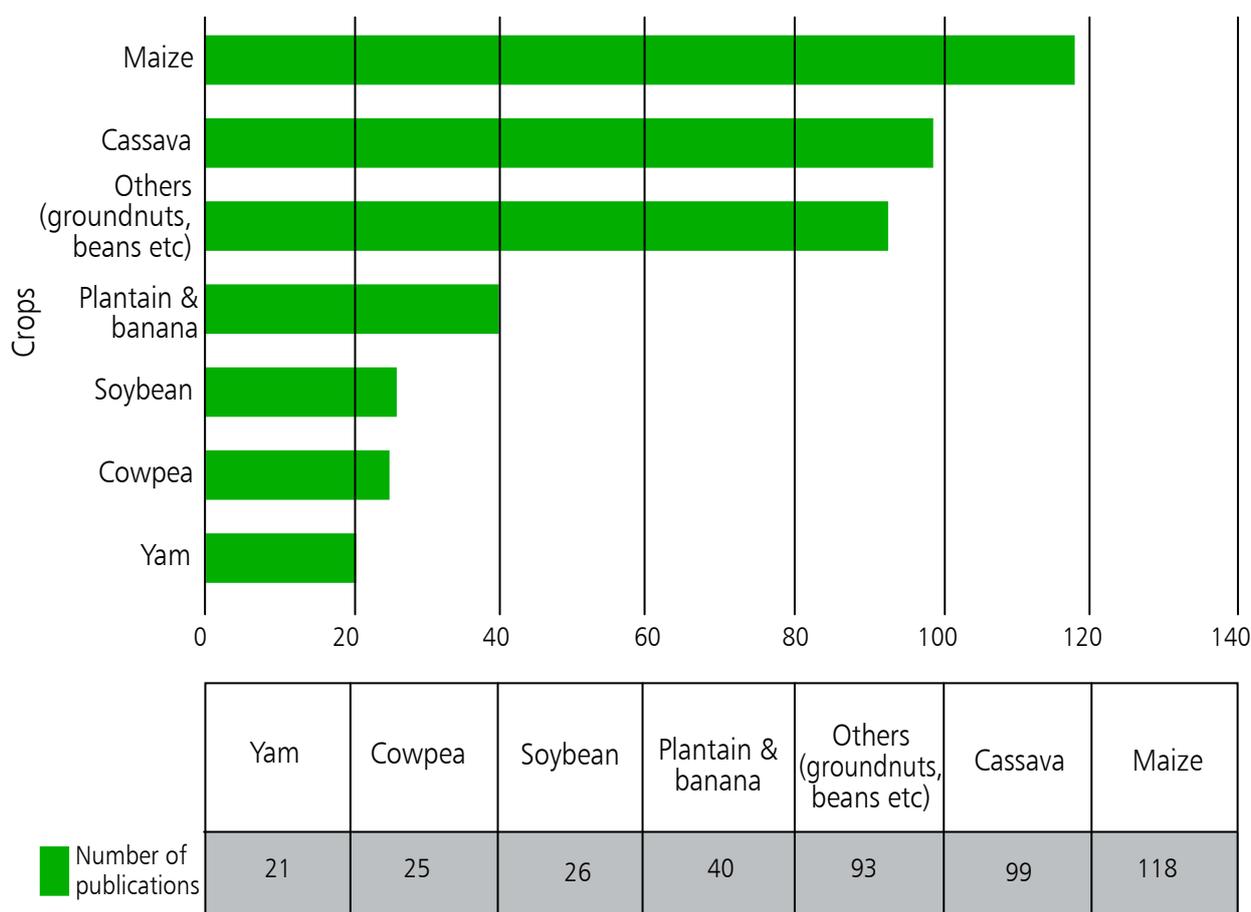


Figure 4. Distribution of publications specifically mentioning the six crops. Source: Authors' analysis

Research crops

IITA's social science and agribusiness research has covered all six of its mandate crops: cooking banana (including plantain), cassava, cowpea, maize, soybean, and yam. Other crops in the published articles co-authored by IITA social scientists include beans, coffee, coconut, sorghum, groundnut, pigeon pea, sunflower, millet, papaya, potato, rice, cocoyam, wheat, and cocoa. The remaining publications were about agriculture in general and did not specifically mention the type of commodity under study. Figure 4 presents the distribution of publications specifically mentioning the six mandate crops. Among these crops, most publications were on maize (118) and cassava (99).

Research methods

The social science and agribusiness research program, which started with an on-farm experiment datasheet and economic analyses of on-farm experiments, has advanced steadily from paper-based data collection and simple descriptive analyses to electronic surveys and more advanced quantitative (econometric and mathematical) models. These cut across ex-ante and ex-post impact assessment and research targeting. In relation to quality data collection, an innovative technique (DNA fingerprinting) was used to accurately identify improved varieties in farmers' fields, and GPS-based area measurements were used to more correctly calculate the area of land allocated to an improved variety. The other achievement contributing to quality

data collection was the digitalization of socioeconomic surveys, enabling the timely collection of more accurate data and their speedy analysis.

Improvements in ex-post impact assessment methodology involved using experimental, quasi-experimental, and non-experimental designs. Particular progress in this area involved the adaptation of a hybrid approach that combines household-level and market-level data to assess the indirect impacts of the technologies, such as food price reduction resulting from a higher food supply due to increased adoption. The adaptation of such advanced quasi-experimental and non-experimental designs and econometric models has made it possible to generate counterfactual income distribution. This led to determining the number of poor Africans lifted out of poverty due to the adoption of technologies developed by IITA and its partners in national and international research systems. Both parametric and non-parametric econometric models (e.g., propensity score matching and instrumental variable models such as the endogenous switch regression model) have been applied to assess the direct impacts of technology adoption. Binary and multinomial discrete choice models were applied to identify adoption barriers. Choice experiments were also applied for the evaluation of nutritional outcomes.

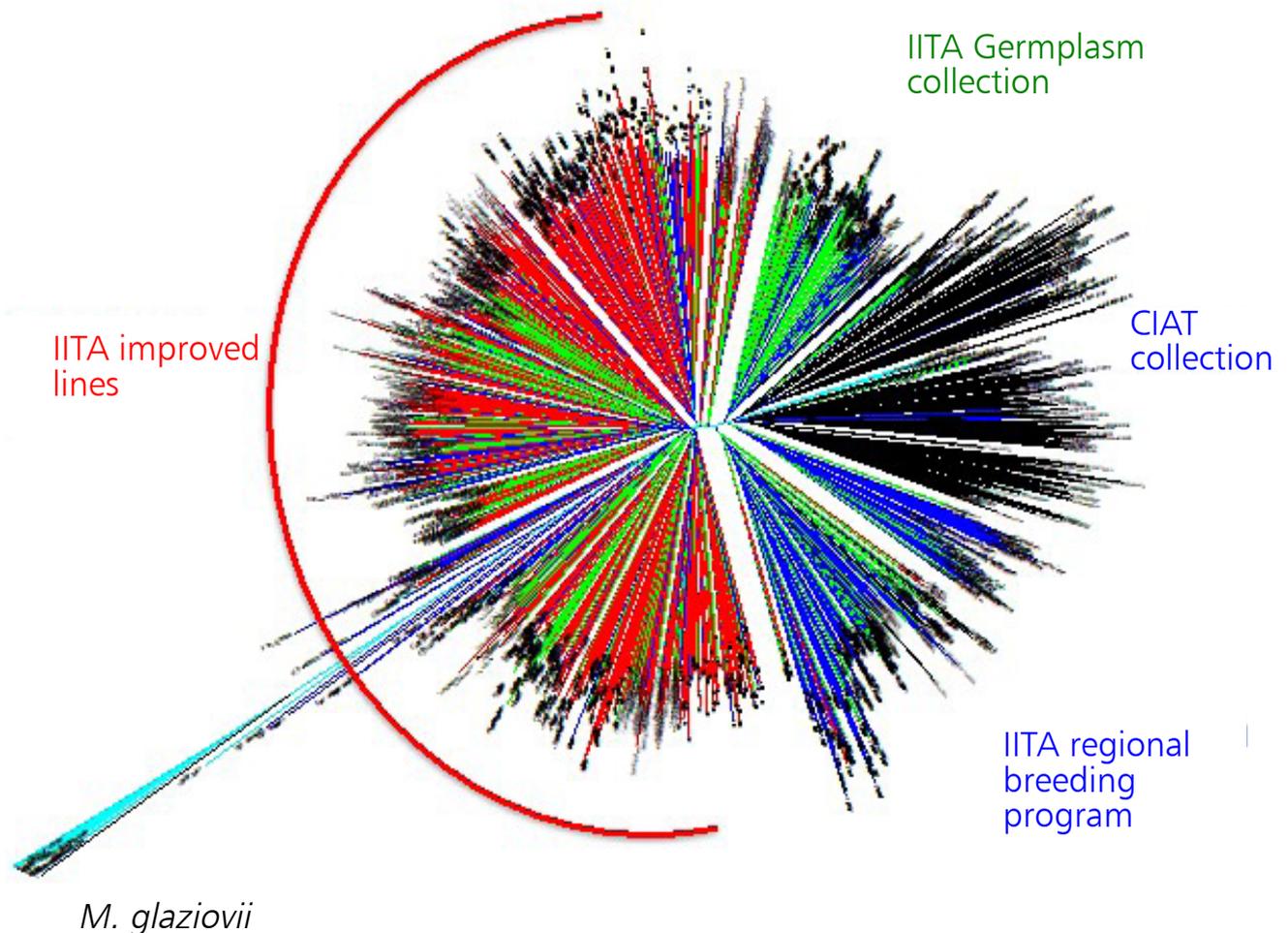
Research priority setting progressed from using simple methods (e.g., a weighted mean score, general linear model test, and Duncan’s multiple range test) to applying foresight modeling and ex-ante analysis using equilibrium models. Based on the economic surplus concept and poverty impact simulations, this application led to support for research priority setting (e.g., cassava research priorities in Africa, Latin America, the Caribbean, and Asia).

Research targeting was improved by applying big data in geospatial crop modeling and geospatial analysis to delineate sustainable recommendation domains (SRDs) and identify priority areas within each SRD. This enabled scaling out of improved technologies (e.g., improved maize technologies in Tanzania).

Table 2. Achievements in research methods by research area

Research area	Data collection technique	Data analysis
Adoption	DNA fingerprinting for accurate variety identification	Binary and multinomial discrete choice models
Impact	GPS-based area for accurate plot area measurement	A hybrid approach that combines household-level and market-level data, equilibrium models based on the economic surplus concept, and poverty impact simulations; choice experiments
Targeting research	Big data	Geospatial analysis, geospatial crop modeling
Socioeconomic data	e-surveys	Parametric and non-parametric econometric models (e.g., propensity score matching endogenous treatment effect), and economic models (e.g., economic surplus)

Source: Authors’ analysis



DNA Techniques: IITA Reference Library for Cassava
 Source: Wossen et al. (2017).

Quality of science

According to Marc F. Bellemare (2021), the co-editor of the *American Journal of Agricultural Economics*, the top 10 journals in the “agricultural economic and policy” category by impact factor are:

- *Annual Review of Resource Economics* (5.184)
- *Aquaculture Economics and Management* (4.761)
- *Food Policy* (4.552)
- *Applied Economic Perspectives and Policy* (4.083)
- *American Journal of Agricultural Economics* (4.082)
- *European Review of Agricultural Economics* (3.836)
- *Journal of Agricultural Economics* (3.581)
- *Australian Journal of Agricultural and Resource Economics* (2.863)
- *Agricultural Economics* (2.585)
- *British Food Journal* (2.518)

Of over 200 journals identified in the study, *Agricultural Economics* had the highest number (22) of articles published by IITA social science and agribusiness researchers over the years, with an impact factor of 2.585.

Figure 5 presents the distribution of articles by journal type for those journals with at least seven articles by IITA researchers. IITA social science and agribusiness research findings were published in 15 top journals from 1967 to 2022, with *Agricultural Economics* ranking first, followed by *Sustainability* and *Agricultural Systems*.

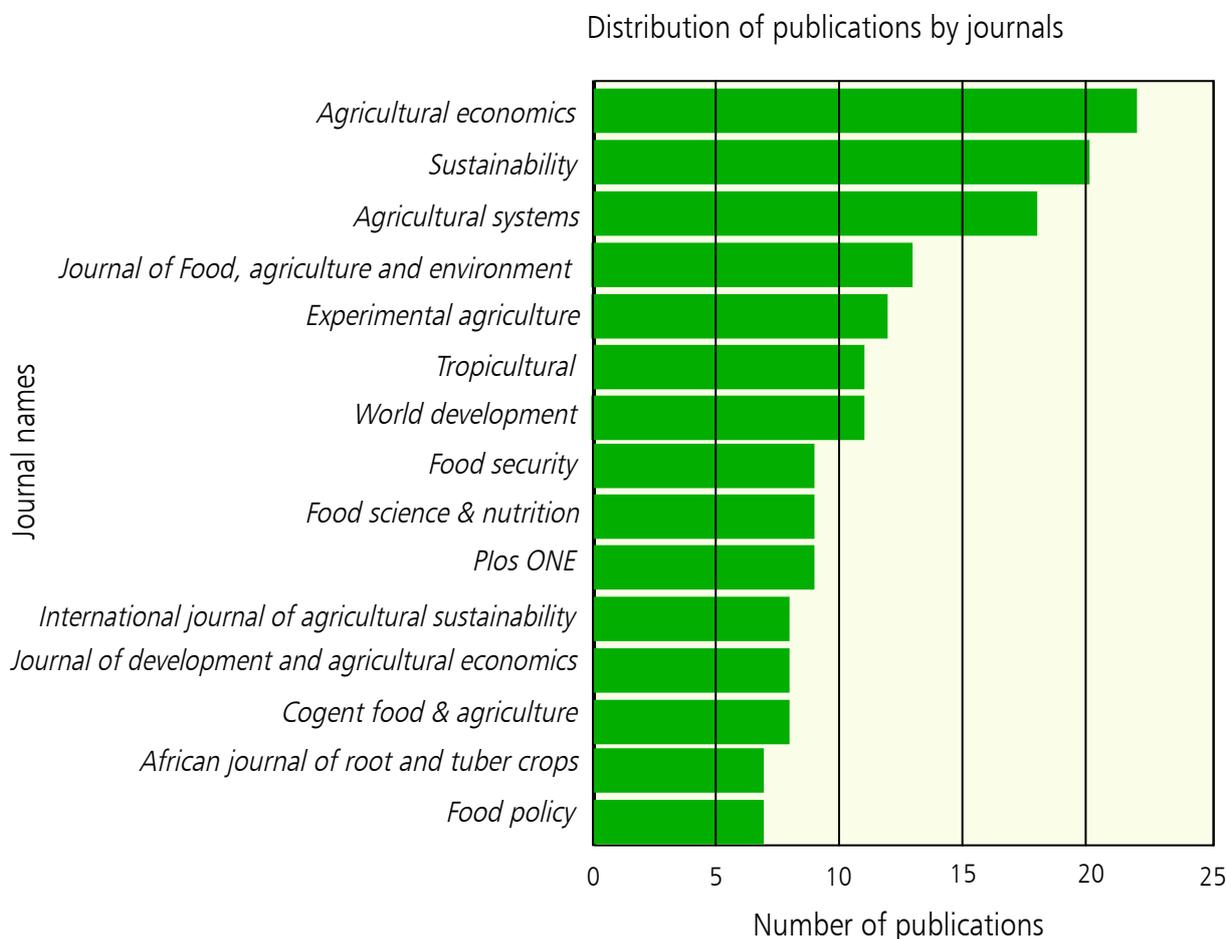


Figure 5. Distribution of publications by journals published with at least seven articles by IITA researchers. Source: Authors' analysis

Year of publication

Figure 6 presents the distribution of the reviewed IITA publications by year of publication. About 83% of the 597 studies were published between 2007 and 2022. The figure shows a steady increase in the number of publications in SSA over time. The largest increase occurred between 2011 and 2022, the period of IITA's refreshed strategy of 2012–2020. During this period, the Institute committed to demonstrating evidence of its contribution to lifting 11 million persons out of poverty, associated with the adoption of IITA technologies as a major key performance indicator. IITA went through a significant expansion in its adoption and impact studies research capacity. At the same time, there was a growing interest in developing youth initiatives to overcome unemployment problems. During this period, IITA's youth in agribusiness initiatives were introduced as one of the research thematic areas. This involved an increase in resources in terms of funds, labor, technologies, and study scope, to mention a few.

Distribution of reviewed publication by year of publication

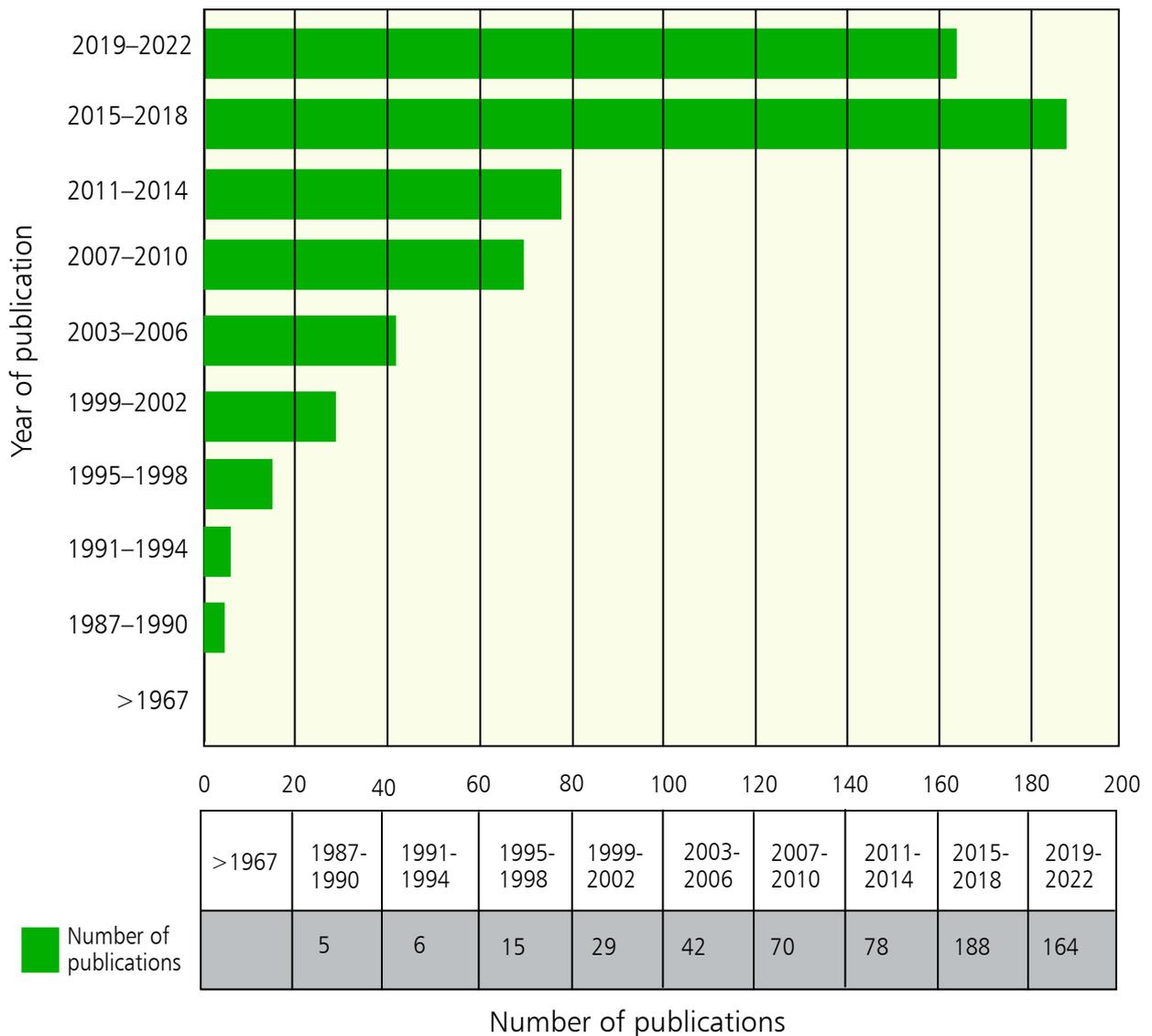


Figure 6. Distribution of reviewed publications by year of publication. Source: Authors' analysis

Spatial distribution

More than 90% of the publications were on studies conducted in African countries, as IITA's mandate primarily targets countries in SSA. Figure 7 presents the distribution of publications by geographic location based on publications covering one or more locations. The results show that most publications were on studies conducted in African countries; five involved collaborations with countries outside SSA (i.e., Latin America and South Asia). The remaining publications (over 50) did not specify the countries where the research was conducted.

Figure 8 shows that nearly half of the published studies were conducted in countries under the West Africa hub, with its headquarters in Nigeria. IITA's research was more concentrated in West Africa before spreading to countries under other IITA hubs.

Distribution of publications by geographic location

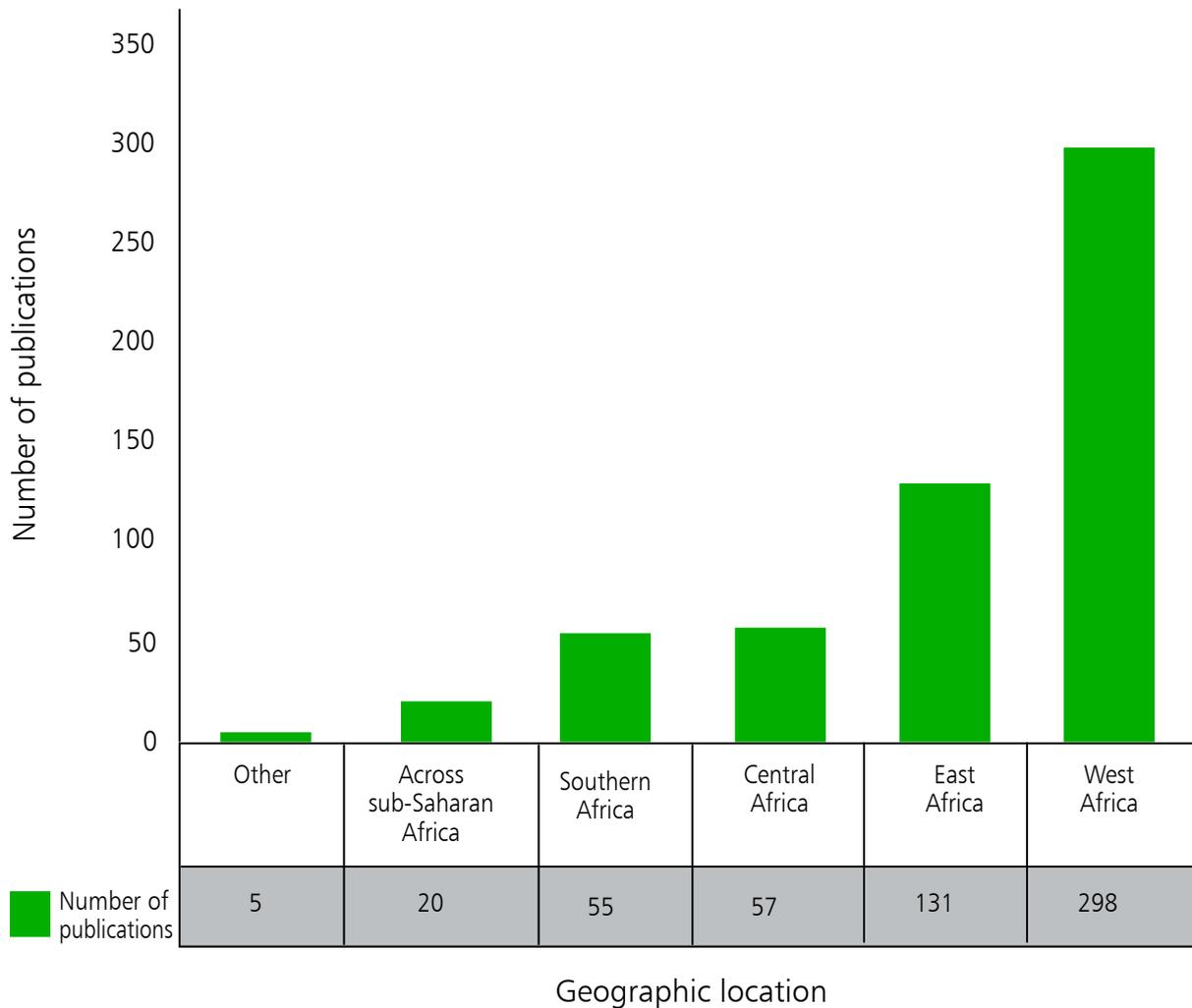


Figure 7. Distribution of publications by geographic location based on publications covering one or more locations. Source: Authors' analysis

Research findings

Adoption and impact

Table 3 presents the research problems, methods, and significant findings of the 239 adoption and impact publications. The significant findings include the determination of adoption rates and identification of adoption barriers; and quantitative measures of impacts based on various outcomes, including crop income, household income, food expenditure, profitability, input efficiency, factor substitution, risk, and sustainability of developed technologies. In particular, the adoption studies identified barriers (biophysical, demographic, socioeconomic, and institutional) to farmers' adoption of improved technologies in several countries. The barriers were identified using discrete choice models (e.g., bivariate, multivariate, or multinomial models). The socioeconomic impact studies generated impact evidence of technologies (varieties of cassava, drought-tolerant maize, soybean, and cowpea, and sustainable agricultural practices in different countries). The impact evidence was generated using parametric (e.g., endogenous treatment effect) and non-parametric

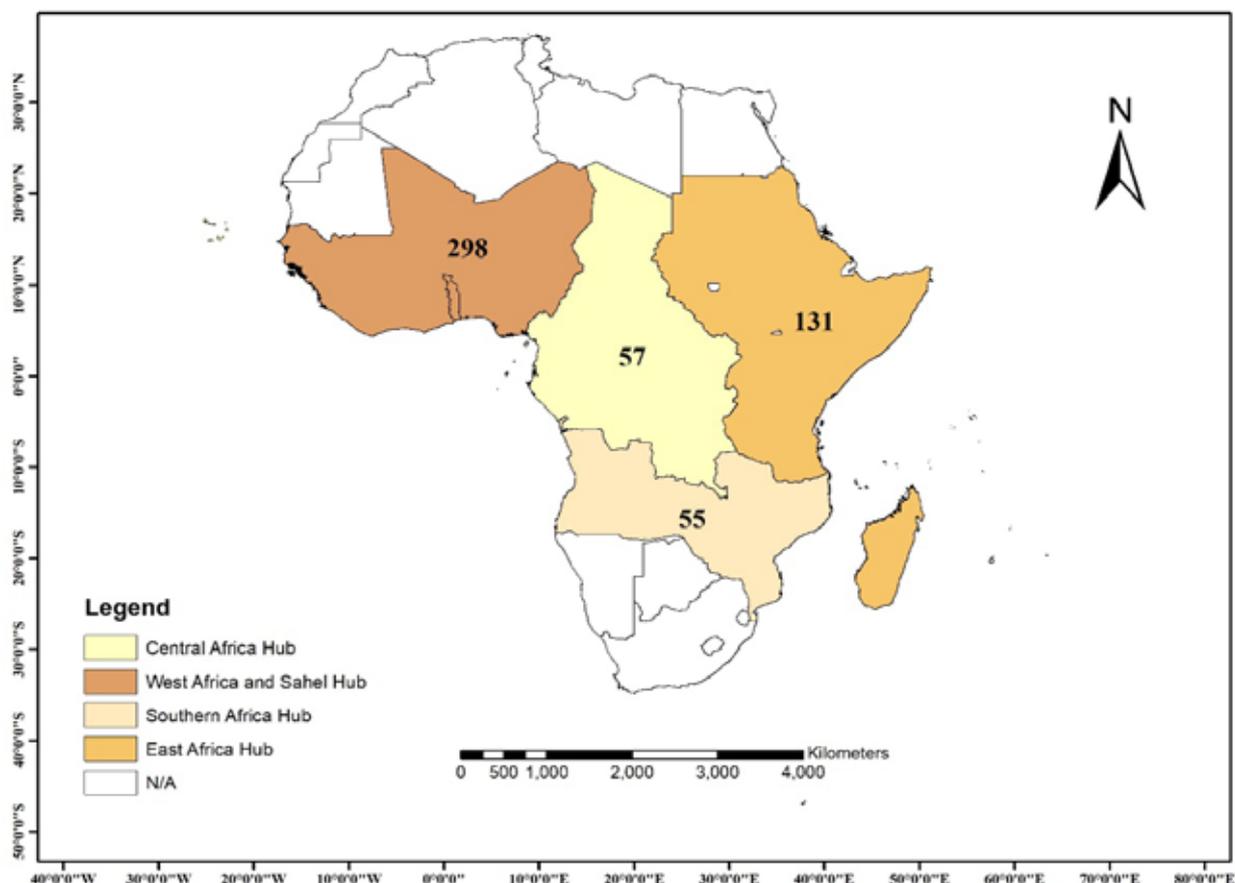


Figure 8. A map showing the distribution of the social science and agribusiness research publications across IITA hubs. Source: Authors' analysis

econometric models (e.g., propensity score matching) and economic models (e.g., economic surplus model). The application of these models led to a determination of the number of poor Africans lifted out of poverty due to the adoption of technologies developed by IITA and its national and international research partners. They also enabled evidence to be generated on the impacts of policies such as subsidies on productivity and farmers' welfare, and the role of subsidies in facilitating farmers' adoption of technologies in the face of their uncertainties about the effectiveness of the technologies and the weak private sector market.

The abstracts of the 239 publications are available in the Appendix (Adoption and impact).

Table 3. Research problems, methods, and findings in adoption and impact studies

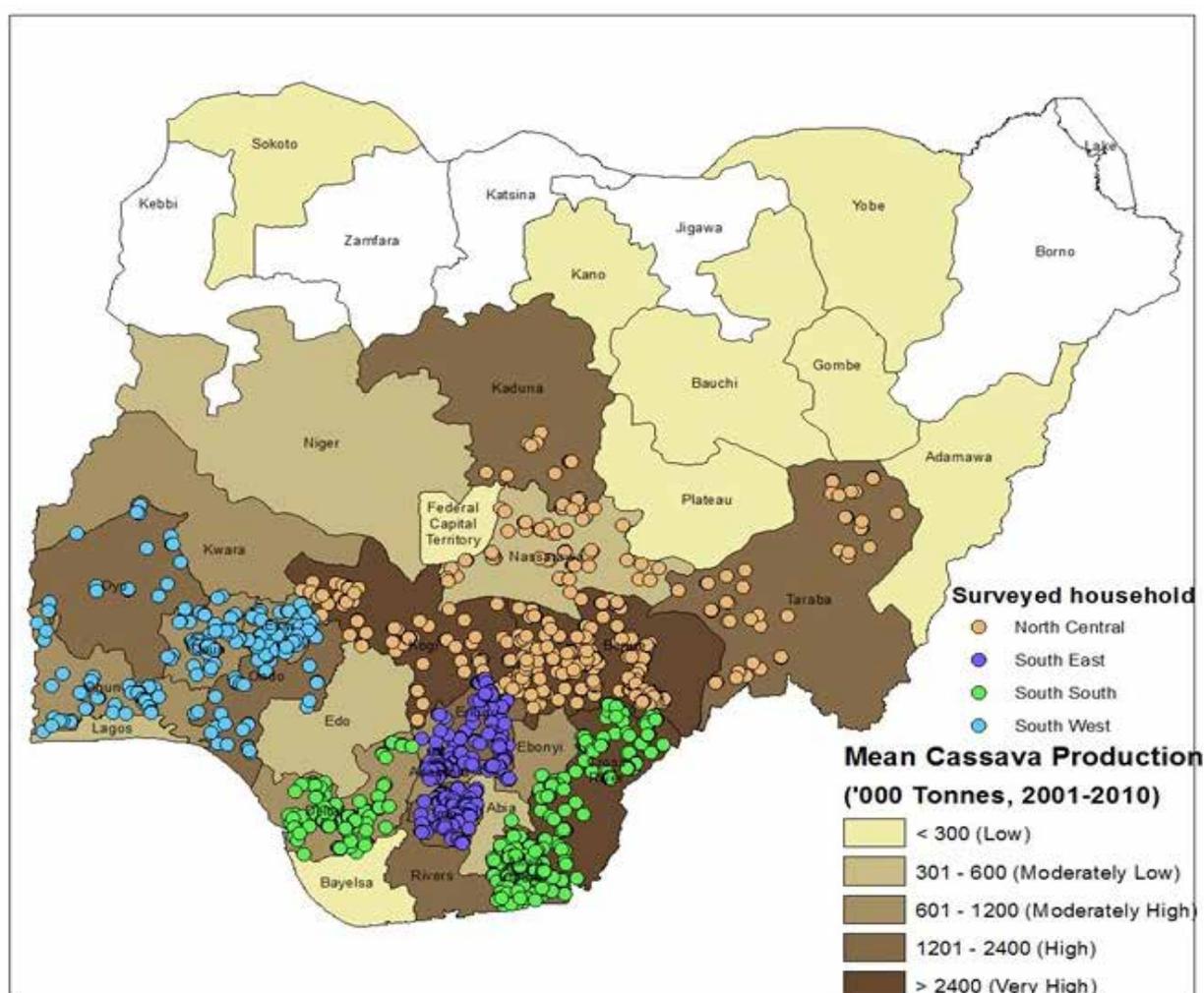
Challenge/problem	Methodology	Findings
What are the barriers to the adoption of agricultural technologies?	Discrete choice models	Barriers to adoption include biophysical, demographic, socioeconomic, and institutional factors
What are the household-level and market-level impacts of improved technologies and policies?	Parametric and non-parametric econometric models and economic models	Adoption of improved technologies led to increased productivity, economic efficiency, improved food security, and poverty reduction

Source: Authors' analysis

Food safety and nutrition

Table 4 presents the research problems, research methods, and major findings of 81 food safety and nutrition studies. The major research problems in food safety are the identification of mycotoxins in crops in the field and post-harvest stages; evaluating the impact of aflatoxin contamination on nutrient loss; and the impact of the biocontrol Aflasafe on nutrient loss reduction. Results show that aflatoxins are a problem not only during production, but also during storage, transport, processing, and handling. Locally processed products, particularly the processed forms of major staple crops such as groundnuts, maize, and sorghum, had the highest levels of aflatoxin contamination compared to unprocessed forms. Studies on the effects of Aflasafe technology have demonstrated that Aflasafe reduces food losses and contributes to food safety in SSA. Controlling aflatoxin contamination also benefited smallholder farmers in terms of increased income due to greater product acceptance, higher market value, or access to high-value markets.

Concerning nutrition, the major research problems are smallholder farmers' perceptions of food quality and the effects of biofortified food products and diet diversification on nutrition. Results show that smallholder farmers do not have definite food quality indicators that can determine or predict the quality of products. Indigenous knowledge, for example, on



Adoption and Impact: CMS Study Area in Nigeria
Source: Wossen et al. (2017), Wossen et al. (2019)

Table 4. Research problems, methods, and findings in food safety and nutrition studies

Challenge/problem	Methodology	Findings
<i>Food safety</i>		
What are the levels of mycotoxins in crops in the field compared with post-harvest stages?	HPLC, LC-MS, immuno-based assays, and optical methods	Locally processed forms of major staple crops have the highest levels of aflatoxin contamination compared to unprocessed forms
What are the effects of aflatoxin contamination on nutrient loss?	Experiments	Aflatoxin contamination causes significant nutrient loss
What are the impacts of using Aflasafe on nutrient loss reduction?	Experiments	The use of Aflasafe technology minimizes food losses in SSA
What are the effects of improved technologies on productivity gains and food loss reduction?	Sensory evaluation	Technical change at the farm level improves productivity and reduces food losses associated with post-harvest activities
<i>Nutrition</i>		
What is the effect of biofortification and diet diversification on households' nutritional status?	Endogenous switching regression	Biofortification improves mineral and vitamin deficiency in staple foods Diet diversification ensures adequate nutrients

Source: Authors' analysis

patterns of leaf foliage and smoothness and shape of tubers, is used to identify species and varieties rather than to predict food quality. The results also show that biofortification improves mineral and vitamin deficiency in staple foods, suggesting that adopting biofortified crops reduces the probability of stunting and malnutrition. Diversified diets also contribute to nutrient adequacy.

The abstracts of the 81 publications are available in the Appendix (Food safety and nutrition).

Situation and context analysis

Table 5 presents the research problems, methods, and significant findings of 59 publications related to situation and context analysis among countries in SSA. The major challenges addressed over time include examining the potential impacts of climate change and variability; identifying climate change adaptation to climate variability; estimating the impacts of climate change-relevant crop varieties on smallholder farmers; and identifying constraints to the effectiveness of past agricultural policies.

The computable general equilibrium (CGE) and partial equilibrium (PE) models have been used to estimate the impacts of climate change on crop productivity. These models helped to understand the market effects of crop production and its responses to climate change. Crop modeling focuses on the physiological dimensions of climate change effects on future crop yields and how adaptation strategies can be used to minimize adverse outcomes. Thus, the



Food Safety and Nutrition: Cassava Products
 Source Ismail Rabbi (2015)

Table 5. Research problems, methods, and findings in situation and context analysis

Challenge/problem	Methodology	Findings
What are the potential impacts of climate change and variability on smallholder agriculture under different adaptation scenarios?	Computable general equilibrium (CGE) model Partial equilibrium (PE) model	Potential impacts of climate change on food security assessed
Which adaptation strategies are viable options for smallholder farmers to cope with climate variability and structural changes?	Crop simulation models Decision Support System for Agrotechnology Transfer (DSSAT) model Cropping system model (CSM)	Potential solutions, such as the promotion of new varieties, identified as effective adaptation options (e.g., heat-tolerant and drought-tolerant varieties)

Source: Authors' analysis.

Table 6. Research problems, methods, and findings in agricultural value chain analysis

Challenge/problem	Methodology	Findings
What drives the performance of the value chain?	Bivariate probit model	Enabling environment, technology, market structure, value chain coordination, farm management, and inputs were identified as drivers for value chain performance
What is the value chain inefficiency?	Stochastic production frontier function	Productive efficiency and food security on farms require the size of the cultivated area to be matched by non-land production inputs such as labor and improved technologies

Source: Authors' analysis.

combination of climate–crop and economic models enabled researchers to capture the effects of climate-induced changes in crop productivity, market effects, and impacts on socioeconomic drivers. Results of simulation models show significant negative impacts on food security. The application of these models captures the uncertainty implicit in future climate conditions by linking crop and economic models to climate simulations. Promoting new varieties was identified as an effective adaptation option (e.g., heat-tolerant and drought-tolerant varieties). Policy instability, inconsistency in policies, narrow base of policy formulation, poor implementation, and weak institutional frameworks for policy coordination are constraints to the effectiveness of policies. These results contribute to the targeting of agricultural research and priority setting.

The abstracts of the 59 publications are available in the Appendix (Situation and context analysis).

Value chain analysis

Table 6 presents the research problems, methods, and significant findings of 58 publications related to value chains. The focus of these studies was on value chain mapping; identifying the determinants of smallholder farmers' participation in agricultural markets; assessing the efficiency of actors at different stages of the value chain; and identifying factors driving the adoption of processing and utilization methods. Results show that the adoption of technology, market structure, value chain coordination, farm management, and inputs are important drivers of value chain performance. These include educational level, social status, primary occupation, intensity of training, availability of commercially produced products in the market/area, and the number of desirable attributes of utilization methods. Other factors influencing market participation included transaction cost-related factors such as the geographical location of households, market information sources, and distance from the nearest urban center. Non-price-related factors, such as land security, labor availability, off-farm income, gender of household head, and years of farming experience, significantly influenced market participation.

The reviewed publications have also identified the factors affecting economic efficiency (technical and allocative) and suggest allocating resources toward more marketable commodities. They also suggest considering the productivity and market orientation of agricultural products and technologies in agricultural commercialization.

The abstracts of the 58 publications are available in the Appendix (Value chain analysis).

Innovation platforms and policy advocacy



IITA research for development provides innovations and platforms for farmers and youths in agricultural research. Photo by IITA.

Table 7 presents the research problems, methods, and significant findings of 51 publications related to innovation platforms and policy advocacy. Over the past years, innovation platforms have increasingly been established within the framework of agricultural research for development. The major research problems addressed in the reviewed publications include the role of innovation platforms in addressing information and communication gaps in traditional agricultural value chains and enhancing connectivity; the contribution of innovation platforms to agricultural research for development; factors influencing changes in multi-stakeholder innovation network characteristics; the contribution of information dissemination to potential beneficiaries; and effects of multi-stakeholder platforms (MSPs) on innovation development.

Table 7. Research problems, methods, and findings in innovation platforms and policy advocacy

Challenge/problem	Methodology	Findings
What is the role of innovation systems and platforms in traditional agricultural value chains?	Value chain analysis approach; qualitative and quantitative methods	Links between actors along the various stages of a value chain can be established through demand articulation, capacity building, and inclusive and participatory action
How do MSPs influence innovation networks?	Social network analysis and logistic models	MSPs do not necessarily expand and decentralize innovation networks, but can lead to contraction and centralization in the initial years of implementation

Source: Authors' analysis.

Results showed that innovation platforms play an important role in enhancing connectivity through demand articulation, capacity building, and inclusive and participatory action. The contribution of innovation platforms can be expressed in terms of the public and private mechanisms allowing innovations to scale beyond the original scope and target audience, and providing the ability to bring stakeholders together. The factors explaining changes in collaboration, knowledge, and influence on the spread of innovation networks were institutional environment, initial innovation network characteristics, types of problems targeted by MSPs, and funding. The potential benefits of innovation platforms can be enhanced through ICT, extension services, training, and practical experiments for learning. These were identified as catalysts to generate and mobilize participation by beneficiaries. MSPs can lead to contraction and centralization in the initial years of implementing innovations. Various innovation platforms, such as digital platforms and MSPs, have been applied in promoting public-private partnerships to commercialize agricultural innovations. They influence roles such as demand articulation, capacity building, and inclusive and participatory action, with a specific interest in environmental monitoring and new forms of organization enabled by enhanced connectivity.

The abstracts of the 51 publications are available in the Appendix (Innovation platforms and policy advocacy).

Gender analysis

Table 8 presents the research problems, methods, and significant findings of 35 publications that used the gender analysis approach. The major focus was identifying the factors influencing women's participation and adoption of agricultural technologies. The gender studies identified gender-differentiated constraints, technology needs, and preferences in vegetable, cassava, maize, and cowpea value chains. Factors such as low level of education, poor market infrastructure, access to extension and credits, and improved agricultural technologies influenced women's participation in value chains.

The abstracts of the 35 publications are available in the Appendix (Gender analysis).



Women farmers are the backbone of agriculture in Africa. Photo by IITA

Table 8. Research problems, methods, and findings in gender analysis

Challenge/problem	Methodology	Findings
What constraints or factors influence gender (women's) participation and adoption of agricultural technologies?	Probit regression models	Low level of education, poor market infrastructure, access to extension and credits, and improved agricultural technologies influence women's participation in vegetable, cassava, maize, and cowpea value chains
What are the gender relationships in production activities, income, market performance, and resource access in vegetable value chains?	Gendered value chain analysis	No pronounced gender division in the production process, but clear differences in the allocation of income from various crops in Tanzania
What is the link between gender differences and activities along the cowpea value chain?	Endogenous switching probit regression model	Women's participation in the cowpea value chain significantly increases cowpea production, marketing, and adoption of improved cowpea varieties in eastern Zambia

Source: Authors' analysis.

Research priority setting

Table 9 presents the research problems, methods, and significant findings of 29 publications related to research priority setting. The key issues addressed are setting research priorities for commodity programs (e.g., cassava program) and defining the target domains for scaling out agricultural technologies from pilot areas. The economic surplus concept was applied in a partial equilibrium model for research priority setting. The research priorities of the cassava program were set for Africa, Latin America, the Caribbean, and Asia. Geospatial analysis was applied for research targeting to develop an impact-based spatial targeting index (IBSTI) and extrapolation suitability index (ESI). These indices formed the basis for identifying priority impact zones in Tanzania to maximize the potential impacts of scaling out technology packages. The ESI utilizes data from agronomic trials and remote sensing to generate maps on the suitability of a particular technology beyond the trial sites. On the other hand, the IBSTI tool performs ex-ante estimations of the potential impacts of the technology if adopted in the suitable zone.

The abstracts of the 29 publications are available in the Appendix (Research priority setting).



Research for development and delivery of innovations are IITA's core business. Photo by IITA.

Table 9. Research problems, methods, and findings in priority setting and targeting studies

Challenge/problem	Methodology	Findings
What are the priorities for commodity research programs?	Partial equilibrium economic surplus models and poverty impact simulations	Cassava research program priorities for Africa, Latin America, the Caribbean, and Asia
How can target domains for scaling out agricultural technologies be defined?	Geospatial tools such as ESI and IBSTI	Impact zones in Tanzania identified

Source: Authors' analysis.

Youth initiatives



Agribusiness opportunities like this in product development and production for youth abound. Photo by IITA.

Table 10 presents the research problems, methods, and significant findings of 26 publications related to youth engagement in agriculture. The relatively small number of publications on this topic is because this is a more recent research area for IITA. The research focused on identifying factors influencing youth participation in agricultural value chains and assessing the contribution of agriculture to youth employment in agribusiness. Results show that the significant determinants of youth participation in agriculture include productivity levels, household responsibilities, social expectations, education level, and media. A diverse set of economic and sociocultural factors influences young people's aspirations toward engagement in agribusiness. Low productivity levels contributed to a negative perception of agriculture among youth. However, the improving profitability of agriculture over the years has changed that perception. Unlike in past years, when agriculture was not perceived as a socially acceptable career, it is now among the most preferred career options among young people. Participation in agricultural programs leads to better income opportunities.

The abstracts of the 26 publications are available in the Appendix (Youth initiatives).

Table 10. Research problems, methods, and findings in youth initiatives

Challenge/problem	Methodology	Findings
What are the factors influencing youth participation in agricultural value chains?	Probit/logit regression models	The level of productivity, household responsibilities, social expectations, education level, and media have an important role in determining youth participation in agriculture
How does agriculture contribute to youth?	Endogenous treatment effect regression	Participation in agricultural programs led to better income opportunities

Source: Authors' analysis.

Table 11. Research problems, methods, and findings in consumer acceptability studies

Challenge/problem	Methodology	Findings
What is farmers' WTP for agricultural technologies?	Contingent valuation	WTP for agricultural technologies such as Aflasafe
What factors affect consumers' WTP for agricultural technologies?	Contingent valuation and logistic regression	Factors determining consumers' WTP include attributes such as color, texture, nutrition, information from extension centers, and availability of products
How do consumer acceptance and WTP affect agricultural development?	Contingent valuation	Higher consumer environmental awareness and WTP stimulate agricultural innovation and adoption of agricultural technologies

Source: Authors' analysis.

Consumer acceptance

Table 11 presents the research problems, methods, and significant findings of 19 publications related to consumer acceptance of agricultural technologies and products among smallholder farmers. The main areas of focus were identifying factors influencing consumer preference and willingness to pay (WTP) for agricultural technologies, and assessing the impacts of consumer acceptance and WTP on agricultural development.



IITA's agricultural technologies provide stable food and income for consumers. Photo by IITA.

Results showed that WTP strongly correlates with consumers' awareness (information from extension centers), farmers' perceptions (attributes such as color, texture, and nutrition), marketing and prices, and availability of products. Higher consumer environmental awareness and WTP stimulate agricultural innovation and adoption of agricultural technologies.

The abstracts of the 19 publications are available in the Appendix (Consumer acceptance).



Scaling innovations: CGIAR centers' research for development helps assure food security and economic gains for Africa's farmers. Photo by IITA.

Conclusion and implications for future research

The systematic review showed that the scope of IITA's social science and agribusiness research program has expanded over the past 55 years, resulting in significant achievements as measured by five indicators. These indicators are the number of research themes; number of research crops; innovativeness of research methods; quality of science (disaggregated by journal type, and temporal and spatial distribution); and research findings.

Over the past five decades, IITA's social science and agribusiness research program focused primarily on the adoption and impact assessment of single improved crop varieties, based on yield, farm production, food security, nutrition, income, food expenditure, and poverty outcome indicators. Quantitative analysis was extensively applied using unitary household behavior models, with limited attention to the intra-household distribution of production and consumption. This systematic review revealed that limited attention was given to technologies outside genetic improvement; general equilibrium effects models; multidimensional poverty analysis; qualitative analysis; sex-disaggregated data; priority setting; and research targeting. Therefore, going forward, it is important to expand the scope of the research in the following ways:

- from single crop varieties to agronomic technologies, multiple and integrated value chain technologies, institutional and policy innovations, mechanical technologies, digital technologies, crop protection, natural resource management, and genetic resources conservation
- from farm production to post-production stages – processing, storage, trade, marketing, and consumption
- from productivity, food security, nutrition, income, and poverty analysis to environmental and health impacts of technologies
- from household models to general equilibrium effects models
- from quantitative analysis to mixed methods
- from inter-household to intra-household analysis of income, nutrition, and health outcomes using sex-disaggregated data
- from a single value chain approach to a food systems approach.

Other areas that have received limited attention are related to partnerships for delivery. For example, research on youth has taken off only in recent years. To this end, it is crucial to adopt a food systems approach.

In thematic areas where research on social science and agribusiness has made noticeable progress, it is still important to refine existing methods of impact assessment to demonstrate impacts at different levels; strengthen R4D priority setting (foresight modeling); and strengthen research targeting (geospatial analysis for identification of recommendation domains and priority areas within each domain).

Quality of publication: IITA in top ranked journals

Journal ranking in the top 10 journals in the Agricultural Economics and Policy based on six different rankings (Finger et al. 2022).

Rank	Journal name	IITA Published?
1	American Journal of Agricultural Economics	✓
2	Food Policy	✓
3.	Journal of Agricultural Economics	✓
4.	Agricultural Economics	✓
5.	European Review of Agricultural Economics	✓
6.	Australian Journal of Agricultural and Resources Economics	✗
7.	Journal of Agricultural and Resource Economics	✗
8.	Applied Economic Perspectives and Policy	✗
9.	Canadian Journal of Agricultural Economics	✗
10.	Agribusiness	✗

Source: Finger et al. (2022)

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A lively marketplace in Africa. Women are one of the main beneficiaries of innovations such as improved varieties, safe and nutritious seeds, and value chain enhancements. Photo by IITA.

Appendix: Abstracts

Adoption and impact (239)

1. A comparative analysis of technical efficiency and profitability of agribusiness and non-agribusiness enterprises in eastern DRC

Nyamahirwa, D.-M. A., Awotide, B. A., Kusinza, D. B., Bishikwabo, V. K., Mignouna, J., Bamba, Z., & Dontsop Nguetzet, P.-M. (2022). A comparative analysis of technical efficiency and profitability of agribusiness and non-agribusiness enterprises in eastern DRC. *Sustainability*, 14(14), 8384. <https://doi.org/10.3390/su14148384>

This study aimed to determine whether agribusiness could be competitive compared to non-agribusiness employment opportunities in terms of technical efficiency and profitability. We used data collected on all seven operating cassava community processing centers (CCPCs) and 150 comparable non-agribusiness enterprises in South Kivu province. A Data Envelopment Analysis (DEA), cost-benefit ratios, and net monthly revenue were used to examine technical efficiency and profitability. Our results showed that agribusiness was more competitive than non-agribusiness in terms of technical efficiency and profitability. The cost-benefit ratio shows that every dollar invested in agribusiness earns investors US \$2.8, while it earns investors in non-agribusiness US \$2.1. Moreover, technical efficiency increases significantly with agribusiness. These results show that agribusiness can compete with other non-agribusiness activities and remains a solution to youth unemployment in the region.

2. A microeconomic analysis of household consumption expenditure determinants in yam-growing areas of Nigeria and Ghana

Mignouna, D., Abdoulaye, T., Alene, A., Manyong, V., Dontsop-Nguetzet, P., Ainembabazi, J. H., & Asiedu, R. (2015). A microeconomic analysis of household consumption expenditure determinants in yam-growing areas of Nigeria and Ghana. *Tropicultura*, 33(3), 226–237. www.researchgate.net/publication/283486311

This paper provides an analysis of microeconomic factors that explain household consumption expenditure in rural areas using cross-sectional data obtained from 1400 randomly selected yam-producing households in Nigeria and Ghana. The correlates of consumption expenditure were examined using two techniques—ordinary least squares (OLS) and a quantile regression (QR) approach—for a more comprehensive picture at different points of the distribution. Determinants of consumption expenditure are markedly different between the regressions and across the conditional quantiles of the expenditure in both countries. Results further indicate that age, education, and household size were important in explaining consumption expenditure using OLS. However, via conditional QR, the following additional factors became evident: membership of formal and informal institutions, main occupation, family structure,

and farm size. Only education was consistently significant in both regressions and across the conditional quantiles, suggesting that responses to investments in education lead to an increase in expenditure that will stimulate other sectors of the economy.

Keywords: household consumption, quantile regression, yam, Nigeria, Ghana

3. A participatory approach to increasing productivity of maize through *Striga hermonthica* control in Northeast Nigeria

Kamara, A., Ellis-Jones, J., Amaza, P., Omoigui, L., Helsen, J., Dugje, I., Kamai, N., Menkir, A., & White, R. (2008). A participatory approach to increasing productivity of maize through *Striga hermonthica* control in Northeast Nigeria. *Experimental Agriculture*, 44(3), 349–364. <https://doi.org/10.1017/s0014479708006418>

Striga hermonthica is a parasitic weed that attacks maize, sorghum, and other staple cereal crops and has long been considered one of the greatest biotic constraints to cereal production in Africa. The use of resistant or tolerant maize varieties, a maize–legume rotation using trap crops that stimulate suicidal germination of *Striga*, and the application of nitrogen fertilizer are all effective in reducing infestation and damage. This paper reports on the use of a participatory research and extension approach in assessing the performance and scaling-up of integrated *Striga* control packages in three agro-ecological zones in Borno State, Nigeria. The participatory process, which encourages close interaction between research, extension, and farmers, involved 30 local communities and 228 farmers representing 193 farmer groups in identifying their own problems and seeking solutions. Results showed effective *Striga* control along with productivity increases of over 200%. The involvement of local farmers and groups in the evaluation process, firstly, helped confirm that *Striga* control can best be achieved using soybean followed by *Striga*-resistant maize together with productivity-increasing management practices and, secondly, promoted farmer-to-farmer extension. A participatory adoption assessment exercise indicated widespread adoption of new varieties and management practices, despite the need for increased labor. Great potential exists to scale out the results to similar areas of Guinea and Sudan savannas in the West Africa region.

4. A participatory evaluation of improved cowpea cultivars in the Guinea and Sudan savanna zones of northeast Nigeria

Kamara, A., Ellis-Jones, J., Ekeleme, F., Omoigui, L., Amaza, P., Chikoye, D., & Dugje, I. (2010). A participatory evaluation of improved cowpea cultivars in the Guinea and Sudan savanna zones of northeast Nigeria. *Archives of Agronomy and Soil Science*, 56(3), 355–370. <https://doi.org/10.1080/03650340903099692>

The International Institute of Tropical Agriculture (IITA) has developed several improved varieties by combining diverse plant types with resistance or tolerance to several diseases, insect pests, and parasitic weeds and possessing other good agronomic traits. Trials were established with farmers to evaluate several new IITA-bred cowpea varieties on-farm in participatory varietal selection. Central to this has been a ‘mother-daughter’ approach

with researcher-managed ‘mother’ trials and farmer-managed ‘daughter’ trials to combine researchers’ and farmers’ criteria in evaluating new varieties. In both sets of trials, new varieties IT89KD-391, IT97K-499-35, and IT89KD-288 were favored by farmers because of their high grain and fodder yields. Farmers have also shown interest in the continuous use of a local variety Kanannado Brown. It is suitable for relay intercropping, has a creeping habit, and can smother weeds. The brown seeds fetch higher market prices. The implications are that improved cowpea varieties should be suitable for relay-intercropping and controlling weeds, be brown, have large grains, be pest resistant, and give high grain and fodder yields. At the same time, it is important that the farmers’ criteria be considered in breeding and varietal selection programs.

Keywords: cowpea varieties, participatory research and extension approach (PREA), farmer participatory evaluation

5. Access to information, price expectations and welfare: The role of mobile phone adoption in Ethiopia

Haile, M. G., Assfaw Wossen, T., & Kalkuhl, M. (2019). Access to information, price expectations and welfare: The role of mobile phone adoption in Ethiopia. *Technological Forecasting and Social Change*, 145, 82–92. <https://doi.org/10.1016/j.techfore.2019.04.017>

Using household survey data from rural Ethiopia, this study explores the role of mobile telephony in smallholder farmers’ price expectation formations. The empirical findings suggest that farmers who own mobile phones and reside closer to markets make smaller price forecasting errors. The beneficial effect of mobile phones is stronger for households that reside farther away from grain markets, indicating that mobile telephony provides information that at least partially compensates location-disadvantaged farmers. Holding all else constant, mobile phone ownership is associated with about a 30% decrease in the conditional mean of a smallholder’s price prediction error. In contrast, an additional kilometer from nearby grain markets reduces the expected prediction error by about 10%. The results are robust across different econometric estimators as well as the use of alternative measurements of price forecasting error. Our simulation analysis shows that accurate information about grain price developments could save a significant welfare loss for smallholders. Depending on their income levels, the analysis hints that smallholder farmers would be willing to pay between 7% and 20% of their income to improve the price signal, in other words, to avoid uncertainty on producer prices. Our work emphasizes an alternative way to deal with price volatility and improve farmers’ welfare that focuses on improving access to information rather than reducing volatility per se.

Keywords: price expectation, prediction error, mobile phones, smallholder farmer, welfare loss

6. Achievements in impact assessment of agricultural research: IITA experience, 2001–2006

Manyong, V. M., Alene, A., Sanogo, D., Coulibaly, O., Abele, S., & Nkamleu, G. B. (2008). *Achievements in impact assessment of agricultural research: IITA experience, 2001–2006*. <https://cgspace.cgiar.org/handle/10568/91730>

The purpose of this document is to take stock of the achievements of and gaps in impact assessment (IA) research at IITA since the last External Program and Management Review in 2001 and to highlight elements of a strategy for the future of impact studies at the Institute. Our vision of IA is that it is a continuous process. It covers a wide range of interrelated activities, including baseline studies, ex-ante impact, on-farm technology evaluation, adoption studies, and ex-post impact. IITA has developed a framework for conceptualizing and promoting impact culture in agricultural research to guide and facilitate the implementation of IA research. During the conduct of impact studies, both quantitative and qualitative techniques have been applied. IITA has made tremendous achievements in assessing the impact of its Research-for-Development products and has contributed significantly to capacity building, communication of findings from IA, and development of international public goods. The review concludes with major IA research initiatives and challenges ahead.

7. Actor diversity and interactions in the development of banana hybrid varieties in Uganda: implications for technology uptake

Sanya, L. N., Sseguya, H., Kyazze, F. B., Baguma, Y., & Kibwika, P. (2018). Actor diversity and interactions in the development of banana hybrid varieties in Uganda: implications for technology uptake. *Journal of Agricultural Education and Extension*, 24(2), 153–167. <https://doi.org/10.1080/1389224X.2017.1401549>

Purpose: We examine the nature of networks through which new hybrid banana varieties (HBVs) in Uganda are developed, and how different actors engage in the technology development process.

Design/methodology/approach: We collected the data through 20 key informant interviews and five focus group discussions with actors involved in the process. We analyzed the data with NVivo and Social Network Analysis software.

Findings: The process of developing HBVs involves many actors with a diversity of roles and interests. The network density was 29.4, implying the existence of only 29.4% of the possible direct linkages. Strong ties mainly existed among research-oriented actors, with other actors in the periphery.

Practical implications: The current position of smallholder farmers and other non-research actors inhibits their influence on decisions in the technology development process. We recommend that smallholder farmers should be empowered through better organization so that they can influence the process of developing HBVs. Researchers, supported with appropriate policies, should engage more with actors in the intermediary, enterprise, and support service domains for a more vibrant agricultural research system.

Theoretical implications: Application of the systems approach to technology development requires a dynamic process that supports the involvement of a diverse range of actors. However, close attention to context is important in dealing with issues of power asymmetries and determining to what extent various actors engage in the process.

Originality/value: This work contributes to literature on systems approaches to agricultural and rural development. The paper demonstrates that actor diversity and interactions are critical in technology development and uptake.

Keywords: agricultural research, technology development, technology uptake, actor, networks, hybrid banana varieties, Uganda

8. Adoption and ex-post impacts of improved cowpea varieties on productivity and net returns in Nigeria

Manda, J., Alene, A., Hirpa Tufa, A., Abdoulaye, T., Kamara, A., Olufajo, O.*, Boukar, O., & Manyong, V. (2019). Adoption and ex-post impacts of improved cowpea varieties on productivity and net returns in Nigeria. *Journal of Agricultural Economics*, 71(1), 165–183. <https://doi.org/10.1111/1477-9552.12331>

Cowpea covers the largest area of any grain legume in Africa and is especially important in West Africa, where Nigeria and Niger alone account for over 75% of the total cowpea production in the world. Despite the successes of international and national cowpea improvement research in developing and releasing several improved varieties, there is limited empirical evidence of adoption and ex-post impacts of improved cowpea. Using nationally representative survey data from a sample of 1,525 cowpea-growing households in northern Nigeria cultivating over 2,500 cowpea plots, we assess the adoption and impacts of improved cowpea varieties on cowpea yields, net returns, and production costs. We apply a control function approach and propensity score matching models to estimate the causal effects of adopting improved cowpea varieties. Our results show that 38% of the cowpea plots were planted with improved varieties, and cowpea yields, net returns, and production costs increase significantly with the adoption of improved cowpea varieties. Adoption of improved cowpea varieties is associated, on average, with 26% yield gains, 61% increase in net returns, and 14% increase in production costs. We also show that farmers who have a lower propensity to adopt improved cowpea varieties also face higher costs of production.

9. Adoption and impacts of sustainable agricultural practices on maize yields and incomes: Evidence from rural Zambia

Manda, J., Alene, A., Gardebroek, C., Kassie, M., & Tembo, G(2015). Adoption and impacts of sustainable agricultural practices on maize yields and incomes: Evidence from rural Zambia. *Journal of Agricultural Economics*, 1–24. <https://doi.org/10.1111/1477-9552.12127>

This paper uses a multinomial endogenous treatment effects model and data from a sample of over 800 households and 3,000 plots to assess the determinants and impacts of adoption

of sustainable agricultural practices (SAPs) on maize yields and household incomes in rural Zambia. Results show that adoption decisions are driven by household and plot level characteristics and that adopting a combination of SAPs raises both maize yields and incomes of smallholder farmers. Adoption of improved maize alone has greater impacts on maize yields, but given the high cost of inorganic fertilizer that limits the profitability of adopting improved maize, higher household incomes are associated rather with a package involving SAPs such as maize-legume rotation and residue retention.

Keywords: multinomial endogenous treatment effects, impacts, adoption, sustainable agricultural practices, maize yields, inorganic fertilizer, household income, Zambia

10. Adoption and impacts of sustainable intensification practices in Ghana

Kotu, B. H., Alene, A., Manyong, V., Hoeschle-Zeledon, I., & Larbi, A. (2017). Adoption and impacts of sustainable intensification practices in Ghana. *International Journal of Agricultural Sustainability*, 15(5), 539–554. <https://doi.org/10.1080/14735903.2017.1369619>

Sustainable agricultural intensification requires the use of multiple agricultural technologies in an integrated manner to enhance productivity while conserving the natural resource base. This study analyzes the adoption and impacts of sustainable intensification practices (SIPs) using a dataset from Ghana. A multivariate probit (MVP) model was estimated to assess the adoption of multiple SIPs. Moreover, we used a multivalued semi-parametric treatment effect (MVTE) model to estimate the effects of adopting multiple SIPs on maize productivity. The MVP model results show, among others, that access to market, capital, and information/knowledge would enhance the adoption of SIPs. The MVTE model results show that a higher number of SIPs is associated with higher productivity which is more visible when commercial inputs are used in combination with cultural practices. These results have the following policy implications. First, they imply that good rural infrastructure and agricultural services such as rural road networks, village-level input delivery system, input credit, and multiple information/knowledge sharing approach (instead of the conventional singular formal information/knowledge sharing approach) can enhance adoption. Second, the results suggest that promoting an integrated use of technologies, instead of a single technology, would have a positive impact on farm productivity and farm household income.

Keywords: sustainable intensification practices, adoption, impacts, Ghana

11. Adoption and welfare impacts of multiple agricultural technologies: evidence from eastern Zambia

Khonje, M. G., Manda, J., Mkandawire, P., Tufa, A. H., & Alene, A. D. (2018). Adoption and welfare impacts of multiple agricultural technologies: evidence from eastern Zambia. *Agricultural Economics*, 49(5), 599–609. <https://doi.org/10.1111/agec.12445>

Using plot-level panel data and multinomial endogenous switching regression, this article analyzes the adoption and welfare impacts of multiple agricultural technologies in eastern

Zambia. We adapt a multinomial endogenous switching/treatment effect regression framework to correct for selection bias and endogeneity originating from both observed and unobserved heterogeneity. Results indicate that joint adoption of multiple agricultural technologies had greater impacts on crop yields, household incomes, and poverty than the adoption of individual components of the technology package. Our findings suggest that efforts aimed at raising household incomes and reducing poverty should focus on promoting the adoption of multiple agricultural technologies through provision of improved support services such as extension and input supply.

12. Adoption of a new maize and production efficiency in western Kenya

Mignouna, D. B., Mutabazi, K. D. S., Senkondo, E. M., & Manyong, V. M. (2010). Adoption of a new maize and production efficiency in western Kenya. Presented at African Association of Agricultural Economists (AAAE) Third Conference/AEASA 48th Conference, September 19–23, 2010, Cape Town, South Africa. <https://ideas.repec.org/p/ags/aaae10/96160.html>

Declining maize yields resulting from *Striga* infestation have necessitated a new technology—Imazapyr-resistant maize (IRM)—to contain the problem. As a result, research and development initiatives with substantial participation of the private sector to transfer this new technology to farmers have been made in western Kenya. This study, therefore, assesses the adoption of IRM variety and efficiency levels of farmers in western Kenya. A multi-stage sampling technique was used to select 600 households from Nyanza and Western provinces for this study. Tobit model and stochastic production frontier analysis were the analytical methods. Results show that age, education, maize production gap, risk, contact with extension agents, lack of seeds, membership in a social group, effective pathway for IRM dissemination, and compatibility of the technology are the variables that were found to be significant ($P < 0.05$) in shaping the decisions of households on whether to adopt or not. The study reveals that the mean technical efficiency of maize production of sampled farmers is 70% indicating some inefficiencies of maize production in western Kenya. Also, adoption of IRM significantly increased frontier maize output ($P < 0.01$); household size decreased inefficiency along with farm size. It was recommended that efforts to increase the adoption of IRM for enhanced farm efficiency should focus on farmers' education, farming experience, and access to information and basic farm inputs.

Keywords: IRM technology, efficiency, stochastic production frontier, Tobit model

13. Adoption of chemical weed control technology among cassava farmers in south eastern Nigeria

Udensi, U., Tarawali, G., Ilona, P., Okoye, B., & Dixon, A. (2012). Adoption of chemical weed control technology among cassava farmers in south eastern Nigeria. *Journal of Food, Agriculture and Environment*, 10(1), 667–674. <https://biblio.iita.org/documents/S12ArtUdensiAdoptionInthomDev.pdf-e58db50f5a675d09190cf48a6e58ad51.pdf>

Various factors influencing the adoption of weed control technologies in Abia State were studied. A multi-stage random sampling procedure was used to select 510 cassava farmers in 2006. Results showed that 56.5% of the respondents were females that are largely (90.2%) in their productive years. Most (78.8%) of the total respondents were married, 83.3% attended formal schooling, and 74.9% had households of more than five persons. All the respondents were basically smallholder farmers, with 46.9% being full-time farmers. Fifty percent of the respondents had secure tenurial arrangements; 92.9% had more than six years of farming experience. Probit analysis shows that factors related to the adoption of weed control technologies were gender at 5% in the negative direction in Abia North (Zone 1) and 10% in the positive direction in Abia Central (Zone 2); age at 5% negatively in Zone 1, educational status at 5% in the positive direction in Zone 1 and 10% pooled (entire State), house-hold size at 5% and 1% positively in Zone 2 and the entire State, respectively. The coefficient for yield was positive and highly significant in Zone 1 and the entire State, the tenurial system was negative and significant at 5% level in Zone 2, as well as application problems but at 5% in Zone 1 and 10% pooled. Training on weed control and average income was positive and significant at 1% as well as farming experience at 5%. The coefficient for no definite market was negative and significant at 5% in Zone 1. The coefficient for the high cost of chemicals had a negative relationship with the adoption of chemical weed control technologies and was significant at the 1% level in Zone 2 and the entire State. The probit model for Abia South (Zone 3) could not be estimated because the percentages responding at all doses were the same. Hence policies should be adopted aimed at improving the educational levels of the farmers and encouraging the experienced farmers to increase adoption would be necessary; there is a need for the intensification of training and educational programs for the potential adopters of the weed control practices; programs that target both gender groups to ensure the equitable adoption of chemical control practices between males and females. Policies need to be designed to convert tenurial arrangements to more secure forms to increase the rate of adoption of weed control technology by the creation of markets for cassava, and the provision and subsidization of chemicals for weed control.

Keywords: adoption, weed control technology, probit analysis

14. Adoption of improved cassava varieties by processors is linked to processing characteristics and products biophysical attributes

Abass, A. B., Awoyale, W., Ogundapo, A., Oluwasoga, O., Nwaoliwe, G., Oyelekan, J., & Olarinde, L. O. (2022). Adoption of improved cassava varieties by processors is linked to processing characteristics and products biophysical attributes. *Journal of Food Processing and Preservation*, 46(3). <https://doi.org/10.1111/jfpp.16350>

Evidence from community cassava processors on product quality traits that influence variety adoption was combined with laboratory methods to identify potential predictors of quality traits of new varieties. The study revealed that high product yield, high starch content, high solubility index (SI), high peak viscosity (PV), low setback viscosity, and

delayed root color change (delayed post-harvest physiological deterioration) are possible laboratory indicators that could be used as proxies for predicting product quality and variety adoption decisions of cassava processors. Fufu exhibited higher swelling power, SI, and PV than gari from the same varieties. Processors preferred quality characteristics are difficult to measure for several hundreds of new germplasms in the early stages of the breeding cycle. The information presented may be helpful during the breeding of new, improved varieties by using the physical and chemical properties of the roots that predict processors' preferred quality traits.

Practical applications: The study identified laboratory parameters that could be used as predictors of processor-preferred traits in new breeding lines with a higher possibility of adoption by processors to make commercial success products.

15. Adoption of improved fallows in West Africa: lessons from Mucuna and Stylo case studies

Tarawali, G., Manyong, V., Carsky, R., Vissoh, P. V., Osei-Bonsu, P., & Galiba, M. (1999). Adoption of improved fallows in West Africa: lessons from Mucuna and Stylo case studies. *Agroforestry Systems*, 47(1–3), 93–122. <https://doi.org/10.1023/A:1006270122255>

Traditional shifting cultivation systems can no longer be sustained in West Africa because of rapid increases in human and livestock populations. Short-duration, improved fallows are among the alternative land-management strategies that have evolved. This paper reviews how velvetbean or mucuna (*Mucuna pruriens*) and stylo (*Stylosanthes hamata* and *Stylosanthes guianensis*) management systems were developed and disseminated in West Africa. Mucuna was first adopted by farmers in southwestern Benin between 1988 and 1992, and the number of testers of the innovation rose to 10,000 farmers throughout Benin by 1996. Suppression of spear grass (*Imperata cylindrica*) was perceived as the main benefit of mucuna fallows. The stylo technology was introduced in the late 1970s and primarily targeted livestock production in the subhumid monomodal rainfall zone. The uptake of stylo has been relatively slow and modest in West Africa in contrast to the faster rate of adoption of mucuna in southwestern Benin. Some of the contributory factors to the slower adoption of stylo than mucuna include rainfall regime, lack of motivation of livestock keepers, insecure land tenure, limited capability and facilities of extension staff, poor communication among scientists, and unsatisfactory establishment of the crop. Recommendations to increase the adoption of improved fallows include the use of a participatory approach in problem identification, expansion of the genetic base of cover crops for use in fallows, optimization of the multiple benefits of cover crops, management of the improved system, promotional strategies, and appropriate policies.

Keywords: adoption, cover crops, green manure, livestock, *Stylosanthes*, velvet bean

16. Adoption of improved soybean and gender differential productivity and revenue impacts: Evidence from Nigeria

Kamara, A. Y., Oyinbo, O., Manda, J., Kamsang, L. S., & Kamai, N. (2022). Adoption of improved soybean and gender differential productivity and revenue impacts: Evidence from Nigeria. *Food and Energy Security*, 11(3). <https://doi.org/10.1002/fes3.385>

Despite the considerable soybean varietal improvement and dissemination efforts in Nigeria and other parts of Sub-Saharan Africa, empirical evidence on farm-level yield and revenue impacts of improved soybean varieties (ISVs) from a gender perspective are limited. In this paper, we analyze the impact of the adoption of ISVs on soybean yield and net revenue, and the associated gender differential effects in northern Nigeria. We use the endogenous and exogenous switching treatment effects regression frameworks to estimate the impacts. We find that the adoption of ISVs significantly increased soybean yield and net revenue of the soybean-producing households by 26% and 32%, respectively. In addition, we find that the gender gap in yield between male and female-headed soybean-producing households was small, with a yield gap of about 1%. However, we find a substantial gender gap in soybean net revenue, as the net revenue of female-headed households was lower by about 20%, as compared to male-headed households. Overall, our findings show that policymakers and their development partners can leverage varietal improvement to boost the yields of both male- and female-headed households. However, closing the gender gap in crop income necessitates reducing the disparity in market linkages so that the female farmers can equally have better market access.

Keywords: adoption, endogenous switching regression, improved soybean varieties, net revenue, yield

17. Adoption of integrated crop–livestock management practices (ICLMPs) among men and women smallholder farmers in Ghana

Asante, B. O, Koomson, I., Villano, R. A., & Wiredu, A. (2021). Adoption of integrated crop–livestock management practices (ICLMPs) among men and women smallholder farmers in Ghana. *Gender, Technology and Development*, 25(2), 163–192. <https://doi.org/10.1080/09718524.2021.1911021>

Integrated crop–livestock management practices (ICLMPs) play a vital role in ensuring food security and improved welfare for smallholder households; however, studies that focus on ICLMP adoption in Ghana (including its gender dimension) remain scant. This paper examines gender differences in the drivers and intensity of ICLMP adoption using farm-level data from 638 smallholder farmers in Ghana. Employing Multivariate Probit, Tobit regression models and dominance analytical procedures, we find that adoption of ICLMPs is generally influenced by non-farm income, extension contacts, and nativity. While age, credit access, soil fertility, distance to markets, total value of assets, and research contacts influence the intensity of ICLMP adoption among the men, intensity of adoption among women farmers is influenced mainly by household size. The dominance analysis showed that being a native of the community/village where one farm had the strongest influence in intensifying ICLMP

adoption, with gender differences being evident regarding the relative influence of the other variables. Policies to enhance the adoption of ICLMPs in Ghana could be designed to focus on women farmers who have large farm assets, access to extension and are engaged in non-farm income-generating activities.

Keywords: gender, agricultural technology, adoption, integrated crop–livestock management practices, Ghana

18. Adoption of mechanized post-harvest cassava processing technologies, and the determinants of high quality cassava flour (HQCF) processing in Tanzania

Amaza, P, Abass, A., Bachwenkizi, B., & Towo, E(2016). Adoption of mechanized post-harvest cassava processing technologies, and the determinants of high quality cassava flour (HQCF) processing in Tanzania. *Tropicultura*, 34(4), 411–423. <http://www.tropicultura.org/text/v34n4/411.pdf>

In this study, the factors influencing the adoption of mechanized technologies for processing cassava into value-added high quality cassava flour (HQCF) by rural households in Tanzania were examined. A structured questionnaire was used to collect data from 400 households in villages that carry out both mechanized and non-mechanized cassava processing activities. The questionnaire focused on the households' socio-economic characteristics and their adoption parameters. Data were analyzed using descriptive statistics and the double-hurdle model. The study revealed a positive correlation between the level of awareness of mechanized cassava processing technologies and their rate of adoption. In addition, the adoption decisions made by the households were significantly influenced by a number of factors, such as the gender of the processors, the distance of the processing sites to the nearest tarmac road, and the cost of capital required to invest in HQCF processing technology. The amount invested by households in the processing of HQCF was influenced by the number of adult females in the household, the education level of the processors, farming experience and the distance from the processing plant to the nearest product market. This suggests that mechanized post-harvest processing of HQCF at the household level was influenced by access to product market. Therefore, the study recommends increased promotion of post-harvest processing technologies, access to capital and enhanced infrastructures, especially rural roads to facilitate improved access to markets for HQCF in Tanzania.

Keywords: adoption, cassava flour, double hurdle model, intervention, post-harvest, Tanzania

19. Adoption of on-farm hermetic storage for cowpea in West and Central Africa in 2012

Moussa, B, Abdoulaye, T., Coulibaly, O., Baributsa, D., & Lowenberg-DeBoer, J. (2014). Adoption of on-farm hermetic storage for cowpea in West and Central Africa in 2012. *Journal of Stored Products Research*, 58, 77–86. <https://doi.org/10.1016/j.jspr.2014.02.008>

This study is based on interviews with 3456 randomly selected cowpea farmers in 322 villages in ten countries in West and Central Africa in 2010 and 2012. It uses descriptive statistics to

track the trends in adoption of cowpea storage technology compared to previous studies and Firth logistic regression to identify important factors in adoption. The interviews indicate that regionally about 46% of respondents use some type of hermetic storage for their cowpeas and about 44% of the quantity of cowpea stored on farms is in hermetic containers. Both the percentage of respondents and the percentage of stored quantity fall slightly short of the 50% benchmark hypothesized. The 2010–2012 estimates compare to about 30% of cowpea quantity stored in hermetic containers in 2003–2004. Regionally, the most commonly used hermetic storage container is the triple layer Purdue Improved Cowpea Storage (PICS) bag. In PICS villages, local unavailability is the most common reason for not using the bags. The logit analysis shows that living in a village with PICS activities is the single most important factor explaining adoption of the technology. In six of the nine regressions participation in the demonstrations was also positive and a statistically significant determinant of adoption. For someone living in a PICS village and participating in the activities the combined effect is highly influential. In Niger such an individual would be 27% more likely than a non-participant from a non-PICS village to use PICS bags. In Senegal he or she would be 55% more likely. Some form of exposure to PICS activities or village technicians is key in adoption of the PICS technologies, though it may not be direct contact with a PICS technician. On average additional cash flow due to storage of cowpea in PICS bags is estimated at \$26.58/100 kg bag more than sale at harvest.

Keywords: hermetic storage, cowpea, impact, adoption, logit

20. Adoption of selected improved cassava varieties among smallholder farmers in South-Eastern Nigeria

Udensi, U., Tarawali, G., Favour, E. U, Asumugha, G, Ezedinma, C., Okoye, B, Okarter, C., Ilona, P., Okechukwu, R., & Dixon, A (2011). Adoption of selected improved cassava varieties among smallholder farmers in South-Eastern Nigeria. *Journal of Food, Agriculture and Environment*, 9(1), 329–335. <https://cgspace.cgiar.org/handle/10568/88156>

Cassava is a dominant component in crop mixtures in South-Eastern Nigeria. It is a preferred food security crop among smallholder farmers, because it can tolerate drought, low soil fertility and its production requires minimum external inputs. Various constraints have been shown to affect the widespread adoption of improved cassava varieties. This study examines various factors influencing the adoption of selected improved cassava varieties by smallholder farmers in Abia State, Nigeria, using the probit model. A multi-stage random sampling procedure was used to select 510 cassava farmers from 17 Local Government Areas of Abia State in 2007. Results of the study showed that 56.5% of the respondents were females. The majority (90.2%) consisted of those who were in their productive years. Most (78.8%) of the respondents were married, 83% attended formal schools; while 75% had a household size of more than 5 persons. All the respondents were basically small-holder farmers; with 47% full time, 50% of the respondents had secured tenurial arrangements; 93% had more than 6 years of farming experience and 82.2% of them had adopted improved cassava varieties. Results indicated that 74% of 510 farmers who responded adopted improved cassava varieties, either solely or

in combination with local varieties. The most popular varieties were NR-8082 (38.6% of total adopters), TME-419 (36.7%) and TMS-980505 (12.9%). Marital status, household size, farm size, cassava maturity period and tenurial status were negatively and significantly related to adoption. Cassava yield and average income had a positive relationship with the adoption of the improved varieties. Implicit in these results is that policies should be aimed at introduction and prompt release of high yielding and early maturing cassava varieties, and converting tenurial arrangements of land to more secure forms.

Keywords: adoption, improved cassava varieties, probit model

21. Adoption of soybeans in sub-Saharan Africa: A comparative analysis of production and utilization in Zaire and Nigeria

Shannon, D., & Kalala, M. (1994). Adoption of soybeans in sub-Saharan Africa: A comparative analysis of production and utilization in Zaire and Nigeria. *Agricultural Systems*, 46(4), 369–364. [https://doi.org/10.1016/0308-521X\(94\)90102-L](https://doi.org/10.1016/0308-521X(94)90102-L)

The issue of soybean adoption in sub-Saharan Africa is addressed. A survey was conducted of soybean [*Glycine max* (L.) Merr.] production and utilization in Gandajika, Zaire. Of 115 farmers sampled from nine villages, all cultivated soybean. Average production per farmer in the previous season was 73 kg. Almost all production was consumed by humans, primarily as full-fat flour mixed with maize (*Zea mays* L.) or maize and cassava [*Manihot esculenta* (L) Crantz], or as roasted grain. Farmers ranked soybean second among grain legumes in area cultivated and fourth for total sales. Most farmers considered marketing the principal constraint to increased production. Survey results from Nigeria revealed similar adoption trends. Common elements were locally adapted foods in which soybean did not displace traditional legumes, promotion of soybean, diffusion, technological breakthroughs and response to local markets. The implications of these findings are discussed with respect to commonly held views on soybean in Africa.

22. Adoption of *Striga* (*Striga hermonthica*) management technologies in northern Nigeria

Hassan, M. B., Baiyegunhi, L. J. S., Ortmann, G. F., & Abdoulaye, T. (2016). Adoption of *Striga* (*Striga hermonthica*) management technologies in northern Nigeria. *Agrekon*, 55(1–2), 168–188. <https://doi.org/10.1080/03031853.2016.1159587>

This study examined the adoption of Integrated *Striga* Management (ISMA) technologies among maize farmers in Bauchi and Kano states of northern Nigeria. It employs a double-hurdle approach to analyze the factors influencing adoption and intensity of ISMA technologies among households, using cross-sectional data of 643 farmers from the two states. The results show that the estimated coefficients of exogenous income and proximity to extension office are negatively significant ($P < 0.05$), while higher total farm income, polygamous households, past participation in on-farm trials, awareness of the technology, contact with extension agents and

access to cash remittances are positive and significant ($P < 0.01$), and are the most significant factors likely to influence ISMA technologies adoption. Marital status, household size, farm size and access to cash remittances are most significant factors influencing adoption intensity. Maize farmers in the study area who adopted ISMA technologies obtained higher output than the non-adopters, which resulted in a positive and significant effect on their total farm income. Hence, policies targeted at increasing maize productivity through *Striga* management need to include ISMA technologies as a potentially feasible option. The study recommends actions to improve farmers' access to financial services to increase their liquidity. Nevertheless, the most immediate action will be improvement in farmers' access to extension services as they have proved to be a reliable source of information in the rural areas.

Keywords: ISMA technology adoption, *Striga* management, double-hurdle model, smallholder farmers, northern Nigeria

23. Adoption of sustainable agricultural technologies for vegetable production in rural Tanzania: trade-offs, complementarities and diffusion

Ochieng, J., Afari-Sefa, V., Muthoni, F., Kansime, M., Hoeschle-Zeledon, I., Bekunda, M., & Thomas, D. (2021). Adoption of sustainable agricultural technologies for vegetable production in rural Tanzania: trade-offs, complementarities and diffusion. *International Journal of Agricultural Sustainability*, 1–19. <https://doi.org/10.1080/14735903.2021.1943235>

Sustainable agricultural technologies have impacted positively on staple crop yields in Asia and some parts of Sub-Saharan Africa. However, the adoption of similar technologies in vegetable subsector is still low among small-scale farmers in Tanzania. Several efforts aimed at promoting the adoption of the technologies such as improved vegetable varieties, mineral fertilizers, manure and pest management practices to raise output, have not yielded the desired impacts. We examine dynamics of farmers' adoption of these technologies and the factors influencing technology choice. We also predict the peak level and speed of adoption of these sustainable technologies. Findings show that complementarities exist among improved varieties, fertilizers and pest management practices, while tradeoffs exist between manure and mineral fertilizers. These complementarities and tradeoffs should be sufficiently exploited for farmers to adopt technologies that are suited for their specific circumstances. Better knowledge, access to credit, group membership, farmer participation in demonstration trials, and, more substantial livestock holdings drive technology adoption decision. Technologies have different peak levels of adoption, which are reached at different time intervals. The policy option is to strengthen collaborative efforts to scale out sustainable agricultural technologies to respond to the increasing demand for nutrient-dense vegetables for income, food and nutrition security.

Keywords: ADOPT model, diffusion, sustainable intensification, smallholder, Tanzania, traditional African vegetables

24. Adoption pattern of fertiliser technology among farmers in the ecological zones of south-western Nigeria: a Tobit analysis

Bamire, A. S., Fabiyi, Y. L., & Manyong, V. M. (2002). Adoption pattern of fertiliser technology among farmers in the ecological zones of south-western Nigeria: a Tobit analysis. *Australian Journal of Agricultural Research*, 53(8), 901–910. <https://doi.org/10.1071/ar01095>

Using data from a survey of farm operators in two major ecological zones of Osun State in south-western Nigeria, this paper empirically evaluates the determinants of farmers' fertilizer adoption decisions and the intensity of use of the technology using a Tobit regression model. With a multi-stage sampling technique, data were collected with the aid of a structured questionnaire drawn on 180 respondents in the agroecological zones of the State. This was complemented with focus group discussions in each of the zones. Data were analyzed using descriptive statistics and Tobit regression techniques. A majority of the respondents in the study area are young and energetic but with low literacy level. Mixed cropping practice was dominant and farming was at a small scale. Large proportions of respondents had extension contact and were members of associations. Tobit estimates show that farmers' fertilizer adoption decisions vary with agroecological location, and a decomposition of the elasticities calculated at the means of the variables revealed that farmers' probability of adoption and non-adoption accounted for more of fertilizer technology response than did the use intensity, given adoption. Thus, a policy that increases the quantity of fertilizer made available to farmers in the right form and time will encourage the adoption and use of the technology in improving the land resource potential.

Keywords: fertilizer, ecology, tobit, Nigeria

25. After all, land belongs to the state: Examining the benefits of land registration for smallholders in Ethiopia

Yami, M., & Snyder, K. A. (2016). *After all, land belongs to the state: Examining the benefits of land registration for smallholders in Ethiopia*. *Land Degradation & Development*, 27(3), 465–478. <https://doi.org/10.1002/ldr.2371>

The role of land registration in reducing rural poverty has been debated for several decades. This article analyzes the impacts of land registration on land rentals, security of land tenure, disputes over land, use of credit facilities from formal financial institutions and gender access and control over land. Our findings are based on data collected between April and December 2011 in irrigation systems in three regional states of Ethiopia using in-depth interviews and field surveys. Land registration has a positive influence on land rentals by reducing the fear of landholders in losing land to renters. Important benefits of land registration also include enhancing tenure security through ensuring usufruct rights over land and addressing the conflicts that arise from the competition to access irrigable land. Joint land titling secures women's access to land and encourages women's decision-making on land rentals, input use, cropping patterns and the marketing of harvest from irrigable plots. While land registration allows for improved tenure security, gender equity and reduced disputes over land, it does little to facilitate access to credit or increase the use of farm inputs. The findings suggest that

more work needs to be carried out to translate the benefits of land registration into improved livelihoods by increasing investment in farm inputs, production of high value, off-season crops and increase market participation.

Keywords: gender, gender analysis, women's participation, farmers, land access, livelihoods

26. Agricultural intensification and efficiency in the West African savannas: evidence from northern Nigeria

Okike, I. O., Jabbar, M. A., Manyong, V. M., Smith, J. W., Akinwumi, J. A., & Ehui, S. K. (2001). Agricultural intensification and efficiency in the West African savannas: evidence from northern Nigeria. *International Livestock Research Institute. Research Reports 182891*. <https://ideas.repec.org/p/ags/ilirrr/182891.html>

Agricultural intensification in West Africa is in its early stages and several hypotheses have been postulated about its evolution and possible pathways. In addition, farm efficiency may vary across farms and other socio-economic domains, opening opportunities to improve efficiency and productivity through reallocation of current resources and introducing new technologies that target farmers. A survey was conducted among 559 households in 8 villages, 4 each in the northern Guinea savannah (NGS) and Sudan savannah (SS) zones of northern Nigeria, each representing a combination of high or low population density and high or low market access, to test these hypotheses.

27. Agricultural technology adoption and household welfare: Measurement and evidence

Wossen, T., Alene, A., Abdoulaye, T., Feleke, S., & Manyong, V. (2019). Agricultural technology adoption and household welfare: Measurement and evidence. *Food Policy*, 87, 101742. <https://doi.org/10.1016/j.foodpol.2019.101742>

Previous studies on the adoption and impacts of improved crop varieties have relied on self-reported adoption status of the surveyed households. However, in the presence of weak variety maintenance and poorly functioning seed certification system, measurement errors in self-reported adoption status can be considerable. This paper investigates how such measurement errors can lead to biased welfare estimates. Using DNA-fingerprinting based varietal identification as a benchmark, we find that misclassification in self-reported adoption status is considerable, with significant false negative and positive response rates. We empirically show that such measurement errors lead to welfare estimates that are biased toward zero and substantially understate the poverty reduction effects of adoption. While the empirical evidence suggests attenuation bias, our theoretical exposition and simulations demonstrate that upward bias and sign reversal effects are also possible. The results point to the need for improved monitoring of the diffusion process of improved varieties through innovative adoption data collection approaches to generate robust evidence for prioritizing and justifying investments in agricultural research and extension.

Keywords: adoption, bias, DNA, misclassification, Nigeria, welfare

28. Agriculture in Nigeria: Identifying opportunities for increased commercialization and investment

Manyong, V., Ikpi, A., Olayemi, J. K., Yusuf, S. A., Omonona, B. T., Okoruwa, V., & Idachaba, F. S. (2005). *Agriculture in Nigeria: Identifying opportunities for increased commercialization and investment*. International Institute of Tropical Agriculture (IITA). <https://biblio1.iita.org/bitstream/handle/20.500.12478/3320/U05BkManyongAgricultureNothomDev.pdf?sequence=1&isAllowed=y>

Scientists from IITA and University of Ibadan (UI) carried out a study to assess Nigerian agricultural policy (ANAP), which was funded by USAID Country Mission. The purpose was to provide the mission with analytical basis on which to design its new Agricultural Policy Strategy. The expected outcomes would also be available to any other investor willing to assist Nigeria in the development of its agricultural sector.

In the planning phase, a three-fold strategy for the implementation of the study was adopted. A 12-member steering committee was added to the core team of scientists to oversee the work and provide policy guidelines. It includes representatives from a wide range of institutions with major stake in agriculture. A group of technical experts visited and surveyed more than 100 institutions. During the implementation phase, it became obvious that the scope should be expanded to review the agricultural sector at large (and not only its policy as planned under ANAP), identify and prioritize options for investment, and design workable strategies to achieve the potentials of the sector. Thus, the current report is on agriculture in Nigeria (AIN).

The study defined six geo-development domains from the diversity of biophysical, socioeconomic, and policy settings. It made a thorough analysis of the performance of the sector, critically reviewed agricultural policies, and provided a direction for their improvement. It captured major constraints to and determinants of investments in Nigeria and its agriculture by compiling data from literature, stakeholders' perceptions, and quantitative analyses. It identified and prioritized opportunities for increased investment in agriculture as a whole and for each of the six domains. Finally, it recommended a set of complementary strategies for accelerated commercialization and investments in agriculture. We believe that this book is a valuable source of information to many practitioners and researchers from the private sector, the government of Nigeria (at the federal, state, and local levels), development agencies, donors, international organizations, universities, or concerned citizens.

Keywords: commercialization and investment, markets, economic growth, constraint, macroeconomic, Nigeria

29. Agronomic and economic benefits of coffee–banana intercropping in Uganda's smallholder farming systems

Van Asten, P., Wairegi, L., Mukasa, D., & Uringi, N. (2011). Agronomic and economic benefits of coffee–banana intercropping in Uganda's smallholder farming systems. *Agricultural Systems*, 104(4), 326–334. <https://doi.org/10.1016/j.agsy.2010.12.004>

Coffee and banana are major cash and food crops, respectively, for many smallholders in the East African highlands. Uganda is the largest banana producer and 2nd largest coffee producer

in Africa. Both crops are predominantly grown as monocultures. However, coffee–banana intercropping is common in densely populated areas. This study assessed the profitability of intercropped coffee–banana systems compared to mono-cropped systems in regions growing Arabica (Mt. Elgon) and Robusta (south and west) coffee in Uganda. The study was carried out in 152 plots in 2006/2007. Data were collected through structured farmer interviews, field measurements and observations. Coffee yields did not differ significantly ($P \leq 0.05$) between mono-crops and intercrops. Arabica coffee yields were 1.23 and 1.18 t ha⁻¹ year⁻¹ of green beans in mono-cropped and intercropped plots, respectively. Robusta yields averaged 1.25 and 1.09 t ha⁻¹ year⁻¹ of green beans in mono-crops and intercrops, respectively. Banana yields were significantly higher ($P \leq 0.05$) in intercrops (20.19 t ha⁻¹ year⁻¹) compared with mono-crops (14.82 t ha⁻¹ year⁻¹) in Arabica growing region. In Robusta growing region, banana yields were significantly lower ($P \leq 0.05$) in intercrops (8.89 t ha⁻¹ year⁻¹) compared with mono-crops (15.04 t ha⁻¹ year⁻¹). Marginal rate of returns of adding banana to mono-cropped coffee was 911% and 200% in Arabica and Robusta growing regions, respectively. Fluctuations in coffee prices are not likely to affect the acceptability of intercrops when compared with coffee mono-crops in both regions, but an increase in wage rates by 100% can make intercropping unacceptable in Robusta growing region. This study showed that coffee–banana intercropping is much more beneficial than banana or coffee mono-cropping and that agricultural intensification of food and cash crops in African smallholder systems should not solely depend on the mono-crop pathway.

Keywords: Arabica coffee, Robusta coffee, profitability, mono-cropped coffee, coffee–banana intercropping

30. An assessment of integrated *Striga hermonthica* control and early adoption by farmers in northern Nigeria

Ellis-Jones, J., Schulz, S., Douthwaite, B., Hussaini, M. A.*, Oyewole, B., Olanrewaju, A., & White, R. (2004). An assessment of integrated *Striga hermonthica* control and early adoption by farmers in northern Nigeria. *Experimental Agriculture*, 40, 353–368. <https://doi.org/doi:10.1017/s0014479704001802>

Two sets of on-farm trials, each covering two years, were conducted in the northern Guinea savannah of Nigeria over the period 1999–2001, the objective being to compare integrated *Striga hermonthica* control measures (soybean or cowpea trap crops followed by maize resistant to *Striga*) with farmers' traditional cereal-based cropping systems. In both sets of trials, this proved to be highly effective in increasing productivity over the two year period, especially where soybean was used as a trap crop. Resistant maize after a trap crop increased the net benefit over the two cropping seasons in both trials by over 100% over farmer practice. However, in the second set of trials there was no significant increase in productivity between a trap crop followed by *Striga* resistant maize, and a trap crop followed by local maize especially where legume intercropping and fertilizer had been applied in the farmer practice. There was also no increase in productivity between two years' traditional cereal cropping and one year's local maize followed by *Striga* resistant maize. This indicates the importance of a legume

trap crop in the first year in order to ensure high productivity in the second year, regardless of variety. Up to 20% of farmers obtained higher productivity from their own practices, notably intercropping of cereals with legumes and use of inorganic fertilizers. Leguminous trap crops and *Striga* resistant maize, together with two key management practices (increased soybean planting density and hand-roguing) were seen to be spreading both within and beyond the research villages, indicating that farmers see the economic benefits of controlling *Striga*. Survey findings show that explaining the reasons why control practices work can greatly increase the adoption of these practices. Wider adoption of *Striga* control will therefore require an extension approach that provides this training as well as encouraging farmers to experiment and adapt *Striga* control options for their local farming systems.

31. An investigation of factors that influence the technical efficiency of soybean production in the Guinea savannas of Nigeria

Amaza, P., & Ogundari, K. (2007). An investigation of factors that influence the technical efficiency of soybean production in the Guinea savannas of Nigeria. *Journal of Food, Agriculture and Environment*, 6(1), 132–136. <https://cgspace.cgiar.org/handle/10568/91442>

The objective of this study was to examine the determinants of technical efficiency (TE) of soybean production in the Guinea savannas. A stochastic frontier production function, using maximum likelihood estimation (MLE) technique was applied in the analysis of data collected in 2006 from a sample of 182 soybean farmers in the Guinea savannas of Borno State, Nigeria. The MLE results revealed that farm size, seeds, family labor, hired labor and fertilizer were the major factors that were associated with change in the output of soybeans and were significant ($p=0.05$). About 78% variations in the farmers output can be attributed to differences in their technical efficiency. The mean farmers TE index was found to be 0.79. The implication is that soybean production could be increased by approximately 21% through the improved use of available resources, given the current state of technology. Farmer-specific efficiency factors, which comprise age, gender and use of animal traction and market accessibility, were the significant factors that account for the observed variation in efficiency among the farmers. The policy implication of this finding is that providing farmers with effective market linkage, access to education, especially extension education and credit facilities to purchase animal traction will strengthen their present level of TE and the productivity potential of the soybean farmers in the study area.

32. Analyse de l'efficience technique des exploitations avicoles productrices d'oeufs de table: cas des jeunes entrepreneurs au Bénin [Technical efficiency analysis on poultry farms producing table eggs: the case of young entrepreneurs in Benin]

Houedjofonon, E.M, Ahoyo Adjovi, N.R., Adeoti, R., Abdoulaye, T., Mignouna, D.B., Chogou, S. K., & Honfoga, B. (2019). Analyse de l'efficience technique des exploitations avicoles productrices d'oeufs de table: Cas des jeunes entrepreneurs au Bénin. *Bulletin de La Recherche Agronomique du Benin*, 24, 194–204. http://www.slire.net/download/2594/article_24_pg_brab_n_sp_cial_itra_oct_2019_houedjofonon_et_al_analyse_efficience_technique.pdf

(French): La filière œuf de table est un secteur d'activité pour de nombreux jeunes entrepreneurs au Bénin. L'objectif de l'étude était d'analyser l'efficacité technique et les sources d'inefficacité des exploitations des jeunes entrepreneurs produisant des œufs de table au Bénin. La statistique descriptive et l'approche de frontière stochastique utilisant une spécification de la fonction Cobb Douglas ont été les méthodes utilisées sur des données de panel non cylindriques couvrant la période de 2010 à 2017. Les résultats ont indiqué que le score moyen de l'efficacité technique a été de 0,91, traduisant une performance technique élevée des exploitations avicoles dirigées par des jeunes entrepreneurs. Mais le score moyen le plus faible a été de 0,48 tandis que le meilleur score était de 0,97. De plus, un peu moins du tiers des exploitations ont obtenu un score d'efficacité technique inférieur à la moyenne. Ce qui montre que des efforts restent à fournir pour améliorer les niveaux actuels d'efficacité techniques de ces exploitations. Les meilleurs scores d'efficacité technique étaient obtenus par les exploitations avicoles de grandes tailles ayant reçu une formation professionnelle et faisant recours aux services vétérinaires pour gérer les maladies. En conséquence, l'Etat peut bien s'appuyer sur les jeunes entrepreneurs avicoles pour réaliser son objectif d'accroître la production des œufs de table. Parmi les actions envisageables, l'appui à l'accroissement de la taille des exploitations avicoles et le renforcement des capacités techniques et managériales des entrepreneurs sont à souligner, avec un accent particulier sur les chefs d'entreprises femmes. Mots clés: Entrepreneur, œufs de table, efficacité technique, frontière stochastique, Bénin.

() The table egg sector is a domain of activity for many young entrepreneurs in Benin. The objective of the study was to analyze the technical efficiency and the sources of inefficiencies of the farms of young entrepreneurs producing table eggs in Benin. The descriptive statistics and the stochastic frontier approach using a specification of the Cobb Douglas function were the methods used on non-displacement panel data covering the period from 2010 to 2017. The results indicated that the average technical efficiency score was 0.91 reflecting a high technical performance of the poultry farms of young entrepreneurs. But the lowest average score was 0.48 while the best score was 0.97. Almost a third of the farms obtained a technical efficiency score below the average. This shows that efforts remain to be made to improve the current levels of technical efficiency of these farms. The highest technical efficiency scores were obtained by large poultry farms that had received professional training and used veterinary services to manage diseases. As a result, the Benin Government may well rely on young poultry entrepreneurs to achieve its goal of increasing the production of table eggs. The actions should contribute to increasing the size of poultry farms and strengthening the technical and managerial capacities of entrepreneurs with a particular focus on women entrepreneurs.

Keywords: entrepreneur, table eggs, technical efficiency, stochastic frontier, Benin

33. Analyses of labour productivity among small-holder cassava farmers for food security and empowerment in central Madagascar

Okoye, B. C., Abass, A., Bachwenkizi, B., Asumugha, G. N., Alenkhe, B., Ranaivoson, R., Randrianarivelo, R., Rabemanantsoa, N., & Ralimanana, I. (2016). Analyses of labour

productivity among small-holder cassava farmers for food security and empowerment in central Madagascar. *International Journal of Agricultural Management and Development*, 6(3), 309–318. <https://cgspace.cgiar.org/handle/10568/77136>

Labor productivity affects food security, but quantifying this relationship has been scarce with respect to empirical literature. The Central Madagascar dataset explores the influence of labor productivity and related variables on the food security status of cassava farmers. Drawing on both theory and empirical evidence, this paper argues that fundamental effects of links between labor productivity and food security are most times often overlooked currently in policy analyses. The study used a probit regression analytical procedure to explain the effect of labor productivity on food security of 180 Malagasy smallholder cassava farmers selected through a multi-stage random sampling technique. Results showed that 25% of the cassava farmers were food insecure. Labor productivity had a direct relationship with food security status of farmers at 1% level of probability as well as membership of cooperatives and farm size. Aged farmers were more food insecure at 10% level of probability than their younger counterparts. Households with high dependency ratio and family labor tend to be food insecure at 1% and 10% level of probability respectively among the farmers sampled. The results therefore call for land re-distribution and re-form policies aimed at encouraging younger farmers who seem to be more labor productive by allocating more land to these group (as cooperatives) to increase cassava cultivation thereby giving a boost to food security.

34. Analysis of adoption and impacts of improved cassava varieties

Khonje, M., Mkandawire, P., Manda, J., & Alene, A. (2015). Analysis of adoption and impacts of improved cassava varieties. *International Association of Agricultural Economists. 2015 Conference, August 9–14, 2015, Milan, Italy*. <https://ideas.repec.org/p/ags/iaae15/211842.html>

This paper analyzes the adoption and welfare impacts of improved cassava varieties in Zambia using data from a sample of 500 farm households. Using different treatment effect estimators—endogenous switching regression, propensity score matching, and inverse probability weighting, the paper shows that adoption of improved cassava varieties leads to significant gains in crop yields, household income, and food security. Results further show that improved cassava varieties have significant poverty-reducing impacts in Zambia. Stimulating agricultural growth largely depends on policies that stimulate adoption of improved cassava varieties.

35. Analysis of adoption and impacts of improved maize varieties in eastern Zambia

Khonje, M., Manda, J., Alene, A., & Kassie, M. (2015). Analysis of adoption and impacts of improved maize varieties in eastern Zambia. *World Development*, 66, 695–706. <https://doi.org/10.1016/j.worlddev.2014.09.008>

This paper analyzes the adoption and welfare impacts of improved maize varieties in eastern Zambia using data obtained from a sample of over 800 farm households. Using both propensity score matching and endogenous switching regression models, the paper shows that adoption of improved maize leads to significant gains in crop incomes, consumption expenditure, and food security. Results further show that improved maize varieties have significant poverty-reducing impacts in eastern Zambia. The paper concludes with implications for policies to promote adoption and impacts of modern varieties in Zambia.

Keywords: adoption, Africa, endogenous switching regression, propensity score matching, welfare, Zambia

36. Analysis of drought-tolerant maize adoption and its effect on food security among farmers in the Sudan Savanna of Northeastern Nigeria

Idrisa, Y. L, Abdoulaye, T., Mohammed, S. T, & Ibrahim, A. A (2014). Analysis of drought-tolerant maize adoption and its effect on food security among farmers in the Sudan Savanna of Northeastern Nigeria. *Asian Journal of Agricultural Extension, Economics and Sociology*, 3(6), 496–504. <http://dx.doi.org/10.9734/AJAEES/2014/8717>

This article examined the factors influencing the adoption of the drought-tolerant Maize (DT) varieties and their effect on food security among farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria. Data for the study were collected from 200 farmers who were selected through a multi-stage sampling procedure. Factors influencing the adoption of DT maize varieties were determined through the use of censored regression (the Tobit model) while the effect of adoption of DT maize on food security was determined through the use of the chi-square test. The results from the chi-square test were further converted to a contingency coefficient in order to obtain the extent of the association between the adoption of DT maize and food security. The study revealed that income ($\rho \leq 0.01$) and access to extension services ($\rho \leq 0.01$) were significant in influencing the adoption of DT maize among farmers. The study also found a strong association ($\chi^2 - \text{cal} = 15.53$; $\chi^2 - \text{tab} = 13.28$) between the adoption of DT maize and food security among farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria with a contingency coefficient of 0.25. The study thus concluded that maize farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria are generally small-scale farmers that produce for subsistence. It was also concluded that the adoption of DT maize significantly reduced the level of food insecurity among farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria. It was therefore recommended that farmers should be linked to source of market for their produce in order to boost their income and that extension services should be strengthened so as to give farmers access to improved technologies.

Keywords: drought-tolerant maize, adoption, food security, Sudan savanna, Nigeria

37. Analysis of technical efficiency among community-based seed producers in the savannas of Borno State, Nigeria

Amaza, P, Udoh, E. J, Abdoulaye, T., & Kamara, A. (2010). Analysis of technical efficiency among community-based seed producers in the savannas of Borno State, Nigeria. *Journal of Food, Agriculture and Environment*, 8(2), 1073–1079. www.researchgate.net/publication/267381886

The study examined the socio-economic characteristics of participating seed farmers in a community-based seed production scheme organized by the project, Promoting Sustainable Agriculture in Borno State (PROSAB). In addition, it determined the technical efficiency of resource use in PROSAB seed farms. Farm level survey data from 396 seed producers who cultivated maize, cowpea, soybean, rice, groundnut and sorghum were obtained using well structured questionnaires. The production parameters were estimated simultaneously with those of the models of inefficiency effects. Using the maximum likelihood estimation technique, asymptotic parameter estimates were evaluated to describe production inputs and efficiency determinants. Based on the results of gross margin analysis, the observed profit margins across the seed types conclusively revealed that every one naira spent in cultivating the seeds, some levels of financial benefits were derived as indicated by the output/input indices. Results further revealed that labor, farm size, seed and fertilizer were the most important inputs across the six crops. Inefficiency model analysis further revealed that the duration of the crop grown and ecological region predominantly affected the seed farm level of technical efficiency in input use. A mean technical efficiency of between 55% and 58% was identified, meaning that seed production under the scheme can still be increase by about 45% and 42% using available technology. The study recommends that, given the significance of seeds that have a shorter duration to maturity, quick maturing varieties of seeds should be promoted among farmers in the study area. Also, timely access to land augmenting input like fertilizer should be ensured.

Keywords: community-based, seed, production, farmers, technical, efficiency, profit, Borno, Nigeria

38. Analysis of trade-offs in agricultural systems: current status and way forward

Klapwijk, C. J., van Wijk, M. T., Rosenstock, T. S., Van Asten, P., Thornton, P., & Giller, K. (2014). Analysis of trade-offs in agricultural systems: current status and way forward. *Current Opinion in Environmental Sustainability*, 6, 110–115. <https://doi.org/10.1016/j.cosust.2013.11.012>

Trade-off analysis has become an increasingly important approach for evaluating system level outcomes of agricultural production and for prioritizing and targeting management interventions in multifunctional agricultural landscapes. We review the state-of-the-art for trade-off analysis, assessing different techniques by exploring a concrete example of trade-offs around the use of crop residues in smallholder farming systems. The techniques for performing trade-off analyses have developed substantially in recent years aided by mathematical advancement, increased computing power, and emerging insights into systems behavior. Combining different techniques allows the assessment of aspects of system behavior via various perspectives, thereby generating complementary knowledge. However, this does not solve the fundamental challenge: trade-off analyses without substantial stakeholder engagement often have limited practical utility for informing practical decision-making. We suggest ways to integrate approaches and improve the potential for societal impact of future trade-off analyses.

Keywords: crop–livestock systems, land use, conservation agriculture, management practices, climate change, Africa

39. Are agricultural technologies pro-poor? The case of improved cassava varieties in sub-Saharan Africa

Feleke, S., Manyong, V., Abdoulaye, T., Alene, A., Wossen, T., & Dontsop, P. (2018). Are agricultural technologies pro-poor? The case of improved cassava varieties in sub-Saharan Africa. *International Association of Agricultural Economists, No 277196, Conference, July 28–August 2*. <https://econpapers.repec.org/paper/agsiaae18/277196.htm>

The paper assesses whether, and if so, to what extent, the adoption of improved cassava varieties are more favorable toward the food insecure (pro-poor) as measured by the share of overall benefits. Data for this study came from a household survey conducted in Tanzania, DR Congo, Sierra Leone and Zambia through multinational-CGIAR support to agricultural research for development of strategic crops project in Africa. Given the observational nature of the data, a parametric approach (endogenous switching and Poisson regression model) was applied, accounting for potential self-selection bias that may arise from unobserved heterogeneities. Results provided consistent findings that adoption of cassava varieties decreased the rate, depth and severity of food insecurity. Decomposition of the overall average gains in calories due to adoption resulted in over four-fifths accruing to food insecure, compared to only one-fifth accruing to the food secure group. This implies that the impacts of cassava varieties are more favorable toward the food insecure than the food secure and thus present important evidence on the effectiveness of the adoption of cassava technology for reducing the rate and depth of food insecurity in sub-Saharan Africa.

Keywords: crop, production, industries

40. Are investments in an informal seed system for cowpea a worthwhile endeavour?

Biemond, P. C., Stomph, T. J., Kamara, A., Abdoulaye, T., Hearne, S., & Struik, P. C. (2012). Are investments in an informal seed system for cowpea a worthwhile endeavour? *International Journal of Plant Production*, 6(3), 367–386. <https://cgspace.cgiar.org/handle/10568/77424>

High seed quality is a critical component for realizing yield potential. For smallholder cowpea farmers in northern Nigeria the informal seed system is a major supplier of genetically high-quality seed, but the physiological quality of farmers' produced seed remains unknown. The project "Promoting Sustainable Agriculture in Borno State" (PROSAB) trained and supported farmers in seed production in Borno State, Nigeria. We analyzed the quality of farmers' produced cowpea seed based on standard quality testing criteria, and evaluated its field emergence as a proxy for non-genetic seed quality. We carried out a survey among seed producing farmers about their production and storage practices, and tested seed quality of samples from these farmers, from seed companies and compared these to foundation seed. Field emergence of farmers' produced seed was not significantly different from that of foundation seed ($P=0.47$) or seed company samples ($P=0.12$). Cowpea seed quality, however, was inadequate in both the formal and informal seed systems. Five out of six foundation seed samples, 79 out of 81 samples of farmers' seed, and six out of six seed company samples failed to meet standards for foundation and certified seeds of the National Agriculture Seed Council (NASC), the seed industry regulatory agency in Nigeria. Multiple regression analyses predicting field emergence

showed that projects like PROSAB can improve seed quality. Especially proper storage and reducing seed damage can increase field emergence significantly. Our findings suggest that it is worth to invest in improving the informal seed system of cowpea.

Keywords: cowpea, *Vigna unguiculata*, seed systems, seed quality, Northern Nigeria

41. Assessing the efficiency of sweet potato producers in the southern region of Ethiopia

Jote, A, Feleke, S., Hirpa Tufa, A., Manyong, V., & Lemma, T.* (2018). Assessing the efficiency of sweet potato producers in the southern region of Ethiopia. *Experimental Agriculture*, 54(4), 491–506. <https://doi.org/10.1017/s0014479717000199>

Applying stochastic frontier Cobb–Douglas production function, the study assessed the efficiency of sweet potato (*Ipomoea batatas*) producers in the Southern region of Ethiopia. The study revealed the existence of fairly large technical inefficiency in sweet potato production. The technical efficiency ranged from 12.6 to 93.7%, with more than half of the producers above the mean efficiency level (66.1%). This suggests that there is room for output gains through technical efficiency improvement. If the average producers in the study region are to achieve the technical efficiency level of the most efficient producer in the sample (93.7%), they can realize nearly 30% output gains. The analysis of allocative efficiency also revealed that sweet potato producers were producing sweet potato with sub-optimal utilization of production inputs, suggesting that potential for output gains remains to be exploited through reconfiguration of the existing resource use. They can make more value out of their sweet potato production by reconfiguring their current utilization of production inputs in favor of more land and manure but less seed rate. Furthermore, age and education are important determinants of the efficiency of sweet potato production. In view of these findings, it is advisable to put in place appropriate extension intervention programs that enable sweet potato producers to exploit the potential gains in sweet potato output through technical and allocative efficiency improvement.

Keywords: stochastic frontier Cobb–Douglas production function, sweet potato, output gains, technical efficiency, allocative efficiency, Ethiopia

42. Assessing the extent and determinants of adoption of improved cassava varieties in south-western Nigeria

Awotide, B, Abdoulaye, T., Alene, A., & Manyong, V. (2014). Assessing the extent and determinants of adoption of improved cassava varieties in south-western Nigeria. *Journal of Development and Agricultural Economics*, 6(9), 376–385. <https://cgspace.cgiar.org/handle/10568/76040>

This paper investigates the determinants of adoption of improved cassava varieties in south-western Nigeria. The data come from a farm household survey of 841 households selected using a three-stage stratified random sampling procedure. The data collection was conducted in 2011 by the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Empirical

estimates of a Double-Hurdle model revealed that adoption increases with the age of the household head and is influenced by the gender of the household head, hired labor, cultivated land, and access to credit. The results further showed that the intensity of adoption is influenced by hired labor and farm size; access to information about the improved cassava varieties is determined by the age, gender, and level of education of the household head, and by off-farm income.

Keywords: adoption, improved cassava, double-hurdle, Nigeria

43. Assessing the impacts of cassava technology on poverty reduction in Africa

Feleke, S., Manyong, V., Abdoulaye, T., & Alene, A. (2016). Assessing the impacts of cassava technology on poverty reduction in Africa. *Studies in Agricultural Economics*, 118(2), 101–111. <https://cgspace.cgiar.org/handle/10568/77389>

In Africa, there have been successes in cassava research in terms of the development of production technologies, particularly improved varieties with high yield potential. The study addresses the question of whether and to what extent adoption of improved cassava varieties has led to rural poverty reduction in four African countries, namely Tanzania, Democratic Republic of Congo, Sierra Leone and Zambia. Data for the study come from a household survey conducted in the above-mentioned countries through a multinational-CGIAR support to agricultural research for development of strategic crops (SARD-SC) project in Africa. Given the observational nature of the data, a parametric approach (endogenous switching regression model) is applied. The results indicate that the model detects selectivity bias. Accounting for the bias, we find that adoption of cassava technology has resulted in an approximately 10 percentage point reduction in the poverty rate. Given an adoption rate of 34 per cent and a 10 percentage point reduction in the poverty rate, an estimated 24,309 households (equivalent to 194,469 individuals) have managed to move out of poverty in these four countries as a result of adoption of the technology. We also find that adoption of the technology has benefitted non-poor and female-headed households, relative to poor and male-headed households. The results present important evidence in favor of promoting cassava technology in a targeted fashion as part of an effective poverty reduction and sustained agricultural growth strategy in Africa. Considering the large realized and even more pronounced potential impacts of the adoption of cassava technology on poverty reduction, it is vital that regional and global development organizations should continue supporting the existing cassava improvement program to sustain the technology development efforts in the continent.

Keywords: cassava varieties, households, adoption, selectivity bias, endogenous switching regression

44. Assessing the potential impact of Integrated Agricultural Research for Development (IAR4D) on adoption of improved cereal-legume crop varieties in the Sudan Savannah Zone of Nigeria

Binam, J. N., Abdoulaye, T., Olarinde, L., Kamara, A., & Adekunle, A. (2011). Assessing the potential impact of Integrated Agricultural Research for Development (IAR4D) on adoption of improved cereal-legume crop varieties in the Sudan Savannah Zone of Nigeria. *Journal of Agricultural and Food Information*, 12(2), 177–198. <https://doi.org/10.1080/10496505.2011.563233>

This article provides an assessment of the potential impact of operationalizing agricultural innovation platforms (IPs) in the Sudan Savannah zone of Nigeria on adoption of improved maize/legume crop varieties, as measured by the potential outcome approach. The results show that, if the whole population in the intervention area were exposed to these varieties, the adoption rate could be increased to 69% instead of 49%. The study also shows that exposure, as well as adoption, is influenced by numerous social and institutional factors and suggests that the operationalization of IPs could help boost the adoption rate to around 51%.

Keywords: Africa, ATE and LATE estimation, ex-ante impact assessment, IAR4D, improved cereal and legume varieties, innovation platforms, Nigeria, Sudan

45. Assessing the productivity of common bean in intercrop with maize across agro-ecological zones of smallholder farms in the northern highlands of Tanzania

Nassary, E. K., Baijukya, F. P., & Ndakidemi, P. A. (2020). Assessing the productivity of common bean in intercrop with maize across agro-ecological zones of smallholder farms in the northern highlands of Tanzania. *Agriculture*, 10(4), 117. <https://doi.org/10.3390/agriculture10040117>

Common bean (*Phaseolus vulgaris* L.) is an important grain legume for food and cash of the smallholder farmers worldwide. However, the total potential benefits to be derived from the common bean as a source of food and income, its complementarities with non-legume food crops, and significance to the environment are underexploited. Intensification of common bean could provide approaches that offer new techniques to better manage and monitor globally complex systems of sustainable food production. Therefore, this study tried to assess the productivity of common bean bushy varieties when are involved as part of an intercrop with maize (*Zea mays* L.) in varying agro-ecological zones. The factors evaluated were the cropping seasons/years (S) (2015 and 2016), agro-ecological zones (A) above sea level (lower 843 m, middle 1051 m, upper 1743 m), and cropping systems (C) (sole, intercrop). The data collected were the total biomass, number of pods per plant and seeds per pod, 100-seed weight as yield components, and grain yield. Bean and maize grain yields were used to calculate the partial (P) and total land equivalent ratio (LER). Results indicated that the main effects of S, A, C, and the interaction effects of S × A, S × C, S × A × C were significant on bean grain yields. Interactions of S × A × C were also significant on all measured variables. Results also indicated that continuous intercropping of bean with maize over two cropping seasons resulted in the increase of bean grain yields from 1.5 to 2.3 t ha⁻¹ in the lower altitude, 2.0

to 2.3 t ha⁻¹ in the middle altitude, and 1.8 to 2.9 t ha⁻¹ in the upper altitude. Land utilization advantage of intercrops over monocultures yielded a total LER of 1.58, whereas the average partial land equivalent ratio (PLER) of individual beans was 1.53.

46. Assessing the technical efficiency of commercial egg production in Tanzania for improved livelihoods

Oleke, J. M., & Isinika, A (2011). Assessing the technical efficiency of commercial egg production in Tanzania for improved livelihoods. *Journal of Development and Agricultural Economics*, 3(8), 343–352. www.cabdirect.org/cabdirect/abstract/20113345779

This study examined the productivity and technical efficiency (TE) of egg production in Tanzania under the intensive system. A multistage random sampling procedure was employed for selecting 80 respondents from two districts; Kibaha and Ilala. This study utilizes the most recent developments in stochastic frontier modeling as specified for a one-step process in Limdep software. Results indicated that the mean TE of egg production is 64%, ranging from 4 to 90%. Egg production was in the rational stage of production (stage II) as depicted by the returns to scale (RTS) of about 1.3. Thus, there is room for improving TE, which will raise net returns of egg production enterprises, hence, improving livelihoods of farmers and their families.

Keywords: technical efficiency, intensive, egg production, stochastic frontier, Tanzania

47. Assessing the technical efficiency of maize producers with Imazapyr-resistant maize for *Striga* control in Western Kenya

Mignouna, D., Manyong, V., Mutabazi, K. D, Senkondo, E, & Oleke, J. M. (2012). Assessing the technical efficiency of maize producers with Imazapyr-resistant maize for *Striga* control in Western Kenya. *Journal of Development and Agricultural Economics*, 4(8), 245–251. <https://cgspace.cgiar.org/handle/10568/77433>

Imazapyr-Resistant Maize (IRM) is a weed control technology, not yet well adopted in the *Striga* prone area in Western Kenya. The adoption may expand in the future because it enhances maize production via efficiency gains. As to help farmers maximize the maize output affected by *Striga* for so long in time, research and development initiatives with substantial participation of the private sector to shift to this novel technology have been made in Western Kenya. A multistage random sampling technique was used to select a total of 600 households from Nyanza and Western provinces for this study. Stochastic production frontier analysis was the analytical method and the study revealed that the mean technical efficiency in the maize production sector is 70% indicating some inefficiencies of maize production. Technical inefficiency effects were influenced by household size along with farm size. Enhancing the technical efficiency will increase net returns of maize production enterprises, hence, improving livelihoods of maize producers.

Keywords: Kenya, technical efficiency, stochastic production frontier

48. Awareness and adoption of improved cassava varieties and processing technologies in Nigeria

Abdoulaye, T., Abass, A., Maziya-Dixon, B., Tarawali, G., Okechukwu, R., Rusike, J., Alene, A., Manyong, V., & Ayedun, B. (2014). Awareness and adoption of improved cassava varieties and processing technologies in Nigeria. *Journal of Development and Agricultural Economics*, 6(2), 67–75. <https://cgspace.cgiar.org/bitstream/handle/10568/72980/U14ArtAbdoulayeAwarenessNothomNodev.pdf?sequence=3&isAllowed=y>

Development of high yielding and disease resistant cassava varieties, coupled with the promotion of efficient processing technologies, was the principal intervention aimed at changing the cassava subsector in Nigeria. National research and extension programs in Nigeria and IITA have been spearheading efforts to disseminate these varieties alongside improving farmer's access to processing machineries. Several Research-for-Development (R4D) projects were implemented to this effect between early 1980 to date. This paper investigated the effects of improved cassava varieties and processing technologies on adopting households. It also attempts to test and establish the link between adoption of improved cassava varieties and access to processing technologies. The data used in this paper come from a sample household survey of 952 households conducted in four regions of Nigeria. The results showed that in all the study sites farmers grow mixture of improved and local cassava varieties. They process cassava at home using small processing machines and also using services of commercial processors. The most common processed cassava products were found to be garri and fufu. Adopters of improved cassava varieties have higher cassava yield of 16 tons/ha compared to 11 ton/ha for non-adopters. There was also significant yield variation between villages that participated (15 tons/ha) in research for development (R4D) training and those which did not (13 tons/ha). The bivariate probit model estimates showed a strong relationship between adoption of improved cassava varieties and farmers' access to grating machines. Moreover, farmers that were members of either community organizations or cooperative organizations had a higher tendency of using improved varieties than others, suggesting that the introduction of new cassava varieties would be enhanced by farmers' access to processing facilities and services. Moreover, training of farmers and processors through R4D programs has led to increased use of improved technologies.

Keywords: cassava, improved varieties, processing, bivariate probit

49. Awareness and adoption of positive selection technology among yam farmers in West Africa

Asante, B. O, Osei-Adu, J, Osei, K, Ennin, S, Aighewi, B., & Opoku, M (2021). Awareness and adoption of positive selection technology among yam farmers in West Africa. *International Journal of Social Economics*, 48(9), 1372–1389. <https://doi.org/10.1108/ijse-07-2020-0474>

Purpose: This paper aims to investigate how awareness influences the adoption of positive selection (PS) technology among smallholder yam farmers in West Africa. PS has the potential of increasing yield and reducing disease incidence and severity in yam production.

Design/methodology/approach: This paper applies the average treatment effect (ATE) methodology to estimate the rates of awareness and adoption of the PS technology and associated factors using data from 678 smallholder seed yam farmers in Ghana and Nigeria.

Findings: The results indicate that the actual adoption rates of PS technology are 58 and 55%, while the potential adoption rates are estimated at 89.5 and 79.3% for Ghana and Nigeria, respectively, if the PS technology was fully disseminated. This leads to adoption gaps of 31.7 and 24.8%, respectively, for Ghana and Nigeria stemming from incomplete awareness of the PS among the population of yam growing farmers. The PS adoption is high among the educated young farmers who are members of farmer based organizations and participate in demonstrations.

Practical implications: Promotional efforts for enhancing awareness and adoption of PS should target educated youth willing to participate in field demonstrations and should focus on scaling up of PS technology to ensure quality farmer saved seed yams and enhance yam productivity in West Africa.

Originality/value: The introduction of PS in seed yam production is quite recent also its introduction to seed yam farmers in West Africa. Subsequently, a better understanding of what the adoption status would be should everyone in the population of yam farmers are aware of PS is vital for policy, research and development.

Keywords: positive selection, awareness, adoption, average treatment effect, seed yam, C21, Q12, Q16, Q55, R5

50. Can food technology innovation change the status of a food security crop? A review of cassava transformation into “bread” in Africa

Abass, A. B., Awoyale, W., Alenkhe, B., Malu, N., Asiru, B. W., Manyong, V., & Sanginga, N. (2018). Can food technology innovation change the status of a food security crop? A review of cassava transformation into “bread” in Africa. *Food Reviews International*, 34(1), 87–102. <https://doi.org/10.1080/87559129.2016.1239207>

Reducing both hunger and high expenditure on food imports is a priority for most developing African countries. Countries that hitherto have relied heavily on food imports are seeking new approaches to increase the utilization of locally grown crops. This review uses the case of cassava to propose that scientific and technological innovations, supported by public investment and appropriate policies, offer opportunities for better utilizing locally grown crops, encouraging agro-industrial development, reducing import expenditure, and providing much-needed income (bread) to smallholders. This review highlights areas that require further research in order to achieve sustainable development in the processing of raw cassava root into cassava flour for bread production.

Keywords: bread, cassava, high-quality cassava flour, import substitution, income, investment, technology

51. Cassava: from poor farmers crop to pacesetter of African rural development

Dixon, A., Bandyopadhyay, R., Coyne, D., Ferguson, M., Ferris, R. S. B., Hanna, R., Hughes, J., Ingelbrecht, I., Legg, J., Mahungu, N., Manyong, V., Mowbray, D., Neuenschwander, P., Whyte, J., Hartmann, P., & Ortiz, R. (2003). Cassava: from poor farmers crop to pacesetter of African rural development. *Chronica Horticulturae*, 43(4), 8–15. <https://cgspace.cgiar.org/handle/10568/96342>

Cassava is called Africa's food insurance because it gives stable yields even in the face of drought, low soil fertility and low intensity management. It can remain in the soil until needed, spreading out food supply over time, helping families through the hungry time each year when seasonal harvests run out and, helping people avert the tragic "boom and bust" cycle of oversupply that is followed by shortage. Cassava's low input requirements and its ability to survive despite the devastation of drought and armed conflict have let it thrive where other crops have failed. Cassava thus plays an important food security role in Africa. In addition, data collected by the Collaborative Study of Cassava in Africa (COSCA) in 563 villages scattered across 11 countries, which account for over 80% of cassava production on the continent, have shown that cassava generates cash income for the largest number of households in comparison with other staples. In fact, today, the crop performs five main roles in Africa: famine reserve crop, rural food staple, cash crop for urban consumption, industrial raw material, and earner of foreign exchange. Thus cassava has tremendous potential for future exploitation to contribute to food security, rural income, and the economy in the continent. At a time when a variety of approaches to poverty alleviation are being considered by governments in the developing world and their development partners, increased attention is being paid to the potential of cassava as a food security, as well as a cash, crop.

52. Commercial-scale adoption of improved cassava varieties: A baseline study to highlight constraints of large-scale cassava based agro-processing industries in Southern Nigeria

Tarawali, G., Iyangbe, C., Udensi, U. E., Ilona, P., Osun, T., Okater, C., & Asumugha, G (2012). Commercial-scale adoption of improved cassava varieties: A baseline study to highlight constraints of large-scale cassava based agro-processing industries in Southern Nigeria. *Journal of Food, Agriculture & Environment*, 10(3/4), 689–694. www.researchgate.net/publication/255966173

Cassava is an important food security crop among smallholder farmers in Southern Nigeria, because it can tolerate drought, low soil fertility and its production requires minimum external inputs. In most African countries, cassava is becoming important cash crop that has high potential for use as an industrial raw material to manufacture starch and flour. The use of cassava flour in confectionery industries recently in Nigeria is new and fast gaining ground. One major constraint faced by the cassava industrial sector is inadequate supply of raw material to boost the industry. This has been attributed to poor yield and harvest from farmers' field, due to several and interrelated factors. Most significant of these factors is lack of large-scale adoption and cultivation of improved cassava varieties. Various constraints have militated against the widespread adoption of improved cassava varieties, with effect evidenced in the poor supply

of raw material need of cassava based agro-processors. This study examined these factors in eight States of Southern Nigeria, using the probit model. Sixty-eight cassava farmers from the eight project states were randomly selected using a multi-stage random sampling procedure during 2008/2009 planting season. Results of the study showed that 23.5% of the respondents were females, while majorities (76.5%) were male. Only about 46% of the farmers were in their productive years (21–50 years), while the majority (54.0%) consisted of those who were >50 years. The average of the farmers was about 50 years, with more than 50% having greater than 15 years farming experience. About 59% of the respondents were basically small-holder farmers with farm size less than one hectare; while 41% had farm size between 1 and \geq 5 ha. Of the 68 respondents, majority (60%) farm on family land, while 40% of them were leaseholders. Land use practices varied among the farmers. Results indicated that 73% of 68 farmers who responded adopted fair land use practices while 16% observed good land use practices. However, about 11% of the respondents maintained a poor land use practice. The results of this study also showed that 66% of the farmers adopted improved cassava variety, either solely or in combination with local varieties; while about 34% of the farmers still rely on their local variety. However, less than 30% of the farmers using improved variety adopted improved crop management practices. Yield from the farmers' field averaged 13.6 ton ha⁻¹. The study also observed that 68% of the cassava roots sold for family income, were sold at the farm-gate, village and urban markets, and seldom to the agro-processors; while 32% were reserved for household consumption. The coefficient for gender, cassava yield and farming experience were positively related to adoption of improved varieties. However, gender and yield had a significant relationship at 5% level of probability, while years of farming experience was not significant at 5% but at 10% level. Land ownership on the other hand had negative effect, significant at 5% level of probability. Implicit in these results is that farming experience and level of yield obtained may determine a farmer's willingness to commercially adopt improved variety. Similarly, the profitability arising from increased yield from improved variety may prompt more farmers to adopt and hence expand their holding and land use, with more leaseholder of land increasing.

Keywords: adoption, improved cassava varieties, agro-processors, probit model

53. Comparing the effectiveness of informal and formal institutions in sustainable common pool resources management in Sub-Saharan Africa

Yami, M., Vogl, C., & Hauser, M. (2009). Comparing the effectiveness of informal and formal institutions in sustainable common pool resources management in Sub-Saharan Africa. *Conservation and Society*, 7(3), 153–164. www.conservationandsociety.org.in/article.asp?issn=0972-4923;year=2009;volume=7;issue=3;page=153;epage=164;aulast=Yami

This article compares the effectiveness of informal and formal institutions for sustainable common pool resources (CPRs) management in Sub-Saharan Africa and investigates the social, political and demographic conditions that influence the institutions' effectiveness.

By focusing on publications addressing micro-level CPR management, a comprehensive literature review was conducted. Articles were grouped, based on the main themes of the study, including types of institutions and conditions that influence their effectiveness. A qualitative meta-analysis was conducted using a deductive coding approach. The results revealed that informal institutions have contributed to sustainable CPR management by creating a suitable environment for joint decision-making, enabling exclusion at low cost for CPR users and using locally agreed sanctions. Although the published evidence suggested less support to formal institutions under decentralised governmental reforms, they played an important role in implementing technologies for sustainable CPR management. Conditions that influence the effectiveness of both types of institutions include high population growth on limited CPRs, the growing scarcity of CPRs due to land use change and the lack of human and financial capacities. Improving the conditions that hinder the contributions of both types of institutions is crucial to enhance the institutions' effectiveness in sustainable CPR management. Moreover, policies and development interventions should strengthen the involvement of well-functioning informal institutions in decision-making so that sustainable CPR management can be achieved.

Keywords: common pool resources, formal, informal, institutions, Sub-Saharan Africa

54. Contribution des femmes à l'adoption des variétés de maïs tolérantes à la sécheresse au Nord Bénin

Baco, M. N., Affoukouk, T., Moumouni, I., Yallou, C. G., & Abdoulaye, T. (2014). *Science et technique, Lettres, Sciences sociales et humaines*, 1, 99–108. <https://biblio1.iita.org/handle/20.500.12478/1097?show=full>

(French). Cette étude présente les résultats d'un processus de sélection variétale participative visant à identifier les préférences des producteurs et productrices en matière de variétés de maïs tolérantes à la sécheresse dans des localités du Nord Bénin. Elle a été initiée pour contribuer au débat sur l'adoption des innovations en relation avec la question du genre. Deux approches méthodologiques ont été utilisées pour identifier les meilleures variétés selon le genre. La première concerne la priorisation indirecte à partir d'une pondération des critères de choix et d'une confrontation des variétés aux critères pondérés. La seconde est une priorisation directe qui s'appuie sur le principe du vote démocratique. Les méthodes de recherche participative ont été utilisées pour collecter et analyser les données. Sur trois sites d'expérimentation, 60 producteurs à raison de 10 hommes et 10 femmes par site ont participé à cette sélection variétale participative. Les sites concernés sont ceux d'Angaradebou (Kandi), de Kokey (Banikoara) et de Tomboutou (Malanville). Les résultats de ce travail montrent l'importance des femmes tout le long du processus de sélection variétale. Au niveau du choix des critères de sélection, elles ont non seulement choisi les mêmes critères que les hommes, mais elles ont aussi identifié un critère spécifique à elles qui est la qualité organoleptique. En confrontant les résultats des deux méthodes de choix, il est apparu que les deux méthodes ont débouché aux mêmes résultats dans le cas des hiérarchisations faites par les femmes, alors que chez les hommes, les résultats varient avec les méthodes. Ces résultats prouvent la consistance des femmes dans les choix des technologies et la nécessité de prendre en compte

leurs préférences dans la mise au point des innovations particulièrement celles relatives aux nouvelles variétés.

(English). This study presents the results of a process of a participatory varietal selection of drought tolerate maize in districts of Kandi, Banikoara and Malanville. It was initiated to contribute to the debate on the adoption of innovations in relation to gender. The methodology used to collect and analyze data is based on the decentralization of research approaches. Three experimental sites, 60 farmers with 10 men and 10 women per site have participated in this stage of the participatory varietal selection. The sites of the experiments were located in the villages of Angaradebou (Kandi), Kokey (Banikoara) and Tomboutou (Malanville). The results of this work showed the importance of women throughout varietal selection process. With regard to the choice of the selection criteria, women didn't only choose the same criteria as men, but they also identified a specific criterion to them which is the organoleptic quality. Regarding to the ranking of varieties seeds, women were more consistent (one variety has the highest score in the ranking of varieties and it is also the same that has the highest frequency in the varietal preference); which was not the case for men. These results showed the importance of women in appropriate technology choosing and the necessity to take into account their preference in the designing of new varieties.

Keywords: gender, maize, drought, participatory varietal selection, adoption, Northern Benin

55. Contributions of agricultural improved technologies to rural poverty alleviation in developing countries: case of imazapyr-resistant maize in Western Kenya

Mignouna, D. B., Mutabazi, K. D. S., Senkondo, E. M., & Manyong, V. M. (2011). Contributions of agricultural improved technologies to rural poverty alleviation in developing countries: case of imazapyr-resistant maize in Western Kenya. 2011 Conference (55th), February 8–11, Melbourne, Australia. Australian Agricultural and Resource Economics Society. <https://ideas.repec.org/p/ags/aare11/100685.html>

Last two decades have been dominated by issues on poverty as major growth area with the adoption by United Nations member countries of the Millennium Development Goals, the first of which calls for halving the incidence of poverty and hunger by 2015, this has underlined the importance of introduction of improved agricultural technologies. Most poor rural households in developing countries usually depend on agriculture and have to cope with poverty, still a rural phenomenon. Agricultural production has continuously decreased, subject to serious limitations such as declining soil fertility, diseases, pests, drought and erosion plaguing crop growing areas. This situation should have encouraged rural households to increasingly consider the use of promising technologies. This study was done using a case of imazapyr-resistant maize (IRM) technology for combating noxious *Striga* weed which has devastating effects on maize production in western Kenya. A cross sectional survey that included randomly a total selected sample of 600 households of which 169 IRM users and 431 non-users was employed.

Keywords: IRM technology, *Striga* control, poverty reduction, Kenya

56. Contributions of integrated soil fertility management (ISFM) to various sustainable intensification impact domains in Tanzania

Kihara, J., Manda, J., Kimaro, A. A., Swai, E., Mutungi, C., Kinyua, M., Okori, P., Fischer, G., Kizito, F., & Bekunda, M. (2022). Contributions of integrated soil fertility management (ISFM) to various sustainable intensification impact domains in Tanzania. *Agricultural Systems*, 203(103496), 1–16. <https://doi.org/10.1016/j.agsy.2022.103496>

Context: The implementation of integrated soil fertility management (ISFM) varies widely among farmers, from no ISFM to multiple computations of ISFM components (i.e., improved germplasm, organic resources, fertilizers, and local adaptations e.g., soil and water conservation (SWC)). There is no comprehensive report on farmers' use of ISFM components and their impact on sustainable intensification domains of productivity, economic, social, human condition, and environment and the associated variations across farmer fields and agro-ecological zones (AEZs).

Objective: This study 1) evaluated the current implementation status of ISFM by farmers in relation to the various ISFM components and 2) provided multi-dimensional multi-scale evidence of ISFM implications that can guide ISFM investments within SSA contexts, with a specific focus on Tanzania.

Methods: We used data collected from 1406 plots between 2013 and 2020 in semi-arid and sub-humid AEZs. The data are from farmer practices. The plots were grouped by the various combinations of ISFM components implemented and analyzed using Tukey's test to examine the association of ISFM use with selected indicators within a domain.

Results and conclusions: The number of ISFM components used by farmers is higher in sub-humid (1 to 4) than in semi-arid AEZ (0 to 3). Except for SWC used by 40% of farmers in both AEZs, the proportion of farmers using improved seeds (95%) and manure (55%) in the sub-humid AEZ are more than double those using these ISFM components in the semi-arid AEZ. Productivity and economic benefits increase with the number of ISFM components at the expense of higher labor demand. Increasing plot-level ISFM benefits also translate to increased household-level whole-farm income but contributions to human nutrition are unclear. The contribution to SOC by increasing ISFM is insignificant, compounded by strong effects of slope position of the field. Differential access to resources, decision-making and control rights drive the number and choice of the specific ISFM components.

Significance: Understanding of ISFM impacts across domains is essential to guide the scaling of ISFM in Tanzania and beyond and therefore recommended in future studies.

Keywords: ISFM components, impact domains

57. Crop residue usage and its determinants in Kano State, Nigeria

Akinola, A. A, Ayedun, B., Abubakar, M., Sheu, M., & Abdoulaye, T. (2015). Crop residue usage and its determinants in Kano State, Nigeria. *Journal of Development and Agricultural Economics*, 7(4), 162–173. <https://cgspace.cgiar.org/handle/10568/73013>

This study examined crop residue usage and determined factors influencing the decision to allocate as well as the intensity of crop residue in Kano state, Nigeria. A multi-stage sampling technique was employed to select 160 farming households in three local government areas of the state. Data collected were analyzed with descriptive statistics and double hurdle Tobit model. The results of the study showed that on a general note, crop residues allocated for own animal feeding had the major share. Farmers preferred using crop residue for feeding than mulching. The allocation of the legume residues for feed purposes was about 64 percent; the share for cereal residues of animal feed was 26 percent. Other important competing uses of crop residue of legumes and cereals were also different. These included stall feeding, burning, house construction and fuel. About 17 percent of legumes residues are sold either on field or offsite. Legume residues were major sources for redistributing nutrient within the farm and between farm units (within the systems). More of legume crop residue (CR) was used within the farm/community (88.9 percent) while only 11 percent was exported. The decision to adopt cereal crop residue as livestock feeds was positively and significantly influenced by age, education, access to credit facilities and quantity of cereal crop residue available to the farmers. On the other hand, decision to use legume crop residue was positively and statistically influenced by farm size and access to extension facilities. However, the intensity of use of both categories of residues was mostly determined by age, education and access to credit. Furthermore, results indicated that where both residues were available, farmers complemented the use of one with another. Concerted efforts should therefore be made at increasing awareness and education on the use of crop residues in the crop–livestock system. Similarly, facilitation of extension services in crop residue training and increased access to credit will reduce the degree of residue export from the system.

Keywords: double hurdle Tobit model, multi-stage sampling technique, legumes, cereal, crop residue

58. Determinants of adopting imazapyr-resistant maize for *Striga* control in Western Kenya: a double-hurdle approach

Mignouna, D., Manyong, V., Mutabazi, K. D, & Senkondo, E (2011). Determinants of adopting imazapyr-resistant maize for *Striga* control in Western Kenya: a double-hurdle approach. *Journal of Development and Agricultural Economics*, 3(11), 572–580. www.cabdirect.org/cabdirect/abstract/20113376841

Discussions and debates have been on going about *Striga*, a major constraint to increasing maize production and food security in western Kenya. To inform these debates this paper applies econometrics to farm survey data in order to estimate and determine the factors which drive farmers' decision to adopt imazapyr-resistant maize (IRM), a novel technology for *Striga* control. The study uses data from a multistage, random sample of 600 households of which,

169 were IRM adopters and 431 were non-adopters. This paper tests the hypothesis that the factors affecting farmers' decision to adopt IRM are not necessarily the same as those affecting their extent of adoption. Results from the double-hurdle model indicates that age of the household head, household size, membership to social group, access to extension services and perception toward IRM for *Striga* control were found to influence the decision to adopt IRM. And, household size, gap between maize production and consumption per capita, access to extension services and perception toward IRM for *Striga* control influenced the extent the farmer is willing to adopt. The paper concludes with policy implications aimed at renewing the focus on IRM transfer in western Kenya and other areas with similar conditions.

Keywords: adoption, double-hurdle model, imazapyr-resistant maize (IRM) technology, *Striga*, Kenya

59. Determinants of adopting imazapyr-resistant maize technologies and its impact on household income in Western Kenya

Mignouna, D., Manyong, V., Rusike, J., Mutabazi, K. D., & Senkondo, E (2011). Determinants of adopting imazapyr-resistant maize technologies and its impact on household income in Western Kenya. *AgBioForum*, 14(3), 1–6. www.researchgate.net/publication/279898584

This study identifies the adoption determinants and causal impact of adoption of imazapyr-resistant maize (IRM) on income and poverty among maize farming households using a logistic model and Heckman selection-correction model. Results from a randomly selected sample of 600 households consisting of 169 adopters and 431 non-adopters reveal that combined specific household, farm, institutional, and technological factors influence the probability of adoption of the technology. The results also showed that adoption of IRM raises farm household income even after controlling for observable and unobservable household characteristics. Conclusions drawn from this study are that the use of IRM for *Striga* control is a reasonable policy instrument to raise small-farm income and reduce poverty among maize farming households.

Keywords: IRM technology, determinants, adoption, impact, Kenya

60. Determinants of adoption and intensity of use of balance nutrient management systems technologies in the northern Guinea savanna of Nigeria

Akinola, A. A., Alene, A., Adeyemo, R., Sanogo, D., Olanrewaju, A., Nwoke, C., & Nziguheba, G. (2010). Determinants of adoption and intensity of use of balance nutrient management systems technologies in the northern Guinea savanna of Nigeria. *Quarterly Journal of International Agriculture*, 49(1), 25–45. www.researchgate.net/publication/262724684

As part of a major effort to address soil fertility decline in West Africa, a project on Balanced Nutrient Management Systems (BNMS) has since 2000 been implemented in the northern Guinea savanna (NGS) of Nigeria. The project has tested and promoted two major technology packages, including a combined application of inorganic fertilizer and manure (BNMS-manure)

and a soybean/maize rotation practice referred to as BNMS-rotation. This study employed Tobit model to examine factors that influence the adoption and intensity of utilization of BNMS technologies in the NGS of Nigeria. Results showed that less than 10% of the sample households adopted at least one of the two components of the technology package by the end of 2002. However, by 2005 the adoption of BNMS-rotation had reached 40% while that of BNMS-manure had reached 48%. A number of factors such as access to credit, farmers' perception of the state of land degradation, and assets ownership were found to be significant in determining farmers' adoption decisions on BNMS-manure while off-farm income was found to be significant in determining farmers' adoption decisions on BNMS-rotation. Extension services and farmer-to-farmer technology diffusion channels were the major means of transfer of BNMS technologies.

Keywords: adoption, BNMS-manure, BNMS-rotation, Northern Guinea Savanna, NGS

61. Determinants of adoption of agricultural innovations and profitability of cereals and legumes in the Sudan savanna of Nigeria

Ayanwale, A. B, Abdoulaye, T., Kamara, A., Adekunle, A, Fatunbi, O, Ayedun, B., & Akinola, A. A.* (2014). Determinants of adoption of agricultural innovations and profitability of cereals and legumes in the Sudan savanna of Nigeria. *Ife Journal of Agriculture*, 27, 95–110. <https://ija.oauife.edu.ng/index.php/ija/article/view/385>

In order to facilitate a scientific assessment of the viability of the IAR4D concept, this paper analyzed the factors affecting adoption of agricultural technologies as well as determined the profitability of cereals and legumes in the Sudan savanna of Nigeria. Data were obtained from the baseline study conducted in 2008 as well as other official secondary data. Descriptive statistics, budgetary as well as logistic regression techniques were used to analyze the data. Results show that the respondent's age range vary between 40 and 55 years implying that they are relatively young elders with large family size of between 12 and 14 possibly providing family labor for farm work. The educational level is expectedly low with only about a third of them having up to six years of formal education. The regression results reveal that the location of the farmer, large family size and awareness encouraged adoption of new technologies across the various sites. The gross margin analysis reveals that among the cereal crops, maize gave the highest yield and revenue, while for legume crops, groundnut gave the highest yield and revenue figures in all sites with labor being the highest variable cost item on all sites. In conclusion, the study affirmed that farmers in the study area possess the potential to adopt agricultural innovations which could increase yields and enhanced income.

Keywords: integrated agricultural research for development, IAR4D, adoption, innovation platforms, gross margin

62. Determinants of crop residue use along an intensification gradient in West Africa's Savannah zones

Akinola, A., Abdoulaye, T., Valbuena, D., Erenstein, O., Haileslasie, A., Germaine, I., Shehu, M., & Ayedun, B. (2016). Determinants of crop residue use along an intensification gradient in West Africa's Savannah zones. *Tropicultura*, 34(4), 396–410. <https://repo.mel.cgiar.org/handle/20.500.11766/6910>

The study compares and contrasts crop residue uses in 3 case study sites along an agricultural intensification gradient in the Sahel-Sudano zone of Niger and Nigeria. It draws on data collected from 24 villages involving 480 households and employs a Tobit model to analyze the determinants of crop residue uses for cereals and legumes. The study uses an innovative classification of crop residue uses as an internal and external service to the farming system. Survey results indicate that internal service as livestock feed constituted the largest share across sites and crop types. Sale of crop residues is the largest external use identified for legumes. The study found that the internal use of cereal crop residue decreases along an intensification gradient. However, legume biomass redistribution within the system (internal service) did not follow a clear intensification gradient. The result of Tobit analyses indicates internal service use was positively influenced by livestock ownership ($p < 0.01$), age ($p < 0.1$), education ($p < 0.01$), training by extension agent on crop-livestock interaction ($p < 0.05$) and crop residue management ($p < 0.01$). However, as household size ($p < 0.01$) increased the probability of enhancing internal services to agricultural systems declined. This suggests that larger households with more pressing demands for cash tend to sell their crop residues at the expense of more sustainable uses such as mulching. The overall pressure on crop residue use was also especially high in the more intensive system of the Kano region. Therefore, given the importance of crop residue for livestock feed and soil cover in these fragile savannah system and the high pressure for competing uses of crop residues, there is need to develop and promote potential substitute to ensure sustainability.

Keywords: tobit model, crop residue, intensification gradient, biomass use, soil amendment, crop

63. Determinants of farm-level technical efficiency among adopters of improved maize production technology in Western Ethiopia

Alene, A., & Hassan, R. M (2003). Determinants of farm-level technical efficiency among adopters of improved maize production technology in Western Ethiopia. *Agrekon*, 42(1), 1–14. <http://dx.doi.org/10.1080/03031853.2003.9523606>

A translog stochastic production frontier was used to analyze the technical efficiency of small farmers using improved maize production technology in Western Ethiopia. The study estimated a mean technical efficiency for the entire sample of 76%, indicating that a significant potential for gains from efficiency improvement in maize production remains to be exploited even among users of improved technology. The study also revealed that farm size, education, access to credit and timely availability of modern inputs are important determinants of technical efficiency

among maize producers in Ethiopia. Policies and strategies that promote rural education, credit, timely availability of inputs through better infrastructure and markets will be greatly instrumental in realizing considerable gains in maize production with available farm resources through more efficient and appropriate use of improved technology.

64. Determinants of fertilizer use in northern Nigeria

Olayide, O, Alene, A., & Ikpi, A (2009). Determinants of fertilizer use in northern Nigeria. *Pakistan Journal of Social Sciences*, 6(2), 91–98. <https://doi.org/10.4314/jext.v8i1.52409>

Animal manure is one of the principal sources of nutrients for soil fertility maintenance and crop production in sub-Saharan Africa. Farm-level decision concerning the use of manure is governed by socioeconomic and institutional factors, as much as by agronomic and ecological concerns. Using data from a sample of 320 farm households obtained from 16 geographic information system (GIS)-referenced villages with the mapping of resource use domains of human population density and market access, the study assessed the determinants of manure use in northern Nigeria. A Tobit model analysis of manure use revealed that livestock ownership, proportion of own-land, distance to tarred road, and the exchange of crop residues for manure positively influenced the probability of adoption and intensity use of manure. On the other hand, land area cropped and crop diversification had a negative influence on the probability of adoption and intensity of manure use. Results show that manure use varies from one resource use domain to another. The results suggest that policies which promote the depth of organic fertilizer use by smallholders in West African savannas will bolster crop–livestock integration and sustainable food production.

Keywords: manure use, soil fertility management, geographic information system, resource use domains, Tobit

65. Determinants of household food security in the Lake Chad Area of Borno State, Nigeria,

Goni, M., & Amaza, P. (2006). Determinants of household food security in the Lake Chad Area of Borno State, Nigeria. *Journal of Research in Agriculture*, 3(3). <https://hal.archives-ouvertes.fr/hal-01326657/document>

The study assessed food security situation among smallholder farming households in arid areas of Borno State, Nigeria. Multi-stage sampling procedure was used in selecting 200 household respondents. Data were collected with the use of interview scheduled and structured questionnaires. Result revealed that 91% of the respondents were male, 59% were full time farmers and 33% of the households had farming experience of 11–15 years. The study further revealed that only 23% of the household respondents were food secure. Logit result indicates that the coefficient of education level ($p \leq 0.01$), farming experience ($p \leq 0.01$), annual non-farm income ($p \leq 0.05$), and farm size ($p \leq 0.05$) were significant and positively related to food security in the study area. However, the coefficient of household size ($p \leq 0.05$)

was significant and negatively related to food security in the study area. Reduction of quantity of meals, sales of assets, purchase of less preferred food and buying food on credit were the coping strategies to food insecurity used by household respondents in the study area. It is recommended that farming household members should be encouraged to go into formal education and respondents should be empowered economically for them to diversify their economy thereby putting them in a better footing to have access to food items.

Keywords: analysis, food security, farming households, Borno, Nigeria

66. Determinants of mechanized cassava processing technology adoption in West Africa

Inaizumi, H., Enete, A., Brodie-Mends, O., & Oyetunji, E. (1997). *Determinants of mechanized cassava processing technology adoption in West Africa*. <https://cgspace.cgiar.org/handle/10568/98628>

This paper aims to identify the determinants of adoption of mechanized processing technologies in cassava processing. The paper is based on information collected at the farm-level in ten major cassava producing countries of Africa within the context of the Collaborative Study of Cassava in Africa. High labor requirement, especially female labor is a constraint to processing of cassava into certain products. Mechanized machines for performing certain processing tasks have been available for nearly fifty years in some West African villages but not in East or Southern Africa. The machines were available at village level where individual farmers may take their cassava for processing. Shortage of female labor, easy farmer access to market centers and production of convenient cassava food products are key determinants of adoption of the mechanized processing machines in a village.

Keywords: processing, cassava, mechanized methods, technology

67. Determinants of productivity of smallholder farmers supplying cassava to starch processors in Nigeria: A baseline evidence

Ojiako, I., Tarawali, G., Okechukwu, R., & Chianu, J. (2017). Determinants of productivity of smallholder farmers supplying cassava to starch processors in Nigeria: A baseline evidence. *Russian Journal of Agricultural and Socio-Economic Sciences*, 2(62), 1–13. <https://doi.org/10.18551/rjoas.2017-02.21>

The influence of socioeconomic and other household characteristics on the productivity of smallholder farmers supplying cassava to the major commercial starch processors in Nigeria were examined. A multi-stage random sampling technique was used to select 96 farmers working in clusters in selected eight cassava producing states. Data were analyzed using a combination of descriptive and inferential statistics, and multivariate regression techniques. Results revealed the calculated average yield to be 12.39 t/ha thereby leaving an average yield-gap of 7.61 t/ha when compared with an average of 20 t/ha being promoted for farmers under the project. Use of improved varieties ($p < 0.01$) and full-time farming ($p < 0.05$) had

significant positive influence on productivity. Also, training, credit use and marital status of farmers influenced productivity positively at $p < 0.10$ levels. Productivity increased with increase in the variables, but the degree of responsiveness was inelastic in each case. Together the included variables explained 72.1% of the variation in the productivity model. The use of improved cuttings should be accompanied by rigorous but appropriate capacity enhancement programs to update farmers on modern issues on cassava production and farm management. Empowerment of farmers through linkage to sources of soft loan and other microcredit facilities was recommended, but such efforts should be targeted more on the married and full-time farmers for greater impact.

Keywords: farmers' characteristics, cassava productivity, yield-gap, full-time farmer, starch processors, Nigeria.

68. Determinants of rural farmers' improved soybean adoption decisions in northern Nigeria

Ojiako, I. A., Manyong, V., & Ikpi, A (2007). Determinants of rural farmers' improved soybean adoption decisions in northern Nigeria. *Journal of Food, Agriculture and Environment*, 5(2), 215–223. <https://cgspace.cgiar.org/handle/10568/92172>

The deficient agronomic qualities of the local soybean germplasm and the need to develop varieties with desirable attributes, such as promiscuous nodulation, low pod shattering, sustained seed viability and resistance to bacterial diseases and viruses necessitated the introduction of new varieties to farmers in northern Nigeria. This study investigates the factors that influenced the soybean farmers' decisions about adoption and use intensity of these improved soybean varieties. A multistage random sampling design was used to select a sample of 307 respondents from a list of soybean growers obtained through household listing conducted by trained enumerators. Data were collected from respondents using a structured questionnaire. The logit and Tobit regression models were used in the analysis for comparison. Empirical results reveal that the farmers' adoption decisions were significantly ($P < 0.01$) influenced by soybean yield, expenditure on labor, memberships of associations and meeting groups, exposure to extension services and ecology. The two models confirm that increases in each of the identified adoption characteristics will lead to increases in the probability of adoption and use intensity. However, the effect of a one-percent increase in each variable is higher for the Tobit than for the logit adoption elasticities. Moreover, the decomposed elasticity values of the Tobit model reveal that a one percentage increase in the variables would result in a higher change in the elasticity of use intensity than in the elasticity of adoption of the improved soybeans. The results have significant implications for research scientists, extension agents and policy-makers. Apart from providing justification for strengthening the extension capacities of the national research systems, the findings underscore the relevance of networks that promote farmer-to-farmer interactions in the circulation of new technologies.

Keywords: soybeans, improved varieties, adoption decisions, use intensity, household listing, random sampling, Tobit, logit, adoption characteristics, elasticities, Nigeria

69. Determinants of wealth and socioeconomic status of rurals households: An application of multinomial logit model to soybean farmers in northern Nigeria

Ojiako, I. A., Manyong, V., Ezedinma, C., & Asumugha, G (2009). Determinants of wealth and socioeconomic status of rurals households: An application of multinomial logit model to soybean farmers in northern Nigeria. *Journal of Social Sciences*, 19(1), 31–39. <https://doi.org/10.1080/09718923.2009.11892688>

This study combined the qualitative and quantitative techniques of data collection and analyses. It used the card-sorting technique of wealth ranking to stratify 307 randomly selected soybean-farming households into wealth categories, examined the validity of the key informants' wealth ranking as a way of assessing the socioeconomic status of rural farmers, and consequently investigated the factors that influenced households' socioeconomic status using the empirical multinomial logistic regression model. Data on the explanatory and other standard economic variables were collected using structured questionnaire administered by trained enumerators. Wealth ranking by key informants categorized 12.0% of respondents as rich, 46.6% as middle class, and 41.4% as poor farmers. The high positive and statistically significant associations found between the standard economic variables, including farm size and incomes, and households' wealth status support the construct validity and empirical evidence of the wealth ranking as a means of stratifying households by socioeconomic status. Results of regression analysis showed that ownership of means of transport, adult women resident in household and household size had significant influences on the households' wealth categories. Increases in these variables reduced the probability of being either in the poor households' category or in the middle class category compared to the probability of being in the rich category, although the effects were stronger for the poor versus the rich than for the middle class versus the rich households. Policies directed toward the improvement of households' wealth and socioeconomic status should emphasize the use of these socioeconomic characteristics.

Keywords: wealth ranking, rural farmers, economic variables, regression, Nigeria

70. Determinants of wheat production and technical efficiency in the Chad basin Development Area, Nigeria

Amaza, P., Kwaghe, P, & Ojo, N. (2005). Determinants of wheat production and technical efficiency in the Chad basin Development Area, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 2(1), 1–6. (no online link, jpeg document available on request)

The study investigated the determinants of wheat production and technical efficiency among small scale wheat producers in Chad Basin Development Area, Nigeria. Structured questionnaires were used to collect data from 80 respondents randomly selected from Marte and Ngala Local Government Areas (LGAs) in the project area. The study utilized Stochastic frontier production function with multiplicative disturbance term to analyze the data. The findings of the study revealed that the coefficients of land, labor and fertilizer were all positive and significant at 5% level. For the inefficiency function, the coefficients of the education and farming experience were found to have significant impact in efficiency of the wheat farmers. The study further revealed that the technical efficiency of the farmers is less than 1 (100%),

indicating that all the farmers are producing below the maximum efficiency frontier. The farmer specific technical efficiency varied between 0.09 and 0.94 with a mean of 0.65. Thus, in the short run, there is a scope of increasing wheat production by 35% by adopting the technology and the techniques used by the best-practice farmer. The study suggests that the output of wheat in the study area could be expected to increase with more use of production inputs of land, labor and fertilizer.

Keywords: production and technical efficiency, smallscale wheat producers, Stochastic frontier production function, Chad Basin Development Area, Nigeria

71. Digital extension, price risk, and farm performance: experimental evidence from Nigeria

Oyinbo, O., Chamberlin, J., Abdoulaye, T., & Maertens, M. (2021). Digital extension, price risk, and farm performance: experimental evidence from Nigeria. *American Journal of Agricultural Economics*. <https://doi.org/10.1111/ajae.12242>

Despite decades of investment in agricultural extension, technology adoption among farmers and agricultural productivity growth in Sub-Saharan Africa remain slow. Among other shortcomings, extension systems often make recommendations that do not account for price risk or spatial heterogeneity in farmers' growing conditions. However, little is known about the effectiveness of extension approaches for nutrient management that consider these issues. We analyze the impact of farmers' access to site-specific nutrient management recommendations and to information on expected returns, provided through a digital decision support tool, for maize production. We implement a randomized controlled trial among smallholders in the maize belt of northern Nigeria. We use three waves of annual panel data to estimate immediate and longer term effects of two different extension treatments: site-specific recommendations with and without complementary information about variability in output prices and expected returns. We find that site-specific nutrient management recommendations improve fertilizer management practices and maize yields but do not necessarily increase fertilizer use. In addition, we find that recommendations that are accompanied by additional information about variability in expected returns induce larger fertilizer investments that persist beyond the first year. However, the magnitudes of these effects are small: we find only incremental increases in investments and net revenues over two treatment years.

Keywords: advisory services, agricultural decision support tools, farm productivity, digital agronomy, extension, fertilizer, price uncertainty, site-specific nutrient management

72. Does a cassava research-for-development program have impact at the farm level? Evidence from the Democratic Republic of Congo

Rusike, J., Mahungu, N., Lukombo, S., Kendenga, T., Bidiaka, S., Alene, A., Lema, A.*, & Manyong, V. (2014). Does a cassava research-for-development program have impact at the farm level? Evidence from the Democratic Republic of Congo. *Food Policy*, 46, 193–204. <https://doi.org/10.1016/j.foodpol.2014.03.012>

This paper evaluates the impact of a cassava research-for-development program on farm level outcomes. The program was implemented in the Democratic Republic of Congo from 2001 to 2009. We apply propensity score matching, Rosenbaum bounds on treatment effects, Altonji et al. method of selection on observables and unobservables and endogenous switching regression to farm survey data collected during the 2009 cropping season. We use these methods to test whether the R4D program has a statistically significant effect on outcomes of interest and if these are not driven by selection on unobservables. Using propensity score matching, we find statistically significant positive effects on household participation in cassava markets, adoption of improved varieties and crop management practices and household food adequacy; and no statistically significant effects on yields and profits. The results show that bias due to selection on unobservables is not severe enough to invalidate the impact estimates. Bias may still be a problem that is present in the analysis. But there is evidence that it is not substantial. Although the program does not have a statistically significant positive effect on yields and profits, the significant program effects on market participation, variety adoption, and food adequacy merit further promotion of the program since these positive outcomes tend to be pre-conditions for realizing long-term yield and profit benefits.

Keywords: Democratic Republic of Congo, cassava, agricultural research-for-development, treatment effects, selection bias

73. Does agricultural cooperative membership impact technical efficiency of maize production in Nigeria: An analysis correcting for biases from observed and unobserved attributes

Olagunju, K. O., Ogunniyi, A. I., Oyetunde-Usman, Z., Omotayo, A. O., & Awotide, B. A. (2021). Does agricultural cooperative membership impact technical efficiency of maize production in Nigeria: An analysis correcting for biases from observed and unobserved attributes. *PLOS ONE*, 16(1), e0245426. <https://doi.org/10.1371/journal.pone.0245426>

The formation of agricultural cooperatives has been widely promoted as an agricultural development policy initiative to help smallholder farmers cope with multiple production and marketing challenges. Using a nationally representative survey dataset of smallholder maize producers from rural Nigeria, this study assesses the impact of agricultural cooperative membership on technical efficiency (TE). We based our estimation approach on the combination of a newly developed sample selection stochastic production frontier model with propensity score matching to control for possible selectivity biases from both observables and unobservables. We estimate stochastic meta-frontiers to examine TE differences between cooperative members and non-members. Our results reveal that TE levels of members are consistently higher than that of non-members. This calls for continued policy incentives targeted at encouraging farmers to form as well as participate in agricultural cooperatives.

74. Does cooperative membership increase and accelerate agricultural technology adoption? Empirical evidence from Zambia

Manda, J., Khonje, M., Alene, A., Hirpa Tufa, A., Abdoulaye, T., Mutenje, M., Setimela, P. S., & Manyong, V. (2020). Does cooperative membership increase and accelerate agricultural

technology adoption? Empirical evidence from Zambia. *Technological Forecasting & Social Change*, 158, 120160. <https://doi.org/10.1016/j.techfore.2020.120160>

In developing countries, agricultural cooperatives are increasingly being used to promote improved agricultural technologies and alleviate food insecurity and poverty. However, little is known about the role of agricultural cooperatives in accelerating the adoption of improved agricultural technologies. Using a comprehensive balanced household panel and varietal data, this study applied the difference-in-difference model to identify factors affecting farmers' decision to become cooperative members and the impact of cooperative membership on the adoption of improved maize, inorganic fertilizer and crop rotation. Furthermore, the study used the inverse probability weighted regression adjustment model to analyze the impact of cooperative membership on the speed of adoption of improved maize varieties. We found that cooperative membership increased the probability of technology adoption by 11–24 percentage points. Results further indicated that the average time to adoption was about 8 years, but it was shorter for cooperative members. The results showed that, on average, cooperative membership increased the speed of adoption of improved maize by 1.6–4.3 years. Generally, the results suggest the need for policies which promote farmer organizations such as cooperatives coupled with effective extension services for faster and greater adoption of improved technologies.

Keywords: duration analysis, time to adoption, improved maize, difference in difference, Zambia

75. Does farmer participatory research matter for improved soil fertility technology development and dissemination in Southern Africa?

Rusike, J., Twomlow, S., Freeman, H., & Heinrich, G. (2011). Does farmer participatory research matter for improved soil fertility technology development and dissemination in Southern Africa? *International Journal of Agricultural Sustainability*, 4(3), 176–192. <https://doi.org/10.1080/14735903.2006.9684801>

Crop management research is increasingly involving farmers in evaluating new technologies, identifying adoption constraints and opportunities for improving farm performance to produce more sustainable impact. ICRISAT and its partners worked with farmers in Malawi and Zimbabwe during the 1999/2000 and 2000/2001 seasons to evaluate a range of 'best bet' soil fertility and water management technologies and evaluate the impact of farmer participatory research. Although there was some variation in methods implemented at different sites, the study found that there is a basis for a comparison of methods. Community entry and participatory approaches that engage farmers in decision making throughout the research-development-diffusion-innovation process have higher setup costs compared to traditional 'top-down' approaches. But they improve efficiency, both in technology development and in building farmers' capacity for experimentation and collective learning. This results in the development of more relevant technologies, joint learning among farmers, researchers and extensionists and better impact. To make farmer participatory research projects more

sustainable and introduce them on a wide scale, the study recommends that public and NGO investments be targeted to building district and village-level innovation clusters.

Keywords: farmer participatory research, innovation, mother and baby trials, soil fertility management technologies

76. Does nitrogen matter for legumes? Starter nitrogen effects on biological and economic benefits of cowpea (*Vigna unguiculata* L.) in Guinea and Sudan Savanna of West Africa

Abdul Rahman, N., Larbi, A., Kotu, B., Marthy Tetteh, F., & Hoeschle-Zeledon, I. (2018). Does nitrogen matter for legumes? Starter nitrogen effects on biological and economic benefits of cowpea (*Vigna unguiculata* L.) in Guinea and Sudan Savanna of West Africa. *Agronomy*, 8(7), Article 7. <https://doi.org/10.3390/agronomy8070120>

The hypothesis that application of starter nitrogen (N) fertilizer to cowpea may increase grain and fodder yields and profitability was tested in the Guinea and Sudan savanna zones of northern Ghana. Two cowpea varieties (Apagbaala: grain-type and Padi-Tuya: dual purpose) and three N fertilizer rates (0-30-30, 15-30-30 and 30-30-30 N-P₂O₅-K₂O kg/ha) were evaluated using a 2 × 3 factorial treatments arrangement in a randomized complete block design with three replicates. Grain and fodder yields, 100 seed weight (SW) and net return of Padi-Tuya increased significantly compared with Apagbaala in both zones. Application of starter N fertilizer increased grain yield, fodder yield, N use efficiency (NUE) and net return by more than 30% compared with the control in both zones. Padi-Tuya cowpea with 15 kg/ha N fertilizer was risk efficient at all risk aversion levels when only grain was considered, but Padi-Tuya with 30 kg/ha N fertilizer becomes the most risk efficient option when the value of fodder was included. The results suggest that small-scale farmers could apply starter N fertilizer at either 15 kg/ha N for grain only or 30 kg/ha N for both grain and fodder yields improvement of cowpea in West Africa and similar ecologies.

Keywords: inorganic fertilizer, profitability, risk, agronomic efficiency, savanna

77. Double burden of malnutrition: Evidence from a selected Nigerian population

Alamu, E. O., Eyinla, T., Sanusi, R., & Maziya-Dixon, B. (2020). Double burden of malnutrition: Evidence from a selected Nigerian population. *Journal of Nutrition and Metabolism*, 2020, 5674279. <https://doi.org/10.1155/2020/5674279>

Indices reflecting the double burden of malnutrition in sub-Saharan Africa are increasing. Evidence to support this claim in households of Africa's most populous country—Nigeria—is scant. This study, therefore, presents results from a study of mother-child pairs sampled from Akwa Ibom State in the southern region of Nigeria. Anthropometric measures for 660 mother-child pairs were collected according to standard procedures. Indices were expressed as the standard deviation of units from the median for the reference group. Chi-square analysis was

used to test significant differences in proportion, and $p < 0.05$ was taken as significant. A total of 37.4% of the children were stunted out of which 19.8% were moderately stunted, and 17.6% were severely stunted. Prevalence of wasting was 13.1%, 6.2% were moderately wasted, and 6.9% were severely wasted. Mean maternal body mass index was (23.54 ± 4.60) kgm^2 . 9.0% were underweight mothers, 23.2% were overweight, and 9.3% were obese. The co-existence of undernutrition among children and overnutrition in women of child-bearing age is prevalent in this population. We recommend that more effort be placed on active nutrition surveillance to ascertain malnutrition prevalence and periodically reassess priority challenges.

78. Drivers of market participation decisions among small-scale farmers in yam growing areas of Nigeria and Ghana

Mignouna, D. B., Abdoulaye, T., Alene, A., Akinola, A. A., & Manyong, V. M. (2015). Drivers of market participation decisions among small-scale farmers in yam growing areas of Nigeria and Ghana. *2015 Conference, August 9–14, 2015, Milan, Italy* (No. 230219). International Association of Agricultural Economists. <https://ideas.repec.org/p/ags/iaae15/230219.html>

Participation in agricultural markets could be the main weapon against hunger to lift millions of poor farmers out of poverty traps. Unfortunately, most of the potential beneficiaries are constrained by several factors in their quest to participate in the yam market. This study, thus, clarified the underpinning drivers of market participation among small-scale farmers in yam belt of West Africa. Using a multistage random sample of 1400 households, the study tests the hypothesis that factors affecting farmers' decision to participate are not necessarily the same as those affecting the extent of participation. Non-price constraints played a significant role in determining decisions on market participation. Policies that reduce transactions costs and induce farmers to commercialize could be critical alternatives to policies based on price to promote a marketed surplus and the commercialization of agriculture by yam farmers and thereby alleviate poverty.

79. Econometric analysis of loan repayment competence of smallholder cassava farmers in Yewa area, Ogun State, Nigeria

Ojiako, I. A., Okechukwu, R., & Olaitan, T (2015). Econometric analysis of loan repayment competence of smallholder cassava farmers in Yewa area, Ogun State, Nigeria. *Journal of Food, Agriculture & Environment*, 13(4–5), 158–167. www.researchgate.net/publication/284748276

The use of financial and input-credit support to promote agriculture was a key intervention strategy aimed at enhancing productivity, reducing poverty, promoting standard of living of the smallholder farmers and fostering the development of the rural sectors. However, the ability of the lending agencies to attain the rural development goal through credit services delivery would depend substantially on capacity and willingness of the beneficiaries to repay the borrowed facility. This study investigated the loan repayment competence of smallholder cassava farmers in the south-west zone, Nigeria. Primary data collected from 121 respondents randomly selected from cassava-farming communities in Ogun State, south-west Nigeria, were

used for the investigation. The respondents were selected using a multi-stage random sampling technique while descriptive and inferential statistics, and multivariate regression analytical techniques were employed for data analysis. Results revealed a high loan delinquency rate of 20.83% among the borrowers. Misapplication of borrowed funds (36.36%), willful tendency to default (16.53%) and natural and man-made disasters (14.9%) were identified among the major challenges to loan repayment. Farmer's age, level of education and non-farm income had significant ($p < 0.01$) positive influence on loan repayment competence while interest rate had a significant ($p < 0.05$) negative influence. However, a unit change in each of the identified determinants resulted to less than a unit change (inelastic) in loan repayment in the study area. To achieve better loan repayment performance, loan administrators should target smallholder farmers who were relatively older; more educated, but with other non-farm income sources. Loan-seeking farmers should be encouraged to engage in other livelihood options, coping strategies and secondary sources of income, especially during the off-farm season. Furthermore, lower rates of interest should be defined for the agriculture sector and for different crops' value chains putting into consideration the volatility of the specific value chain.

Keywords: farm credit, delinquency rate, repayment competence, smallholder farmers, cassava, value chains, Nigeria

80. Economic analysis of balanced nutrient management technologies for maize production in Kaduna state, Nigeria

Omadachi, U. O., Ahmed, B., Manyong, V., Olukosi, J., & Yusuf, O. (2007). Economic analysis of balanced nutrient management technologies for maize production in Kaduna state, Nigeria. *Journal of Applied Sciences*, 7(1), 132–136. <https://dx.doi.org/10.3923/jas.2007.132.136>

The overall goal of Balanced Nutrient Management Systems (BNMS) a collaborative project between International Institute of Tropical Agriculture (IITA) and Katholieke Universiteit Leuven (K.U. Leuven) is to curb the vicious cycle of plant nutrient depletion in maize-based farming systems in the moist savanna and humid forest zone of West Africa. This is through integrated nutrient management systems geared to land use practices which are economically viable, ecologically sound and socially acceptable. In Kaduna state of Nigeria (Northern Guinea Savannah), three improved maize-based technologies were tested in a series of farmer-managed field trials since 2000. The first technology was a continuous maize treatment characterized by high fertilizer rates (Sasakawa Global 2000 (SG 2000)). In the second technology, half of the fertilizer quantity was replaced with organic manure (BNMS-manure). The third technology was a soybean-maize rotation treatment in which the fertilizer rates to the maize was reduced by a half (BNMS-soybean/maize). The broad objective of the study was to conduct economic analysis of the three introduced BNMS maize-based technologies along with the farmers' own practice of maize production. The specific objectives of the study were to: determine the costs and returns to the BNMS technologies and farmers' practice and to examine the farmers' perception of the BNMS technologies. The tools used for the analysis of the data were: partial budget analysis to determine the costs and returns to the introduced

BNMS technologies and farmers' practice and the scoring technique to examine the farmers' perception of the BNMS technologies. Findings from the partial budget analysis showed that, BNMS-soybean/maize was the best in both the demonstration and adaptation trials by having the highest gross margins of 18,462 and 19,785, respectively, with the inorganic fertilizer cost constituting over 50% of the total production cost. The farmers gave overall best perception to both the BNM-soybean/maize and the BNMS-manure technologies.

Keywords: maize, balanced nutrients, organic matter fertilizer, economic analysis, Nigeria

81. Economic analysis of Imazapyr-resistant maize technology for small farm households in western Kenya

Mignouna, D., Manyong, V., Mutabazi, K. D, Senkondo, E, Madulu, R. B, Labintan, C. A., & Akinola, A. A (2012). Economic analysis of Imazapyr-resistant maize technology for small farm households in western Kenya. *Eastern and Southern Africa Journal of Agricultural Economics and Development*, 9, 26–38. <https://hdl.handle.net/10568/80863>

Farmers in western Kenya are still facing the problem of *Striga*, the major constraint to cereal production threatening food security of thousands of poor farming households. Some *Striga* species also attack tropical legumes hence further augmenting protein malnutrition of vulnerable younger children. Imazapyr-resistant maize (IRM) technology is being promoted as a response to the increasing *Striga* problem. The overall objective was to carry out an economic analysis of IRM, novel technology for *Striga* control to improve maize production in western Kenya. A multistage sampling technique was used to select a total of 600 households from Nyanza and Western provinces for this study. Gross margins and cost to benefit ratios were used as the main tools in data analysis. Evaluation of the use of IRM indicated that the technology is profitable and viable. Encouraging IRM use by farmers can improve food production and therefore is relevant to food policy decisions.

Keywords: IRM technology, economic analysis, Kenya

82. Economic analysis of seed yam production systems in Nigeria

Mignouna, D., Abdoulaye, T., Alene, A., Aighewi, B., Pelemo, O., Manyong, V., Asiedu, R., & Akoroda, M. O (2013). Economic analysis of seed yam production systems in Nigeria. *Journal of Root Crops*, 39(2), 221–229. www.researchgate.net/publication/283486828

New seed yam systems from minisetts, minitubers and vine cuttings have been developed for yam production to supplant the traditional systems, which have proven inefficient and costly. The new techniques provide producers in tropical countries with the opportunity to minimize production costs, reduce seed yam price and promote greater seed availability. A discounted cash flow budget with a whole farm perspective was used to analyze the economic performance and risk implications of a hectare investment in the new seed yam system over time for a representative farm. Data based on realistic process costs and review of past reported studies

were employed to reflect the relative economic worthiness and opportunity cost of investment and operating capital of seed yam systems in Nigeria. From the net present value (NPV) and benefit:cost ratio (BCR) analyses, the new seed yam production systems were more viable than current traditional seed yam production systems through milking of live immature plants. This raises the need to identify which among the new production techniques could be the most profitable and recommendable. Therefore, understanding the economics of seed yam production systems would not only help a significant proportion of local, regional and national stakeholders but also assist the policymakers, funding agencies and other organizations involved in yam projects and programs.

Keywords: NPV, BCR, viability, seed yam production, Nigeria

83. Economic analysis of soil erosion effects in alley cropping, no-till and bush fallow systems in southwestern Nigeria

Ehui, S. K., Kang, B., & Spencer, D. (1990). Economic analysis of soil erosion effects in alley cropping, no-till and bush fallow systems in southwestern Nigeria. *Agricultural Systems*, 34(4), 349–368. [https://doi.org/10.1016/0308-521X\(90\)90013-G](https://doi.org/10.1016/0308-521X(90)90013-G)

Most upland soils in humid and sub-humid tropical Africa are characterized by low inherent fertility and are also susceptible to soil erosion and compaction with cultivation. Based on simulation model, this study uses a capital budgeting approach to determine the profitability of alternative land use systems, taking into account the short and long-run impact of soil erosion on agricultural productivity in southwestern Nigeria. The fallow systems include: (1) two continuous cultivation alley cropping systems with leucaena hedgerows planted at 2 m and 4 m interhedgerows spacings; (2) the continuous cultivation no-till farming system; and (3) two traditional bush fallow systems with a 3-year cropping period in 6- and 12-year cycles. Under a 10 % discount rate, when no yield penalties are imposed (reflecting the case of population density), the 12-year cycle shifting cultivation system is most profitable, followed by the 4 m alley cropping, the no-till, the 2 m alley cropping and the 6-year cycle shifting cultivation systems. When penalties are imposed on yields due to land being taken out of production because of fallow vegetation (reflecting the case of rising land values), the 4 m alley cropping is most profitable, followed by the no-till, the 2 m alley cropping, the 12- and 6-year cycle bush fallow systems. Thus where access to new forest land is 'costless', slight yield from erosion will not detract significantly from the immediate profit advantage of traditional bush fallow systems, with longer fallow periods.

Keywords: alley cropping, land, cropping systems, soil erosion, farming systems

84. Economic analysis of soybean farming in northern Nigeria

Ojiako, I. A., Manyong, V., & Ikpi, A.* (2010). Economic analysis of soybean farming in northern Nigeria. *Nigeria Agricultural Journal*, 41(1), 1–7. www.ajol.info/index.php/naj/article/view/90558

The variations in soybean farmers' output and income were investigated alongside their improved soybean adoption status and other socio-economic factors. Data from 307 farmers randomly selected from two states in northern Nigeria were analyzed using descriptive statistics and regression models. Results show that the lower-income farmers cultivated smaller farm sizes and incurred higher production costs than the higher-income farmers. Adopters incur higher production costs but receive commensurate higher returns per hectare than nonadopters for all income categories. Hectarage ($t=11.92$), farming experience ($t=4.15$), yield ($t=4.43$), adoption status ($t=2.39$) and own farm-gate price ($t=2.19$) have positive and significant influence on output while farmgate price of beans ($t=3.26$) has significant negative effect. Moreover, hectarage ($t=15.05$), farming experience ($t=2.67$) and adoption status ($t=2.27$) have positive and significant effects on income. The findings have among other things, underscored the benefit of improved technology and its adoption in promoting well-being of rural soybean farmers. Notwithstanding the additional cost involvement, investment in improved soybean technology is worthwhile since through higher yield, output and income farmers' welfare is enhanced. Easing farmers' access to credits will encourage willing farmers to invest in farmlands and improved technology while adequate training workshops and Field Days would help to update them on the appropriate use of new technologies and build up their knowledge and experience.

Keywords: soybean, improved technology adoption, output, yield, income, farming experience, northern Nigeria

85. Economic impacts of cassava research and extension in Malawi and Zambia

Alene, A., Khataza, R., Chibwana, C., Ntawuruhunga, P., & Moyo, C. (2013). Economic impacts of cassava research and extension in Malawi and Zambia. *Journal of Development and Agricultural Economics*, 5(11), 457–469. <https://cgspace.cgiar.org/handle/10568/76400>

This paper estimates the economic impacts of cassava research and extension in Malawi and Zambia over the period 1990-2008. The data come from sample household surveys, planting material production records, and a series of cassava improvement experiments conducted in the two countries. Past investments in cassava improvement have led to the development and release of a good number of high-yielding and cassava mosaic virus disease (CMD)-tolerant cassava varieties. The results show relatively higher adoption rates for the CMD-free local varieties compared to CMD-tolerant varieties that have been released in the two countries. The adoption of new varieties has been low and slow largely due to the fact that most of these varieties lacked the consumption attributes highly valued by farmers. The multiplication and distribution of CMD-free planting materials of the recommended local varieties led to greater adoption, but infection with CMD three to four years after adoption meant that the yield gains and economic benefits could not be sustained. Nevertheless, the multiplication and distribution of clean cassava planting materials generated a modest rate of return of 24%, which is actually consistent with an earlier rate of return estimate of 9 to 22% for cassava improvement in developing countries. Analysis of the ex ante impacts of current and future investments in cassava improvement shows that cassava improvement research that focuses on the development and dissemination of varieties with highly preferred consumption and industrial attributes would yield a greater rate of return of 40%.

Keywords: adoption, cassava, economic surplus, impact, Malawi, Zambia

86. Economic impacts of fall armyworm and its management strategies: evidence from southern Ethiopia

Kassie, M., Assfaw Wossen, T., De Groote, H., Tefera, T., Sevgan, S., & Balew, S. (2020). Economic impacts of fall armyworm and its management strategies: evidence from southern Ethiopia. *European Review of Agricultural Economics*, 47(4), 1473–1501. <https://doi.org/10.1093/erae/jbz048>

This paper explores the economic implications of fall armyworm (FAW) and its management strategies by exploiting exogenous variation in FAW exposure amongst households in southern Ethiopia. We find that FAW exposure affects maize yield and sales negatively, but not consumption. Furthermore, we find evidence of crowding-in and intensification of insecticide use in response to FAW exposure. We also find suggestive evidence that existing extension service arrangements lack the capacity to deal with emerging threats such as FAW. Results imply that targeted interventions aimed at improving the effectiveness of control measures and institutional capacity would be key to reduce the adverse effects of FAW.

Keywords: fall armyworm, control strategies, maize productivity, maize sales, maize consumption

87. Economic impacts of soil fertility management research in West Africa

Akinola, A. A, Alene, A., Adeyemo, R, Sanogo, D., & Olanrewaju, A. (2009a). Economic impacts of soil fertility management research in West Africa. *African Journal of Agricultural and Resource Economics*, 3(2), 159–175. <https://cgspace.cgiar.org/handle/10568/91514>

This paper assesses the potential economic impacts of balanced nutrient management systems technology options: BNMS-manure, which combines inorganic fertilizer and organic manure, and BNMS-rotation, which is maize–soybean rotation, in maize-based systems in the northern Guinea savanna areas of Nigeria, Ghana, Togo and Benin. The economic surplus analysis suggested that BNMS-manure research and extension could achieve returns ranging from 17 to 25% and a maximum adoption of 24 to 48%, for the conservative and base scenario respectively; and that BNMS-rotation research and extension could achieve returns ranging from 35 to 43% and a maximum adoption of 20 to 40%, for the conservative and base scenario respectively. Our results were consistent with earlier economic analyses, which showed that BNMS-rotation was more productive, profitable and acceptable to farmers than BNMS-manure. It may be difficult to achieve large-scale adoption of BNMS-manure because the increases in yields are smaller and markets for manure are missing.

Keywords: balanced nutrient management systems, BNMS-manure, BNMS-rotation, economic surplus, Northern Guinea Savanna

88. Economic, production, and poverty impacts of investing in maize tolerant to drought in Africa: An ex-ante assessment

Rovere, R. L., Abdoulaye, T., Kostandini, G., Guo, Z., Mwangi, W., MacRobert, J., & Dixon, J. (2014). Economic, production, and poverty impacts of investing in maize tolerant to drought in Africa: An ex-ante assessment. *Journal of Developing Areas*, 48(1), 199–225. <https://doi.org/10.1353/jda.2014.0016>

The potential impacts of investing in drought tolerant maize (DTM) in 13 countries of eastern, southern and western Africa were analyzed through an innovative economic surplus analysis framework, to identify where greatest economic returns and poverty reduction may be achieved. Assuming a potential full replacement of improved varieties with DTM varieties, by 2016 there would be economic gains of US\$ 907 million over all countries under conservative yield gains, or US\$ 1,535 million under optimistic yield gains. Largest gains in terms of consumer and producers surplus are in Nigeria, Zimbabwe and Malawi. However, in terms of production gains and poverty reduction, the countries gaining most are Nigeria, Kenya and Malawi (in terms of production); and Zimbabwe, Malawi and Kenya (number of people out of poverty). A total of 4 million people—both producers and consumers—would have their poverty greatly reduced in all countries. To achieve these impacts, deployment strategies are discussed and various options are suggested, which depend on local context and state of the national seed sectors.

Keywords: Africa, drought tolerant, maize, poverty, ex-ante assessment

89. Efficiency and its determinants among smallholder farming units supplying cassava to commercial starch processors in Nigeria: Data envelopment analysis approach

Ojiako, I., Tarawali, G., Okechukwu, R., Chianu, J., Ezedinma, C., & Edet, M. (2018). Efficiency and its determinants among smallholder farming units supplying cassava to commercial starch processors in Nigeria: Data envelopment analysis approach. *Journal of Economics and Sustainable Development*, 9(16), 120–134. www.researchgate.net/publication/327594914

Understanding the resource allocation and use efficiency is essential considering the supportive role of agriculture in the advancement of other productive sectors of the economy. Technical efficiency and its determinants were investigated among smallholder cassava-farming and decision-taking units selected from eight states of the southeast and southwest zones of Nigeria. The states' selection was purposive, being the states in which the IITA-Nestlé cassava starch project was implemented from 2011-2015. However, a multi-stage random sampling technique was used to select a sample of 96 farming units from the clusters established under the project's out-growers' scheme. Primary data were collected from the farming units' heads by administering the pre-tested household survey instrument. Data were analyzed using descriptive statistics, inferential statistics, data envelopment analysis, and multivariate ordinary least square regression techniques. The DEA results revealed that majority (73.9%) of the farming units had efficiency scores less than 1 and as such classified as inefficient. Over 30.2% of the cassava farming units had efficient scores greater than 0.8

including 3.1% with scores that ranged from 0.81- 0.99. Farming units with efficiency scores from 0.6-0.8 constituted 17.7% of the sample while those with scores from 0.4-0.6 consist of 33.3%, which also corresponds to the percentage of farming units with efficiencies scores of less than 0.5. Only three variables: cassava farming experience, fertilizer use and quantity of stems used were statistically significant ($p < 0.05$) in explaining cassava farming efficiency. Of these the influence of farming experience was positive while that of fertilizer use and stems were negative. The finding suggests that the elderly and better experienced farmers combined their versatile previous knowledge of farming with willingness to adopt and use improved farming practices to achieve efficiency. Contrary to expectation, fertilizer and stems were associated with less efficiency, a surprising result that could have resulted from misapplication and wastage of the vital resources. The results highlight the need for appropriate training and technical backstopping for the heads of farming units to enhance their knowledge of the good agricultural practices and improve their levels of efficiency.

Keywords: DEA, best farming practices, efficiency, processing, cassava value chain, Nigeria

90. Efficiency of food production under old and new technology: The case of farmers within and outside the Extension Package Program in Ethiopia

Alene, A., & Hassan, R. M.* (2008). Efficiency of food production under old and new technology: The case of farmers within and outside the Extension Package Program in Ethiopia. *Journal of Developing Areas*, 41(2), 233–249. <https://cgspace.cgiar.org/handle/10568/90793>

This paper measures the technical, allocative, and economic efficiencies of farmers within and outside the Extension Package Program (EPP) in high and low potential agro-ecological zones in eastern Ethiopia. Within-group farmer efficiencies are analyzed relative to respective technologies to examine performance variation under traditional and improved technology. The results showed considerable efficiency variation not only among farmers outside EPP who mainly used traditional technologies, but also among farmers within the EPP who used improved technological packages. The results further showed that, in the high potential zone, farmers within the EPP used a superior technology, whereas both groups in the low potential zone used a homogenous technology, confirming the lack of appropriate technologies for less-favored agricultural areas. Education, credit, and the share of the leading cropping system are significantly related to production efficiency. The results suggest that an integrated credit, extension, and input supply system with appropriate technologies would raise food production efficiency.

Keywords: economic efficiencies, extension package, technology, efficiency variation, farmers, Ethiopia

91. Efficiency-equity tradeoffs and the scope for resource reallocation in agricultural research: evidence from Nigeria

Alene, A., Manyong, V., Tollens, E. F., & Abele, S. (2009). Efficiency-equity tradeoffs and the scope for resource reallocation in agricultural research: evidence from Nigeria. *Agricultural Economics*, 40(1), 1–14. <https://doi.org/doi: 10.1111/j.1574-0862.2008.00340.x>

On the basis of projected economic and poverty impacts of alternative commodity research programs, this article assessed efficiency and equity tradeoffs and the scope for research resource reallocation in Nigeria. Given the importance of major food staples to both poor and nonpoor households in production and consumption, introducing a poverty dimension revealed no significant shift in priorities compared with those implied by efficiency. The results showed that neither the additional benefits to the poor nor the foregone benefits to society are significant from prioritizing research according to equity—relative to efficiency—criteria. As current priorities are supported by neither efficiency nor equity criteria, however, there is considerable scope for maximizing research benefits to the poor through informed reallocation of research resources. The article concludes with a discussion of the patterns of resource reallocations implied by efficiency and equity criteria.

92. Eliminating hunger: yam for improved income and food security in West Africa

Aighewi, B., Maroya, N., Asiedu, R., Mignouna, D., Balogun, M., & Kumar, P. L. (2022). Eliminating hunger: yam for improved income and food security in West Africa. In Kiba, D. I. (ed.) *Transitioning to Zero Hunger*. Basel, Switzerland: MPDI. <https://www.mdpi.com/books/edition/1311/article/6365-eliminating-hunger-yam-for-improved-income-and-food-security-in-west-africa>

Yam, *Dioscorea* spp., is a valuable vegetatively propagated crop grown in many parts of the tropics. In West Africa, the species *Dioscorea rotundata* is a nutritious staple and provides food security and a means of livelihood to millions of people. Yam is produced mainly by smallholder farmers using local landraces with limited inputs. Increased annual production is attained by increasing the area while productivity is low and stagnated. Significant contributors to the low productivity include unavailability, high cost, poor quality of planting material, nematode and viral infections, and declining soil fertility. The multiplication ratio of yam in traditional production methods is low (1:3). Seed to replant the same size of field harvested consumes about a third of the total production, i.e., about 23.6 million tonnes out of 70.8 million tonnes of the annual production of the West African sub-region are reserved for planting the next crop. Improving the seed yam multiplication ratio and productivity will improve the availability of more yams for food. The initiative “Yam Improvement for Income and Food Security in West Africa (YIIFSWA)” has developed new strategies for improved propagation of quality yam planting materials and increased the multiplication ratio to 1:300 using nodal vine cuttings from plants produced in hydroponic systems instead of tubers, thereby releasing more tubers for food use. By using improved yam varieties with good agronomic practices as well as nematode and viral disease management, the productivity of yam is improved. These improvements have great potential to enhance food security and alleviate hunger and poverty.

93. Endogenous technology adoption and household food security: the case of improved cowpea varieties in northern Nigeria

Alene, A., & Manyong, V. (2006a). Endogenous technology adoption and household food security: the case of improved cowpea varieties in northern Nigeria. *Quarterly Journal of International Agriculture*, 45, 211–230. <https://cgspace.cgiar.org/handle/10568/91759>

Impact studies assuming exogenous technology adoption are bound to overstate or understate the true impact of improved agricultural technologies, especially in situations where agricultural technologies are targeted to, or adopted by, a certain group of farmers. This paper examined the impact of improved cowpea varieties on household food security in northern Nigeria using the method of instrumental variables to account for endogenous technology adoption. We found that adopters of improved cowpea varieties were more food-secure than non-adopters. The results further showed that social capital and the intensity of cultivation of soybean had a positive and significant impact. Supply of improved seeds and access to markets and extension services are important factors conditioning the rate of adoption and hence the contribution of improved cowpea varieties to food security in northern Nigeria.

Keywords: adoption, cowpeas, food security, instrumental variables

94. Estimating impact of cassava research for development approach on productivity, uptake and food security in Malawi

Rusike, J., Mahungu, N., Jumbo, S., Sandifolo, V, & Malindi, G (2010). Estimating impact of cassava research for development approach on productivity, uptake and food security in Malawi. *Food Policy*, 35(2), 98–111. <https://doi.org/10.1016/j.foodpol.2009.10.004>

Cassava in Malawi is the second most important staple food crop after maize. This paper assesses the impact of agricultural research for development approach in Malawi on cassava yields, per capita area planted to cassava and household calorie intake from cassava and maize. Given the growing interest over the past decade in agricultural research for development as an innovation systems approach for improving the delivery of research-derived benefits to smallholder farmers and having impact in Africa, this paper provides empirical evidence as to the effects of this framework. The paper concludes that Malawi's cassava research for development has contributed to measurable gains in area planted to cassava, cassava yields and household caloric intake.

Keywords: cassava research for development approach, treatment effects, impact pathway, Malawi

95. Estimating returns to fertilizer adoption with unobserved heterogeneity: Evidence from Ethiopia

Assfaw Wossen, T., Gatiso, T. T., & Kassie, M. (2018). Estimating returns to fertilizer adoption with unobserved heterogeneity: Evidence from Ethiopia. *Food and Energy Security*, 1–9. <https://doi.org/10.1002/fes3.156>

This paper examines the relationship between chemical fertilizer adoption and agricultural productivity in Ethiopia. Our results suggest that average returns to fertilizer adoption are high. Further, we find substantial heterogeneity across farm households in returns to fertilizer adoption, with comparative advantage playing a significant role in the adoption decision of

farmers. While the adoption decision of farmers was largely rational, fertilizer use across plots was sub-optimal. The results of this paper underscore the importance of improving farmers awareness about proper use of fertilizer through site-specific extension services for improving agricultural productivity.

Keywords: comparative advantage, Ethiopia, fertilizer, heterogeneity, misallocation

96. Estimating the actual and potential adoption rates and determinants of NERICA rice varieties in Nigeria

Dontsop-Nguezet, P., Diagne, A., Okoruwa, V, Ojehomon, V, & Manyong, V. (2013). Estimating the actual and potential adoption rates and determinants of NERICA rice varieties in Nigeria. *Journal of Crop Improvement*, 27(5), 561–585. <https://doi.org/10.1080/15427528.2013.811709>

The paper uses the average treatment effect (ATE) to estimate the population potential adoption rates of the New Rice for Africa (NERICA) varieties in Nigeria when awareness and access to their seed are not constrained to farmers. It thus extends previous works in the literature that have focused on estimating potential adoption rates when only awareness of technology is not a constraint to farmers. The adoption gaps because of lack of awareness and access to seed, and the determinants of adoption are estimated as well. Results show that the potential NERICA adoption rate in Nigeria will be 54% if the entire population is aware and up to 62% if they have access to NERICA seed. The actually observed 19% adoption rate implies a population adoption gap of 35% and 43% because of lack of awareness and access to NERICA seed, respectively. It is also inferred from these results that, when awareness is not a constraint, about 8% of the population will fail to adopt NERICA because of lack of access to its seed. Also farmers with secondary education and farmers with access to extension services are more likely to adopt NERICA than farmers without them.

Keywords: awareness, access to seed, NERICA adoption, average treatment effect

97. Estimating the productivity impacts of technology adoption in the presence of misclassification

Assfaw Wossen, T., Abdoulaye, T., Alene, A., Nguimkeu, P., Feleke, S., Rabbi, I. Y., Haile, M. G., & Manyong, V. (2019). Estimating the productivity impacts of technology adoption in the presence of misclassification. *American Journal of Agricultural Economics*, 101(1), 1–16. <https://doi.org/10.1093/ajae/aay017>

This article examines the impact that misreporting adoption status has on the identification and estimation of causal effects on productivity. In particular, by comparing measurement error-ridden self-reported adoption data with measurement-error-free DNA-fingerprinted adoption data, we investigate the extent to which such errors bias the causal effects of adoption on productivity. Taking DNA-fingerprinted adoption data as a benchmark, we find 25% “false

negatives” and 10% “false positives” in farmers’ responses. Our results show that misreporting of adoption status is not exogenous to household characteristics, and produces a bias of about 22 percentage points in the productivity impact of adoption. Ignoring inherent behavioral adjustments of farmers based on perceived adoption status has a bias of 13 percentage points. The results of this article underscore the crucial role that correct measurement of adoption plays in designing policy interventions that address constraints to technology adoption in agriculture.

Keywords: adoption, cassava, DNA-fingerprinting, impact, misclassification, Nigeria

98. Evaluating the distributional impacts of drought tolerant maize varieties on productivity and welfare outcomes: an instrumental variable quantile treatment effects approach

Olagunju, K. O., Ogunniyi, A. I., Awotide, B. A., Adenuga, A. H., & Ashagidigbi, W. M.* (2019). Evaluating the distributional impacts of drought tolerant maize varieties on productivity and welfare outcomes: an instrumental variable quantile treatment effects approach. *Climate and Development*, 12(10), 865–875. <https://doi.org/10.1080/17565529.2019.1701401>

In an attempt to go beyond the conventional mean impact assessment of agricultural interventions, this paper examines the distributional impacts of adoption of drought-tolerant maize varieties (DTMVs) on the productivity and welfare outcomes of rural farming households in Nigeria. The study employed a conditional instrumental variable quantile treatment effects approach to control for selection bias that may arise from both observed and unobserved factors. The empirical findings revealed that adoption significantly impacts the distributions of maize yield and farming households’ welfare. In particular, the effects of adoption are larger at the lower tails of the distributions of yield and welfare outcomes, suggesting that the strategic roles of DTMVs adoption in raising productivity and reducing poverty are better among poor farming households. These findings emphasize that effective targeting and dissemination of improved agricultural technologies are critical for increasing maize yield and improving welfare outcomes of rural farmers in Nigeria. Policy measures targeted at tackling dissemination constraints, such as the promotion of informal seed sector, may help enhance the successful dissemination and adoption of DTMVs or any agricultural intervention without masking out any sub-groups.

Keywords: distributional impact assessment, DTMVs, livelihood, yield

99. Evaluating the heterogeneous impacts of adoption of climate-smart agricultural technologies on rural households’ welfare in Mali

Awotide, B. A., Ogunniyi, A., Olagunju, K. O., Bello, L. O., Coulibaly, A. Y., Wiredu, A. N., Kone, B., Ahamadou, A., Manyong, V., & Abdoulaye, T. (2022). Evaluating the heterogeneous impacts of adoption of climate-smart agricultural technologies on rural households’ welfare in Mali. *Agriculture*, 12(11), 1853. <https://doi.org/10.3390/agriculture12111853>

Climate change is negatively affecting agricultural production in the Sahel region. Climate-Smart Agricultural Technologies (CSATs) are disseminated to reduce these negative effects, and particularly those on resource-poor farm households. This article investigates the distributional impacts of the adoption of CSAT on farm households' welfare using a dataset that covers four regions, 32 communes, 320 villages, and 2240 households in Mali. Using an instrumental variable quantile treatment effects model, the paper addresses the potential endogeneity arising from the selection bias and the heterogeneity of the effect across the quantiles of the outcome variables' distribution. The results show that the adoption of CSAT is positively associated with improved households' welfare. The farmers' decision to adopt any CSAT is influenced by access to credit, contact with extension agents, participation in training, access to information through the television, and being a member of any organization such as a cooperative society. Moreover, the effect of the adoption of CSAT on household welfare varies across the different households. In particular, the results show that the impact of the adoption of CSAT on households' welfare is generally higher for the poorest (farmers located at the bottom tail of the distribution) end of the welfare distribution. The findings, therefore, highlight the pro-poor impact of the adoption of CSAT in the rural Malian context, as well as the need to tailor the CSAT interventions toward specific socio-economic segments of the rural population in Mali.

Keywords: climate-smart agricultural technologies, quantile regression, endogeneity, Sahel region, Mali

100. Evaluation of application timing in fertilizer micro-dosing technology on millet production in Niger, West Africa

Hayashi, K., Abdoulaye, T., Gerard, B., & Bationo, A. (2008). Evaluation of application timing in fertilizer micro-dosing technology on millet production in Niger, West Africa. *Nutrient Cycling in Agroecosystems*, 80(3), 257–265. <https://doi.org/10.1007/s10705-007-9141-3>

Micro-dosing technology has been developed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and its partners to help subsistence farmers in the Sahel improve inorganic fertilizer application. However, the ICRISAT's recommendations regarding fertilizer application through this technology are only applicable at sowing and do not allow any flexibility in terms of labor and/or capital management. In rural areas, fertilizer cannot always be applied at sowing due to financial and labor constraints. The purpose of this study was to evaluate the effect of the timing of fertilizer application on millet production. A 2-year on-station experiment and a 1-year on-farm field experiment were conducted in the western region of Niger, West Africa. Even under the heterogeneous climatic conditions of the region during our experimental period, the results showed that the trend was the same as observed in previous studies: millet production improved through fertilizer application compared to the control (without fertilizer). The harvest index was also higher compared to that of the control. This increased production was consistently the same for all application timings. The marginal value–cost ratio on the investment calculated using a budgeting analysis for the on-farm experiment showed that – regardless of application timing – millet farmers who fertilized their fields with inorganic fertilizer made more profit than those who did not (control). This was also

true for farmers who were unable to fertilize at sowing – delayed application was still the more profitable option relative to the no fertilizer control. Our results indicate that small subsistence farmers can be offered more options for inorganic fertilizer application timing using the micro-dosing technology. Delayed inorganic fertilizer application can help small farmers who are often labor constrained at the sowing period improve their yields as well as their economic returns.

Keywords: application timing, fertilizer micro-dosing technology, marginal value–cost ratio, millet production, Niger, Sahel, West Africa

101. Evaluation of local maize (*Zea mays* L.) varieties from Burkina Faso as source of tolerance to drought

Olaoye, G, Menkir, A., Ajala, S., & Jacob, S. (2009). Evaluation of local maize (*Zea mays* L.) varieties from Burkina Faso as source of tolerance to drought. *Journal of Applied Biosciences*, 17, 887–898. <https://cgspace.cgiar.org/handle/10568/90208>

Field studies were conducted in Nigeria, in 1999 and 2000, to evaluate local maize cultivars from Burkina Faso under moisture deficiency to identify suitable genotypes to serve as sources of drought tolerance alleles for incorporation into improved cultivars. A total of 14 local maize cultivars from Burkina Faso and a hybrid control were evaluated under well-watered conditions and drought stress imposed by withdrawing irrigation from 23 days before 50% anthesis until harvest. Moisture deficiency significantly reduced the number of ears per plant by 22% and grain yield by 53%. Three local cultivars (Bondokuy-1, Dogona-1 and Douana-1) had grain yields that were either comparable to or higher than that of the hybrid control under moisture deficit. Relative ranking of genotypes for grain yield under well-watered condition was different from those under moisture deficiency. Two major clusters were formed for genotypes tested under each irrigation treatment, with entries in cluster 2 combining high grain yield with shorter anthesis-silking interval and lower leaf senescence rating. Some local cultivars exhibited comparable performance to the hybrid control, suggesting the possibility that genes for high grain yield and other desirable agronomic attributes may have been introgressed into the local maize cultivars through pollen transfer from adjacent improved cultivars that have been cultivated in the region and thus increasing their utility values. Three genotypes, i.e. Bondokuy-1, Dogona-1 and Douana-1, had high grain yields under both well watered and moisture deficiency conditions. These accessions could serve as potential sources of favorable alleles for developing high yielding varieties adapted to areas affected by drought in West and Central Africa.

Keywords: drought stress, landraces, drought sensitivity index, yield potential, genotypes, maize varieties, cultivars, germplasm

102. Examining the relationship between farm size and productive efficiency: a Bayesian directional distance function approach

Khataza, R., Hailu, A., Doole, G. J., Kragt, M. E., & Alene, A. (2019). Examining the relationship between farm size and productive efficiency: a Bayesian directional distance function approach. *Agricultural Economics*, 50, 237–246. <https://doi.org/10.1111/agec.12480>

Achieving sustainable food security and increased farm income will depend on how efficient production systems are in converting available inputs to produce outputs. Using data from Malawi, we estimate a Bayesian directional technology distance function to examine the relationship between farm size and technical efficiency. Our results support the existence of an inverse relationship between farm size and productive efficiency, where small farms are more efficient than large farms. On average, farms exhibit inefficiency levels of 60%, suggesting that productivity could be improved substantially. Improving productive efficiency and food security will require farms to operate in ways where the size of cultivated area is matched by nonland production inputs such as labor, fertilizer, and improved seeds. The results highlight the need for policies that could incentivize farmers to adopt productivity-enhancing technologies and, where possible, to allocate excess land to lease markets.

Keywords: food security, farm size, technical efficiency, food security, inverse productivity, Malawi

103. Exploring the profitability of improved storage technologies and their potential impacts on food security and income of smallholder farm households in Tanzania

Kotu, B. H., Abass, A. B., Hoeschle-Zeledon, I., Mbwambo, H., & Bekunda, M. (2019). Exploring the profitability of improved storage technologies and their potential impacts on food security and income of smallholder farm households in Tanzania. *Journal of Stored Products Research*, 82, 98–109. <https://doi.org/10.1016/j.jspr.2019.04.003>

This study assesses the profitability of selected improved grain storage technologies and the potential impact of their adoption on food security and income of smallholder maize producers in Tanzania. We used on-farm experiment data, time series maize price data, and household survey data to address the objectives. For the improved technologies, we considered Purdue Improved Crop Storage (PICS) bags, metallic silos of different sizes, and polypropylene (PP) bags treated with Actellic Super®. We compared them with PP bags without insecticide treatment as the control. Results show that PICS bags and PP bags plus Actellic Super are profitable in all locations and not significantly different. While the feasible period varies by location, profit is most likely negative if farmers sell their maize in the first two months after harvest and in the last two months before the next harvest. There are mixed results with regards to the profitability of metallic silos; bigger silos are profitable for farmers who have economies of scale to use them while smaller ones are profitable only within the context of higher grain price and bigger seasonal price gap. The results also show that PICS bags (or PP bags plus Actellic Super) are useful to address food security and income objectives among poor rural households whereas metallic silos with bigger storage capacity can increase the income of those farmers who have bigger surplus grain to sale.

Keywords: maize, PICS bags, metallic silos, price seasonality, potential impact, Tanzania

104. Factors affecting farm-specific production efficiency in the savanna zones of West Africa

Okike, I., Jabbar, M., Manyong, V., Smith, J., & Ehiu, S. (2004). Factors affecting farm-specific production efficiency in the savanna zones of West Africa. *Journal of African Economies*, 13(1), 134–165. <https://doi.org/10.1093/jae/13.1.134>

Agricultural intensification involving greater crop–livestock interactions and integration is emerging as the most promising strategy for improving agricultural production and productivity in much of Sub-Saharan Africa. In West Africa, where this process is at various stages of evolution, 559 farm households from the Sudan Savanna (SS) and Northern Guinea Savanna (NGS) zones were studied to examine the factors affecting production efficiency. The farms in each zone were divided into four socio-economic domains using a combination of population density and market access as criteria. Estimation of stochastic frontier production function indicated the need to include ecological and socioeconomic variables in both the production function and the accompanying inefficiency equation, failing which such models may suffer from omitted variables bias. The results showed that inefficiency effects of a stochastic nature existed among the sample farms and average efficiency was 76%: 68% in the SS and 86% in the NGS zones. Further, increased resource use associated with agricultural intensification was not always accompanied by an increase in production efficiency; and while agricultural intensification based on high external input strategies yields higher marginal returns in the NGS, a similar strategy is not critical to success in the SS given current use levels and the biophysical endowments of the latter ecological zone.

105. Factors affecting the adoption of agroforestry practices by farmers in Cameroon

Nkamleu, G. B., & Manyong, V. (2005). Factors affecting the adoption of agroforestry practices by farmers in Cameroon. *Small-scale Forest Economics, Management and Policy*, 4(2), 135–148. <https://doi.org/10.1007/s11842-005-0009-6>

This paper presents empirical evidence on the impact of socio-economic factors on the adoption of agroforestry practices in Cameroon. The analysis uses primary farm-level data collected from June to December 1996. Three major provinces of the country were covered, namely Centre, Southwest, and Northwest. Several agroforestry technologies have been promoted among farmers in the zone, including alley farming, improved fallow, live fencing, cut-and-carry fodder and apiculture. The status of adoption of each agroforestry practice is described and factors that affect adoption identified. These are gender of farmer, household family size, level of education, farmer's experience, membership within farmers' associations, contact with research and extension, security of land tenure, agroecological zone, and distance of the village from nearest town, village accessibility and income from livestock. Research findings indicate that since factors affecting farmers' adoption of agroforestry practices differ across techniques, generalization is to be avoided.

Keywords: agroforestry, adoption, econometric analysis, socio-economic characteristics, logit model

106. Factors affecting the adoption of disease-resistant plantain and banana (*Musa* spp.) hybrids in Nigeria

Aitchedji, C., Tenkouano, A., & Coulibaly, O. (2010). Factors affecting the adoption of disease-resistant plantain and banana (*Musa* spp.) hybrids in Nigeria. *Acta Horticulturae*, 2(879), 741–748. <http://dx.doi.org/10.17660/ActaHortic.2010.879.80>

The study assesses the level of adoption of hybrid cultivars of plantain and banana (*Musa* spp.), promoted through plantain promotion projects based on farmer-to-farmer diffusion and extension events, and determines the factors affecting their adoption and dissemination in four plantain and banana growing areas of Nigeria. Data have been analyzed with an econometric Logit model. The results indicate that the farmer capacity to choose and use planting materials and related production techniques has been significantly improved by training programs over a period of four years. Farmer awareness has been increased through field days, demonstration plots, farmer exchange visits and a platform for sharing information on hybrids and associated techniques. Reasons reported by farmers to adopt the hybrids include high yields, resistance to black leaf streak, taste/good cooking quality, and access to planting materials due to the rapid multiplication technique deployed by the project. Farmers, who participated in on-farm trials, demonstration plots, field days and/or other training programs on hybrids and associated technologies during the five last years, adopted the hybrid cultivars because of their direct participation and contact with breeders and other project partners. The project's collaboration with the national extension system for the organization of annual training programs with pioneer farmers on hybrid cultivars and associated technologies has highly contributed to the large and effective dissemination and adoption of plantain and banana hybrids by small farmers.

Keywords: binary logit model

107. Factors affecting the adoption of fertilizers by rice farmers in Cote d'Ivoire

Adesina, A. (1996). Factors affecting the adoption of fertilizers by rice farmers in Cote d'Ivoire. *Nutrient Cycling in Agroecosystems*, 46(1), 29–39. <https://link.springer.com/article/10.1007/BF00210222>

This paper analyzed the factors that affect the adoption of chemical fertilizers by rice farmers in Côte d'Ivoire using a Tobit model. The results show that the major factors that positively influence farmers' use of fertilizers in rice fields are cultivation of lowlands, use of mechanization, farm size, land pressure and availability of non-farm income. Factors found to negatively affect the use of fertilizer in rice fields are the distance of the field to the village, distance of the village to the major market, and if the cultivator is a female. The paper concludes with strategies for targeting soil fertility interventions on farmers' rice fields.

108. Factors driving fertilizer adoption in banana (*Musa* spp.) systems in Uganda

Van Asten, P., Wairegi, L., Bagamba, F., & Drew, C (2010). Factors driving fertilizer adoption in banana (*Musa* spp.) systems in Uganda. *Acta Horticulturae*, 879, 465–478. <http://dx.doi.org/10.17660/ActaHortic.2010.879.51>

Low soil fertility is among the important factors limiting highland banana (*Musa* spp., AAA-EA genome) yields in Uganda. We monitored 179 on-farm demonstration and control plots in Central, South, Southwest and East Uganda to identify constraints and opportunities to fertilizer adoption in banana systems. Demonstration plots received on average 71-8-32 kg ha⁻¹ y⁻¹ of N-P-K fertilizers. Most plots (53%) received external mulch, whereas farmer control plots received no fertilizer and little external mulch (13% of the plots). The demonstration plots were used for learning by nearby collaborating farmers. Structured interviews were conducted to get information on farmer perceptions of demonstrated technologies. Farmers observed that demonstration plots had consistently higher yields than control plots due to bigger bunches and better quality. Yield increases varied from 3.5 t ha⁻¹ y⁻¹ in Luwero (Central Uganda) to 13.1 t ha⁻¹ y⁻¹ in Masaka (South Uganda). Fertilizer use was highly profitable at sites close to Kampala market but not at sites far away (>250 km). The marginal rates of return exceeded 575% in Wakiso district (Central Uganda) but only averaged 10% in Bushenyi (Southwest Uganda). Foliar analysis indicated that fertilizer use will become more profitable when site-specific plant nutrient deficiencies are targeted. Farmers perceived fertilizer prices as the most important constraint to adoption, despite limited knowledge of actual prices. Other important constraints perceived by farmers were poor supply, labor required for fertilizer application, and the belief that fertilizer negatively affected soil quality. The demonstration plot approach simultaneously allowed participatory evaluation, fine-tuning and adoption and adaptation of fertilizer recommendations. This approach shortens and strengthens the adoption pathway, provided the process is supported by proper agronomic and economic evaluation of the technologies tested.

Keywords: demonstrations, profitability, returns to investment, soil fertility, yield constraints

109. Factors driving the adoption of cooking banana processing and utilisation methods in Nigeria

Lemchi, J., Tshiunza, M., Onyeka, U. P., & Tenkouano, A. (2005). Factors driving the adoption of cooking banana processing and utilisation methods in Nigeria. *African Journal of Biotechnology*, 4(11), 1335–1347. www.researchgate.net/publication/228349983

As part of efforts in realizing her aim of introducing cooking banana into Nigeria, the International Institute of Tropical Agriculture (IITA) mounted training and awareness campaigns on its utilization in collaboration with Shell and Agip Oil companies between 1991 and 1997. This study looked into the adoption profile of the utilization methods and the factors that may have influenced it. Data were collected from a random sample of 232 respondents from 24 villages in southeast Nigeria. Results showed an overall adoption level of 79.5%. The highest adoption levels were obtained for those utilization methods similar to local and traditional methods of plantain consumption and lowest for non-traditional uses. The extent or intensity of adoption by the respondents ranged from 1 processing method to 7, with an average of 3. As a proportion of the number of utilization methods on which training was given, the intensity of adoption ranged from 12.5% to 100% with a mean of 52.2%, meaning that the respondents have adopted more

than 50% of the total number methods on which they received training. The major factors which have strongly influenced the adoption process were the level of educational attainment, social status, primary occupation, intensity of training received, availability of commercially-produced plantain products in the market/area, trialability as well as the number of desirable attributes of the utilization methods.

Keywords: cooking banana, adoption, processing methods

110. Factors influencing farmer-to-farmer transfer of an improved cowpea variety in Kano State, Nigeria

Kormawa, P., Ezedinma, C., & Singh, B. (2004). Factors influencing farmer-to-farmer transfer of an improved cowpea variety in Kano State, Nigeria. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 105(1), 1–13. <https://cgspace.cgiar.org/handle/10568/103375>

Diffusion of improved technologies among small-scale farmers, especially where formal methods and market mechanisms are inefficient, can be enhanced through the participation of farmers. Unfortunately, formal methods of disseminating improved seed in most African countries have not taken advantage of the farmers' traditional transfer methods. This article deals with the role of farmer-to-farmer transfer and dissemination of an improved cowpea seed variety in Nigeria. Using household and farm level data from 133 respondents, the study adopts a logit model to investigate the determinants of the farmers' decision to transfer the new seed variety to other farmers. Area of improved cowpea cultivated, yield, market price of seed, use of pesticides and threshing quality were found to be significant variables affecting farmers' decision to transfer the improved cowpea variety.

Keywords: farmer-to-farmer, seed, dissemination, cowpea, logit, Nigeria

111. Factors influencing risk aversion among maize farmers in the Northern Guinea Savanna of Nigeria: Implications for sustainable crop development programmes

Olarinde, L., Manyong, V., & Akintola, J. (2010). Factors influencing risk aversion among maize farmers in the Northern Guinea Savanna of Nigeria: Implications for sustainable crop development programmes. *Journal of Food, Agriculture and Environment*, 8(1), 128–134. <https://biblio.iita.org/documents/S10ArtOlarindeFactorsInthomDev.pdf-56a6c4c21f35b632fc1bf896df3eea53.pdf>

The attitudes of farmers toward risks influence their decision to invest in farming. Understanding the factors that influence these attitudes is important for crop development. This paper uses a combination of Ridge and Tobit regression analyses to determine the factors influencing risk aversion among maize farmers in the Northern Guinea Savanna agro-ecological zone of Nigeria. Preliminary categorization of a cross-sectional sample of 348 farmers shows that 8.91% are risk preferers, 48.56% are risk averters while the remaining 42.53% are risk neutral farmers. Risk aversion among the sampled farming households was found to be influenced

by socioeconomic factors (e.g., age of household head, household size) and farm specific variables (e.g., proportion of income from maize, non-farm income). Probability and elasticity estimates from further Tobit analysis revealed that an improvement on the variables considered can actually reduce high risk aversion. The key socioeconomic and farm specific variables that have direct bearing on the farmers' risk attitudes, as revealed in this study, indicate the important and crucial role that extension could play in sensitizing both the research, donor agencies, government and the farmers on the need to target particular areas of the farm families' needs. Since the major issues raised here impinge on the farmers' financial status, enterprise diversification which can guarantee the security of the farmers' immediate financial future is a key element in planning at regular farming seasons and intervals. This will in effect, result in increased maize productivity. The findings in this study have policy implications for crop development programs.

Keywords: risk aversion, safety-first, ridge regression, Tobit model, Northern Guinea Savanna, Nigeria

112. Factors influencing the adoption of improved cowpea varieties in the Sudan Savannas of Northern Nigeria

Mbavai, J. J., Shitu, M. B., Abdoulaye, T., Oyinbo, O., & Kamara, A. Y. (2019). Factors influencing the adoption of improved cowpea varieties in the Sudan Savannas of Northern Nigeria. *Journal of Agricultural Extension and Rural Development*, 11(11), 200–207. https://www.researchgate.net/publication/337653235_Factors_influencing_the_adoption_of_improved_cowpea_varieties_in_the_Sudan_Savannas_of_Northern_Nigeria

The study was undertaken to determine the level and factors influencing adoption of improved cowpea varieties introduced by the Sudan Savanna Taskforce project in Musawa Local Government Area of Katsina State. Data were collected from a random sample of 300 households from ten communities in the study area. The analytical tools used for data analysis include descriptive statistics to examine the level of adoption of improved cowpea varieties and Probit and Tobit regression models to identify factors that influence the adoption and intensity of use of the varieties respectively. Results from the analyzed data indicate that more farmers were aware of improved cowpea varieties by a magnitude of 40% and adoption improved by a magnitude of 35.7% adoption. In addition, households with formal education, extension contact, those who participated in the project activities, members of associations and cowpea growing experience are more likely to adopt improved cowpea varieties. Similarly, factors influencing the intensity of adoption were gender of farmers, extension contact, membership of association, participation in project activities and rearing of livestock. Finally, the study recommends that farm expansion and intensification of extension services would be an incentive to adoption decisions by small-scale farmers in the study area and extended to the less educated farmers. Furthermore, there is a need for special training, seminars, field demonstrations and technical support for the cowpea farmers.

Keywords: adoption, factors, improved cowpea varieties, Sudan Savanna Taskforce

113. Factors influencing the use of selected inputs in yam production in Nigeria and Ghana

Mignouna, D., Abdoulaye, T., Akinola, A., Alene, A., & Nweke, F. (2015). Factors influencing the use of selected inputs in yam production in Nigeria and Ghana. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 116(2), 131–142. https://www.researchgate.net/publication/283486739_Factors_influencing_the_use_of_selected_inputs_in_yam_production_in_Nigeria_and_Ghana

In West Africa, yam can be an important crop to reduce poverty and hunger if Research and Development measures identify and properly engage its key production factors for enhanced outputs and better income. Data from 1400 households in Ghana and Nigeria were collected in a multistage random sampling survey (and complementary data from 76 farm family fields) with a structured questionnaire and qualitative interview questions. The results showed that yam is produced mainly with crude inputs/technologies to reduce high dependence on labor, seed production and control of pests and diseases. Yam is produced widely with purchased inputs, including seed yam and hired labor; chemical fertilizer, herbicide and pesticides are less often used. Analyses of determinants of use of purchased inputs reveal three serious impediments to expansion in yam production: the increasing scarcity and high cost of hired labor, shortage of suitable land and poor farm roads. As employment opportunities for unskilled labor in urban centers are presently expanding, increased yam production will be hard to achieve without labor-saving inputs for at least some of the production tasks, especially seedbed preparation and weeding, and without improvement in infrastructure.

Keywords: yam, production factors, Nigeria, Ghana

114. Factors informing the smallholder farmers' decision to adopt and use improved cassava varieties in the south-east Area of Nigeria

Ojiako, I. A., Udensi, U. E., & Tarawali, G. (2015). Factors informing the smallholder farmers' decision to adopt and use improved cassava varieties in the south-east Area of Nigeria. *Journal of Economics and Sustainable Development*, 6(22), 94. <https://www.iiste.org/Journals/index.php/JEDS/article/view/27354>

The factors influencing farmers' adoption and use intensity decisions on improved cassava varieties were investigated. Data collected from 510 cassava farmers randomly selected among the users (62.9%) and non-users (37.1%) from Abia State, south-east, Nigeria were used for the study. Descriptive and inferential statistics and tobit regression technique, with its associated elasticity decomposition framework were used in data analysis. Results revealed that plot size ($p < 0.01$), farmer's age ($p < 0.01$), education status ($p < 0.01$), and awareness through workshop and trainings ($p < 0.05$) had significant positive influences on adoption and use while awareness through friends ($p < 0.01$) and radio/television ($p < 0.01$) had negative influences. Results were consistent for all three variants of the regression output considered. Elasticity results showed that the marginal effects of changes in all variables increased the elasticity of the probability of use more than they increased the probability of adoption for all

households. The implication is that constant training and retraining of farmers on best farming and management practices would foster adoption and use of improved varieties to impact on the farmers' wellbeing. Interactions among farmers during meetings, co-operatives, and other non-formal forums should be encouraged, but appropriately monitored, to ensure that only right messages were circulated to avoid distortion and negative outcomes.

Keywords: adoption decisions, *Manihot esculenta*, improved varieties, rural farmers, tobit, use intensity

115. Factors that transformed maize productivity in Ethiopia

Abate, T., Shiferaw, B, Menkir, A., Wegary, D., Kebede, Y., Tesfaye, K., Kassie, M., Bogale, G, Tadesse, B, & Keno, T (2015). Factors that transformed maize productivity in Ethiopia. *Food Security*, 7, 965–981. <https://doi.org/10.1007/s12571-015-0488-z>

Maize became increasingly important in the food security of Ethiopia following the major drought and famine that occurred in 1984. More than 9 million smallholder households, more than for any other crop in the country, grow maize in Ethiopia at present. Ethiopia has doubled its maize productivity and production in less than two decades. The yield, currently estimated at >3 metric tons/ha, is the second highest in Sub-Saharan Africa, after South Africa; yield gains for Ethiopia grew at an annual rate of 68 kg/ha between 1990 and 2013, only second to South Africa and greater than Mexico, China, or India. The maize area covered by improved varieties in Ethiopia grew from 14% in 2004 to 40% in 2013, and the application rate of mineral fertilizers from 16 to 34 kg/ha during the same period. Ethiopia's extension worker to farmer ratio is 1:476, compared to 1:1000 for Kenya, 1:1603 for Malawi and 1:2500 for Tanzania. Increased use of improved maize varieties and mineral fertilizers, coupled with increased extension services and the absence of devastating droughts are the key factors promoting the accelerated growth in maize productivity in Ethiopia. Ethiopia took a homegrown solutions approach to the research and development of its maize and other commodities. The lesson from Ethiopia's experience with maize is that sustained investment in agricultural research and development and policy support by the national government are crucial for continued growth of agriculture.

116. Farm diversity and resource use efficiency: targeting agricultural policy interventions in East Africa farming systems

Kansiime, M. K, VanAsten, P., & Sneyers, K.* (2018). Farm diversity and resource use efficiency: Targeting agricultural policy interventions in East Africa farming systems. *NJAS: Wageningen Journal of Life Sciences*, 85(1), 32–41. <https://doi.org/10.1016/j.njas.2017.12.001>

This paper aimed to provide empirical evidence on the links between farm diversity and resource use efficiency. Using farm typology and stochastic production frontier approaches, we grouped households into those pursuing similar livelihood strategies and assessed their resource use efficiency. At 60% coefficient of similarity, we identified three distinct farm types

– Farm-specialised, Diversified and Off-farm specialised. Significant ($p < 0.01$) differences across farm types were observed for, the proportion of income from farming, farmed area, and land use patterns, confirming these as good indicators for distinguishing between farm types. Over 50% of surveyed households were categorised as Diversified and Off-farm specialised, and mainly pursued off-farm livelihood strategies. Farm-specialised households pursued mainly farm-based activities and earned higher net incomes compared to other farm types. However, they exhibited technical inefficiency in the use of labor and fertilizer compared to other farm types. Access to extension and commercial orientation showed significant ($p < 0.01$) positive effect on technical efficiency for Farm-specialised households. Results have implications for policies and programs aimed at improving agricultural productivity. There is need to focus support on interventions that make a significant contribution to farm efficiency, in particular, extension services and market access. Agricultural programs are likely to be successful if they are targeted to households reliant on agriculture, while, off-farm households could be oriented toward off-farm agri-enterprises such as processing and marketing.

Keywords: diversification, farm typology, livelihood strategies, principal component analysis, stochastic production frontier

117. Farm production diversity: Is it important for dietary diversity? Panel data evidence from Uganda

Sekabira, H., & Nalunga, S (2020). Farm production diversity: Is it important for dietary diversity? Panel data evidence from Uganda. *Sustainability*, 12(3), 1028. <https://doi.org/10.3390/su12031028>

The substantial existence of malnutrition globally, especially in developing countries, has usually driven policy initiatives to focus on improving household food security and nutrition primarily through prioritizing farm production diversity. Although indeed some empirical evidence has pointed to farm production diversity remedying malnutrition, other evidence has pointed to markets. Therefore, evidence is mixed and may be country or region variant. To contribute to closing such a gap in the literature, we used three waves of national panel survey data from Uganda and panel regression models to investigate associations between farm production diversity and dietary diversity, as well as impact pathways. We found that farm production diversity was positively and significantly associated with household dietary diversity. Farm production diversity influenced dietary diversity through own farm production, and market consumption food security pathways. The own farm production pathway showed a stronger associated impact. Increasing food expenditure by 1000 UGX via own farm production yielded an eight percentage point increment in household dietary diversity, while an equal expenditure via markets yielded a 5.3 percentage point increment. We also found existence of gender effects. Male headed households were associated with relatively poorer household dietary diversity. These findings could have broader implications for countries practicing smallholder agriculture.

Keywords: farm production diversity, household dietary diversity, nutrition security, Uganda

118. Farm size, relative efficiency and agrarian policy in Côte d'Ivoire: profit function analysis of rice farms

Adesina, A., & Djato, K (1996). Farm size, relative efficiency and agrarian policy in Côte d'Ivoire: Profit function analysis of rice farms. *Agricultural Economics*, 14(2), 93–102. <https://www.sciencedirect.com/science/article/abs/pii/0169515096011814>

This paper examines the relative economic efficiency of small and large rice farms in Côte d'Ivoire using a profit function approach. No differences in the relative economic efficiency of small and large farms were found. This conclusion is robust under alternative model specifications. Agrarian reforms directed toward further concentration of landholding for large farms in Côte d'Ivoire cannot be justified based on economic efficiency. Results show that access to credit and use of modern rice varieties significantly increase profits. To improve technical efficiency of rice farms, an accelerated program to provide information, credit, improved seeds and other inputs is needed. When all the farms (i.e. large and small) are taken together, there is evidence of allocative inefficiency. Strategies are needed to remove such management related inefficiencies in rice production either through the development of a better market price information system or effective farmer-oriented technical training programs by rice extension workers.

119. Farmer knowledge as an early indicator of IPM adoption: A case study from cocoa farmer field schools in Ghana

David, S., & Asamoah, C. (2011). Farmer knowledge as an early indicator of IPM adoption: A case study from cocoa farmer field schools in Ghana. *Journal of Sustainable Development in Africa*, 13(4), 213–223. https://www.worldcocoafoundation.org/wp-content/uploads/files_mf/david2011.pdf

Researchers assessing post-training adoption of integrated crop and pest management (ICPM) practices in perennial crops face methodological challenges in measuring yield, an expected outcome of improving farmers' knowledge and decision-making capacity. This paper proposes using post-training farmer knowledge as an early indicator of ICPM adoption. Based on knowledge test scores from Ghanaian farmers who graduated from farmer field schools (FFS) on cocoa ICPM, the study shows that the training exposed participants to agro-ecological principles and knowledge about biological processes (e.g. what causes black pod disease and how it spreads) not known by most Ghanaian cocoa farmers and suggests that improved knowledge is likely to translate to improved practice. The paper calls for additional research to confirm these findings with field-based data on how effectively farmers apply ICPM practices and discusses some of the circumstances and conditions where farmer knowledge may be a useful indicator of adoption.

Keywords: IPM, farmer field schools, cocoa, impact assessment

120. Farmers' perception of the *Striga* problem and its control in northern Nigeria

Emechebe, A., Ellis-Jones, J., Schulz, S., Douthwaite, B., Kureh, I., Tarawali, G., & Kormawa, P. (2004). Farmers' perception of the *Striga* problem and its control in northern Nigeria. *Experimental Agriculture*, 40, 215–232. <https://doi.org/10.1017/S0014479703001601>

The parasitic angiosperms, *Striga hermonthica* and *S. gesnerioides*, obligate root parasites endemic in sub-Saharan Africa, constitute severe constraints to cereal and legume production in West and Central Africa. Over the years, a range of effective component technologies has been identified for *Striga* control in Africa. The potential of these technologies has been demonstrated under researcher-managed conditions. To promote farmer testing of the technologies, community workshops were conducted in 42 rural communities in Kaduna State, northern Nigeria. These revealed that agriculture was the main source of livelihood for most households. The three most important crops, maize, sorghum and pearl millet are attacked by *S. hermonthica*, regarded as the major constraint to crop production, often causing 70–100% crop loss. Farmers recognised two types of *Striga* damage (underground and aboveground), with greater damage being caused by underground *Striga*. Farmers attributed increasing incidence and severity of *Striga* damage to lack of capital, poor soil fertility, infestation of previously uninfested land by *Striga* seeds, and continuous cropping of host crops. The most widely used among the 15 existing *Striga* control techniques identified by the farmers were hoe weeding and hand pulling, application of inorganic fertilizer and manure, crop rotations, fallowing, and early planting. In assessing possible control measures, farmers considered increased crop yield, reduced *Striga* reproduction and *Striga* emergence, greater crop vigour, and increased soil fertility as positive attributes. Negative attributes comprised increased labor requirement, higher costs, increased risk of crop damage or yield reduction, and lower quantity and quality of produce. Overall, a legume–cereal rotation was the most highly rated control option for *S. hermonthica* management evaluated by the farmers. The implications of these results are examined with respect to farmers' adoption and adaptation of *Striga* control options beyond the experimental plots.

121. Farmer-to-farmer technology diffusion and yield variation among adopters: the case of improved cowpea in northern Nigeria

Alene, A., & Manyong, V. (2006c). Farmer-to-farmer technology diffusion and yield variation among adopters: the case of improved cowpea in northern Nigeria. *Agricultural Economics*, 35(2), 203–211. <https://doi.org/10.1111/j.1574-0862.2006.00153.x>

This article examines the magnitude and sources of yield variation among adopters of improved cowpea varieties in northern Nigeria promoted through farmer-to-farmer diffusion. The results reveal important efficiency differences between the lead farmers who have contacts with breeders and the follower farmers who get technology and information from the lead farmers. Differential adoption of the package of seed, insecticide, fertilizer, and recommended cereal–cowpea cropping pattern provides much of the explanation for yield variation among adopters. The component often missing, and hence accounting for much of the yield variation, is the

crop management technology relating to the cereal–cowpea cropping pattern. No efficiency variation is attributed to the source of technology and information, such as whether improved cowpea was obtained from breeders or lead farmers. Technology source has a rather indirect influence on efficiency through its effect on package adoption where breeders promote greater package adoption among the lead farmers than the lead farmers do among the follower farmers. Possible ways of disseminating crop management technological information through the farmer-to-farmer technology diffusion are recommended to better exploit the yield and profitability potentials of improved cowpea varieties in northern Nigeria.

122. Farmers' perception of coconut mite damage and crop diversification alternatives in the coastal belt of Tanzania

Oleke, J. M., Isinika, A., Manyong, V., Hanna, R., & Sabelis, M. (2012). Farmers' perception of coconut mite damage and crop diversification alternatives in the coastal belt of Tanzania. *International Journal of Acarology*, 38(6), 471–479. <https://doi.org/10.1080/01647954.2012.682093>

This article analyzed farmers' perceptions of the effects of coconut mite in their livelihood and assessed crop diversification as a coping strategy for reduced coconut production. A socio-economic model of farmers' decisions on intercropping as an indicator for overall crop diversity was developed. The study was conducted between November 2009 and March 2010 in five districts in Tanzania, which were selected on the basis of the coconut's economic importance, using structured questionnaires which were administered to 200 household heads. Respondents were categorized in three groups – resource-poor farmers (43% of sample), medium-level farmers (50%) and well-off farmers (7%) according to six criteria. More than 80% of farmers were aware of the negative effects of the coconut mite. The result further indicated that the damaged nuts cause a loss of more than 30% of the cash income from coconut. Intercropping coconut with cassava, maize, cashew nut, sorghum and pineapples were the alternatives used by farmers to cope with declining coconut production caused by coconut mite and lethal yellowing disease. Land ownership and size, income from crops, non-farm income and family size were the main factors that influenced the farmer's decision to diversify crops. Although farmers diversify their cropping systems in order to be self-reliant, there is still a need to promote policies and programs that will address coconut production constraints such pests and diseases such as rehabilitation of old plantations.

Keywords: *Cocos nucifera*, socio-economics, diversification, Benin, Tanzania

123. Farmers' perceptions and adoption of new agricultural technology: analysis of modern mangrove rice varieties in Guinea Bissau

Adesina, A., & Seidi, S. (1995). Farmers' perceptions and adoption of new agricultural technology: Analysis of modern mangrove rice varieties in Guinea Bissau. *Quarterly Journal of International Agriculture*, 34(4), 358–371. <https://cgspace.cgiar.org/handle/10568/101102>

This paper examines the diffusion and adoption of improved mangrove swamp rice varieties (MV's) in Guinea Bissau, using evidence from the Cumbidja River Basin, a major mangrove

rice growing area of the country. The results of the study show that the adoption of MV's has been rapid and impressive in the Cumbidja zone. Diffusion of the MV's which started in 1983 with 13% of farmers, had reached 70% of farmers by 1993. A Logit model was used to quantify the factors that determine the observed adoption patterns. While contact with extension or rice development projects has positively influenced farmers' adoption, it is farmers' assessments of the superiority of these MV's to local varieties (for some key technology attributes) that has principally motivated farmers' adoption of the MV's. Farmers' perceptions and adoption of new agricultural technology: analysis of modern mangrove rice varieties in Guinea Bissau.

Keywords: rice, farmers, technology

124. Farmers' perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa

Adesina, A., & Baidu-Forson, J. (1995). Farmers' perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa. *Agricultural Economics*, 13(1), 1–9. <https://www.sciencedirect.com/science/article/abs/pii/0169515095011428>

Economists investigating consumer demand have accumulated considerable evidence showing that consumers generally have subjective preferences for characteristics of products and that their demand for products is significantly affected by their perceptions of the product's attributes. However, the role of farmers' preferences in adoption decisions have received very limited attention in adoption studies conducted by economists. This paper tests the hypothesis that farmers' perceptions of technology characteristics significantly affect their adoption decisions. The analysis, conducted with Tobit models of modern sorghum and rice varietal technologies in Burkina Faso and Guinea, respectively, strongly supports this hypothesis. Our results provide a strong case for future adoption studies to expand the range of variables used away from the broad socioeconomic, demographic and institutional factors to include farmers' subjective perceptions of the characteristics of new agricultural technologies.

125. Farmers' perceptions and the dynamics of adoption of a resource management technology: the case of Mucuna fallow in southern Benin, West Africa

Manyong, V., & Tchetché, N. (1999). Farmers' perceptions and the dynamics of adoption of a resource management technology: the case of Mucuna fallow in southern Benin, West Africa. *International Forestry Review*, 1(4), 228–235. <https://www.jstor.org/stable/42609210>

Concern about the increasing degradation of natural resources in developing-country agriculture has led to the development of improved systems that make use of biological processes to promote production in a sustainable manner. The paper uses a case study on the adoption of Mucuna (*Mucuna pruriens* var. *utilis*) to examine the farmers' perceptions and dynamics in the adoption of such improved systems. Small-scale farmers ranked Mucuna fallow more highly than chemical fertilizers because of its weedicide effect, long-term improvement of soil fertility,

low cost, and ease of availability at the village level. The grass roots extension organizations played a significant role in the dissemination of *Mucuna*. The removal of incentives to adopt did not adversely affect the trends in the spread of the technology. However, farmers consider insecure land tenure a constraint to adoption for (even) this non-perennial species.

Keywords: adoption, cover crop, farmers' perceptions, *Mucuna pruriens*, West Africa

126. Farmers' perceptions of benefits and factors affecting the adoption of improved dual-purpose cowpea in the dry savannas of Nigeria

Kristjanson, P., Okike, I., Tarawali, S., Singh, B., & Manyong, V. (2005). Farmers' perceptions of benefits and factors affecting the adoption of improved dual-purpose cowpea in the dry savannas of Nigeria. *Agricultural Economics*, 32(2), 195–210. <https://doi.org/10.1111/j.0169-5150.2005.00338.x>

This study links participatory research methods, geographic information systems (GIS) techniques, village and household-level surveys, and a tobit analysis to examine the adoption and impact issues related to a new technology, improved varieties of dual-purpose cowpea (IDPC), developed by International Institute of Tropical Agriculture (IITA) and International Livestock Research Institute (ILRI) and recently released in Nigeria. The article analyzes factors affecting the adoption and impact of the technology across different socioeconomic domains as defined by degree of market access and population density. The results show multiple benefits from this flexible leguminous crop, many of which relate to the fodder and soil fertility-enhancing aspects of IDPC rather than higher grain yields per se. The intensity of adoption was affected by different village- and household-level factors in each socioeconomic domain, allowing more sharply defined recommendation domain-targeting strategies. The multiple research approaches taken also provided useful lessons at different system levels regarding the benefits of, and perceived problems with, this technology for researchers, development practitioners, and policy makers. The collaborative research approaches taken in this study are helping to close the “feedback loop” from farmers back to researchers and others attempting to disseminate the technology, and by doing so, should contribute to faster and more widespread uptake of this technology.

127. Farmers' perceptions of constraints to plantain production in Ghana

Schill, P., Afreh-Nuamah, K., Gold, C., & Green, K. (2000). Farmers' perceptions of constraints to plantain production in Ghana. *International Journal of Sustainable Development and World Ecology*, 7(1), 12–24. <https://doi.org/10.1080/13504500009470025>

Plantain (*Musa AAB*), a primary food crop in Ghana, is a key component in sustainable agricultural systems in high rainfall zones. Recently, there has been a substantial yield decline and reduction in plantation life. To elucidate the context in which intervention strategies should be developed, a Participatory Rural Appraisal (PRA) was conducted at five villages in the major plantain-producing belt of Ghana. The importance of plantain as a preferred food was

confirmed, although farmers tended to sell plantain for cash income, using cheaper, less preferred alternatives for home consumption. Farmers identified decreasing soil fertility, the high cost of labor for weeding, pests and diseases, lack of good quality planting material and marketing-related issues as the major production constraints. Due to declining productivity in less fertile regions, plantain has been replaced with other food crops such as cassava and maize. Farmers overestimated the importance of insect pests but were unaware of the extensive damage that could be caused by nematodes and the foliar disease, black sigatoka. They observed, however, that pest damage is more severe when soil fertility is poor. Clearly, integrated pest management is likely to be most effective when practiced within the context of cropping systems management; sustainable strategies that are being developed for resource-limited plantain farmers in Ghana are discussed.

Keywords: plantain, Ghana, agriculture, sustainability

128. Farmers' knowledge, use and preferences of parasitic weed management strategies in rain-fed rice production systems

Tippe, D. E., Rodenburg, J., Schut, M., van Ast, A., Kayeke, J., Bastiaans, L. (2017). Farmers' knowledge, use and preferences of parasitic weed management strategies in rain-fed rice production systems. *Crop Protection*, 99, 93–107. <https://doi.org/10.1016/j.cropro.2017.05.007>

Rain-fed rice production in sub-Saharan Africa is often hampered by parasitic weeds. This study assessed farmers' awareness, use, preference and adoption criteria of parasitic weed management practices in rain-fed rice production environments in Tanzania. Surveys and workshops were organized in three affected rice growing areas in Morogoro-rural, Songea and Kyela district, supplemented with on-farm experiments in Kyela. In all districts, farmers were aware of the locally occurring parasitic weed species, *Rhamphicarpa fistulosa* (lowland) and *Striga asiatica* (upland), and they considered these weeds more problematic than non-parasitic weeds. Though they mostly practise hand weeding, farmers were aware of a wide range of control options. Local access, affordability, ease of implementation and control efficacy were considered important criteria for adoption, whereas trade-offs, like lack of preferred grain quality traits in resistant varieties, were mentioned as an important break on adoption. Based on informal discussions with farmers, altered sowing times, resistant rice varieties and soil amendments were marked as feasible control options and tested in a farmer-participatory manner in four years of experimentation in upland and lowland fields. In both types of fields, the contribution of soil amendment to parasitic weed suppression was not evident, but rice husk was marked as a suitable and cheap alternative to inorganic fertilizers. Control of *R. fistulosa* in lowlands was perceived to be best realized by early crop establishment, escaping major parasite damage due to the relatively slow early development of this weed species. The local variety Supa India, appreciated for its grain qualities and marketability, remained the preferred variety. For the control of *S. asiatica*, late planting was preferred, requiring a short-duration variety to minimize risk of drought stress during grain filling. The short-duration NERICA-10 was most preferred, as it combined a favorable short cycle length with resistance

to *S. asiatica* and good grain appearance. Farmer participation in technology testing showed to be crucial in defining locally adapted and acceptable parasitic weed control strategies. Yet, it is argued that without lifting important constraints related to credit and input supply, it will be impossible to sustainably solve the parasitic weed problem in rain-fed rice.

Keywords: *Oryza sativa*, witchweed, *Striga asiatica*, rice vampireweed, *Rhamphicarpa fistulosa*, participatory research

129. Fertilizer market reforms and factors influencing fertilizer use by small-scale farmers in Benin

Kormawa, P., Munyemana, A, & Soule, B (2003). Fertilizer market reforms and factors influencing fertilizer use by small-scale farmers in Benin. *Agriculture, Ecosystems and Environment*, 100(2/3), 129–136. [https://doi.org/10.1016/S0167-8809\(03\)00181-6](https://doi.org/10.1016/S0167-8809(03)00181-6)

Bénin, like other countries in sub-Saharan Africa, has initiated programs to reform agricultural input and output markets. While the impact of the reform programs has been different for each country, it is commonly observed that impact at the farm level has been less than anticipated. A central theme of this paper is to assess the impact of fertilizer market reforms on the fertilizer market structure and fertilizer use for both food and export (cotton) crop production in Bénin. This analysis of farm-level policy impact is based on data from 899 farm households randomly selected and interviewed in all six départements of Bénin in 1998/1999. Results of the study show that there have been only insignificant changes in the fertilizer market structure. Access to fertilizers has not improved; prices for fertilizer have risen in real terms, resulting in application rates lower than that recommended by extension agents. The effects of the reform programs are vital for investment decisions and provide lessons for introducing alternative approaches for improving soil fertility or management. Since 1992, 54% of farmers find maize (*Zea mays* L.) production more profitable, while 38% reported that cotton (*Gossypium hirsutum* L.) production has become more profitable. As a result of the mixed effects of the fertilizer market reform program on the level of fertilizer use and profitability, there is need to develop efficient soil fertility management strategies for small-scale farmers. Such strategies should incorporate the use of complementary inputs, such as seeds with a high level of response to the balanced nutrient package.

Keywords: impact, fertilizer, policy, balanced nutrient, Bénin

130. Fertilizer use and definition of farmer domains for impact-oriented research in the northern Guinea savanna of Nigeria

Manyong, V., Makinde, K., Sanginga, N., Vanlauwe, B., & Diels, J. (2001). Fertilizer use and definition of farmer domains for impact-oriented research in the northern Guinea savanna of Nigeria. *Nutrient Cycling in Agroecosystems*, 59(2), 129–141. <https://doi.org/10.1023/a:1017522022663>

One of the options to alleviate soil fertility constraints for sustainable agriculture in the savannas of West Africa is to develop soil nutrient management technologies from an adequate supply and feasible share of organic and mineral inputs. This paper makes a diagnosis of farm-level use of organic and inorganic inputs, as a basis for the development of technologies. The results from the diagnosis are then used to develop a framework for characterizing farmers for impact-oriented research on soil nutrient management systems. The survey was carried out with 200 farmers carefully selected in two villages in the northern Guinea savanna of Nigeria. The results showed that more than 90% of farmers in both villages used chemical fertilizers. This is contrary to a general belief that they are not widely applied to food crops by small holders in African agriculture. However, up to 81% of the fields received less than half of the recommended 120 because of high costs due, probably to removal of subsidies and inefficient marketing systems. Organic inputs such as animal manure were applied in very small quantities (about 8% of the requirements). However there is evidence of integrated use of inorganic fertilizers and organic manure on some (24%) of the fields. The problem to be addressed is that of the production (and efficient utilization) of organic inputs in the northern Guinea savanna. Nitrogen deficiency is the most limiting soil nutrient in the cereal-dominated systems of study area. On this basis, farmers were classified into two a-priori groups using a threshold of 30, and multiple quantitative variables were fitted in a discriminant analysis to validate the typology. Results indicated that more than 75% of farmers were well classified into two groups that had the characteristics of the a-priori groups. Two others were a typical and included the remaining 25% of farmers. Thus, there are a total of four groups of farmers referred to as farmer domains in this paper. The two domains with 75% of well-classified individuals are suitable for the selection of farmers with whom to conduct applied research or for development activities because they represent the general patterns in the supply and use of soil nutrients in the study area. Although basic research can be done in the four domains, the two atypical groups are most suited for process-level studies to improve the understanding of factors that make the systems either more efficient or less efficient than the two other farmer domains. In either case, representative farmers were easily identified by their highest probability of belonging to a specific domain from the model results. Multivariate models constitute a good framework to make a typology of, and to select farmers for, participatory research and extrapolation of results in the northern Guinea savanna.

131. Foreign direct investment in Nigeria: Reassessing the role of market size

Ojide, M., Agu, C, & Eke, A (2016). Foreign direct investment in Nigeria: Reassessing the role of market size. *International Journal of Academic Research in Business and Social Sciences*, 6(2), 95–104. <https://doi.org/10.6007/ijarbss/v6-i2/2014>

This paper examines the influence of market size on foreign direct investment to Nigeria for the period 1970–2011. It answers the question: do multinational enterprises consider market size in the allocation of their foreign direct investment (FDI) to Nigeria? Unlike similar previous studies on Nigeria, this paper examines market size in terms of economy size and population size. Autoregressive Distributed Lag (ARDL) model and Granger Causality Tests

were estimated. The results show that economy size and population size has positive and significant effect on foreign direct investment to Nigeria. Market size also Granger causes FDI to Nigeria. This paper, therefore, concludes that multinational enterprises consider Nigerian market size in the allocation of their foreign direct investment (FDI) to the country.

132. Household expenditure patterns in the rural areas of Oyo State, Nigeria: evidence of rural households' vulnerability to food insecurity

Ogundapo, A. T., Manyong, V., Kormawa, P. M., & Fabiyi, Y (2008). Household expenditure patterns in the rural areas of Oyo State, Nigeria: evidence of rural households' vulnerability to food insecurity. *Journal of Agricultural and Food Economics*, 3(1/2), 139–152. <https://cgspace.cgiar.org/handle/10568/90833>

The changes in household income result in a rapid shift in the composition of food demanded by the food-secure and food-insecure households. In this paper, we applied popular AIDS model to estimate the budget shares and determinant factors of demand for different food groups. The analysis of food security status reveals that 21 per cent only of the rural households were food secured while the large majorities (79%) were food in-secured. Household income and the prices of various food groups affected the demand for a specific group of food. The budget share indicates an increase in households' food expenditure as the level of income decreases. Conversely, the per capita expenditure on food is directly correlated with income level. Roots and tubers remain the major staples in Oyo State, Nigeria, but interestingly, poor households rely more on cereals and fruit and vegetables than rich households. The high level of vulnerability suggests that broad-based agricultural interventions and pro-poor poverty reduction schemes remain the key to poverty reduction.

Keywords: economy, food consumption, food security, household, poverty reduction, food insecurity, food commodities

133. Household livelihood diversification in rural Africa

Musumba, M., Palm, C. A., Komarek, A. M., Mutuo, P. K., & Kaya, B. (2022). Household livelihood diversification in rural Africa. *Agricultural Economics*, 53(2), 246–256. <https://doi.org/10.1111/agec.12694>

Diversification is a common livelihood strategy for rural households in developing countries, with diversification being either a choice or necessity depending on individual household contexts. Using two waves of data (from 2009 and 2011) for 1773 households from eight countries in sub-Saharan Africa, we examined livelihood diversification and its drivers. We examined livelihood diversification by considering household involvement in three livelihood activities: crop, livestock, and non-farm. Results indicated that 40% of households conducted all three livelihood activities, but there was heterogeneity in diversity levels. We used a correlated random effects model to identify the factors that pushed or pulled households to diversify their activities. Access to non-agricultural credit was positively associated with

livelihood diversity as it can catalyze involvement in non-farm activities. Drought had a negative effect on livelihood diversity. Area of crop land had a positive effect on the number of livelihood activities conducted. We found that 53% of households added or removed at least one livelihood activity between 2009 and 2011, and the addition of non-farm activities was the most common change. Our results demonstrated the dynamic nature of livelihoods and importance of shocks (such as drought) and resource endowments (land) in understanding household livelihood diversification.

134. Household typology based analysis of livelihood strategies and poverty status in the Sudan Savannah of Nigeria: baseline conditions

Damisa, M. A., Sanni, S. A., Abdoulaye, T., Kamara, A. Y., & Ayanwale, A. (2011). Household typology based analysis of livelihood strategies and poverty status in the Sudan Savannah of Nigeria: baseline conditions. *Journal of Agriculture and Environmental Studies*. <https://cgspace.cgiar.org/handle/10568/88161>

The Sub-Saharan Africa Challenge Programme (SSACP) was initiated with an overall objective of tackling poverty related issues among the rural farmers in sub-Saharan Africa through an innovation focussed approach referred to as Integrated Agricultural Research for development (IAR4D). This paper employs some baseline data of the Sudan Savanna Task Force in analyzing household livelihood strategies and their poverty status. Stratified random sampling technique was employed in collecting data from the respondents. The respondents were classified on the basis of whether the farmers are future IAR4D (intervention), conventional (ARD) or clean sites (little intervention). This is necessary for the end-line survey and for the impact assessment of the Challenge Programme. A total of 600 households were surveyed for the study. Descriptive statistics, estimated poverty line and the Tobit regression model were employed in the analysis. The result showed that sales of crops and livestock constitute the highest proportion of household income in all the IP sites implying that the households are highly dependent on agriculture for their livelihood. There was no significant difference ($P < 0.05$) in the number of households below the estimated poverty line in all the treatments however, the poverty gap index was highest for the IAR4D sites and least for some R & D sites; Results of the Tobit analysis explaining the factors determining the intensity of household poverty in the region (regales of village type) shows that eight variables affect household poverty intensity ($P < 0.05$) viz: Household Head Education, Child Dependency Ratio, Household Size, Farm Income, Household Production Enterprise Portfolio, Non Farm Income, Household total farm area and Extension Contact. According to the results obtained from the elasticity coefficients, the important factors that reduce household poverty intensity in the study area were farm income ($P < 0.05$), household total farm area ($P < 0.10$) and non-farm income in order of importance ($P < 0.10$). Factors that significantly increase poverty intensity were household size and child dependency ratio ($P < 0.05$). The results thus imply that given that IAR4D is designed to act directly on farm income through adoption of sustainable agricultural technologies, taskforce interventions are likely to contribute to reduction of poverty in the area.

Keywords: IAR4D, household, livelihood strategies, poverty, Tobit

135. Household welfare impacts of an agricultural innovation platform in Uganda

Ahimbisibwe, B. P., Morton, J. F., Feleke, S., Alene, A., Abdoulaye, T., Wellard, K., Mungatana, E., Bua, A., Asfaw, S., & Manyong, V. (2020). Household welfare impacts of an agricultural innovation platform in Uganda. *Food and Energy Security*, 9(3). <https://doi.org/10.1002/fes3.225>

Technical approaches to food production are important to the food security of growing populations in developing countries. However, strategic investments in research and farm-level adoption require greater coherence in agricultural, societal, and local policies. The Agricultural Innovation System (AIS) and formation of the Cassava Innovation Platform (CIP) in Uganda were designed to stimulate interactions between researchers and farmers, leading to the development of improved cassava varieties through participatory plant breeding (PPB) and participatory variety selection (PVS). Moreover, the establishment of a community-based commercialized seed system called Cassava Seed Entrepreneurship (CSE) has made an important contribution to the rapid multiplication and dissemination of clean planting materials in Uganda. The impact of CIP participation on rural household welfare was measured by household consumption expenditure per capita. The Endogenous Switching Regression (ESR) model was applied to data from a formal household survey conducted in the eastern, northern, and mid-western regions of Uganda. The education, farm size, livestock size, access to credit, cost of cassava planting materials, access to extension service, access to training, and social group membership are significantly associated with CIP participation. CIP participation resulted in a 47.4% increase in household consumption expenditure. This important evidence highlights the need to promote agricultural innovation platform for improving rural livelihoods. Moreover, CIP participation has impact heterogeneity within the participant group that is conditional on household characteristics such as the gender of the household head, pointing to the need to tailor specific interventions and target specific groups within farm households.

Keywords: agricultural innovation systems, innovation platform, participation, rural household welfare, Uganda

136. How to enhance the sustainability and inclusiveness of smallholder aquaculture production systems in Zambia?

Avadí, A., Cole, S. M., Kruijssen, F., Dabat, M.-H., & Mungule, C. M. (2022). How to enhance the sustainability and inclusiveness of smallholder aquaculture production systems in Zambia? *Aquaculture*, 547, 737494. <https://doi.org/10.1016/j.aquaculture.2021.737494>

Fish is a key source of income, food, and nutrition in Zambia, although unlike in the past, capture fisheries no longer meet the national demand for fish. Supply shortfalls created an opportunity to develop the aquaculture sector in Zambia, which is now one of the largest producers of farmed fish (*Tilapia* spp.) on the continent. In its present form, the aquaculture sector exhibits a dichotomy. It comprises, on the one hand, a smallholder sector that mainly produces for and supplies within local markets, and on the other hand, a burgeoning larger-scale commercial sector consisting of a small number of pioneering lead firms who are (re)

shaping how the value chain supplies domestic, mainly urban, markets. A notable challenge confronting the development of the aquaculture value chain in Zambia is ensuring that the larger-scale commercial sector can continue to grow and generate economic benefits for the country, while simultaneously safeguarding inclusive and sustainable growth of smallholder production systems. An in-depth, mixed-methods aquaculture value chain study was carried out in Zambia in 2017 that aimed at providing relevant stakeholders with pertinent information on the value chain's contribution to economic growth and its inclusiveness, as well as its social and environmental sustainability aspects. In this article, we present some key findings from the study to shed light on how the sustainability of smallholder production systems could be enhanced while preserving the growth trend of larger producers in an inclusive way. The study found that the value chain is contributing positively toward economic growth in the country. Smallholder farmers classified as "semi-subsistence" and "commercial" face several albeit somewhat different constraints to production, thus influencing their "sustainability" status. Semi-subsistence smallholders achieve positive (yet negligible) profit margins, and their production system is not environmentally sustainable and the value chain that supports them performs sub-optimally on several social markers. The "commercial" smallholder system is more economically viable and environmentally sustainable. The study juxtaposes these findings with those from the analysis of larger pond and cage-based systems to point to a set of key options Government, research, and development organizations could consider to support smallholder farmers and enhance the sustainability of the semi-subsistence smallholder production system in particular, without overlooking the whole system.

Keywords: cages, ponds, smallholder, *Tilapia*, value chain

137. Identification of factors that influence technical efficiency of food crop production in West Africa

Amaza, P., Bila, Y., & Iheanacho, A. (2006). Identification of factors that influence technical efficiency of food crop production in West Africa. *Journal of Agriculture in the Tropics and Subtropics*, 107, 137–145. www.jarts.info/index.php/jarts/article/view/128

The objective of this study was to examine the determinants of food crop production and technical efficiency in the guinea savannas of Borno State, Nigeria. A stochastic frontier production function, using the maximum likelihood estimation (MLE) technique was applied in the analysis of data collected from 1086 sample farmers in 2004. The MLE results reveal that farm size; fertilizer and hired labor are the major factors that are associated with changes in the output of food crops. The effect of land area on output is positive and the coefficient found to be significant ($p = 0.01$). Fertilizer and hired labor have positive effects on output and their coefficients are significant ($p = 0.01$). Mean farmers' technical efficiency index was found to be 0.68. Farmer-specific efficiency factors, which comprise age, education, credit, extension and crop diversification, were found to be the significant factors that account for the observed variation in efficiency among the farmers. The implication of the study is that technical efficiency in food crop production could be increased by 32% through better use of available resources, given the current state of technology.

Keywords: stochastic frontier, productivity, technical efficiency, food crops, farmers, Nigeria

138. Identifying determinants, pressures and trade-offs of crop residue use in mixed smallholder farms in Sub-Saharan Africa and South Asia.

Valbuena, D., Homann-Kee Tui, S., Erenstein, O., Teufel, N., Duncan, A., Abdoulaye, T., Swain, B., Mekonnen, K., Germaine, I., & Gérard, B. (2014). *Agricultural Systems*, 134, 107–118. <https://doi.org/10.1016/j.agsy.2014.05.013>

Crop residues (CR) have become a limited resource in mixed crop-livestock farms. As a result of the increasing demand and low availability of alternative resources, CR became an essential resource for household activities, especially for livestock keeping, a major livelihood element of smallholder farmers in the developing world. Farmers' decisions on CR use are determined by farmers' preferences, total crop production, availability of alternative resources and demand for CR. Interaction of these determinants can result in pressures and trade-offs of CR use. Determinants, pressures and trade-offs are shaped by the specific socioeconomic and agro-ecological context of these mixed farms. The objective of this paper is to provide a comparative analysis of the determinants of CR use and to examine some options to cope with pressures and trade-offs in 12 study sites across Sub-Saharan Africa and South Asia. Drawing on socioeconomic data at household and village level, we describe how cereal intensification and livestock feed demand influence use, pressures and trade-offs of CR use across study sites, specifically cereal residue. Our results show that in low cereal production and livestock feed demand sites, despite a low demand for CR and availability of alternative biomass, pressures and trade-offs of CR use are common particularly in the dry season. In sites with moderate cereal production, and low–moderate and moderate livestock feed demand, alternative biomass resources are scarce and most residues are fed to livestock or used to cover household needs. Subsequently, pressures and potential trade-offs are stronger. In sites with low cereal production and high livestock feed demand, pressures and trade-offs depend on the availability of better feed resources. Finally, sites with high cereal production and high livestock feed demand have been able to fulfill most of the demand for CR, limiting pressures and trade-offs. These patterns show that agricultural intensification, better management of communal resources and off-farm activities are plausible development pathways to overcome pressures and trade-offs of CR use. Although technologies can largely improve these trends, research and development should revisit past initiatives so as to develop innovative approaches to tackle the well-known problem of low agricultural production in many smallholder mixed systems, creating more sustainable futures.

Keywords: intensification, intensity, crop-livestock farms, biomass, sustainable intensification, conservation agriculture

139. IITA's genebank, cowpea diversity on farms, and farmers' welfare in Nigeria

Kouakou, A.-G., Ogundapo, A., Smale, M., Jamora, N., Manda, J., & Abberton, M. (2022). IITA's genebank, cowpea diversity on farms, and farmers' welfare in Nigeria. *CABI Agriculture and Bioscience*, 3(1), 14. <https://doi.org/10.1186/s43170-022-00083-w>

Cowpea or black-eyed pea (*Vigna unguiculata* L.) is one of the preferred food crops in Nigeria, as expressed in land area and production. The popularity of the crop is in part related to the successful development and adoption of improved cowpea varieties. Although the genebank of

the International Institute of Tropical Agriculture (IITA) has contributed to cowpea conservation and improvement efforts by breeding programs internationally and in Nigeria, few studies have attempted to link the genebank to the management of cowpea genetic resources (CGRs) on farms. This study explores the linkage between IITA's genebank and cowpea variety diversity on farms and other measures of farmers' welfare in Nigeria.

Methods: A multistage stratified sampling was used to select the sample households. A cross-sectional household survey was conducted to collect data from 1524 cowpea-producing households. In addition, "Helium", a multi-platform pedigree visualization tool with phenotype display was used to gather information about improved cowpea breeding lines and their pedigrees. For data analysis, ecological indices of spatial diversity were employed, and a conditional recursive mixed-process model and a multinomial endogenous treatment effect model were developed.

Results: We found that growing an improved variety with genebank ancestry is not significantly associated with lower spatial diversity among cowpea varieties. While they may introduce new traits through ancestry, improved varieties do not displace other cowpea varieties or landraces. We also found that genebank ancestry is positively and significantly associated with cowpea yield and farmers' welfare.

Conclusions: These findings show additional benefits from IITA's genebank in Nigeria and that adoption of improved varieties with genebank ancestry does not contribute to the erosion of CGRs on smallholder farms in Nigeria. Policymakers and practitioners should consider these findings when analyzing the benefits of conserving crop genetic diversity in genebanks and on farms.

Keywords: genebank, on-farm cowpea diversity, farmers' welfare, Nigeria

140. Imazapyr-resistant maize technology adoption for witch weed control in West Kenya

Mignouna, D., Mutabazi, K. D, Senkondo, E, & Manyong, V. (2011). Imazapyr-resistant maize technology adoption for witch weed control in West Kenya. *African Crop Science Journal*, 19(3), 187–196. www.ajol.info/index.php/acsj/article/view/74163

Witch weed (*Striga* genus) is a major constraint to cereal production in sub-Saharan Africa. A new technology known as imazapyr-resistant maize (IRM) has proven to be effective in controlling it. This study examined the status of IRM adoption in western Kenya. A cross sectional survey that included 600 households, of which 169 were IRM adopters and 431 were non-adopters, was conducted in Nyanza and Western Provinces of Kenya. There was a considerable difference in IRM use according to location. The adoption rate was 28% of the targeted farming population. The performance difference in adoption between the intervention and non-intervention areas was in the range of 25%. Initiating a cluster-based approach to enhance information flow and increasing stakeholders' interaction and involvement within the farmers' clusters can help potential adopters to make more informed decisions by protecting maize (*Zea mays* L.) crop in western Kenya from *Striga*.

Keywords: adopters, *Zea mays*

141. Impact of access to credit on agricultural productivity: Evidence from smallholder cassava farmers in Nigeria

Awotide, B. A., Abdoulaye, T., Alene, A., & Manyong, V. M. (eds) (2015). Impact of access to credit on agricultural productivity: Evidence from smallholder cassava farmers in Nigeria. Presented at International Association of Agricultural Economists Conference, August 9–14, 2015, Milan, Italy, 34. <http://dx.doi.org/10.22004/ag.econ.210969>

This study examines the impact of access to credit on agricultural productivity in Nigeria using the Endogenous Switching Regression Model (ESRM). The first stage of the ESRM reveals that total livestock unit and farm size are positive and statistically significant in determining the farmers' access to credit. The second stage reveals that total livestock unit and farm size are negative and statistically significant in explaining the variations in cassava productivity among the farmers that have access to credit, while household size, farm size, and access to information assets are negative and statistically significant in explaining the variation in cassava productivity among the farmers without access to credit. Access to credit has a significant positive impact on cassava productivity. Thus, credit institutions should consider boosting their credit services to rural farming households in order to guarantee that more households benefit from it.

Keywords: credit, impact, cassava, productivity, farmers, Nigeria

142. Impact of agricultural technology adoption on asset ownership: the case of improved cassava varieties in Nigeria

Awotide, B, Alene, A., Abdoulaye, T., & Manyong, V. (2015). Impact of agricultural technology adoption on asset ownership: the case of improved cassava varieties in Nigeria. *Food Security*, 7(6), 1239–1258. <https://doi.org/10.1007/s12571-015-0500-7>

Using household survey data from a sample of about 850 households selected from six States in south-west Nigeria, this paper analyzes the effects of the adoption of improved cassava varieties (ICVs) on asset ownership among smallholder farmers. The results of the linear regression with endogenous treatment effects showed that adoption of ICVs is positively related to asset ownership. The results further showed that ICVs had greater impact on asset ownership among female-headed households. The impact analysis using propensity score matching (PSM) showed a significant and positive effect of adoption of ICVs on asset ownership and a negative effect on asset poverty. The empirical results suggest that improved agricultural technologies can play a key role in strengthening asset ownership of smallholder farmers for increased agricultural productivity and income generation.

Keywords: adoption, assets, poverty, impact, PSM, farmer, cassava, Nigeria

143. Impact of IITA improved germplasm on maize production in West and Central Africa

Manyong, V. M., Kling, J., Makinde, K., Ajala, S., & Menkir, A. (2000). *Impact of IITA improved germplasm on maize production in West and Central Africa*. Ibadan, Nigeria: International Institute of Tropical Agriculture. <https://cgspace.cgiar.org/handle/10568/92686>

The International Institute of Tropical Agriculture (IITA) is among the major suppliers of genetic materials to national agricultural research and extension systems in West and Central Africa for the development of improved maize varieties. This paper presents the results of a survey of the impact of germplasm from IITA on maize production and food security in 11 countries, which together contain over 90% of the area cultivated to maize in West and Central Africa. Between 1965 and 1998, the public sectors of these countries released a total of 186 varieties while the private sectors released 86 varieties. In the 1990s, IITA was the major source of maize germplasm used by these countries. Increased maize production from improved varieties was 2.6 million tonnes of grain in 1998, which could provide 2200 kcal per person per day to about 9.3 million people for one year. A total of 490 scientists were trained by IITA in maize research between 1970 and 1998.

Keywords: maize production, germplasm, inbred lines, food security, weevil, *Striga*-resistant, maize varieties

144. Impact of improved maize varieties on food security in eastern Zambia: A doubly robust analysis

Manda, J., Gardebroeck, C., Kuntashula, E., & Alene, A. (2018). Impact of improved maize varieties on food security in eastern Zambia: A doubly robust analysis. *Review of Development Economics*, 22(4), 1709–1728. <https://doi.org/10.1111/rode.12516>

This study investigates the impact of improved maize varieties on household food security in eastern Zambia using household survey data from a sample of over 800 rural households. Since treatment effect estimates are often prone to misspecification in either the treatment or outcome equation, we use the doubly robust inverse probability weighted regression adjustment method, complemented with propensity score matching on six different food security measures to obtain reliable impact estimates. Generally, we find a positive impact of improved maize adoption on food security across the two econometric approaches. Maize being the most important food staple in Zambia has a great bearing on the food security status of farm households. It is therefore imperative that a conducive environment is created that promotes the adoption of maize yield improving technologies.

Keywords: improved maize varieties, propensity score matching, adoption, food security, Zambia

145. Impact of irrigation technology use on crop yield, crop income and household food security in Nigeria: A treatment effect approach

Ogunniyi, A, Omonona, B. T, Abioye, O., & Olagunju, K. (2018). Impact of irrigation technology use on crop yield, crop income and household food security in Nigeria: A treatment effect approach. *AIMS Agriculture and Food*, 3(2), 154–171. <https://doi.org/10.3934/agrfood.2018.2.154>

Using household survey data from a sample of about 2305 households selected from eighteen states in Nigeria, this paper analyzes the impact of irrigation technology usage on crop yield, crop income and household food security in Nigeria among smallholder farmers. The logistic regression estimate revealed that years of education, household size, rainfall information, access to credit, regional dummies are the main drivers of usage decision. The results of the linear regression with endogenous treatment effects showed that irrigation technology use is positively related to crop yield, crop income and household food security. In consistence, the impact analysis using propensity score matching (PSM) also showed a significant and positive effect of irrigation technology use on crop yield, crop income and household food security. We suggest to policy makers, implementers, and any funding agencies with similar interest to further capitalize and scale up the irrigation technology facilities, especially for the poor households, and create more awareness to improve the livelihood of rural households. However, despite the positive impact of irrigation technology use, we contend that other sustainable irrigation sources, such as rainwater harvesting should be used due to possible environmental impact in the excessive use of irrigation technology. Moreover, rained agriculture can be improved with other farming techniques such as agroforestry and soil and water conservation practices.

Keywords: irrigation, food security, crop yield, treatment effect approach

146. Impact of mobile-based extension service on wheat yield among rural farmers of Settat Province, Morocco

Karen, A., Azhari, M. E., Laamari, A., Martin, J., Hattab, S., Bomba, Z., & Abdoulaye, T. (2021). Impact of mobile-based extension service on wheat yield among rural farmers of Settat Province, Morocco. *International Journal of Financial Accountability, Economics, Management, and Auditing*, 3(5), 918–935. <https://doi.org/10.52502/ijfaema.v3i5.150>

Despite the undeniable advantages of innovative agricultural production technology, their adoption rate in Morocco is relatively low. In addition to research institutes and private institutions, agricultural information is provided by extension agents who are limited in terms of financial and logistical resources. In this study, we examine, on the one hand, the factors influencing the adoption of mobile phones to access extension services. On the other, we measure the impact of this adoption on wheat production and farmers' income in the province of Settat (Morocco). In this study we use data collected through a survey of 130 farmers from the province of Settat (Morocco). As analysis methods, we use stratified sampling, descriptive statistics, and the propensity score matching model. The results revealed that farmers who use their mobile phones for extension purposes have slightly higher wheat production than those who do not. The developed model showed that the adoption of mobile phone-based extension services is influenced by farmer's age, educational level, primary source of income, the use of inorganic fertilizers, access to credit and the availability of road infrastructure. The study is a contribution to the efforts of various national stakeholders who have launched a national strategy focused on the digitalisation of extension services.

Keywords: adoption, extension services, wheat production, propensity score matching, mobile phones

147. Impact of packaging material and storage condition on retention of provitamin A carotenoids and xanthophylls in yellow-seeded maize flour

Awoyale, W., Alamu, E. O., Irondi, E. A, Maziya-Dixon, B., & Menkir, A. (2018). Impact of packaging material and storage condition on retention of provitamin A carotenoids and xanthophylls in yellow-seeded maize flour. *Functional Foods in Health and Disease*, 8(10), 462–477. <https://doi.org/10.31989/ffhd.v8i10.535>

Background: Pro-vitamin A carotenoid (pVAC) rich foods are those foods that contain substance which can be converted within the human body into retinol. These foods also contribute to the reduction of vitamin A deficiency diseases. Yellow-seeded maize flour is a pVAC rich food. Identifying the right packaging materials and storage conditions that retain pVAC in this food is essential for their health benefits. Traditionally, maize flour is stored with different packaging materials to increase its shelf life. For example, previous studies have shown how during storage in different food matrices, carotenoids, including maize grains, are highly susceptible to degradation by temperature, light, and oxygen. Therefore, in this study we investigated the effect of storage packaging materials (polypropylene woven sacks-PWS, high-density polyethylene bags-HDPE, and polyvinyl plastic containers-PPC) and storage condition (temperature and relative humidity) on retaining pVAC in yellow-seed maize flour.

Methods: The yellow-seeded maize grains were collected and ground into flour. The maize flour was divided into portions (200 g). Each portion was packed and sealed in PWS, HDPE, and PPC. The control samples (12 pieces) were stored on top of the storage box. The packed samples were stored in both the upper (12 samples) and lower (12 samples) compartment of a storage wooden box. The interior of the upper part was lightened with aluminum foil and fitted with fluorescent tube to increase the light intensity. The lower compartment was darkened with gloss black painting. The flour samples were stored for 28 days. Samples were collected for pVAC and xanthophylls analyses at 7 day intervals using standard methods.

Results: The results demonstrated how packaging in PPC and storing in a dark compartment resulted in the highest total pVAC (92.39%) and total xanthophylls (89.44%) retention and retinol equivalent (RE) (0.40 µg/g). In contrast, packaging in HDPE and storing in lighted compartment resulted in the lowest pVAC (44.92%) and total xanthophylls (46.76%) retention and RE (0.19 µg/g).

Conclusions: Packaging yellow-seeded maize flour in PPC and storing in the dark may be recommended for maximum retention of carotenoids in yellow-seeded maize flour since, as the packaging material and storage condition resulted in the highest pVAC retention and retinol equivalent.

Keywords: yellow-seeded maize, carotenoids, packaging materials, storage conditions, retinol equivalent

148. Impact of promoting sustainable agriculture in Borno (PROSAB) program on adoption of improved crop varieties in Borno State of Nigeria

Bamire, A. S., Abdoulaye, T., Amaza, P., Tegbaru, A., Alene, A., & Kamara, A. (2010). Impact of promoting sustainable agriculture in Borno (PROSAB) program on adoption of improved crop varieties in Borno State of Nigeria. *Journal of Food, Agriculture and Environment*, 8(3/4), 391–398. www.researchgate.net/publication/286316274

This paper evaluates the impact of the intervention of Promoting Sustainable Agriculture in Borno (PROSAB) project on the livelihoods of farming households in Borno State, Nigeria. Specifically, the paper identifies and provides information on farmers' adoption of improved crop varieties introduced by PROSAB; measures their adoption rates, and analyzes the factors that affect the probability and intensity of adoption of the crop varieties. A multi-stage sampling procedure was used to select respondents in three agroecological zones (AEZs) – the northern Guinea savanna (NGS), southern Guinea savanna (SGS), and the Sahelian savanna (SS), and a structured questionnaire was used to collect data on their socioeconomic characteristics and adoption parameters in the 2009 period. Data were analyzed using descriptive statistics and the Tobit regression techniques. The paper demonstrates how adoption and use decisions were significantly influenced by education, membership in associations, and yield in the NGS; yield and labor in the SGS, and age and labor in the SS, implying that these variables, and particularly yield, are important for consideration by development agencies who are interested in improving agricultural production and the livelihoods of the people.

Keywords: impact, adoption, improved crop varieties, agroecologies, farming households, livelihoods, PROSAB, Tobit regression

149. Impact of soil fertility management practices on the nutritional quality of soybean (*Glycine max* (L.) Merr.) varieties grown in eastern Zambia

Alamu, E. O., Gondwe, T., Akinwale, M. G., Suzuki, K., Chisonga, C., Chigeza, G., & Maziya-Dixon, B. (2019). Impact of soil fertility management practices on the nutritional quality of soybean (*Glycine max* (L.) Merr.) varieties grown in eastern Zambia. *Cogent Food & Agriculture*, 5, 1–13. <https://doi.org/10.1080/23311932.2019.1671117>

Zambia has three primary agro-ecological regions, with each region having specific ecological characteristics. Region II agro-ecological zone of Zambia has low nutrient reserves and poor water holding capacity due to moderately leached clayey to loamy soil; this has led to low soybean productivity. Soil fertility management (ISFM) strategies such as the use of inorganic fertilizers and the use of inoculants of rhizobia have been introduced and promoted among small-scale farmers in Eastern Province. Two soybean varieties (Lukanga and Kafue) were used for this study and 96 samples from on-farm soil fertility management trials in Chipata, and Petauke districts were collected for the determinations of nutritional and anti-nutritional properties. The proximate analysis of Chipata samples showed that the ash content 5.10–6.23%, fat content 17.71–25.57%, protein content 27.73–37.11%, amylose content 1.26–4.56 %, sugar content 6.75–9.62%, and starch content 4.00–18.57%, while anti-nutritional properties

ranged between 3.07 and 8.21% for phytate and 1.42–3.35% for tannin. With Petauke, the ash content 3.32–6.8 %, fat content 19.16–26.85%, protein content 27.68–35.62%, amylose 2.00–4.37%, sugar content 6.23–9.76%, and starch content 5.70–18.63%. Phytate and tannin contents were 3.37–7.90% and 0.14–3.32%, respectively. The highest protein content was found at the level of 37.11% in Kafue with 40kg P/ha and inoculant, and the least was 27.73% for Lukanga without inputs in Chipata while in Petauke, Lukanga with 40 P/ha and inoculant had the highest protein content of 35.62% and the least was 27.68% for Lukanga with inoculant. The co-application of rhizobia inoculant and P nutrient increased phytate, and tannin content significantly ($P < 0.05$).

Keywords: soil fertility, inoculants, phosphorous fertilizer, physiochemical properties, anti-nutritional properties

150. Impacts of balanced nutrient management systems technologies in the northern Guinea savanna of Nigeria

Akinola, A. A, Alene, A., Adeyemo, R, Sanogo, D., & Olanrewaju, A. (2009b). Impacts of balanced nutrient management systems technologies in the northern Guinea savanna of Nigeria. *Journal of Food, Agriculture and Environment*, 7(2), 496–504. www.researchgate.net/publication/47416605

As part of a major effort to address soil fertility decline in West Africa, a project on balanced nutrient management systems (BNMS) has been implemented in the northern Guinea savanna (NGS) of Nigeria. The project has tested and promoted two major technology packages: a combined application of inorganic fertilizer and manure (BNMS-manure) and a soybean/maize rotation practice (BNMS-rotation). This study used two-stage least squares regression models to examine the socioeconomic impacts of the BNMS technologies on household incomes and food security of the adopting farmers. Results showed that average crop yields for maize, sorghum, and soybean increased by more than 200% in the villages covered by the project. Among the adopters, the gross margin per ha from maize production was highest for the adopters of BNMS-rotation and lowest for adopters using inorganic fertilizer only. The two-stage least squares regression estimates indicated that increases in farm income due to adoption of BNMS technologies led to an increase of both calorie and protein intake of adopters. An additional one ha of land under BNMS-manure stimulates an increase in food expenditure by about 52%, while a similar change in land area under BNMS-rotation increases food expenditure by 128%.

Keywords: BNMS-manure, BNMS-rotation, northern Guinea savanna, Nigeria, West Africa

151. Impacts of climate variability and food price volatility on household income and food security of farm households in East and West Africa

Assfaw Wossen, T., Berger, T., Haile, M. G., & Troost, C. (2017). Impacts of climate variability and food price volatility on household income and food security of farm households in East and West Africa. *Agricultural Systems*, 163, 7–15. <https://doi.org/10.1016/j.agsy.2017.02.006>

This paper provides an ex-ante assessment of the impacts of climate and price variability on household income and food security in Ethiopia and Ghana. The study applies an agent-based modelling approach to highlight the role of coping and adaptation strategies under climate and price variability. Our simulation results show that climate and price variability adversely affects income and food security of households in both countries. Self-coping mechanisms are found to be important but insufficient to mitigate the adverse effects of variability, implying the need for policy interventions. Adaptation strategies composed of a portfolio of actions such as the provision of production credit and access to improved seeds are found to be effective in reducing the impacts of climate and price variability in Ethiopia. Similarly, policy interventions aimed at improving the provision of short-term production credit along with the existing irrigation facilities are important in Ghana. Finally, this study highlights the importance of capturing the distributional aspects of adaptation options by highlighting heterogeneous effects of variability and adaptation options.

Keywords: climate variability, food price volatility, food security, simulation, adaptation, Ethiopia, Ghana.

152. Impacts of extension access and cooperative membership on technology adoption and household welfare

Assfaw Wossen, T., Abdoulaye, T., Alene, A., Haile, M. G., Feleke, S., Olanrewaju, A., & Manyong, V. (2017). Impacts of extension access and cooperative membership on technology adoption and household welfare. *Journal of Rural Studies*, 54, 223–233. <https://doi.org/10.1016/j.jrurstud.2017.06.022>

This paper examines the impacts of access to extension services and cooperative membership on technology adoption, asset ownership and poverty using household-level data from rural Nigeria. Using different matching techniques and endogenous switching regression approach, we find that both extension access and cooperative membership have a positive and statistically significant effect on technology adoption and household welfare. Moreover, we find that both extension access and cooperative membership have heterogeneous impacts. In particular, we find evidence of a positive selection as the average treatment effects of extension access and cooperative membership are higher for farmers with the highest propensity to access extension and cooperative services. The impact of extension services on poverty reduction and of cooperatives on technology adoption is significantly stronger for smallholders with access to formal credit than for those without access. This implies that expanding rural financial markets can maximize the potential positive impacts of extension and cooperative services on farmers' productivity and welfare.

Keywords: impact evaluation, extension access, cooperatives, adoption, welfare, Nigeria

153. Impacts of improved maize varieties in Nigeria: ex-post assessment of productivity and welfare outcomes

Abdoulaye, T., Assfaw Wossen, T., & Awotide, B. (2018). Impacts of improved maize varieties in Nigeria: ex-post assessment of productivity and welfare outcomes. *Food Security*, 10, 369–379. <https://doi.org/10.1007/s12571-018-0772-9>

Investment in agricultural research and development is an important intervention for improving crop productivity and household welfare in most developing countries where agriculture is the main source of livelihoods. This paper uses nationally representative plot- and household-level data from the major maize producing regions of Nigeria to assess the impacts of adoption of improved maize varieties on maize yield and household welfare outcomes. The paper employed an endogenous switching regression approach to control for both observed and unobserved sources of heterogeneity between adopters and non-adopters. Adoption of improved maize varieties increased maize grain yield by 574 kg/ha and per-capita total expenditure by US\$ 77 (US\$ 0.21/day). We found that the incidence of poverty among adopters would have been higher by 6% without adoption of the improved varieties. These findings underscore that investments and policy measures to increase and sustain the adoption of improved maize cultivars are critical for improving the productivity of maize in Nigeria and reducing poverty.

Keywords: adoption, improved maize varieties, Nigeria, productivity, poverty

154. Improved cowpea-cereals-based cropping systems for household food security and poverty reduction in West Africa

Singh, B., & Ajeigbe, H. (2007). Improved cowpea-cereals-based cropping systems for household food security and poverty reduction in West Africa. *Journal of Crop Improvement*, 19(1/2), 157–172. https://doi.org/10.1300/J411v19n01_08

Food production in West Africa has not been keeping pace with the population growth because the bulk of the agriculture in this region is still based on traditional inter-cropping systems with little or no application of fertilizers and chemicals. The average use of fertilizers in West Africa is less than 10 kg/ha/year. This leads to a negative balance of nutrients in the soil and continuous decline in crop yields, which perpetuates malnutrition, hunger and poverty through the vicious circle of 'low input-low production-low income' and food insecurity. How to reverse this trend is one of the major challenges of agricultural research in this region. The International Institute of Tropical Agriculture (IITA), in collaboration with relevant national, regional and international partners, has developed an appropriate model that seems to hold great promise for increasing food production in West Africa without affecting the environment and degrading the soils. This model involves a holistic combination of new, more productive dual purpose and resilient cultivars of cowpea [*Vigna unguiculata* (L.) Walp.], maize (*Zea mays* L.), sorghum [*Sorghum bicolor* (L.) Moench] and millet (*Pennisetum glaucum* and other species) in a strip-cropping pattern with a minimum and selective application of fertilizers and pesticides, feeding of crop residues to small ruminants in permanent enclosures on the home compound and returning of manure to the field. Based on this model, two 'best bet' options have become popular with farmers in northern Nigeria. These are: (1) an improved strip-cropping system involving two rows of a densely planted, improved sorghum variety: four rows of a densely planted, improved medium-maturity cowpea variety in the Sudan savanna where the rainfall is about 600 mm and (2) an improved strip-cropping system involving two rows of a densely planted, improved maize variety: four rows of densely planted double cropping of an improved 60-day cowpea in the northern Guinea savanna where the rainfall is about

1000 mm. The two-third cowpea and one-third cereal combination minimizes fertilizer use and maximizes profit because of the higher prices of cowpea grain and fodder and at the same time it leaves positive residual soil nitrogen balance and reduces *Striga hermonthica* seed bank, both of which benefit the cereal crops. This combination is also appropriate in view of the global surplus of cereals and global deficit of legumes. The on-station and on-farm evaluation of these systems covering several states and more than 2000 farmers in northern Nigeria, with the financial support from USAID, Gatsby Foundation and DFID, has shown over 300% increase in productivity, enhanced income generation and improved livelihoods of the farm families.

Keywords: cowpea, cereals, intercropping, planting pattern, strip-cropping.

155. Improved cropping systems for higher productivity in the dry savannas of West Africa

Singh, B., & Ajeigbe, H. (2000). Improved cropping systems for higher productivity in the dry savannas of West Africa. *European Society of Agronomy*, 135. <https://hdl.handle.net/10568/99920>

Most of the farmers in the dry savannas of West Africa plant local varieties of cowpea, millet, sorghum, and groundnut in various intercropping systems with little or no purchased inputs. In this system, the cowpea and groundnut yields are low due to shading by cereals and lack of plant protection measures. The cereal yields are low mainly due to lack of fertilizer. Efforts are being made, therefore, to develop a combination of improved varieties and improved cropping systems for higher productivity and profitability with a minimum use of insecticides and fertilizers. We evaluated four cereal-cowpea intercropping row arrangements involving cereals: one cowpea, one cereal: four cowpea, two cereal: four cowpea intercrops, and sole crops of improved and local varieties of millet, cowpea, and sorghum with selective application of two sprays of insecticides on cowpea only and 100 kg/ha fertilizer (N.P.K. 15:15:15) basal and 20 kg N/ha top-dressed to cereals only. The results indicated sole crop improved cowpea to be most profitable followed by the two cereals: four cowpea intercrop system. Farmer participatory evaluation of the improved intercrop system involving two rows of sorghum: four rows of improved cowpea with inputs as indicated above, gave 100 to 300% gross economic superiority over the traditional intercropping systems. Smallholder farmers prefer the improved intercropping system over sole crops because it provides them with sufficient sorghum and cowpea for home use and additional cowpea for cash income.

Keywords: farmers, cereals, intercropping, yields, fertilizers

156. Improving the speed of adoption of agricultural technologies and farm performance through farmer groups: evidence from the Great Lakes Region of Africa

Ainembabazi, J. H., Van Asten, P., Vanlauwe, B., Ouma, E., Blomme, G., Birachi, E., Dontsop-Nguezet, P., Mignouna, D., & Manyong, V. (2016). Improving the speed of adoption of agricultural

technologies and farm performance through farmer groups: evidence from the Great Lakes Region of Africa. *Agricultural Economics*, 48, 1–19. <https://doi.org/10.1111/agec.12329>

The article examines the effect of membership in farmer groups (MFG) on adoption lag of agricultural technologies and farm performance in Burundi, the Democratic Republic of Congo and Rwanda. We use duration and stochastic production frontier models on farm household data. We find that the longer the duration of MFG, the shorter the adoption lag and much more so if combined with extension service delivery. Farmer groups function as an important mechanism for improving farm productivity through reduced technical inefficiency in input use. We discuss policy implications under which farmer groups are a useful channel to reduce adoption lag, and the means through which improved farm performance can be achieved.

157. Influence of nitrogen fertilization on the performance of early and late maturing maize varieties under natural infestation with *Striga hermonthica* (Del.) Benth

Kamara, A., Ekeleme, F., Omoigui, L., Menkir, A., Chikoye, D., Dugje, I, Abdoulaye, T., & Amaza, P. (2009). Influence of nitrogen fertilization on the performance of early and late maturing maize varieties under natural infestation with *Striga hermonthica* (Del.) Benth. *Archives of Agronomy and Soil Science*, 55(2), 125–145. [10.1080/03650340802342284](https://doi.org/10.1080/03650340802342284)

Field studies were conducted in northeast Nigeria to evaluate the response of early and late-maturing maize varieties infested with natural populations of *Striga* to different rates of nitrogen (N) fertilizer. There were significant reductions in the number of emerged *Striga* at 120 kg N ha⁻¹ for the early varieties and at 60 and 120 kg N ha⁻¹ for the late varieties. The number of emerged *Striga* only significantly differed among the late varieties. Averaged across varieties, grain yield of the early varieties was 144% higher at 60 kg N ha⁻¹ and 192% higher at 120 kg N ha⁻¹ than without added N. For the late varieties the increase in grain yield was 85% higher at 60 kg N ha⁻¹ and 144% higher at 120 kg N ha⁻¹ than without added N. Among the early varieties, TZE COMP4 C3 had significantly lower grain yield than the other varieties. Among the late varieties, grain yields of 8338-1-1 and TZB-SR were significantly lower than in the other varieties. Our results show that the application of 60–120 kg N/ha to *Striga* resistant or tolerant varieties may reduce damage and increase grain yield. Higher economic rates of return was obtained at N rates of 60–120 kg N/ha than the other rates.

Keywords: maize varieties, *Striga* emergence, nitrogen fertilization, grain yield

158. Is Africa “ready” for an integrated bioeconomy approach?

Abass, A. (2014). Is Africa “ready” for an integrated bioeconomy approach? *Rural 21*, 48(3), 32–33. https://www.rural21.com/fileadmin/downloads/2014/en-03/Rural21_3_2014.pdf

With its abundance of natural resources, Africa appears to be predestined for a type of economy that centers on the use of bio-based resources. However, before a comprehensive approach can be applied, a large number of framework conditions and policies will have to change, Adebayo Abass maintains.

Keywords: food security

159. Land tenurial systems and the adoption of *Mucuna* planted fallow in the derived savannas of West Africa

Manyong, V., & A. Victorin, H. (2000). *Land tenurial systems and the adoption of *Mucuna* planted fallow in the derived savannas of West Africa*. CAPRI Working Papers 4. Washington, DC: CGIAR System-wide Program on Property Rights and Collective Action, International Food Policy Research Institute. www.researchgate.net/publication/5057172

In 1987, an improved resource management system that incorporates velvet bean (*Mucuna pruriens* var. *utilis*) to address soil fertility and weed (*Imperata cylindrica*) infestation was introduced to the small-scale farmers in a densely populated area of the derived savannas in Benin Republic (West Africa). Six years later, an adoption study was conducted to assess factors driving the adoption process. Four types of land tenure systems based on mode of access to land were identified: divided inheritance, purchasing, gifts, and sharecropping/renting. The first three provide long-term security over land, and together, they represent about 76 percent of the survey fields. Results from three variants of a probit model indicated that security over land was among the factors that significantly affect the adoption of the technology, with a high marginal effect on the probability of adoption, while gender did not have a significant effect. The most important determinant for adoption is the number of times a field is weeded during a cropping season (a proxy for the amount of labor required to tend a crop for better yields). High weeding requirements favorably affect the adoption of velvet bean only if farmers have full security on the degraded (weedy) land. The predominance of land tenure systems that provide secure property rights, namely the traditional acquisition of land through inheritance or gift mode and the gradual development of a land market, facilitated a quick spread of the *Mucuna* planted fallows in the study region.

160. Manure marketing in the savannas of Nigeria: implications for sustainable food security

Olayide, O., Alene, A., Ikpi, A., & Nziguheba, G. (2009). Manure marketing in the savannas of Nigeria: implications for sustainable food security. *Journal of Food, Agriculture & Environment*, 7(2); 540–545. <https://cgspace.cgiar.org/handle/10568/90194>

Achieving sustainable food security in Nigeria is feasible through organic farming. However, unavailability and resource constraints hamper the adoption of agricultural inputs; hence the market offers opportunity for use of purchased organic inputs. In assessing the importance of the market, the study developed and employed a socio-economic-ecological-modeling (SEEM) framework in its analyses. Using data from a sample of 320 farm households and manure agents, the study aimed at bridging the knowledge gap on the importance, nature, structure and performance of manure market in northern Nigeria. Results show that cereal-legume-based cropping systems accounted for major use of total manure applied on the farm; maize-based cropping systems received the highest amount of the total manure applied. There was asymmetric information flow in the manure market. The market concentration ratios show that none of the manure agents was sufficient in exercising monopoly power in the manure market. The Gini coefficients of the Lorenz curve analyses further showed

considerable degrees of inequalities in the volume of manure marketed by different agents both across the agro-ecological zones and socio-economic domains. Manure marketing was found to be inefficient. Further, manure marketing in the study area is profitable with huge potentials for market development.

Keywords: manure, marketing, socio-economic, self-sufficiency, out-sourcing, geographic information system, Nigeria

161. Maize–legume strip cropping effect on productivity, income, and income risk of farmers in northern Ghana

Abdul Rahman, N., Larbi, A., Kotu, B., Asante, M. O., Akakpo, D. B., Mellon-Bedi, S., & Hoeschle-Zeledon, I. (2021). Maize–legume strip cropping effect on productivity, income, and income risk of farmers in northern Ghana. *Agronomy Journal*, 113(2), 1574–1585. <https://doi.org/10.1002/agj2.20536>

Maize (*Zea mays* L.)–legume intercropping is common cropping system among smallholder farmers in West Africa. However, little is known about the income risk reduction associated with maize–legume strip cropping in West Africa. A 3-yr study was conducted in Upper West and Northern regions of Ghana to determine the effect of maize–legume strip cropping on productivity, income, and income risk using a randomized complete block design with five replications in each region. Seven treatments were used: sole crops of maize (M) cowpea [*Vigna unguiculata* (L.) Walp.] (C) and groundnut (*Arachis hypogaea* L.) (G), a combination of two rows of M and two rows of legumes (L) (2M:2C and 2M:2G), and two rows of M and four rows of L (2M:4C and 2M:4G). Maize–legume strip cropping options (2M:2L and 2M:4L) on the average saved 90–100% of agricultural land, significantly increased income by about threefold, and reduced risk of operating at a financial loss by 75% compared with sole cropping. Smallholder farmers, especially sole legume cropping farmers in the Guinea savanna of northern Ghana and similar agro-ecologies in West Africa, could adopt maize–legume strip cropping systems (2M:4L or 2M:2L) to mitigate production risk and increase financial return.

162. Measurement and determinants of food insecurity in northeast Nigeria: some empirical policy guidelines

Amaza, P., Adejobi, A. O., & Fregene, T (2008). Measurement and determinants of food insecurity in northeast Nigeria: Some empirical policy guidelines. *Journal of Food, Agriculture and Environment*, 6(2), 92–96. <https://hdl.handle.net/10568/90859>

The objectives of the study were to identify and analyze the food security measures of rural households in Borno State of Nigeria. Using multi-stage sampling techniques, 1,200 households spread across 30 communities located in four Local Government Areas of Borno State were selected through a random sample selection procedure. Cost-of-calories method and Logit model were used as analytical techniques for the study. Based on the recommended daily energy levels of 2250 kcal, a food insecurity line of N23,700.12 or US \$176.87 per adult

equivalent per year was obtained for the households. Over 58% of the sample households are therefore food insecure. The logit analysis revealed that the major determinants of food insecurity in the study area are household size, gender, educational level, farm size and type of household farm enterprise. A large household size was observed to affect household food insecurity. Therefore, the government should give adequate priority and attention to policy measures directed toward the provision of better family planning. In addition, there is the need for a policy to promote formal education at little or no cost as a means of enhancing efficiency in food crop production over the long-term period. In the short term, informal education could be effective, especially when targeted at farmers who have had limited formal educational opportunities. Also a policy, which provides adequately trained and equipped extension workers to disseminate improved agricultural technologies, has the potential to raise efficiency in food crop production and so enhance food security.

Keywords: determinants, measures, calorie, food intake, households, food security, food production, consumption, policies

163. Measurement of the sustainability of African smallholder farming systems: case study of a systems approach

Manyong, V., & Degand, J. (1997). Measurement of the sustainability of African smallholder farming systems: case study of a systems approach. *IITA Research*, 14/15, 1–6. <https://biblio1.iita.org/handle/20.500.12478/6430>

Sustainability in agriculture has been and remains a difficult concept to define and measure. Its importance has been recognized for over a decade now in efforts to preserve the resource base on which agriculture depends, while producing adequate food to feed growing populations. This article presents a case study (from the highland areas of Burundi in Central Africa) to show that the systems approach is best utilized when the sustainability of a farming system is measured at the community level of the individual farmer. Such measurements has to account for the socioeconomic and biophysical context in which the farmer operates, and multiple objective mathematical programming models provide an appropriate tool in this context.

Keywords: farming systems, sustainability, measurement, smallholders

164. Measuring the impacts of adaptation strategies to drought stress: The case of drought tolerant maize varieties

Assfaw Wossen, T., Abdoulaye, T., Alene, A., Feleke, S., Menkir, A., & Manyong, V. (2017). Measuring the impacts of adaptation strategies to drought stress: The case of drought tolerant maize varieties. *Journal of Environmental Management*, 203(1), 106–113. <https://doi.org/10.1016/j.jenvman.2017.06.058>

This study measured the impacts of drought tolerant maize varieties (DTMVs) on productivity, welfare, and risk exposure using household and plot-level data from rural Nigeria. The study employed an endogenous switching regression approach to control for both observed and

unobserved sources of heterogeneity between adopters and non-adopters. Our results showed that adoption of DTMVs increased maize yields by 13.3% and reduced the level of variance by 53% and downside risk exposure by 81% among adopters. This suggests that adoption had a “win-win” outcome by increasing maize yields and reducing exposure to drought risk. The gains in productivity and risk reduction due to adoption led to a reduction of 12.9% in the incidence of poverty and of 83.8% in the probability of food scarcity among adopters. The paper concluded that adoption of DTMVs was not just a simple coping strategy against drought but also a productivity enhancing and welfare improving strategy. The results point to the need for policies and programs aimed at enhancing adoption as an adaptation strategy to drought stress in Nigeria and beyond.

Keywords: downside risk, drought tolerant maize varieties, endogenous switching regression, Nigeria, productivity, welfare

165. Mineral fertilizer quality: Implications for markets and small farmers in Tanzania

Fairbairn, A., Michelson, H., Ellison, B., & Manyong, V. (eds) (2016). Mineral fertilizer quality: Implications for markets and small farmers in Tanzania. Presented at the 2016 Agricultural and Applied Economics Association, Boston, MA, July 31–August 2. <https://doi.org/10.22004/ag.econ.236818>

Small farmers in Sub-Saharan Africa exhibit low adoption rates for mineral fertilizers. A promising hypothesis explaining these puzzlingly low rates remains untested: a perception among farmers that fertilizer in the market has been compromised in ways that raise concerns about its effectiveness. Information about fertilizer quality problems is anecdotal rather than backed by reliable evidence. A challenge: little research to date has focused on understanding the relationships between input supply chains and product quality. To achieve a clearer understanding of this problem, this research links results from tests of the quality of 661 samples of fertilizers for sale in the markets of the Morogoro Region of Tanzania with data from a survey of the region’s 225 input dealers. Fertilizer nutrient and moisture content tests are performed on the same samples in multiple laboratories located in East Africa and in the United States. Results from our research provide the first assessments of market-available fertilizer quality in the region, as well as the first analysis of relationships between fertilizer quality and mineral fertilizer supplier characteristics.

Keywords: fertilizer, small farmers, agricultural inputs, Tanzania, East Africa, poverty

166. Mineral fertilizers improve the sensory quality of East African highland bananas (Musa AAA-EA, cv. ‘Kisansa’)

Taulya, G., Van Asten, P., Nowakunda, K.*, & Kaddu-Mukasa, P.* (2010). Mineral fertilizers improve the sensory quality of East African highland bananas (Musa AAA-EA, cv. ‘Kisansa’). *Tree and Forestry Science and Biotechnology*, 4(1), 93–96. www.researchgate.net/publication/241868831

Some farmers in Uganda believe that fertilizers negatively affect the sensory attributes of cooking type bananas. This belief may hamper the adoption of fertilizers. To verify the validity of this belief, bunches (Musa AAA-EA, cv. 'Kisansa') from fertilized (i.e. N-P-K-Mg-Zn-S-B-Mo) and non-fertilized plots were harvested from on-station trials in central (Wakiso) and southwestern (Ntungamo) Uganda. Samples were anonymously tagged for preparation (boiled or steamed) and sensory evaluation by farmers from southwestern (n=33) and central Uganda (n=35). Data were analyzed in STATA using Tau-b rank test for proportions, median ranks and odds ratios. The frequency of evaluators ranking fertilized steamed bananas highly (i.e. 'Best' or 'Second-best') was significantly ($P \leq 0.05$) higher (60%) than for non-fertilized bananas (42%). The opposite was true for boiled bananas (fertilized, 43% vs. non-fertilized, 60%). Irrespective of site of cultivation and evaluators' origin, gender or age, fertilizers significantly ($P \leq 0.05$) improved the appearance, odor, softness and acceptability of steamed bananas. For boiled bananas, attributes did not significantly differ between fertilizer treatments, except for appearance, which was significantly inferior ($P \leq 0.05$) for fertilized bananas. This study shows that the belief that fertilizers negatively affect the sensory attributes of cooking type bananas is generally incorrect. Only when boiled, fertilized bananas appeared less attractive than non-fertilized bananas. The dominant and traditional way of preparing cooking type bananas in Uganda is through steaming (i.e., matooke). We recommend the application of fertilizer, as it will not only positively affect yield, but also the sensory quality of cooking type bananas.

Keywords: matooke, odor, softness, taste, Uganda

167. Misperceived quality: Fertilizer in Tanzania

Michelson, H., Fairbairn, A., Ellison, B., Maertens, A., & Manyong, V. (2021). Misperceived quality: Fertilizer in Tanzania. *Journal of Development Economics*, 148, 102579. <https://doi.org/10.1016/j.jdeveco.2020.102579>

Fertilizer use remains below recommended rates in most of Sub-Saharan Africa, contributing to low crop yields and poverty. We explore the role of fertilizer quality. We interviewed fertilizer sellers in an important agricultural region in Tanzania and sampled their fertilizer to establish that the nutrient content of fertilizers is good, meeting industry standards. However, we find farmers' beliefs to be inconsistent with this reality. Beliefs about adulteration push down farmer willingness-to-pay for fertilizer; with farmers willing to pay more if quality is verified. In addition, we find some evidence of a quality inference problem: many fertilizers have degraded appearance, and farmers appear to rely on these observable attributes to (incorrectly) assess unobservable nutrient content. Market prices reflect neither nutrient content nor degradation in appearance, even in competitive markets. Our results suggest the existence of an equilibrium where farmer beliefs about fertilizer are inconsistent with the truth, and seller incentives to invest to alter beliefs are limited, motivating future research into the origins and persistence of such an equilibrium.

Keywords: farmer beliefs, market failure, technology adoption, asymmetric information, fertilizer, sub-Saharan Africa

168. Misperceiving and misreporting input quality: Implications for input use and productivity

Assfaw Wossen, T., Abay, K. A., & Abdoulaye, T. (2022). Misperceiving and misreporting input quality: Implications for input use and productivity. *Journal of Development Economics*, 157, 102869. <https://doi.org/10.1016/j.jdeveco.2022.102869>

Farmers in developing countries routinely misperceive or misreport input quality for various reasons, which introduces substantial measurement error in farm survey data. In this paper, we motivate and illustrate, both analytically and empirically, the inferential and behavioral implications of misperception and misreporting using a unique crop variety identification data from Nigeria. Using a non-parametric framework for testing the presence of measurement error, we show that crop variety misclassification in our data is mostly driven by misperception. We then demonstrate the inferential challenges of treating misperception as misreporting and vice versa. Finally, we show that misperception induces crowding-in (out) of complementary agricultural inputs but these misperception-driven input allocations may not necessarily be yield-enhancing. As such, rectifying misperception by addressing agricultural input market imperfections may improve farmers' investment choices and productivity outcomes.

Keywords: agricultural inputs, misclassification, misperception, misreporting, Nigeria, smallholders

169. Model results versus farmer realities. Operationalizing diversity within and among smallholder farm systems for a nuanced impact assessment of technology packages

Michalscheck, M., Groot, J. C. J., Kotu, B. H., Hoeschle-Zeledon, I., Kuivanen, K. S., Descheemaeker, K., & Tittonell, P. (2018). Model results versus farmer realities. Operationalizing diversity within and among smallholder farm systems for a nuanced impact assessment of technology packages. *Agricultural Systems*, 162, 164–178. <https://doi.org/10.1016/j.agsy.2018.01.028>

Agricultural production in Northern Ghana is dominated by smallholder farm systems, which are characterized by low inputs and low outputs, declining soil fertility, large yield gaps and limited adoption of agricultural technologies. There is an urgent need for alternative farm designs that are more productive, yet more sustainable. Technology packages for sustainable intensification are promoted by an R4D project in the Upper East, Upper West and Northern Regions of Ghana. In this paper, we analyze differences in perceived suitability, and modelled technical impact per technology package. We used a locally validated framework to categorise farm systems diversity that considers both, the horizontal (between households) and vertical (within households) dimension of diversity. Farm households were classified along a gradient of resource endowment. We selected one representative farm per type and per region to assess and compare their socio-economic and environmental performance (farm profitability, labor and soil organic matter inputs) using the whole-farm model Farm DESIGN. We then used Farm DESIGN to assess the potential impact of five proposed technology packages and

to explore promising alternative farm configurations. We discussed model assumptions and results with farmers, including alternative cropping patterns and trade-offs. We evaluated the packages with different household members using a weighted scoring technique, subsequently juxtaposing model results with farmer perceptions. Large differences prevailed among and within farms per type and per region, with low resource endowed farms being projected to benefit most in relative and least in absolute terms from an adoption of the packages. Farmer feedback confirmed the accuracy of alternative farm configurations, as determined by the model. However, the feedback also revealed that the most profitable farm designs would be hard to attain in reality, particularly for members of low and medium resource endowed households, due to high initial investment costs. Within households, women were more positive about the packages than men, since men heavily penalized extra costs and labor, translating into a greater congruence of model results with the male evaluation. We discuss the importance of distinguishing between technical (technology i.e. purchased tools and inputs) and managerial (techniques e.g. row planting) package components. We conclude that operationalizing inter- and intra-household diversity is a fundamental step in identifying sensible solutions for the challenges smallholder farm systems face in Northern Ghana.

Keywords: whole-farm model, Farm DESIGN, typologies, technology adoption, ex-ante impact assessment, Northern Ghana

170. Motivational factors influencing farming practices in northern Ghana

Mellon-Bedi, S., Descheemaeker, K., Hundie-Kotlu, B., Frimpong, S., & Groot, J. C. J. (2020). Motivational factors influencing farming practices in northern Ghana. *NJAS: Wageningen Journal of Life Sciences*, 92(1), 1–13. <https://doi.org/10.1016/j.njas.2020.100326>

Socio-economic factors that influence the adoption of management practices and technologies by farmers have received wide attention in the adoption literature, but the effects of socio-psychological farmer features such as perceptions and motivations have been analyzed to a lesser extent. Using farm household survey data from three regions in northern Ghana, this study explores farmers' motivations and perceived adoption impediments for three sustainable intensification practices (SIPs): improved maize varieties, cropping system strategies, and combined SIPs (i.e. improved maize and cropping system strategies), and the effect of motivational factors on decisions to adopt SIPs. First, explorative factor analysis (EFA) was used in identifying factors of motivations and impediments for adoption of SIPs. Then, a multinomial logit model was used to analyze the effect of socioeconomic farm characteristics and motivational factors on farmers' decisions to adopt SIPs. EFA identified three motivational factors: personal satisfaction, eco-diversity and eco-efficiency, which differed in importance between the three regions. Across these regions, higher scores for aspects of personal satisfaction were associated with lower interest in improved maize varieties compared to cropping system strategies, while the opposite was true for eco-efficiency which was related to a stronger preference for improved maize varieties. Uncertainty, absence of social support, and resource constraints were identified as impediment factors. The logit model demonstrated that extension services seemed to support the use of improved maize varieties more than

the implementation of cropping system strategies. We conclude that motivational factors significantly influence farmer adoption decisions regarding sustainable intensification practices and should be considered systematically in combination with socio-economic farm features and external drivers to inform on-farm innovation processes and supporting policies.

Keywords: motivations, impediments, sustainable intensification, adoption, factor analysis

171. Nigeria zero hunger strategic review – Nutritional status of children under the age of 5 in Benue state, Nigeria

Okike, I., Ayoola, G. B, Ogundapo, A. T., Ojide, M, Abdoulaye, T., Dashiell, K., & Manyong, V. (2021). Nigeria zero hunger strategic review – Nutritional status of children under the age of 5 in Benue state, Nigeria. Nigeria Zero Hunger/IITA Policy Brief No. 1. *Journal of Food Science and Nutrition*, 7, 114. <https://doi.org/10.24966/fsn-1076/100114>

In September 2015, the Federal Republic of Nigeria committed to achieving the “2030 Agenda for Sustainable Development” (also known as Sustainable Development Goals – SDGs). Among the goals, numbering seventeen, Nigeria prioritized SDG 2, the so-called Zero Hunger goal, calling on member states to “End hunger, achieve food security and improved nutrition, and promote sustainable agriculture” by 2030. The Nigeria Zero Hunger Strategic Review was established that sought to articulate what Nigeria must do to achieve SDG2 (zero hunger) by 2030 through an open and consultative process led by His Excellency, Chief Olusegun Obasanjo, former President of the Federal Republic of Nigeria. It was deemed necessary to conduct a baseline survey to establish the true situation at the start of the review and enable tracking of the progress. The International Institute of Tropical Agriculture (IITA) was charged with the responsibility to lead baseline surveys in partnership with the Farm & Infrastructure Foundation (FIF) in five states – Benue, Ebonyi, Kebbi, Ogun, and Sokoto – spread across four of Nigeria’s six major agro-ecological zones. Following a design workshop by stakeholders, field activities for data collection were conducted with full support of governments in the states, the National Bureau of Statistics (NBS), UNICEF and the World Food Programme (WFP). The preliminary findings of the surveys were reviewed and validated by the representatives of the five states and other stakeholders at IITA, Ibadan in 2017.

This policy brief summarizes findings for key parameters for Benue state to provide guidance for policy formulation and implementation. The brief focuses on the issues of poverty, hunger, nutrition and health care, and other nutritional outcomes in children under 5 years. It ends with policy recommendation to attain the goals of SDG2. The statistical comparisons summarized are between Benue state and the average from all 5 surveyed states.

Keywords: policy brief, zero hunger review, children U5, Benue State, Nigeria

172. Nigeria zero hunger strategic review – Nutritional status of children under the age of 5 in Ebonyi state, Nigeria

Okike, I., Ayoola, G. B, Ogundapo, A. T., Ojide, M, Abdoulaye, T., Dashiell, K., & Manyong, V. (2021). Nigeria zero hunger strategic review – Nutritional status of children under the age of 5

in Ebonyi state, Nigeria. Nigeria zero hunger/IITA policy brief No. 2. *Journal of Food Science and Nutrition*, 7, 116. <https://doi.org/10.24966/fsn-1076/100116>

The Federal Republic of Nigeria committed to achieving the “2030 Agenda for Sustainable Development” (also known as Sustainable Development Goals - SDGs). The country prioritized SDG 2, the so-called Zero Hunger goal, requesting all UN member states to “End hunger, achieve food security and improved nutrition, and promote sustainable agriculture” by 2030. In September 2015, the Nigeria Zero Hunger Strategic Review was established under the leadership of His Excellency, Chief Olusegun Obasanjo, and former President of the Federal Republic of Nigeria. It sought to articulate what Nigeria must do to achieve SDG2 by 2030 through an open and consultative process. The initial activity was to conduct a baseline survey to establish the true situation at the start of the review and enable tracking of the progress. The International Institute of Tropical Agriculture (IITA) was charged with the responsibility to lead baseline surveys in partnership with the Farm & Infrastructure Foundation (FIF) in five states- Benue, Ebonyi, Kebbi, Ogun, and Sokoto. Following a design workshop by stakeholders, field activities for data collection were conducted with full support of governments in the states, the National Bureau of Statistics (NBS), UNICEF and the World Food Programme (WFP). The preliminary findings of the surveys were reviewed and validated by the representatives of the five states and other stakeholders at IITA, Ibadan in 2017. This policy brief summarizes findings for key parameters for Ebonyi that include poverty, hunger, nutrition & health care, and other nutritional outcomes in children under 5 years. It ends with policy recommendation to attain the goals of SDG2. The statistical comparisons summarized are between Ebonyi state and the average from all 5 surveyed states.

Keywords: policy brief, zero hunger review, children U5, Ebonyi state, Nigeria

173. Nigeria zero hunger strategic review – Nutritional status of children under the age of 5 in Ogun state, Nigeria

Okike, I., Ayoola, G. B.*, Ogundapo, A. T., Ojide, M.*, Abdoulaye, T., Dashiell, K., & Manyong, V. (2021). Nigeria zero hunger strategic review – Nutritional status of children under the age of 5 in Ogun state, Nigeria. Nigeria zero hunger/IITA policy brief No. 3. *Journal of Food Science and Nutrition*, 7, 117. <https://doi.org/10.24966/fsn-1076/100117>

The “2030 Agenda for Sustainable Development” (also known as Sustainable Development Goals - SDGs), has 17 goals, to which the Federal Republic of Nigeria committed to achieving in September 2015. Among the SDGs, Nigeria prioritized SDG 2, the so-called Zero Hunger goal, calling on member states to “End hunger, achieve food security and improved nutrition, and promote sustainable agriculture”. The Nigeria Zero Hunger Strategic Review was established, and it sought to apply an open and consultative process to articulate what Nigeria must do to achieve SDG2 by 2030. That process was led by His Excellency, Chief Olusegun Obasanjo, and former President of the Federal Republic of Nigeria. The Nigeria Zero Hunger Strategic Review determined to conduct a baseline survey to establish the true situation at the start of the review to enable tracking of the progress. The International Institute of Tropical Agriculture

(IITA) was charged with the responsibility to lead baseline surveys in partnership with the Farm & Infrastructure Foundation (FIF) in five states – Benue, Ebonyi, Kebbi, Ogun, and Sokoto aiming to capture the nutrition outcomes along agricultural intensification and market access gradients across four of Nigeria’s six major agro ecological zones. A design workshop by stakeholders was held and followed by field activities for data collection were conducted with full support of governments in the states, the National Bureau of Statistics (NBS), UNICEF and the World Food Programme (WFP). The preliminary findings of the surveys were reviewed and validated by the representatives of the five states and other stakeholders at IITA, Ibadan in 2017. This policy brief summarizes findings for key parameters for Ogun state especially on the issues of poverty, hunger, nutrition & health care, and other nutritional outcomes in children under 5 years. The statistical comparison summarized are between Ogun state and the average for all five surveyed states. It ends with policy recommendation to attain the goals of SDG2.

Keywords: policy brief, zero hunger review, children U5, Ogun state, Nigeria

174. Nigeria zero hunger strategic review – Nutritional status of children under the age of 5 in Sokoto state, Nigeria

Okike, I., Ayoola, G. B.*, Ogundapo, A. T., Ojide, M.*, Abdoulaye, T., Dashiell, K., & Manyong, V. (2021). Nigeria zero hunger strategic review – Nutritional status of children under the age of 5 in Sokoto state, Nigeria. Nigeria zero hunger/IITA policy brief No. 4. *Journal of Food Science and Nutrition*, 7, 118. <https://doi.org/10.24966/fsn-1076/100118>

The United Nations’ “2030 Agenda for Sustainable Development” (also known as Sustainable Development Goals - SDGs) has 17 goals [1], to which the Federal Republic of Nigeria committed to achieving. Out of the 17 goals, Nigeria prioritized SDG 2, the so-called Zero Hunger goal, calling on member states to “End hunger, achieve food security and improved nutrition, and promote sustainable agriculture”. Under the leadership of His Excellency, Chief Olusegun Obasanjo, former President of the Federal Republic of Nigeria, the Nigeria Zero Hunger Strategic Review (aka “The Review”) was established which sought to articulate what Nigeria must do to achieve SDG2 by 2030 through an open and consultative process. The Review decided, as a first step, to conduct a baseline survey to establish the true situation at the start of its strategic intervention to enable tracking of the progress. The International Institute of Tropical Agriculture (IITA) was charged with the responsibility to lead baseline surveys in partnership with the Farm & Infrastructure Foundation (FIF) in five states-Benue, Ebonyi, Kebbi, Ogun, and Sokoto. This selection enabled spread across four of Nigeria’s six major agroecological zones to also provide insights along the country’s gradients of agricultural intensification and market access. Following a design workshop by stakeholders, field activities for data collection were conducted with full support of governments in the states, the National Bureau of Statistics (NBS), UNICEF and the World Food Programme (WFP). The preliminary findings of the surveys were reviewed and validated by the representatives of the five states and other stakeholders at IITA, Ibadan in 2017. This policy brief summarizes findings for key parameters for Sokoto state focusing on the issues of poverty, hunger, nutrition

& health care, and other nutritional outcomes in children under 5 years. The results also present comparisons between Sokoto state and the average from all five surveyed states. It ends with policy recommendation to attain the goals of SDG2.

Keywords: policy brief, zero hunger review, children U5, Sokoto state, Nigeria

175. Nigeria zero hunger strategic review – Nutritional status of children under the age of 5 in Kebbi state, Nigeria

Okike, I., Ayoola, G. B.* , Ogundapo, A. T., Ojide, M.* , Abdoulaye, T., Dashiell, K., & Manyong, V. (2021). Nigeria zero hunger Strategic review – Nutritional status of children under the age of 5 in Kebbi state, Nigeria. Nigeria zero hunger/IITA policy brief No. 5. *Journal of Food Science and Nutrition*, 7, 119. <https://doi.org/10.24966/fsn-1076/100119>

The Federal Republic of Nigeria committed to achieving the “2030 Agenda for Sustainable Development” (also known as Sustainable Development Goals - SDGs) in September 2015. There are 17 SDGs from which Nigeria prioritized SDG 2, the so-called Zero Hunger goal, calling on member states to “End hunger, achieve food security and improved nutrition, and promote sustainable agriculture” by 2030 [1]. Following Nigeria’s commitment to this initiative and under the leadership of His Excellency, Chief Olusegun Obasanjo, former President of the Federal Republic of Nigeria, the Nigeria Zero Hunger Strategic Review (aka “The Review”) was established. Through an open and consultative process, the Review sought to articulate what Nigeria must do to achieve SDG2 (zero hunger) by 2030. It was deemed necessary to conduct a baseline survey to establish the true situation at the start of the review to enable tracking of the progress. The International Institute of Tropical Agriculture (IITA) was charged with the responsibility to lead baseline surveys in partnership with the Farm & Infrastructure Foundation (FIF) in five states-Benue, Ebonyi, Kebbi, Ogun, and Sokoto-spread across four of Nigeria’s six major agroecological zones to also capture the country’s gradients of agricultural intensification and market access. Following a design workshop by stakeholders, field activities for data collection were conducted with full support of governments in the states, the National Bureau of Statistics (NBS), UNICEF and the World Food Programme (WFP). The preliminary findings of the surveys were reviewed and validated by the representatives of the five states and other stakeholders at IITA, Ibadan in 2017. This policy brief summarizes findings for key parameters for Kebbi state especially on the issues of poverty, hunger, nutrition & health care, and other nutritional outcomes in children under 5 years old. It ends with policy recommendation to attain the goals of SDG2. The statistical comparisons summarized are between Kebbi state and the average from all 5 surveyed states.

Keywords: policy brief, zero hunger review, children U5, Kebbi state, Nigeria

176. Non-farm activities and adoption of improved cassava and beans varieties in South Kivu, DR Congo

Dontsop-Nguezet, P., Manyong, V., Abdoulaye, T., Alene, A., Amato, M. S, Ainembabazi, J. H., Mignouna, D., & Okafor, C. (2016). Non-farm activities and adoption of improved cassava and beans varieties in South Kivu, DR Congo. *Tropicultura*, 34(3), 262–275. <http://www.tropicultura.org/text/v34n3/262.pdf>

Non-farm activities have been generally considered as important strategy for overcoming credit constraints faced by rural households as well as for reducing poverty through income effect. This paper employs binary probit and average treatment effect to estimate the impact of participation in non-farm activities on adoption of improved cassava and beans varieties in South Kivu, DR Congo. Results showed on one hand that the participation rate in non-farm activities in South Kivu was 38% and 52.1% respectively for crafts and small businesses. On the other hand, the rate of adoption of new cassava and beans varieties were 14 and 28% respectively. Factors affecting the adoption rate were gender, education, household size, the presence of non-farm activities, household assets in terms of livestock owned, market access and access to the information on new technologies. These results demonstrate the tendency of rural households to include the practice of non-farm activities among their strategies for survival and diversify their sources of income or supplement farm income. Results of this study indicate a positive relationship between engagement of rural households in non-farm activities and their propensity to adopt improved varieties. There is still a huge gap between potential adoption rate and actual rate of adoption for cassava and beans improved varieties in the study area. Therefore, actors involved in the development of the agricultural sector have to be aware of the importance of these factors even when they are working for the promotion of purely agricultural activities.

Keywords: adoption, improved cassava and beans varieties, non-farm activities, South Kivu, DR Congo

177. On-farm evaluation of maize varieties in the transitional and savannah zones of Ghana: Determinants of farmer preferences

Etwire, P. M.*, Abdoulaye, T., Obeng-Antwi, K.*, Bua, A.*, Kanton, R.*, Asumadu, H.*, Abdulai, M. S.*, Haruna, A.*, & Etwire, J.* (2013). On-farm evaluation of maize varieties in the transitional and savannah zones of Ghana: Determinants of farmer preferences. *Journal of Development and Agricultural Economics*, 5(6), 255–262. <https://www.globalscienceresearchjournals.org/abstract/onfarm-evaluation-of-maize-varieties-in-the-transitionaland-savannah-zones-of-ghana-determinants-of-farmernpreference-46116.html>

Maize is one of the most important food crops in Ghana even though its production has not reached self sufficiency levels. Drought and *Striga* infestation are among the most important production constraints of maize in Ghana. Promising high yielding, drought and *Striga* tolerant maize varieties are being evaluated by CSIR and IITA in participatory on-farm trials and demonstrations. These varieties however need to meet farmers' varietal preferences in order for them to adopt. This study therefore sought to assess farmers' preference for the different drought tolerant maize varieties, and determine factors that influence their choices. Kendall's coefficient of concordance was used to test the level of agreement between farmers on their preferences. The ordered logistic regression was used to estimate the determinants of farmer's preference using cross-sectional observations from 120 maize farmers in the Transitional and Savannah zones of Ghana. Results indicate that maize varieties that are early maturing (2.38) and drought tolerant (2.45) were most preferred by farmers. Area under maize

cultivation, fertilizer usage and family size are the factors that were found to influence farmers' preference for improved maize varieties. These factors should therefore be considered in varietal promotion.

Keywords: drought tolerant, farmers' preferences, determinant, savannah and transition zones of Ghana, ordered logit

178. On-farm participatory evaluation of feeding approaches used by farmers for tilapia (*Oreochromis macrochir*) production in northern Zambia

Lundeba, M., Cole, S. M., Mekkawy, W., Yossa, R., Basiita, R. K., Nyirenda, M., Muyuni, N., & Benzie, J. A. H. (2022). On-farm participatory evaluation of feeding approaches used by farmers for tilapia (*Oreochromis macrochir*) production in northern Zambia. *Aquaculture*, 549, 737747. <https://doi.org/10.1016/j.aquaculture.2021.737747>

This paper reports the first benchmarking of smallholder tilapia farming practices in rural northern Zambia, measuring fish growth, feed utilization and water quality parameters, using a participatory action research approach. The effects of three different feeding regimes that are currently used in smallholder farming systems in northern Zambia on the growth of the native tilapia, *Oreochromis macrochir*, were tested with 15 farmers (40% female), each having three ponds (one pond per feed treatment per farmer = 45 in total), over eight months in 2016–2017. The three feed treatments included: (1) formulated feed only comprising maize and soybean; (2) goat manure only; and (3) formulated feed and manure together. Three hundred (300) *O. macrochir* mixed-sex fingerlings, 0.5 ± 0.1 g average weight, were stocked in each pond. Water quality (pH, dissolved oxygen, and water temperature and transparency) was measured monthly, as was fish growth in each pond by randomly sampling thirty (30) fish and taking individual weights and lengths. Results showed that the water quality parameters were broadly similar in the different feed treatments over the eight-month experiment period, except for the water transparency values that were higher in the feed only treatment when compared to the other two treatments at months four through eight. Means for survival rate, weight gain, specific growth rate, total amount of fish harvested, and yield were all higher for the feed and manure together treatment than the other two feed treatments at the end of the experiment. A linear mixed-effects regression analysis that controlled for several fixed effects and included pond as a random effect found that the feed and manure together treatment increased fish growth by 10.8 ± 3.7 g at month eight compared to the manure only treatment. The analysis also found a negative effect on fish growth (-9.4 ± 3.8 g) in ponds that used the feed only treatment. The pond effect accounted for 10.1% of the total variance in the data at month eight. Future research and development efforts in Zambia should examine more closely the factors that influence fish growth and that make up the pond effect to determine which innovations and better management practices could help smallholder farmers increase the productivity of their ponds.

Keywords: aquaculture, feeding, participatory research, smallholder, rural, Zambia

179. Patterns and structure of household income inequality in rural Ethiopia

Gebeyehu, B., Feleke, S., Tufa, A., Lemma, T., Tefera, T., & Manyong, V. (2018). Patterns and structure of household income inequality in rural Ethiopia. *World Development Perspectives*, 10–12, 80–82. <https://ideas.repec.org/a/eee/wodepe/v10-12y2018ip80-82.html>

The report examines patterns of gender income inequality in rural Ethiopia and draws insights and implications on whether income growth policy should be gender-neutral or gender-responsive. The report also examines the structure of the income distribution and draws insights and implications on whether income distribution policy should primarily address the disparity in income across the households within the same group or the gap between the different groups.

Keywords: rural livelihoods, income diversification, Ethiopia.

180. Politiques et Pratiques Foncières et Engagement des Jeunes dans la Production de l'igname (*Dioscorea* spp) en République du Bénin

Rosaire, A.-T., Abdoulaye, T., & Bernard, F. (2022). Politiques et Pratiques Foncières et Engagement des Jeunes dans la Production de l'igname (*Dioscorea* spp) en République du Bénin. *European Scientific Journal*, 18(23), 87. <https://doi.org/10.19044/esj.2022.v18n23p87>

La culture d'igname, très exigeante en fertilité du sol, est de plus en plus confronté à la raréfaction des terres fertiles au Bénin. La présente étude analyse l'influence des politiques et pratiques foncières sur l'engagement des jeunes dans la production de l'igname en République du Bénin. Les données sont collectées à l'aide de questionnaires administrés à 383 producteurs d'igname du Département des Collines identifiés selon un échantillonnage à choix raisonné. Les résultats montrent que les politiques foncières en cours au Bénin sont fondées sur la loi n° 2013-01 du 14 août 2013 modifiée par la loi n° 2017-15 portant code foncier et domanial en République du Bénin. Ce code, sans remettre en cause les droits fonciers coutumiers, promeut la reconnaissance administrative des droits sur un terrain par la délivrance d'un certificat de propriété foncière. Les pratiques foncières en cours sont fondées sur le principe selon lequel la terre est un patrimoine sacré et commun de l'humanité. Le mode d'accès le plus répandu dans le département est l'héritage (55 %). Les lois foncières et les institutions étatiques et locales ont en commun l'avantage de garantir l'accès à la terre agricole et surtout la sécurité des propriétés foncières ($R^2 = 0,988$). Quant aux us et coutumes et les institutions traditionnelles, ils ont en commun le mérite de faciliter l'accès à la terre ($R^2 = 0,997$). Toutefois, les politiques et pratiques foncières en cours dans le département des Collines présentent des faiblesses telles que le monolinguisme des textes, le caractère oral des clauses, le faible niveau de fonctionnement des institutions de gestion du foncier, la corruption, la transhumance, le système de production de l'igname, le développement des plantations.

Yam cultivation, which is very demanding in terms of soil fertility, is increasingly confronted with the scarcity of fertile land in Benin. This paper focuses on analyzing the influence of land policies and practices on youth engagement in yam production in the Republic of Benin. Data were collected using questionnaires administered to 383 yam producers in the Collines

Department identified according to a reasoned choice sampling. The results show that the current land policies in Benin are based on Law No. 2013-01 of August 14, 2013, amended by Law No. 2017-15 on the Land and State Code in the Republic of Benin. This code, without calling into question the customary land rights, promotes the administrative recognition of rights to land through the issuance of a land ownership certificate. Current land practices are based on the principle that land is a sacred and common heritage of humanity. The most common mode of access in the department is inheritance (55%). Land laws and state and local institutions have in common the advantage of guaranteeing access to agricultural land and especially the security of land ownership ($R^2 = 0.988$). As for habits and customs and traditional institutions, they have in common the merit of facilitating access to land ($R^2 = 0.997$). However, current land policies and practices in the Collines department have weaknesses such as the monolingualism of the texts, the oral nature of the clauses, the low level of functioning of land management institutions, corruption, transhumance, the system yam production, and the development of plantations.

181. Potential impact of groundnut production technology on welfare of smallholder farmers in Ghana

Kotu, B. H., Nurudeen, A. R., Muthoni, F., Hoeschle-Zeledon, I., & Kizito, F. (2022). Potential impact of groundnut production technology on welfare of smallholder farmers in Ghana. *PLOS ONE*, 17(1), e0260877. <https://doi.org/10.1371/journal.pone.0260877>

This study was conducted to assess the potential impact of applying a new groundnut planting density on welfare of smallholder farmers in northern Ghana. We used data from on-farm experiments, focus group discussions, and a household survey. We followed three steps in our analysis. First, we conducted cost-benefit analysis in which we showed the economic advantage of the new technology over the farmers' practice. Second, we predicted adoption rates along timeline using the Adoption and Diffusion Outcome Prediction Tool (ADOPT). Third, using the results of the first and the second steps, we estimated the potential impact of the technology on poverty at household level using a combination of methods such as economic surplus model and econometric model. The cost-benefit analysis shows that increasing plant density increases farmers' financial returns i.e., the benefit-cost-ratio increases from 1.05 under farmers' practice to 1.87 under the best plant density option, which is 22 plants/sqm. The adoption prediction analysis shows that the maximum adoption rate for the best practice will be 62% which will take about nine years to reach. At the maximum adoption rate the incidence of extreme poverty will be reduced by about 3.6% if farmers have access to the international groundnut market and by about 2% if they do not have. The intervention will also reduce poverty gap and poverty severity. The results suggest that policy actions which can improve farmers' access to the international market will enhance farmers' welfare more than the situation in which farmers have access to domestic markets only. Furthermore, promoting a more integrated groundnut value-chain can broaden the demand base of the produce resulting in higher and sustainable impact of the technology on the welfare of groundnut producers and beyond.

182. Potential impacts of increasing average yields and reducing maize yield variability in Africa

Kostandini, G., La Rovere, R., & Abdoulaye, T. (2013). Potential impacts of increasing average yields and reducing maize yield variability in Africa. *Food Policy*, 43, 213–226. <https://doi.org/10.1016/j.foodpol.2013.09.007>

This study evaluates the potential impacts of investing in Drought Tolerant Maize (DTM) in 13 countries of East, South and West Africa. The analysis utilizes geo-referenced production data at the regional and household levels and employs a model that estimates both the conventional mean yield gains and the additional benefits from yield stability gains of DTM varieties as well as impacts on poverty. The results indicate that by 2016, adoption of DTM can generate between US\$ 362 million and US\$ 590 million in cumulative benefits to both producers and consumers. Yield variance reductions stand to generate considerable benefits, especially in high drought risk areas. These benefits translate into poverty reductions in the range of 0.01–4.29% by 2016. Significant benefits are also found among different types of households living in drought risk areas of Kenya, Ethiopia and Nigeria.

Keywords: Africa, maize, drought, technology adoption, yield stability, poverty

183. Potential returns to yam research investment in sub-Saharan Africa and beyond

Mignouna, D., Akinola, A., Abdoulaye, T., Alene, A., Manyong, V., Maroya, N., Aighewi, B., Kumar, P. L., Balogun, M., Lopez-Montes, A., Rees, D., & Asiedu, R. (2020). Potential returns to yam research investment in sub-Saharan Africa and beyond. *Outlook on Agriculture*, 49(3), 215–224. <https://doi.org/10.1177/0030727020918388>

Lack of good-quality planting materials has been identified as the most severe problem militating against increased agricultural productivity in sub-Saharan Africa (SSA) and beyond. However, investment of research efforts and resources in addressing this menace will only be feasible and worthwhile if attendant economic gains are considerable. As a way of investigating the economic viability of yam investment, this research has been initiated to address problems confronting yam productivity in eight countries of SSA and beyond: Nigeria, Ghana, Benin, Togo, Côte d'Ivoire, Papua New Guinea, Jamaica, and Columbia. Research options developed were to be deployed and disseminated. Key technologies include the adaptive yam miniset technique (AYMT), varieties adapted to low soil fertility and drought, nematode-resistant cultivars (NRC), and crop management and post-harvest practices (CMPP). This article aims at estimating the potential economic returns, the expected number of beneficiaries, and poverty reduction consequent to the adoption of technology options. Estimates show that the new land area that will be covered by the technologies in the eight countries will range between 770,000 ha and 1,000,000 ha with the highest quota accounted for by AYMT. The net present value will range between US\$584 and US\$1392 million and was highest for the NRC. The CMPP had the lowest benefit-cost ratio of 7.74. About 1,049,000 people would be moved out of poverty by these technologies by 2037 in the region. These technologies are less responsive to changes in cost than that in adoption rate. Therefore, the realization of the

potential economic gains depends on the rate and extent of adoption of these technologies. Giving the knowledge-intensive nature of some of these interventions, capacity building of potential adopters will be critical to increasing the sustainability of the yam sector, thereby enhancing food security and reducing poverty.

184. Poverty reduction effects of agricultural technology adoption: The case of improved cassava varieties in Nigeria

Assfaw Wossen, T., Alene, A., Abdoulaye, T., Feleke, S., Rabbi, I. Y., & Manyong, V. (2019). Poverty reduction effects of agricultural technology adoption: The case of improved cassava varieties in Nigeria. *Journal of Agricultural Economics*, 70(2), 392–407. <https://doi.org/10.1111/1477-9552.12296>

We use DNA-fingerprinting to estimate the poverty reduction effect of adoption of improved cassava varieties in Nigeria. We estimate the counterfactual household income distribution of cassava producers by combining farm-level treatment effects with a market-level model. Our results suggest that adoption of improved cassava varieties has led to a 4.6 percentage point reduction in poverty, though this is sensitive to the measurement of adoption status. Therefore, accurate measurement of adoption is crucial for a more credible estimate of the poverty reduction effect of adoption. Our analysis also suggests that farmers who are more likely to be adopters are also likely to face higher structural costs. Addressing structural barriers that make improved technologies less profitable for the poor would therefore be important to increase the poverty reduction effect of improved cassava varieties.

185. Productivity and limitations of plantain (*Musa spp. cv AAB*) production in compound gardens in southeastern Nigeria

Nweke, F., Njoku, J. E. *, & Wilson, G. F. (1988). Productivity and limitations of plantain (*Musa spp. Cv AAB*) production in compound gardens in southeastern Nigeria. *Fruits*, 43(3), 161–166. <https://biblio.iita.org/documents/nweke-productivity-1988.pdf-6d6d22f0b9bf836b7dc0dd518f6f9e06.pdf>

This paper, based on a socio-economic survey, investigates the productivity of compound plantain production and constraints to large scale production on the basis of the compound production method. The paper shows that production under the compound system results in nearly four times as much yield as in non-compound system. This is attributed to regular application of kitchen and other compound wastes, close cultural attention given by the farmer, and to nutrient recycling to the benefit of the compound plantains from deep rooted perennial tree crops inter-planted large scale production employing the compound methods is limited by supply of organic matter and by available market for plantains. Available market can be expanded by increased production during the slack period of June to September when output is low and by packaging to reduce damage in transit to take advantage of distant markets.

186. Productivity and welfare effects of Nigeria's e-voucher-based input subsidy program

Assfaw Wossen, T., Abdoulaye, T., Alene, A., Feleke, S., Ricker-Gilbert, J., Manyong, V., & Awotide, B.A. (2017). Productivity and welfare effects of Nigeria's e-voucher-based input subsidy program. *World Development*, 97, 251–265. <https://doi.org/10.1016/j.worlddev.2017.04.021>

In an attempt to go beyond the so called “smart” subsidies, Nigeria has embarked on a potentially innovative mobile phone-based input subsidy program that provides fertilizer and improved seed subsidies through electronic vouchers. In this article, we examined the productivity and welfare effects of the program using household-level data from rural Nigeria. The article employed instrumental variable regression approach to control for the potential endogeneity of the input subsidy program. Our results suggest that the program is effective in improving productivity and welfare outcomes of beneficiary smallholders. The size of the estimated effects suggests a large improvement in productivity and welfare outcomes. Moreover, the distributional effects of the program suggest no heterogeneity effects based on gender and farm land size. These results are robust to using alternative measurements of program participation. The benefit–cost ratio of 1.11 suggests that the program is marginally cost-effective. Overall, our results suggest that while improving average productivity is a good outcome for improving food security, improving the distributional outcome of the program by targeting the most disadvantaged groups would maximize the program’s contribution to food security and poverty reduction.

Keywords: agricultural input subsidies, welfare, productivity, smallholders, Nigeria, mobile phone

187. Productivity growth and the effects of R&D in African agriculture

Alene, A. (2010). Productivity growth and the effects of R&D in African agriculture. *Agricultural Economics*, 41(3–4), 223–238. <https://doi.org/10.1111/j.1574-0862.2010.00450.x>

This article measures and compares total factor productivity growth in African agriculture under contemporaneous and sequential technology frontiers over the period 1970–2004. The sources of productivity growth are examined using a fixed-effects regression model and a polynomial distributed lag structure for agricultural R&D expenditures. While conventional estimates show an average productivity growth rate of only 0.3% per year, the improved measures under sequential technology show that African agricultural productivity grew at a higher rate of 1.8% per year. Technical progress, rather than efficiency change, was the principal source of productivity growth. Agricultural R&D, weather, and trade reforms turned out to have significant effects on productivity in African agriculture. With a rate of return of 33% per year, R&D is shown to be a socially profitable investment in African agriculture. While a strong R&D expenditure growth of about 2% per year in the 1970s led to strong productivity growth after the mid 1980s, stagnation of R&D expenditure in the 1980s and early 1990s led to slower productivity growth in the 2000s. Consistent with recent economic recovery in Africa evidenced by stronger agricultural GDP growth rates, results showed that policy reforms as well as improved weather contributed to the recovery of agricultural productivity after the mid 1980s.

188. Productivity growth, technical progress, and efficiency change in Africa agriculture

Nkamleu, G. B. (2004). Productivity growth, technical progress, and efficiency change in Africa agriculture. *African Development Review*, 16(1), 203–222. <https://doi.org/10.1111/j.1467-8268.2004.00089.x>

The paper examines the economic performance of a large number of African countries using an international comparable data set and the latest technique for analysis. The paper focuses on growth in total factor productivity and its decomposition into technical change and efficiency change components. The analysis is undertaken using the data envelopment analysis (DEA). The present study uses data of 16 countries over the period 1970–2001. It was found that, globally, during that period, total factor productivity has experienced a positive evolution in sampled countries. This good performance of the agricultural sector was due to good progress in technical efficiency rather than technical progress. The region suffered a regression in productivity in the 1970s, and made some progress during the 1980s and 1990s. The study also highlights the fact that technical change has been the main constraint of achievement of high levels of total factor productivity during the reference period in sub-Saharan Africa. Contrariwise, in Maghreb countries, technological change has been the main driving force of productivity growth. Finally, the results indicate that institutional factors as well as agro-ecological factors are important determinants of agricultural productivity growth.

189. Productivity, profitability and partial nutrient balance in maize-based conventional and organic farming systems in Kenya

Adamtey, N., Musyoka, M. W., Zundel, C., Cobo, J. G., Karanja, E., Fiaboe, K. K., Muriuki, A.*, Mucheru-Muna, M.*, Vanlauwe, B., Berset, E., Messmer, M. M., Gattinger, A., Bhullar, G., Cadisch, G., Fließbach, A., Mader, P., Niggli, U., & Foster, D. (2016). Productivity, profitability and partial nutrient balance in maize-based conventional and organic farming systems in Kenya. *Agriculture, Ecosystems and Environment*, 235, 61–79. <https://doi.org/10.1016/j.agee.2016.10.001>

In 2007 two long-term trials were established in Kenya to contribute research-based evidence to the global debate on the productivity, economic viability and sustainability of different agricultural production systems. These trials compare conventional (Conv) and organic (Org) farming systems at high and low input levels at two locations, i.e. Chuka, with Humic Nitisols, high inherent soil fertility and rainfall, and Thika, with Rhodic Nitisols with low soil fertility and rainfall. The high input systems (High) represent commercial-scale, export-oriented production that uses the recommended amounts of fertilizers, pesticides and irrigation water to generate high yields, whilst the low input systems (Low) represent local smallholder practices, using relatively few fertilizers and pesticides and operating under rain-fed conditions. The conventional systems received synthetic fertilizers and organic manure, whilst the organic systems only received organic inputs. The trials so far have consisted of a 6-season, 3-year, crop rotation with maize (*Zea mays* L.) planted in the long rainy seasons (March–September), and vegetables in the short rainy seasons (October–February). Generally, there were no significant differences in the dry matter yields and nutrient uptake by maize, baby corn or beans between the conventional and organic systems at either site. Similar maize grain and baby corn yields were also obtained at Chuka. However, at Thika, maize grain yields in Org-High in 2007 (at conversion) were lower than the yields in Conv-High, but the yields became similar in 2010 (after conversion). At the same site the yields of maize grain under sole cropping in Org-Low were 3.2 times lower than the yields in Conv-Low in 2007 and 1.7 times lower in 2010.

When intercropped with beans the yields of the two systems were similar. In the first two years profits from Conv-High were 0.5–1.8 times and 0.2–2.4 times higher than in Org-High when selling the produce at local (Chuka and Thika) and regional markets (Nairobi), but thereafter the profit from the two was similar, even when organic produce was sold at regular market prices. From the fifth year onwards Org-High attracted a price premium of 20 to 50% and this made it 1.3 to 4.1 times more profitable than Conv-High when selling on local and regional markets (in Chuka, Thika and Nairobi). Compared to Conv-High, partial N and K balances at the two sites were positive and higher in Org-High, except for N at Chuka. Our findings demonstrate that Org-High is productive, economically viable, resource-conserving and can contribute to sustainable agriculture production in Kenya depending on regional conditions and the crops cultivated.

Keywords: organic farming systems, conventional farming systems, high-inputs, low-inputs, nutrient export, partial nutrient balance

190. Profitability and technical efficiency of soybean production in northern Nigeria

Ugbabe, O. O, Abdoulaye, T., Kamara, A., Mbaval, J., & Oyinbo, O (2017). Profitability and technical efficiency of soybean production in northern Nigeria. *Tropicultura*, 35(3), 203–214. <https://cgspace.cgiar.org/handle/10568/89022>

The International Institute of Tropical Agriculture and collaborating partners have been introducing and disseminating short season soybean varieties among farm households in the Sudan savannas of Northern Nigeria since 2008. Yet, there is no empirical information on the profitability and technical efficiency of soybean production. This study estimated the profitability and efficiency of production of the early maturing soybean. Nine hundred soybean farming households in thirty communities from three Local Government Areas (LGAs) in Kano State were sampled for the study. Partial budget technique and stochastic frontier production function were used to analyze the data elicited from the sampled farm households. Results from the study established the profitability of soybean production in all the three LGAs of Kano State. The highest profit of N178,613/ha and returns per naira invested of 2.5 respectively was earned by the soybean producing households of Dawakin-Tofa LGA. Net profit was N157,261 in Shanono with a returns of 1.75 per naira invested. In Bunkure, net benefit was N143,342 with returns of 1.66 per Naira invested. The mean technical efficiency was highest for the Dawakin-Tofa LGA soybean growing households (87%), followed by Bunkure LGA (68%), and Shanono LGA (59%). This result implies that given the current level of resources available to the soybean producing households, they can increase their soybean output in the short run by a margin 13%, 32% and 41% in Dawakin-Tofa, Bunkure and Shanono LGAs respectively through efficient utilization of their available resources. Farmer-specific efficiency factors, which comprise age, education, access to credit, extension contact and farming experience, were found to be the significant factors that account for the observed variation in efficiency among the farmers in the 3 LGAs. It was recommended that the soybean farmers through the assistance of extension agents should be encouraged to adhere strictly to the recommended soybean production practices toward ensuring efficient utilization of their available resources so

that they can improve their technical efficiency and increase their profit level toward enhancing their household food security.

Keywords: profitability, efficiency, soybean production, Nigeria

191. Profitability of intensification technologies among smallholder maize farmers in the forest-savanna transition zone of Nigeria

Bamire, A. S.*, & Manyong, V. (2003). Profitability of intensification technologies among smallholder maize farmers in the forest-savanna transition zone of Nigeria. *Agriculture, Ecosystems and Environment*, 100(2/3), 111–118. [https://doi.org/10.1016/S0167-8809\(03\)00179-8](https://doi.org/10.1016/S0167-8809(03)00179-8)

Sustaining the productive capacity of the land resource under the existing land-use system and increasing population pressure requires the use of appropriate technologies that will enhance farm productivity and income levels. This paper examines the effect on farm profitability of smallholder maize farmers' use of intensification technologies in tropical agriculture. The survey was conducted in southwest Nigeria. A multi-stage sampling technique was used to select 300 respondents from two major agroclimatic zones in Osun State. Primary data were collected using a structured questionnaire and complemented with focus group discussions (FGDs), while the State's Ministry of Agriculture provided secondary data. Pressure on land was found high because farmland was continuously cropped for an average of 10 years with a mean fallow period of 2 years only. Technologies used to intensify agriculture included inorganic fertilizer, organic manure, alley cropping, and tree planting. Results from costs and returns analysis showed that average net returns to inorganic fertilizer use ranked highest in the two zones, while tree planting ranked lowest. There was a significant ecoregional difference on the average net returns/year earned by users of mineral fertilizer. While organic manure use earned higher net returns than alley cropping practice in the rain forest, the reverse was the case for the derived savanna. FGDs revealed that respondents' preferred to use inorganic fertilizer despite its inadequate supply because, apart from enhancing higher returns and net gains, it also improved output level and provided an opportunity for the continuous use of the scarce land. These results imply that economic returns play a critical role in farmers' use of intensification technologies and consequently affect their resource management decisions. Policy measures aimed at promoting research on appropriate technologies that are profitable on farmers' fields will be more effective in enhancing farmers' use of intensification technologies.

Keywords: intensification, technologies, profitability, forest-savanna transition, Nigeria.

192. Promoting the adoption of innovations through participatory approaches: Example from northern Nigeria

Abdoulaye, T., Amaza, P.*, Olanrewaju, A., & Ellis-Jones, J. (2012). Promoting the adoption of innovations through participatory approaches: Example from northern Nigeria. *Tropicultura*, 30(3), 155–160. <https://cgspace.cgiar.org/handle/10568/80855>

Participatory research and development approaches involving all stakeholders along the value chain have recently been hypothesized to produce quicker outcomes than the linear technology transfer model. This paper analyzed the crop yield obtained by farmers and their uptake of improved technologies in a 2009 survey, one year after the completion of project field activities. It was a multi-stakeholder project involving research, extension, farmer groups, marketers and policymakers, that operated for 4 years (2005–2008) in Borno state of Nigeria. Survey results indicated that farmers who participated in project activities' have been successful in increasing crop yields. Both yields and per capita production of major crops were statistically significantly higher ($p \leq 0.05$) in project communities compared to non-project ones. It is also estimated that there was a decline in percentage of households in food insecurity situation in project communities. Probit regression revealed that participation in project activities had a positive and significant effect on household food security ($p \leq 0.05$). It is then concluded that development interventions that involve multiple stakeholder partnership, use of participatory research and extension approach can help increase technology uptake among resource-poor farmers as well as increase food production and food security in a region.

Keywords: research for development, technology adoption, food security, regression, participatory approaches, Nigeria

193. Promoting the use of drought tolerant maize in Nigeria

Abdoulaye, T., & Anyebe, O. (2013). Promoting the use of drought tolerant maize in Nigeria. *IITA R4D Review*, 10, 22–23. https://www.academia.edu/32117491/R4D_Review_Maize_special

The DTMA project of IITA-CIMMYT aims to develop and deploy drought tolerant varieties in 13 sub-Saharan African countries. In West Africa, the project, led by IITA and its national partners, is being implemented in Nigeria, Bénin, Mali, and Ghana. In Nigeria, the project covers all the maize-producing agroecologies. This article is a short review of the achievements of this project and lessons learnt after 4 years.

Keywords: drought tolerant maize variety, promotion efforts, lessons learnt, Nigeria

194. Prospects and determinants of adoption of IITA plantain and banana based technologies in three Niger Delta States of Nigeria

Faturoti, B. O., Emah, G. N., Isife, B. I., Tenkouano, A., & Lemchi, J. (2006). Prospects and determinants of adoption of IITA plantain and banana based technologies in three Niger Delta States of Nigeria. *African Journal of Biotechnology*, 5(14), 5. https://www.researchgate.net/publication/27797529_Prospects_and_determinants_of_adoption_of_IITA_plantain_and_banana_based_technologies_in_three_Niger_Delta_States_of_Nigeria

High yielding and disease resistant plantain and banana hybrids and its associated technologies generated by IITA to combat the menace of black Sigatoka disease (*Mycosphaerella fijiensis*) were massively disseminated in year 2000. Since the hybrids were slightly different from the existing varieties in fruit size there was a need to assess their prospects. Structured

questionnaire and interview schedule were used to collect data on the adoption of the fourteen disseminated innovations among 85 randomly selected farmers in 15 villages drawn from the three states. Correlation analysis was used to test the strength of relationship between the respondents personal and socio economic factors, the variables investigated and the adoption index. The results showed that all the respondents adopted at least one of the 14 disseminated innovations. Average adoption level was 40.33% ranging from Rivers 36%, Akwa-Ibom 38% and Bayelsa 47%. The adoption process was strongly influenced by household size, educational attainment, farming experience, frequency of extension visit, overall experience from innovation, market access, access to credit and profit as a result of the technology. It was concluded that the high level of adoption of the technology was not unconnected with the induced model of adoption where farmers saw the yield before embarking on the cultivation and the support (educational and material incentive) received from the disseminating institutions.

195. Small-scale farming, agricultural productivity and poverty reduction in Nigeria: The enabling role of agricultural technology adoption

Olusayo, O., Adebayo, O., Kayode, S. K., Olagunju, K., Ayodeji, I., & Ogundipe, A. A. (2019). Small-scale farming, agricultural productivity and poverty reduction in Nigeria: The enabling role of agricultural technology adoption. *Journal of Agriculture and Ecology Research International*, 19(1), 1–15. <https://doi.org/10.9734/jaeri/2019/v19i130074>

Existing literature affirms the importance of agricultural technology adoption on productivity, income and livelihood outcomes. Evidences subsist on the adoption of improved cassava varieties (ICVs) in Nigeria but little is known about its impact among the farmers. We used data from a survey conducted by International Institute of Tropical Agriculture (IITA) to explore this research gap. Propensity Score Matching and Heckman's two-stage model were the analytical tools. Given an estimated poverty line of (₦21717.53); 52.0% of the farmers were poor. We found that 75.6% of the respondents are adopters of ICVs. Primary occupation of household head and total non-production asset of farmers were key determinants for adoption. Adoption of improved cassava variety has positive effect on farmers' productivity and poverty reduction. The Average Treatment Effect on the Treated (ATT) for productivity increased by 70 % among ICVs farmers. Income was also higher among the adopters than the non- adopters by ₦43463.77. In the same vein, the income of the adopters increased by 17%. Furthermore, adopters of ICVs have the probability of reducing poverty headcount by 20%. The empirical results suggest that improved agricultural innovation adoption can play a key role in strengthening and impacting agricultural productivity of smallholder farmers for increased income generation and food security.

Keywords: adoption, productivity, Nigeria

196. Smallholder farmers' preferences for sustainable intensification attributes in maize production: Evidence from Ghana

Kotu, B. H., Oyinbo, O., Hoeschle-Zeledon, I., Nurudeen, A. R., Kizito, F., & Boyubie, B. (2022). Smallholder farmers' preferences for sustainable intensification attributes in maize production: Evidence from Ghana. *World Development*, 152, 105789. <https://doi.org/10.1016/j.worlddev.2021.105789>

While sustainable intensification has been aggressively promoted as an agricultural development strategy among smallholder farmers since the beginning of the last decade, there is a dearth of evidence on whether farmers are interested in practicing it and how much value they put to its different components. This study aims at analyzing farmers' preferences for maize production technologies within the lens of sustainable intensification. Employing a discrete choice experiment to generate over 12,500 observations from a sample of about 700 maize-producing households in northern Ghana, we analyze farmers' preferences with respect to five domains of sustainable intensification including productivity, economic, human, environmental, and social conditions. We find that farmers are favorably disposed to maize-based cropping systems that align with the domains of sustainable intensification over their current cropping practices. While farmers value all the sustainable intensification attributes considered in the study, we observe substantial heterogeneities among them in the pooled sample and in the sub-samples between regions and gender categories. The findings suggest that sustainable intensification is not just a fad within the academic and research circles but something farmers are interested in and that development actions are more likely to succeed when they consider preference heterogeneities among farmers and adapt to local conditions. The findings can be used to set an evaluation criterion in designing and testing technologies (or a mix of technologies) for sustainable maize production among smallholder farmers in northern Ghana as well as similar socio-cultural and agroecological settings, supporting national and regional level efforts for R&D prioritization.

Keywords: sustainable intensification, maize, preferences, choice experiment, Ghana

197. Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya

Alene, A. D., Manyong, V. M., Omany, G., Mignouna, H. D., Bokanga, M., & Odhiambo, G. (2008). *Food Policy*, 33(4), 318–328. <https://doi.org/10.1016/j.foodpol.2007.12.001>

This paper assessed the effects of transactions costs—relative to price and non-price factors—on smallholder marketed surplus and input use in Kenya. A selectivity model was used that accounts for the effects of transactions costs, assets, technology, and support services in promoting input use and generating a marketable surplus. Output supply and input demand responses to changes in transactions costs and price and non-price factors were estimated and decomposed into market entry and intensity. The results showed that while transactions costs indeed have significant negative effects on market participation, institutional innovations—such as group marketing—are also emerging to mitigate the costs of accessing markets. Output price has no effect on output market entry and only provides incentives for increased supply by sellers. On the other hand, both price and non-price factors have significant influence on adoption and intensity of input use. Overall, the findings suggest that policy options are available other than price policies to promote input use and marketed surplus. The paper concludes with implications for policy to induce greater input-output market participation among smallholders in Africa.

Keywords: commercialization, Kenya, Africa

198. Social impact of soybean in Nigeria's southern Guinea savanna

Sanginga, P. C., Adesina, A. A., Manyong, V. M., Otite, O., & Dashiell, K. E. (1999). *Social Impact of Soybean in Nigeria's Southern Guinea Savanna*. Ibadan, Nigeria: IITA. <https://cgspace.cgiar.org/handle/10568/96026>

Most impact studies of agricultural technologies use economic models, with little direct attention being paid to the actual impact on the lives of resource-poor farmers. This paper uses a social impact assessment (SIA) framework to examine the level of adoption and impact of soybean on farm households in Nigeria based on a survey of 203 households in Benue State. The results show that the status of soybean has changed from a traditionally male controlled minor export crop, to one of the most important crops cultivated by the majority of male and female farmers. More women have become involved in soybean production as improved varieties and household utilization technologies have become readily available. The new varieties have been widely adopted, beginning with 9% of farmers in 1989 reaching over 75% in 1997, and these now occupy about 30% of the total soybean land area. Analysis conducted with a Tobit model showed that farmers' socioeconomic characteristics and farmers' assessment of the attributes of improved varieties were both important in explaining their adoption behavior. The adoption of soybean has had a clear positive impact on household income generation and distribution, material welfare, human capital development, gender relations, resource use, social equity, and other social processes in the community. Many innovations in soybean utilization have been adopted, to the extent that soybean has become a staple food. The results further showed that the nutritional status of children was significantly better in soybean producing/using households than in those that did not use soybean. A multivariate analysis of the nutritional status of children showed that soybean consumption, income earned from soybean, and women's production of soybean had significant positive impacts on both the short- and long-term nutritional status indices. The results of this study provide a strong case for the promotion of soybean as a cheap solution for malnutrition and a means of poverty alleviation for poor people.

Keywords: farmers' welfare, social impact assessment (SIA), soybean, Nigeria, sub-Saharan Africa

199. Socio-economic determinants for adoption of improved technologies disseminated through Farmer Field Schools for cowpea production in the regions of Maradi and Zinder in Niger.

Rabe, M. M., Baoua, I., Adeoti, R., Sitou, L., Amadou, L., Pittendrigh, B., & Mahamane, S. (2017). Socio-economic determinants for adoption of improved technologies disseminated through Farmer Field Schools for cowpea production in the regions of Maradi and Zinder in Niger. *International Journal of Biological and Chemical Sciences*, 11(2), 744–756.

Cowpea is a staple food in sub-Saharan Africa. The Farmer Field School project introduced new improved technologies to increase cowpea's yield in Maradi and Zinder regions. This study, involved 300 producers, its aim is to identify the entomological constraints of cowpea production and determine the factors affecting the adoption of agricultural technologies. The

LOGIT regression model was used as an analytical tool and the following main results were obtained: 1) pod sucking bug *Clavigralla tomensicollis* Stall and Aphids, *Aphis craccivora* Koch are the main insect pests of the crop according 53 to 61% of respondents; 2) the average adoption rates per technology were 74.9% for improved varieties, 57.2% for chemical pesticides, 20% for organic fertilizer and NPK combination; 21.7% for the NPK fertilizer, 7.4% for Neem seeds' biopesticides and 5.7% for the respect of sowing density. These ratios were 2 to 16 times higher with trained producers compared with untrained ones; 3) the variables "training by farmer field school" and "access to loan" have positively influenced the adoption of improved varieties, biopesticides and fertilizers; 4) the gender was positively determinant for application of recommended sowing density and the use of fertilizers; 5) age of respondents had significant difference in term of adopting sowing density. These data, helped to assess the practice levels of technologies related to cowpea production and could also help to improve rural extension programs about agricultural technologies.

Keywords: pest arthropods, biopesticides, black-eyed peas, advisory services, extension activities, fertilizers, socioeconomic aspects, sub-Saharan Africa

200. Socio-economic factors and smallholder cassava farmers' access to credit in south-western Nigeria

Awotide, B, Abdoulaye, T., Alene, A., & Manyong, V. (2019). Socio-economic factors and smallholder cassava farmers' access to credit in south-western Nigeria. *Tropicicultura*, 37(1), 1–10. <https://doi.org/10.25518/2295-8010.262>

Access to credit is an important factor in the attainment of agricultural productivity increase. We adopted a Tobit model to assess the factors that influence the intensity of rural smallholder cassava farmers' access to credit in Southwest Nigeria, using primary data collected from 856 rural households by the International Institute of Tropical Agriculture (IITA) in 2011. The results of the empirical Tobit model indicate that seven out of the 11 variables included in the model are statistically related to the intensity of access to credit. However, only total livestock unit, cassava output, monetary value of the households' productive assets and household size are positively and statistically significant. This implies that increase in output, diversification of households' income sources into livestock production and accumulation of assets are important variables that have the potential to enhance farmers' access to larger amounts of credit. Therefore, policies that will lead to improve farmers' outputs and/or increase diversification and assets accumulation are recommended for this region.

Keywords: cassava, credit, farmers, impact, Nigeria, productivity

201. Subsidies for agricultural technology adoption: Evidence from a randomized experiment with improved grain storage bags in Uganda

Omotilewa, O.J., Ricker-Gilbert, J., & Ainembabazi, J. H. (2019). Subsidies for agricultural technology adoption: Evidence from a randomized experiment with improved grain storage bags in Uganda. *American Journal of Agricultural Economics*, 101(3), 753–772. <https://doi.org/10.1093/ajae/aay108>

This article addresses the question of whether subsidizing an entirely new agricultural technology for smallholder farmers can aid its adoption early in the diffusion process. Based on a theoretical framework for technology adoption under subjective uncertainty, we implemented a randomized field experiment among 1,200 smallholders in Uganda to estimate the extent to which subsidizing an improved grain storage bag crowds-out or crowds-in commercial buying of the technology. The empirical results show that on average, subsidized households are more likely to buy an additional bag at commercial prices relative to the households with no subsidy who are equally aware of the technology. This suggests that under certain circumstances, such as when there is uncertainty about the effectiveness of a new agricultural technology, and the private sector market for the technology is weak or nascent, a one-time use of subsidy to build awareness and reduce risk can help generate demand for the new technology and thus crowd-in commercial demand for it. In this context, a subsidy can allow farmers to experiment with the technology and learn from the experience before investing in it.

Keywords: crowding-in, hermetic technology adoption, RCT, subjective uncertainty, subsidy, sub-Saharan Africa, Uganda.

202. Sustaining participation in irrigation systems of Ethiopia: what have we learned about water user associations?

Yami, M. (2013). *Water Policy*, 15(6), 961–984. <https://doi.org/10.2166/wp.2013.031>

Community participation, defined as engaging users of schemes in the decision-making processes for the planning and implementation of irrigation projects, is critical for the sustainability of irrigation schemes. This study was carried out in three regional states of Ethiopia to investigate the contribution of water user associations (WUAs) to sustaining participation in irrigation projects. The paper demonstrates that the poor understanding of community participation and institutional development by project staff in donor-supported irrigation projects results in the poor performance of WUAs in enhancing participation in irrigation systems. The interventions of external bodies in setting up the WUA by-laws and in determining the responsibilities of users and WUA committees contributed to the low level of participation. The transfer of schemes to WUAs without building WUA committees' abilities in operation and maintenance constrained their ability to sustainably manage irrigation schemes. The WUA committees are male-dominated and the views of women are hardly represented in the decision making. Therefore, establishing WUA committees that reflect the interests and inputs of scheme users is crucial to achieve fair decision making. Local authorities and non-governmental organizations could do more to change perceptions and behavior to reflect the importance of gender equity in sustaining the positive outcomes of irrigation at household and community levels.

Keywords: agricultural water management, Ethiopia, gender equity, livelihoods, sustainability, water governance, WUAs

203. Sustaining the beneficial effects of maize production in Nigeria: does adoption of short season maize varieties matter?

Oyinbo, O., Mbavai, J. J., Shitu, M. B., Kamara, A., Abdoulaye, T., & Ugbabe, O. O. (2019). *Experimental Agriculture*. 55(6), 1–13. <https://hdl.handle.net/10568/99216>

In order to ensure sustainability of maize production in short-season environments of Nigeria, the Sudan savanna taskforce of Kano–Katsina–Maradi (KKM) Pilot Learning Site promoted short-season maize varieties in 2008 via Innovation Platforms (IPs). In the light of the promoted varieties, we evaluated the adoption and net benefits (productivity and income) of the maize varieties. We used cross-sectional household data elicited from 600 sampled households, double-hurdle model and propensity score matching. There was a remarkable increase in the adoption of short-season maize varieties in 2014 compared to what was obtained in a baseline conducted in 2008. Our empirical findings revealed that the adoption of the short-season maize varieties promoted through the IPs had significant productivity and income increasing effects. This implies that policy interventions to ensure sustainable maize intensification in the face of environmental limitations, such as early and late season drought, should intensify the promotion of short season varieties in Sudan savannas. This will require well-concerted agricultural extension that can leverage IPs in view of its potentials.

Keywords: maize, impact, marketing, data analysis, sustainability, innovation platforms

204. Socioeconomic assessment of adoption of production and processing technologies on farming households in Nigeria

Ayedun, B., Okuneye, P. A, Dipeolu, A, & Abdoulaye, T. (2013). Socioeconomic assessment of adoption of production and processing technologies on farming households in Nigeria. *Journal of Agricultural Management and Rural Development*, 4(1), 134–147. <https://hdl.handle.net/10568/77455>

The study examined ‘Socioeconomic assessment of adoption of production and processing technologies on farming households’. Using multistage sampling techniques, 480 farming households from Intervention villages – IVs and the Non-Intervention villages – NIVs were sampled from South Zones of Nigeria and interviewed. Targeted respondents were interviewed with the aid of questionnaires. This study was carried out to provide credible evidence of the impact of IITA-ICP (International Institute of Tropical Agriculture, Integrated Cassava Project) research on cassava incited by cassava presidential initiative (PI) of 2002 in Nigeria and to draw lessons from these interventions. Using descriptive and econometric tools, the result showed that cassava occupies 43% of the total field cultivated for crops. Awareness and adoption of production and processing technology were generally poor: for production technology, it was highest for improved cassava sett both in awareness (87%) and adoption (68%) and IVs took the lead. In processing technology among households, grating machine had the highest awareness (88%) and adoption rate (78%) followed by pressing machine. In many cases, intervention households and enterprises had better awareness and adoption rates. Poverty status estimation revealed that less people were below poverty lines among adopters compared to non-adopters, and among IVs compared to counterfactuals. Using logit model, variables that had poverty reducing effect included being from intervention villages, adoption of grater machine for processing cassava, having non-farm income, and being educated.

Keywords: impact, production, processing, model, cassava

205. Status of cooking banana in Nigeria: analysis of the adoption level by farmers

Lemchi, J., Tshiunza, M., Tenkouano, A., & Ezedinma, A. (2005). Status of cooking banana in Nigeria: Analysis of the adoption level by farmers. *Nigerian Journal of Agricultural Technology*, 12, 56–73. https://www.researchgate.net/publication/265684596_Status_of_Cooking_Banana_in_Nigeria_Analysis_of_the_adoption_level_by_farmers

As part of efforts in realizing her aim of introducing cooking banana into Nigeria, the International Institute of Tropical Agriculture (IITA) mounted training and awareness campaigns on its utilization in collaboration with Shell and Agip Oil companies between 1991 and 1997. This study looked into the adoption profile of the utilization methods and the factors that may have influenced it. Data were collected from a random sample of 232 respondents from 24 villages in southeast Nigeria. Results showed an overall adoption level of 79.5%. The highest adoption levels were obtained for those utilization methods similar to local and traditional methods of plantain consumption and lowest for nontraditional uses. The extent or intensity of adoption by the respondents ranged from 1 processing method to 7, with an average of 3. As a proportion of the number of utilization methods on which training was given, the intensity of adoption ranged from 12.5% to 100% with a mean of 52.2%, meaning that the respondents have adopted more than 50% of the total number methods on which they received training. The major factors which have strongly influenced the adoption process were the level of educational attainment, social status, primary occupation, intensity of training received, availability of commercially-produced plantain products in the market/area, trialability as well as the number of desirable attributes of the utilization methods.

Keywords: cooking banana, adoption, processing methods

206. Taking agricultural technologies to scale: Experiences from a vegetable technology dissemination initiative in Tanzania

Gramzow, A., Sseguya, H., Afari-Sefa, V., Bekunda, M., & Lukumay, P. J. (2018). Taking agricultural technologies to scale: Experiences from a vegetable technology dissemination initiative in Tanzania. *International Journal of Agricultural Sustainability*, 16(3), 297–309. <https://doi.org/10.1080/14735903.2018.1473103>

One of the widely suggested approaches to meet the increasing food demand of a substantially growing world population is sustainable intensification. We present a unique agricultural research and scaling program in Tanzania, focusing on the key elements necessary for results related to: gender analysis; private sector engagement; social capital; improvement and adaptation; and program performance monitoring and evaluation. Since 2014, more than 6000 farmers have benefited from either the adaptive research or the scaling component of the program. Preliminary impact analysis results from six pilot locations indicate that program participants realized significantly higher yields compared to non-participants. In addition to productivity improvements, introducing resistant and drought-tolerant elite vegetable varieties improved the resilience of the existing farming systems. Finally, considering the needs of both male and female participants had a positive impact on technology adoption rates and reach.

Keywords: sustainable intensification, Tanzania, technology scaling, vegetables

207. Technical efficiency and impact evaluation differentials between the adopters and non-adopters of NERICA in the six baseline states in Nigeria

Obayelu, A. E, Adeoti, J. O, & Dontsop-Nguezet, P. (2017). Technical efficiency and impact evaluation differentials between the adopters and non-adopters of NERICA in the six baseline states in Nigeria. *Review of Agricultural and Applied Economics*, 20(1), 3–15. <https://doi.org/10.15414/raae/2017.20.01.03-15>

The study examined the adoption rate of New Rice for Africa (NERICA), technical efficiency differentials of production of these varieties between adopters and non-adopters and the determinants. It further analyzed the impact of adoption of NERICA on area cultivated, output, yield, expenditure and total income of rice farmers in the NERICA baseline states in Nigeria. To achieve the objectives, it employed the descriptive statistics, stochastic production frontier and counterfactual outcomes framework of modern evaluation technique (the Local Average Treatment Effect) to analyze 621 rice farmers across the six NERICA baseline states in Nigeria in 2012. The findings show that NERICA adopters were more technically efficient than the non-adopters. In addition, adoption of NERICA was found to significantly increase the areas of land cultivated, output, yield, household expenditure, per capita household expenditure and total income among NERICA adopters by 1.2ha ($p < 0.01$), 1998.2kg ($p < 0.01$), 191.2kg/ha ($p < 0.1$), N13,222.63≈\$66.4 ($p < 0.05$), N2,015.6≈\$10.1 ($p < 0.05$) and N145,098.7 ≈ \$728.0 ($p < 0.01$) respectively despite their high level of inefficiency (39%) by the adopters. The positive impact of NERICA adoption on rice yields, poverty status measured by the per capita household expenditure and total farm income of farmers is a clear indication that NERICA has the potential to increase rice productivity, reduce poverty and food insecurity. NERICA adoption rate will rise if more farmers are aware of the varieties in the study. Farmers who had adopted, and government at all levels should therefore intensify their efforts to encourage others rice farmers possibly through the extension agents on the need to grow NERICA varieties so as to increase rice production level, reduce rice importation and ensure a sustainable rice production.

Keywords: economic benefits, rice farmers, counterfactual approach, with and without adoption, poverty

208. Technical efficiency and productivity potential of cocoa farmers in West African countries

Binam, J. N., Gockowski, J., & Nkamleu, G. B. (2008). Technical efficiency and productivity potential of cocoa farmers in West African countries. *The Developing Economies*, 46(3), 242–263. <https://doi.org/10.1111/j.1746-1049.2008.00065.x>

This paper uses survey data to examine the technical efficiency and productivity potential of cocoa farmers in West and Central Africa. Separate stochastic frontier models are estimated for farmers in Cameroon, Ghana, Nigeria, and Côte d'Ivoire, along with a stochastic metaproduction frontier to obtain alternative estimates for the technical efficiencies of farmers in the different countries. The mean productivity potential of cocoa farmers is also estimated, by using a decomposition result applied to both the national and the metaproduction frontiers. The determinants of technical efficiency are assessed to identify the reasons for differences across countries.

209. Technical innovations for small-scale producers and households to process wet cassava peels into high quality animal feed ingredients and aflasafe™ substrate

Okike, I., Samireddypalle, A., Kaptoge, L., Fauquet, C., Atehnkeng, J., Bandyopadhyay, R., Kulakow, P., Duncan, A., Alabi, T., & Blummel, M. (2015). Technical innovations for small-scale producers and households to process wet cassava peels into high quality animal feed ingredients and aflasafe™ substrate. *Food Chain*, 5(1/2), 71–90. <https://doi.org/10.3362/2046-1887.2015.005>

Nigeria, the world's largest producer of cassava, harvests 54 million metric tonnes (Mt) of cassava tubers annually. More than 95 per cent of its uses require peeling which generates up to 14 Mt of waste annually; mostly due to challenges related to drying. Sun drying is practically impossible during the wet season and it takes 2–3 days in the dry season to reduce the moisture content of fresh peels from about 60 per cent to 20 per cent or less – a marketable state. This is a report on a multi-center and multi-disciplinary research work (in its early stages) to better utilize the waste. Ongoing work is showing great potential and has so far dramatically reduced cassava peels moisture content to 12–15 per cent within six sunshine hours using only equipment in current use by small-scale processors and households. The considerably shorter processing ensures high-quality products, low in aflatoxins contamination. Also, in a small sample experiment, when compared to sorghum grains currently being used for the production of aflasafe™ as control, the pellets supported the sporulation of *Aspergillus flavus* up to 87.5 per cent of the control with better cost effectiveness. The research challenges remain in terms of circumventing drying technologies, creating and maintaining product quality standards, and facilitating and catalysing collective action among adopters. Nevertheless, the research carries huge potential to address feed scarcity, contribute to food security and food safety, clean up the environment, and improve the incomes and livelihoods of people currently engaged in processing cassava tuber into food – 85 per cent of them women.

210. Technology adoption and farmer efficiency in multiple crops production in eastern Ethiopia: A comparison of parametric and non-parametric distance functions

Alene, A., & Zeller, M. (2005). Technology adoption and farmer efficiency in multiple crops production in eastern Ethiopia: A comparison of parametric and non-parametric distance functions. *Agricultural Economics Review*, 61(1), 5–17. www.researchgate.net/publication/23772352

This study compares the empirical performances of the parametric distance functions (PDF) and data envelopment analysis (DEA) with applications to adopters of improved cereal production technology in eastern Ethiopia. The results from both approaches revealed substantial technical inefficiencies of production among the sample farmers. Technical efficiency estimates obtained from the two approaches are positively and significantly correlated. However, the DEA approach is shown to be very sensitive to outliers as well as to the choice of orientation. The PDF results are relatively more robust. The results from the preferred PDF approach revealed that adopters of improved technology have average technical efficiencies of 79%, implying that they could potentially raise their food crop production by an average 21% through full

exploitation of the potentials of improved varieties and mineral fertilizer. The results confirm that food production even under improved technology involves substantial inefficiency. The paper concludes with a discussion of potential underlying factors influencing farmer efficiency under improved technology, such as poor extension, education, credit, and input supply systems.

Keywords: multiple outputs, distance functions, DEA, technical efficiency, Ethiopia

211. Testing farmers' cropping decisions and varietal adoption behavior: The case of cowpea producers in northern Nigeria

Alene, A., & Manyong, V. (2006b). Testing farmers' cropping decisions and varietal adoption behavior: The case of cowpea producers in northern Nigeria. *Journal of Agricultural and Food Economics*, 1, 1–15. www.researchgate.net/publication/344364294

This paper compared alternative tobit models to investigate farmers' cropping decisions in the adoption of improved cowpea varieties in northern Nigeria. Rather than imposing a particular (unobserved) farmer decision process on the analysis of varietal adoption, the alternative decision processes were tested for consistency with observed practices. The tobit model was found to be an adequate representation of the data, given the specifications of the alternative tobit model with sample selection. The selected model suggests that local and improved cowpea varieties are not mutually exclusive choices and farmers thus undertake separate local and improved cowpea cropping decisions in view of the distinct attributes of local and improved varieties. This is consistent with the observation that farmers simultaneously cultivate the local varieties for livestock fodder and the improved varieties for grain.

Keywords: adoption; cowpea; food security; instrumental variables; Nigeria

212. The adoption of alley farming and *Mucuna*: lessons for research, development, and extension

Douthwaite, B., Manyong, V., Keatinge, J., & Chianu, J. (2002). The adoption of alley farming and *Mucuna*: lessons for research, development, and extension. *Agroforestry Systems*, 56, 193–202. <http://dx.doi.org/10.1023/A:1021319028117>

This paper evaluates the utility of the 'learning selection' model of the early adoption process, based on a constructivist conceptual framework, to explain farmers' adoption and rejection of two soil-improving technologies – alley farming and the use of *Mucuna* cover crops. The analysis showed that *Mucuna* was more successful than alley farming because: (1) early research and extension took farmers' perceptions more into account when changing from recommending *Mucuna* for soil improvement to weed suppression; (2) it was then introduced into areas where there was a real need for the technology; (3) it gave short-term benefits; and (4) it was more amenable to farmer modification and adaptation. The analysis also provided support for the conclusion reached elsewhere that separate trials are needed to gather biophysical data, where researchers need to keep a high degree of control, as opposed to adoptability trials where farmers must be able to manage the technology as they wish. The paper also used the learning selection model to derive research and extension guidelines.

The close match between these guidelines and the literature suggests that a constructivist perspective in general, and the learning selection model in particular, can provide a useful 'road map' to plan and carry out research and extension.

213. The agronomic and economic benefits of fertilizer and mulch use in highland banana systems in Uganda

Wairegi, L.W.I., & van Asten, P.J.A. (2010). *Agricultural Systems*, 103(8), 543–550. [http://www.sciencedirect.com/science/article/pii/S0308-521X\(10\)00077-6](http://www.sciencedirect.com/science/article/pii/S0308-521X(10)00077-6)

Banana is the most important food crop in Uganda. However, there has been a decline in productivity, attributed to declining soil fertility, drought, pests and diseases and crop management factors. This study aimed to explore the possibility of increasing yields through the use of fertilizer and mulch, and to evaluate the benefits of these inputs across the major banana producing regions in Uganda. This study was carried out in 179 smallholder plots in Central, South, Southwest and East Uganda in 2006/7. Half of the plots were 'demonstration plots' of an agricultural development project, while the other half were neighboring farmer plots that acted as 'control'. Demonstration plots received mineral fertilizer (100% of plots), averaging 71 N, 8 P, 32 K kg ha⁻¹ yr⁻¹ and external mulch from grass and crop residues (64% of plots), whereas control plots received no mineral fertilizer and little external mulch (26% of plots). Demonstration plots had significantly ($P \leq 0.05$) higher yields than control plot in Central, South and Southwest, but average yield increases varied from 4.8 t ha⁻¹ yr⁻¹ (Southwest) to 8.0 (Central), and 10.0 (South). Average weevil corm damage (3%) and nematode-induced root necrosis (7%) was low and similar for both plot types, so yield increases could only be explained by the use of fertilizer and mulch. The highest demonstration plot yield increases were observed where fertilizer addressed key nutrient deficiencies identified using the compositional nutrient diagnosis approach. Farm gate bunch prices declined from 0.17 (Central Uganda) to 0.07 USD kg⁻¹ (Southwest Uganda). Consequently, average marginal rate of return (MRR) of fertilizer and mulch use ranged from 0.1 (Southwest) to 5.8 (Central). The technologies were likely to be acceptable to farmers (MRR ≥ 1.00) up to 160 km away from the capital. Fertilizer use is likely to be acceptable in all regions (MRR = 0.7–9.4) if local fertilizer prices of 2006/7 (average USD 0.56 kg⁻¹ of fertilizer) declined by 50%. Doubling of fertilizer prices is likely to make fertilizer use unacceptable beyond 100 km away from the capital. The study concludes that there is scope for increased input use in banana systems in Uganda, but that regional variations in crop response, input/output prices, and price fluctuations have to be taken into account.

Keywords: distance to market, farm gate prices, fertilizer, mulch, nutrient deficiencies, profitability

214. The contribution of IITA-improved cassava to food security in sub-Saharan Africa. IITA Impact Study

Manyong, V. M., Dixon, A. G. O., Makinde, K. O., Bokanga, M., & Whyte, J. (2000). The contribution of IITA-improved cassava to food security in sub-Saharan Africa. IITA Impact Study. <https://hdl.handle.net/10568/92689>

Since its foundation in 1967, the International Institute of Tropical Agriculture (IITA) has worked, in partnership with national agricultural research systems in sub-Saharan Africa, on the improvement of cassava and dissemination of improved cassava germplasm. This paper describes the impact of this work, by looking at the spread of improved cassava varieties, their use in national breeding programs, and the ultimate benefits of this work on food security in sub-Saharan Africa. Twenty countries were surveyed, which together account for over 90% of cassava production in sub-Saharan Africa. A total of 206 cassava varieties were released between 1970 and 1998 by the national agricultural research systems of these countries. Genetic materials from IITA represented the major source of germplasm used in the development of released varieties. In 1998, improved cassava varieties were grown on about 22% of the 9 million hectares that were planted to cassava in the 20 countries. The use of improved varieties resulted in a yield increase of 49% over the average yield, and an additional production of 10 million tonnes of fresh storage roots per year, or 2200 kcal per person per day for 14 million people. Between 1970 and 1998 a total of 1381 scientists were trained at IITA, accounting for 38% of senior and 49% of intermediate level researchers currently working in cassava research in these countries.

Keywords: cassava, sub-Saharan Africa, germplasm, food security, African cassava mosaic virus, cassava bacterial blight, cassava varieties

215. The economic and poverty impacts of maize research in West and Central Africa

Alene, A., Menkir, A., Ajala, S., Badu-Apraku, B., Olanrewaju, A., Manyong, V., & Ndiaye, A.* (2009). The economic and poverty impacts of maize research in West and Central Africa. *Agricultural Economics*, 40(5), 535–550. <https://doi.org/10.1111/j.1574-0862.2009.00396.x>

This article assembles the results of three multicountry surveys on variety performance and adoption patterns to measure the impacts of maize research in West and Central Africa from 1981 to 2005, and uses cost data since 1971 to compute social rates of return on public investments in maize research in the region. Adoption of modern varieties increased from less than 5% of the maize area in the 1970s to about 60% in 2005, yielding an aggregate rate of return on research and development (R&D) investment of 43%. The estimated number of people moved out of poverty through adoption of new maize varieties rose gradually in the 1980s to more than one million people per year since the mid 1990s. Over half of these impacts can be attributed to international maize research at IITA and CIMMYT. The article concludes with a discussion of strategic options to enhance the impacts of maize research in the region.

216. The effect of agricultural extension service on the technical efficiency of teff (*Eragrostis tef*) producers in Ethiopia

Elias, A., Nohmi, M., Yasunobu, K., Ishida, A., & Alene, A. D. (2014). *American Journal of Applied Sciences*, 11(2), 223–239. <https://doi.org/10.3844/ajassp.2014.223.239>

Teff (*Eragrostis tef*) is a major staple food crop in Ethiopia, but smallholder teff production is characterized by persistently low average yield. A major government effort aimed at raising the productivity and competitiveness of smallholder agriculture in Ethiopia involved reforming and implementing agricultural extension service known as Participatory Demonstration and Training Extension System (PADETES). Therefore, this study investigates the effect of agricultural extension service and other factors on the Technical Efficiency (TE) of teff producers in northern Ethiopia. Using cross sectional data we compare TE level of teff producers who are participants and non-participants of Agricultural Extension (AE) program. We address self-selection in to AE program participation using propensity score matching method. Trans-log stochastic frontier production function is used for TE analysis. The empirical results reveal that AE program participants' and non-participants' farms have an average TE of 72 and 71% respectively. Both groups of farms have considerable overall technical inefficiencies, suggesting the existence of immense potentials for enhancing production through more efficient use of available technology and resources. Determinants of TE are explained significantly by livestock ownership, credit and improved seed. Based on the results, we derive policy recommendations to improve farmers' teff production performance. These policy measures include the provision of extension services related to technical skill and farm management capacity of the farmers, demand driven livestock extension service, greater access to credit and increasing the availability, quality and adoption of improved seed.

Keywords: technical efficiency, stochastic frontier model

217. The effectiveness of crop improvement programmes from the perspectives of varietal output and adoption: cassava, cowpea, soybean and yam in Sub-Saharan Africa and maize in West and Central Africa

Alene, A.D., Abdoulaye, T., Rusike, J., Manyong, V., & Walker, T.S. (2015). Crop improvement, adoption, and impact of improved varieties in food crops in sub-Saharan Africa. In Walker, T. S., & Alwang, J. (eds) *Crop Improvement, Adoption, and Impact of Improved Varieties in Food Crops in Sub-Saharan Africa*. Wallingford, UK: CABI Publishing. <http://dx.doi.org/10.1079/9781780644011.0074>

In this chapter, varietal output, adoption and change are assessed for five of the 20 food crops covered in the Diffusion and Impact of Improved Varieties in Africa (DIIVA) Project. The chapter evaluates the performance of genetic improvement programs in cassava, cowpea, soybean and yam for sub-Saharan Africa and maize improvement in West and Central Africa.

Keywords: varietal output, adoption, diffusion, Sub-Saharan Africa

218. The effectiveness of village bylaws in sustainable management of community-managed exclosures in northern Ethiopia

Yami, M., Mekuria, W., & Hauser, M. (2013). *Sustainability Science*, 8(1), 73–86. <https://doi.org/10.1007/s11625-012-0176-2>

Communities in Tigray, Northern Ethiopia, have established exclosures on formerly degraded grazing lands and other land uses to promote natural regeneration of plants. Village bylaws devised by communities govern the management of exclosures. We analyzed the effectiveness of village bylaws that are used to manage exclosures in addressing forest degradation, resolving conflicts among users over natural resource use, and meeting high expectations of users to realize economic benefits from exclosures through enhancing revenue from sale of grass and dry wood. We collected data using qualitative methods during July and November 2008 in two villages of Tigray. The village bylaws mitigated forest degradation by facilitating users to have common goals in the management of exclosures, and resolved conflicts among users by using monetary sanctions including penalties. The village bylaws were not effective in meeting the high expectations of users to realize economic benefits from exclosures. In some cases, the enforcement of village bylaws was constrained by high social capital, which resulted in the negligence among users in exposing free riders. This indicates that high social capital does not always enhance communal resource management. Moreover, recurrent drought, shortage of fuel wood, and the growing number of landless youths in both villages constrained the effectiveness of village bylaws and further expansion of exclosures. Village committees should focus on addressing the low level of rule enforcement and minimize negligence among users of exclosures through developing a sense of responsibility among users rather than focusing on penalties.

Keywords: closed area, communal forest, institutions, land degradation, rules

219. The effects of education on agricultural productivity under traditional and improved technology in northern Nigeria: an endogenous switching regression analysis

Alene, A.D., Manyong, V.M. (2007). The effects of education on agricultural productivity under traditional and improved technology in northern Nigeria: an endogenous switching regression analysis. *Empirical Economics*, 32, 141–159. <https://doi.org/10.1007/s00181-006-0076-3>

This paper estimates a more efficient version of an endogenous switching regression model to examine the effects of farmer education—schooling and extension contact—on cowpea production under traditional and improved technology in northern Nigeria. The results revealed significant productivity-enhancing effects of schooling and extension contact only under improved technology. Factors that promote technology adoption will thus indirectly raise the marginal contributions of farmer education; these include schooling, participatory technology evaluation, improved seed supply, and market access. The results demonstrate that schooling not only enhances agricultural productivity following technology adoption but also promotes adoption itself.

Keywords: cowpeas, schooling, extension, technology adoption, agricultural productivity

220. The efficiency of traditional and hybrid maize production in Eastern Ethiopia: An extended efficiency decomposition approach

Alene, A., & Hassan, R. (2006). The efficiency of traditional and hybrid maize production in Eastern Ethiopia: An extended efficiency decomposition approach. *Journal of African Economies*, 15(2), 91–116. <https://doi.org/10.1093/jae/eji017>

The productive efficiencies of traditional and hybrid maize producers in eastern Ethiopia are derived using an efficiency decomposition technique that we extend to account for scale effects. The paper illustrates the sensitivity of the conventional approach to scale effects. The results revealed high inefficiency among both traditional and hybrid maize producers. High inefficiency among hybrid maize producers is consistent with the argument that food production gains from improved agricultural technologies have not been realized in poor countries like Ethiopia due mainly to poor support services, including extension, education, credit and input supply.

Keywords: maize production, traditional, hybrid, productive efficiencies, Ethiopia

221. The extent and determinants of production efficiency of farmers in the rainforest margins in Central Sulawesi, Indonesia: Implications for land use and support services

Alene, A.D., Zeller, M., Schwartz, S., & Dar, N. (2005). The extent and determinants of production efficiency of farmers in the rainforest margins in Central Sulawesi, Indonesia: Implications for land use and support services. *Quarterly Journal of International Agriculture*, 44(4), 335–353. www.researchgate.net/publication/287017913

There has been widespread concern regarding agricultural land expansion through deforestation, and a number of policy options have been proposed to counteract this trend. However, little effort has been made to assess the role of more efficient use of existing agricultural land and technology in combating deforestation. This study uses a translog stochastic frontier production function to analyze the technical efficiency of a sample of farmers in the rainforest margins in Indonesia. The sample farmers have an average technical efficiency of 53%, suggesting that there is a considerable potential for increasing production through efficient use of existing agricultural land and available technology. An analysis of socio-economic and institutional factors revealed that education, extension services, and social capital have a positive and significant influence on the farmers' performance.

Keywords: deforestation, farmers, agricultural land and technology, technical efficiency, agricultural production, stochastic frontier, rice, markets

222. The impact of agricultural research on productivity and poverty in sub-Saharan Africa

Alene, A., & Coulibaly, O. (2009). The impact of agricultural research on productivity and poverty in sub-Saharan Africa. *Food Policy*, 34(2), 198–209. <https://cgspace.cgiar.org/handle/10568/90227>

While it is widely recognized that agricultural research is a key driver of broad-based technological change in agriculture that benefits the poor in many different ways, little is known about its aggregate impacts on productivity growth and poverty reduction in sub-Saharan Africa (SSA). Using a polynomial distributed lag structure for agricultural research within a simultaneous system of equations framework, this paper first demonstrates that agricultural research contributes significantly to productivity growth in SSA. Productivity growth is again shown to raise per capita incomes, with income increases finally having significant poverty-reducing effects. With an aggregate rate of return of 55%, the payoffs to agricultural research are also impressive. Agricultural research currently reduces the number of poor by 2.3 million or 0.8% annually. While the actual impacts are not large enough to more than offset the poverty-increasing effects of population growth and environmental degradation, the potential impacts of agricultural research are far greater. Apart from low research investments, SSA faces several constraints outside the research system that hinder realization of potential research benefits. The results show that doubling research investments in SSA would reduce poverty by 9% annually. However, this would not be realized without more efficient extension, credit, and input supply systems.

Keywords: agricultural research, poverty reduction, rate of return, sub-saharan africa, productivity growth, research investments

223. The impact of mechanized processing of cassava on farmers' production efficiency in Uganda

Abass, A., Amaza, P, Bachwenkizi, B., Wanda, K, Agona, A, & Cromme, N. (2017). The impact of mechanized processing of cassava on farmers' production efficiency in Uganda. *Applied Economics Letters*, 24(2), 102–106. <https://doi.org/10.1080/13504851.2016.1167817>

The study investigates the impact of adopting mechanized processing of cassava on farmers' production efficiency in Uganda. A stochastic production function, using translog functional form, was used to compare efficiency measures of farmers in mechanized cassava-processing villages compared with the farmers in nonmechanized cassava-processing villages in 2014. Given the specification of the translog production function, the mean technical efficiencies of the farmers were 0.69 and 0.52 in mechanized and nonmechanized villages, respectively. The significant determinants of technical inefficiency among the respondents are farming experience, education, membership of farmer association, access to markets, sale of cassava to processors and farmers who planted cassava as sole crop are all negative, which confirm to a priori expectations and significant at different levels. The policy implication of the study is that mechanization of cassava processing, particularly if done at the right scale, could create demand that can transform primary production for increased yields, higher incomes and production efficiency of smallholder farmers who constitute a significant proportion of Uganda's agricultural sector.

Keywords: adoption, cassava, mechanized, processing, efficiency

224. The policy and practice of sustainable biofuels: Between global frameworks and local heterogeneity. The case of food security in Mozambique

Schut, M., & Florin, M.J. (2014). The policy and practice of sustainable biofuels: Between global frameworks and local heterogeneity. The case of food security in Mozambique. *Biomass and Bioenergy*, 72, 123–135. <https://doi.org/10.1016/j.biombioe.2014.11.009>

This study explores the relationship between different biofuel production systems, the context in which they operate, and the extent to which various types of frameworks and schemes are able to monitor and promote their sustainability. The paper refers to the European Union Renewable Energy Directive and two international certification schemes (Roundtable on Sustainable Biofuels and NTA 8080/81) that can provide a ‘licence to sell’ biofuels on the EU market, and to the Mozambican policy framework for sustainable biofuels that provides a ‘licence to produce’ biomass for biofuels in Mozambique. Food security is used as a case study, and the food security impacts of two agro-industrial and two smallholder biofuel projects in Mozambique are described and analyzed. The sustainability frameworks and schemes used in this study are able to address some, but not all, of the heterogeneity between and within different biofuel production systems. The emphasis is on monitoring agro-industrial projects while smallholder projects tend to slip through the net even when their negative impacts are evident. We conclude that globally applicable sustainability principles are useful, however, they should be operationalised at local or production system levels. This approach will support balancing between global frameworks and local heterogeneity.

Keywords: bioenergy, certification, regulation, trade, biodiesel, *Jatropha*

225. The poverty impacts of improved cowpea varieties in Nigeria: A counterfactual analysis

Manda, J., Alene, A., Hirpa Tufa, A., Abdoulaye, T., Assfaw Wossen, T., Chikoye, D., & Manyong, V. (2019). The poverty impacts of improved cowpea varieties in Nigeria: A counterfactual analysis. *World Development*, 122, 261–271. <https://doi.org/10.1016/j.worlddev.2019.05.027>

Adoption of improved agricultural technologies has long been recognized as critical for reducing poverty through increased productivity, incomes, and asset accumulation. Using a nationally representative survey data from a sample of over 1500 households in Nigeria, this paper evaluates the impacts of adoption of improved cowpea varieties on income and asset poverty reduction using an endogenous switching regression model. The results showed that adoption of improved cowpea varieties increased per capita household income and asset ownership by 17 and 24 percentage points, respectively. The results based on the observed and counterfactual income and asset distributions further showed that adoption reduced both income poverty and asset poverty by 5 percentage points. The paper concludes with a discussion of the policy options for increasing adoption and impacts of improved cowpea varieties in Nigeria.

Keywords: endogenous switching regression, counterfactual, improved cowpea varieties, Nigeria, poverty reduction

226. The poverty impacts of improved soybean technologies in Malawi

Tufa, A. H., Alene, A. D., Manda, J., Feleke, S., Wossen, T., Akinwale, M. G., Chikoye, D., & Manyong, V. (2021). The poverty impacts of improved soybean technologies in Malawi. *Agrekon*, 60(3), 297–316. <https://doi.org/10.1080/03031853.2021.1939075>

Improved soybean varieties and agronomic practices have been widely disseminated to smallholder farmers in Malawi over the last 15 years. However, there is no empirical evidence on the welfare impacts of adopting improved soybean technologies. This paper estimated the poverty impacts of adopting improved soybean technologies using data from 1,234 households in six soybean growing districts accounting for over 80% of the total soybean production in the country. The results from an endogenous switching regression model showed that 32% of the sample households adopted improved soybean varieties and agronomic practices. The adoption benefits were higher for female-headed households and increased with the household head's education and cultivated land areas. A comparison of the observed and counterfactual incomes for adopters based on the international poverty line of US\$1.90 per capita per day showed a 4.16 percentage-point reduction in poverty among the sample households, translating to over 150,000 people lifted out of poverty. The household head's education level, household size, cultivated land area, livestock size, and asset ownership are associated with the daily per capita income. The results point to the need for scaling up of improved soybean varieties and agronomic practices for greater impacts on poverty reduction among smallholders in Malawi.

Keywords: soybeans, poverty, impacts, endogenous switching regression, Malawi

227. The production efficiency of intercropping systems annual and perennial crops in southern Ethiopia: A comparison of distance functions and production frontiers

Alene, A., Manyong, V., & Gockowski, J. (2006). The production efficiency of intercropping systems annual and perennial crops in southern Ethiopia: A comparison of distance functions and production frontiers. *Agricultural Systems*, 91(1/2), 51–70. <https://doi.org/10.1016/j.agsy.2006.01.007>

This study measures the efficiency of intercropping systems of annual and perennial crops production in southern Ethiopia using the stochastic frontier production function (SFP), parametric distance functions (PDF), and data envelopment analysis (DEA), and compares the empirical performances of the three methods. The results from the multi-output PDF and DEA approaches have revealed significantly higher efficiency of the systems than the single-output SFP approach. We find that both DEA and PDF are appropriate in multi-output agriculture involving intercropping of annual and perennial crops. Single-output measures of productivity and efficiency may thus underestimate resource use efficiency of intercropping systems. Based on the geometric mean technical efficiency predictions for each data point using the preferred PDF and DEA approaches, the sample farmers in southern Ethiopia have an average technical efficiency of 91%. The results confirm farmers' efficient use of land and other resources through innovative cropping systems. Technologies that are appropriate to such systems may thus be needed for greater intensification.

Keywords: distance functions, intercropping, stochastic frontiers, DEA, Ethiopia

228. The productivity and income effects of adoption of improved soybean varieties and agronomic practices in Malawi

Hirpa Tufa, A., Alene, A., Manda, J., Akinwale, M. G., Chikoye, D., Feleke, S., Assfaw Wossen, T., & Manyong, V. (2019). The productivity and income effects of adoption of improved soybean varieties and agronomic practices in Malawi. *World Development*, 124, 1–10. <https://doi.org/10.1016/j.worlddev.2019.104631>

Soybean constitutes an important component of the maize-based smallholder cropping systems in Malawi and holds considerable potential for countering soil fertility decline, enhancing household food and nutrition security, and raising rural incomes. A number of yield-enhancing improved soybean varieties and agronomic practices (ISVAPs) have been developed and disseminated in Malawi, but there is limited evidence on the adoption and impacts of these technologies. This paper assesses the productivity and income effects of adopting ISVAPs using plot level data collected from a nationally representative sample of 1237 soybean growing households in Malawi. Our results show that over a third of the sampled households have adopted ISVAPs. Furthermore, results from a stochastic dominance analysis showed that soybean yields and net crop incomes for adopters are significantly higher than those of non-adopters over the entire probability distribution of ISVAPs adoption. Endogenous switching regression model results further demonstrated that adoption of ISVAPs is associated with an average of 61% yield gain and 53% income gain for adopters. Overall, the results point to the need for further scaling of ISVAPs for greater adoption and impact on the livelihoods of smallholder farmers in Malawi.

Keywords: soybean, adoption, impacts, agronomic practices, income, Malawi

229. The role of farming experience on the adoption of agricultural technologies: Evidence from smallholder farmers in Uganda

Ainembabazi, J. H., & Mugisha, J. (2014). The role of farming experience on the adoption of agricultural technologies: Evidence from smallholder farmers in Uganda. *Journal of Development Studies*, 50(5), 666–679. <https://doi.org/10.1080/00220388.2013.874556>

This article investigates the relationship between adoption of and experience with agricultural technologies. We use both non-parametric and parametric estimations on data from rural farmers in Uganda. We find an inverted-U relationship between adoption of and experience with agricultural technologies in banana, coffee and maize. This suggests that farming experience is useful in early stages of adoption of a given technology when farmers are still testing its potential benefits, which later determine its retention or disadoption over time. Thus, gradual advances in technology development and continuous retraining of farmers are essential for sustainable adoption of agricultural technologies for some crops.

230. The technical and cost efficiencies of hybrid maize production in western Ethiopia

Alene, A., Hassan, R., & Demeke, M. (2005). The technical and cost efficiencies of hybrid maize production in western Ethiopia. *Quarterly Journal of International Agriculture*, 44(2), 167–181. <https://cgspace.cgiar.org/handle/10568/91874>

Conventional farmer efficiency studies have addressed the question of whether possibilities exist for inexpensive gains in production through better use of traditional technology. The question of whether the production potentials of new seed technologies have been fully exploited by poor farmers has rarely been a concern. This paper uses a translog stochastic frontier and inefficiency model to analyze technical efficiency and the factors underlying efficiency differentials among a sample of hybrid maize producers in western Ethiopia. It also uses a dual cost frontier model to compute the cost efficiency of the sample farmers. The results revealed an average technical inefficiency of 25%, showing that farmers actually operate with substantial inefficiency under new technology. This suggests that a considerable maize yield potential remains to be exploited through better use of the technology. An average cost inefficiency of 39% was obtained from the dual model, indicating that farmers could raise the profitability of maize production by 39% by fully adjusting input use. In view of the prevailing high prices of fertilizer against very low price of maize, fertilizer cost inefficiencies among farmers were mainly due to the use of more, rather than less, fertilizer, and this indicates the divergence between economic and biological optimum arising from unfavorable input and output prices facing the farmers. Education, provision of input credit, land tenure, and timely availability of critical inputs are found to be important factors influencing the technical efficiency of maize farmers.

Keywords: dual cost frontier, technical efficiency, cost efficiency, hybrid maize, Ethiopia

231. Transforming yam seed systems in West Africa

Maroya, N., Balogun, M., Aighewi, B., Mignouna, D. B., Kumar, P. L., & Asiedu, R. (2022). Transforming yam seed systems in West Africa. In Thiele, G., Friedmann, M., Campos, H., Polar, V., & Bentley, J. W. (eds) *Root, Tuber and Banana Food System Innovations* (pp. 421–451). Springer International Publishing. https://doi.org/10.1007/978-3-030-92022-7_14

The availability of clean planting materials and functional seed regulatory systems is indispensable for fostering a sustainable seed yam system. The Yam Improvement for Income and Food Security in West Africa (YIIFSWA) project of the International Institute of Tropical Agriculture (IITA) developed the capacity of National Agricultural Research Institutes (NARIs) in their use of standardized Temporary Immersion Bioreactor (TIB) and Vivipak (VP) systems for high-ratio propagation and post-flask handling of yam breeder seed plantlets. Foundation seed was enhanced by supporting five private seed companies in Nigeria and three in Ghana. They were equipped with aeroponic and hydroponic technologies for foundation seed tuber production using single-node vine seedlings. For certified seed, seed yam out-growers were trained in good agronomic practices and entrepreneurship for certified seed tuber production using the adaptive yam miniset technique (AYMT). New certification standards were established for various classes of seed produced using different propagation methods and quality assurance procedures in Ghana and Nigeria. The capacity of the national regulatory organizations in both countries was enhanced to implement seed quality control and certification. Increased public sensitization and advocacy were done to raise awareness among relevant stakeholders to enhance the uptake of the seed propagation technologies and

ensure a smooth interaction between the public and private sectors. This chapter summarizes the accomplishments of YIIFSWA in Ghana and Nigeria and the spillover impact on the yam belt of West Africa and beyond. The key lessons could inform the design and implementation of more effective seed projects, especially for vegetatively propagated crops.

Keywords: seed yam systems, high-ratio propagation, Temporary Immersion Bioreactor, Vivipak, aeroponics, hydroponics, yam miniset technique, single node vine cutting, certification standards, Ghana, Nigeria, tuber

232. Understanding the process of agricultural technology adoption: Mineral fertilizer in eastern DR Congo

Lambrecht, I., Vanlauwe, B., Merckx, R., & Maertens, M. (2014). Understanding the process of agricultural technology adoption: Mineral fertilizer in eastern DR Congo. *World Development*, 59, 132–146. <https://doi.org/10.1016/j.worlddev.2014.01.024>

We analyze the adoption of mineral fertilizer in South Kivu. We model technology adoption as a three-step-process, including awareness, tryout, and adoption; and empirically analyze these steps using cross-sectional farm-household data, and bivariate and Heckman selection probit models. We find that awareness about fertilizer is high (57%) and mainly determined by education and social capital. Tryout is low (13% of aware farmers) but positively influenced by extension interventions. Continued adoption is high (70% of tryout farmers) but capital constraints are important and not all extension interventions are effective for continued adoption. Our results entail implications for extension policies in poor areas.

Keywords: mineral fertilizer, sub-Saharan Africa, eastern DR Congo, technology adoption, soil fertility, agricultural research and extension

233. Video as a tool for agricultural extension in Africa: A case study from Ghana

David, S., & Asamoah, C. (2011). Video as a tool for agricultural extension in Africa: A case study from Ghana. *International Journal of Education and Development using ICT*, 7(1), 26–41. www.learntechlib.org/p/42255/

The paper explores the effectiveness of video viewing clubs (VVCs) as a training method based on a formal survey of 32 Ghanaian women farmers who were trained on cocoa integrated crop and pest management (ICPM) using this method. Results suggest that the video viewing club is effective as a relatively low cost, interactive training method for providing low literacy populations with skills, information and knowledge on complex technical topics. While there was no significant difference between VVC participants and a control group in farmers' reported implementation of selected ICPM practices or yield difference in the single year observed one year after the training largely due to methodological limitations, the study demonstrated that VVC training significantly improved farmers' knowledge of most topics covered. Farmers' perception of changes in their practices provided further evidence of the positive impact of the training, as did their high rate of knowledge diffusion. The use of local facilitators in the VVCs,

which created a sense of ownership and added to the credibility of the technical messages, contributed to farmers' appreciation of the method. The paper concludes by discussing the challenges of scaling up VVCs and identifying issues for further research.

Keywords: cocoa, extension, Ghana, ICTs, training, video, women cocoa farmers

234. Welfare impacts of climate-smart agriculture in Ghana: Does row planting and drought-tolerant maize varieties matter?

Martey, E, Etwire, P. M, & Abdoulaye, T. (2020). Welfare impacts of climate-smart agriculture in Ghana: Does row planting and drought-tolerant maize varieties matter? *Land Use Policy*, 95, 104622. <https://doi.org/10.1016/j.landusepol.2020.104622>

This study provides new evidence of the impact of climate-smart agriculture (CSA) – row planting and drought-tolerant maize varieties – on farm and welfare outcomes by estimating a multinomial endogenous switching regression model that corrects for selection bias and farmer heterogeneity in CSA choice. Application of our model to panel observations of 438 households in Ghana show that adoption of CSA increases both yield and intensity of maize commercialization but negatively affect own consumption. Specifically, the magnitude of the impact is relatively higher for adopters of row planting relative to adopters of drought-tolerant maize seeds. These results suggest the need for development practitioners to increase awareness and emphasize the importance of row planting as a key component of climate-smart agriculture.

Keywords: climate-smart agriculture, multinomial endogenous switching regression, farm and welfare impact, Ghana

235. Welfare impacts of improved groundnut varieties in eastern Zambia: A heterogeneous treatment effects approach

Manda, J., Khonje, M., Alene, A., & Gondwe, T. (2017). Welfare impacts of improved groundnut varieties in eastern Zambia: A heterogeneous treatment effects approach. *Agrekon*, 56(4), 313–329. <https://doi.org/10.1080/03031853.2017.1400447>

This paper examines the welfare impacts of improved groundnut varieties in eastern Zambia using data from a survey of over 600 households. We use the stratification-multilevel, matching-smoothing, and smoothing-differencing methods to analyze how treatment effects vary with the propensity to adopt improved groundnut varieties. We find consistent results across the models indicating that crop yields and incomes increase significantly with the propensity to adopt improved groundnut varieties. The results point to the need for policies and strategies that increase access to market information and overcome the constraints to adoption for realizing the benefits from improved groundnut varieties in Zambia.

Keywords: adoption, heterogeneous treatment effects, impact, improved groundnut varieties, Zambia

236. Welfare impacts of smallholder farmers' participation in multiple output markets: Empirical evidence from Tanzania

Manda, J., Azzarri, C., Feleke, S., Kotu, B. H., Claessens, L., & Bekunda, M. (2021). Welfare impacts of smallholder farmers' participation in multiple output markets: Empirical evidence from Tanzania. *PLOS ONE*, 16(5), e0250848. <https://doi.org/10.1371/journal.pone.0250848>

A relatively large body of literature has documented the welfare effects of smallholder farmers' participation in single-commodity output markets. However, limited empirical evidence is available when smallholder farmers participate in multiple-commodities output markets. We tried to fill this gap in the literature by estimating the impacts of smallholder farmers' contemporaneous participation in both maize and legume markets vis-à-vis in only maize or legume markets using household-level data from Tanzania. Applying a multinomial endogenous switching regression model that allows controlling for observed and unobserved heterogeneity associated with market participation in single-commodity and multiple-commodity markets, results showed that smallholder farmers' participation in both single- and multiple-commodity markets was positively and significantly associated with household income and food security. Moreover, the greatest benefits were obtained when farmers participated in multiple-commodity markets, suggesting the importance of policies promoting diversification in crop income sources to increase welfare and food security. Our findings also signal the complementary – rather than substitute – nature of accessing multiple-commodity markets for enhancing household livelihoods under a specialization strategy. Finally, important policy implications are suggested, from promoting and supporting public infrastructure investments to expanding road networks to reduce transportation costs, especially in remote communities, to enhance smallholder farmer access to profitable maize and legume markets in Tanzania.

237. Who benefits from which agricultural research-for-development technologies? Evidence from farm household poverty analysis in Central Africa

Ainembabazi, J. H., Abdoulaye, T., Feleke, S., Alene, A., Dontsop-Nguezet, P. M., Ndayisaba, P. C., Hicintuka, C., Mapatano, S., & Manyong, V. (2018). Who benefits from which agricultural research-for-development technologies? Evidence from farm household poverty analysis in Central Africa. *World Development*, 108, 28–46. <https://doi.org/10.1016/j.worlddev.2018.03.013>

It remains a challenge for agricultural research-for-development (AR4D) institutions to demonstrate to donors which technologies contribute significantly to poverty reduction due to a multitude of impact pathways. We attempt to overcome this challenge by utilizing the potential outcomes framework and quantile treatment effects analytical approaches applied on panel household data collected from Central Africa. Our findings show that adoption of AR4D technologies reduced the probability of being poor by 13 percentage points. A large share of this poverty reduction is causally attributable to adoption of improved crop varieties (32%) followed by adoption of post-harvest technologies (28%) and crop and natural resource management (26%), with the rest 14% attributable to unidentified and/or unmeasured intermediate outcomes or factors. The findings further indicate that relatively poor farm households benefit from adopting improved crop varieties more than the relatively better-

off households. Correspondingly, the relatively better off households benefit from adopting post-harvest technologies enhancing crop commercialization much more than the relatively poor households. The findings reveal interesting policy implications for successful targeting of agricultural interventions aimed at reducing rural poverty.

Keywords: AR4D, poverty, impact evaluation, Central Africa.

238. Who does what and why? Intra-household roles and explanatory models for sourcing soybean seed from the formal sector in Malawi

Cole, S. M., Feleke, S., Manda, J., Gondwe, T., & Akinwale, M. G. (2021). Who does what and why? Intra-household roles and explanatory models for sourcing soybean seed from the formal sector in Malawi. *Outlook on Agriculture*, 50(3), 315–327. <https://doi.org/10.1177/00307270211033918>

This study asks whether there is utility in knowing who sources soybean seed within the household and why when explaining variation in seed obtained from the formal versus informal sector. Survey data collected in Malawi in 2018 were used to explore the question. Results suggest that the identity of the person who sources seed has little to do with whether the seed was obtained from the formal sector. Instead, why the person sources soybean seed is the better predictor. As formal seed system actors mobilize to persuade more smallholder farmers to adopt improved varieties, understanding why people source seed may be key for targeting and when designing agricultural development interventions.

239. Why promising technologies fail: the neglected role of user innovation during adoption

Douthwaite, B., Keatinge, J., & Park, J. (2001). Why promising technologies fail: the neglected role of user innovation during adoption. *Research Policy*, 30(5), 819–836. [https://doi.org/10.1016/S0048-7333\(00\)00124-4](https://doi.org/10.1016/S0048-7333(00)00124-4)

The paper analyzes innovation histories of two agro-mechanical and two seed-based technologies with high and low technological complexity, introduced into simple and complex farming systems in Asia. The main conclusion, which may be seen as a hypothesis for further testing, is that, as technology and system complexity increase so does the need for interaction between the originating R&D team and the key stakeholders (those who will directly gain and lose from the innovation) when the latter first replicate and use the new technology. This is because a successful technology represents a synthesis of the researcher and key stakeholder knowledge sets, and creating this synthesis requires more iteration and negotiation as complexity increases. Instead of assuming a new technology is 'finished' when it leaves the research institute, a more effective way of developing complex technologies is for the R&D team to release them as soon as the key stakeholders will adopt, and then nurture the technology's continued development in partnership with the key stakeholders.

Food safety and nutrition (80)

1. **Accruing genetic gain in pro-vitamin A enrichment from harnessing diverse maize germplasm**

Menkir, A., Maziya-Dixon, B., Mengesha, W., Rocheford, T., & Alamu, E. O. (2017). Accruing genetic gain in pro-vitamin A enrichment from harnessing diverse maize germplasm. *Euphytica*, 213, 105. <http://dx.doi.org/10.1007/s10681-017-1890-8>

Maize has been targeted as one of the major crops for pro-vitamin enrichment and delivery because it is an inexpensive and easily available source of food for millions of people in sub-Saharan Africa. Although tropical-adapted yellow maize contains provitamin-A carotenoids that can be converted into vitamin A in the human body, they represent less than 25% of the total carotenoids in most widely grown and consumed maize cultivars in Africa. Novel genes conditioning high concentration of β -carotene and other carotenoids were then continually introduced from the temperate zone and tropics to boost provitamin A in tropical-adapted maize. Several promising inbred lines developed from backcrosses involving diverse exotic donor lines displayed provitamin A concentrations that match or surpass the current breeding target of 15 $\mu\text{g g}^{-1}$. Some of these lines attained high provitamin A content by accumulating mainly high β -carotene while others contained high provitamin A by promoting accumulation of high levels of both carotenes and xanthophylls. Several inbred lines with intermediate to high levels of provitamin A have already been used to develop hybrids and synthetics without compromising grain yield and other adaptive traits that are required to profitably cultivate maize by farmers in West and Central Africa.

Keywords: maize, pro-vitamin A enrichment, genetic gain, exotic germplasm, carotenes, sub-Saharan Africa

2. **Aflatoxin awareness and Aflasafe adoption potential of Nigerian smallholder maize farmers**

Johnson, A. M., Fulton, J. R., Abdoulaye, T., Ayedun, B., Widmar, N. J., Akande, A., Bandyopadhyay, R., & Manyong, V. (2018). Aflatoxin awareness and Aflasafe adoption potential of Nigerian smallholder maize farmers. *World Mycotoxin Journal*, 11(3), 437–446. <https://doi.org/10.3920/WMJ2018.2345>

Aflatoxin is a potent mycotoxin that can cause cancer and death and is associated with stunted growth. Prevalence of aflatoxin is widespread in Africa negatively impacting health and trade. Aflasafe is a biological control product that can be applied to maize or groundnut fields to reduce aflatoxin contamination. This study examines the levels of aflatoxin and Aflasafe awareness and understanding among smallholder maize farmers in Nigeria. In addition, the factors affecting Aflasafe purchase patterns and sustained usage over multiple growing seasons by farmers were evaluated. In-person surveys of 902 Nigerian smallholder farmers were conducted during October and November of 2016. This work contributes to the existing literature by documenting awareness levels of aflatoxin and use of Aflasafe as a control in Nigeria. Results suggest that the level of awareness of aflatoxin was very high in states where

Aflasafe was promoted as an intervention for aflatoxin management. In Kaduna state, the region with the longest intervention, there was a consistent increase in the usage of Aflasafe since its introduction in 2010. Furthermore, farmers who purchase Aflasafe bundled (combined) with other inputs were more likely to persist in using the product. Education was found to significantly and positively impact continued usage of Aflasafe. Continued interventions, promotion and general education of the public are recommended for increased awareness, trial, and adoption of Aflasafe in Nigeria.

Keywords: mycotoxin, biological control, atoxigenic strain, technology uptake, Nigeria

3. Aflatoxin contamination in Tanzania: quantifying the problem in maize and groundnuts from rural households

Boni S.B., Beed F., Kimanya M.E., Koyano E., Mponda O., Mamiro D., Kaoneka B., Bandyopadhyay R., Korie S., Mahuku G. (2021). Aflatoxin contamination in Tanzania: quantifying the problem in maize and groundnuts from rural households. *World Mycotoxin Journal*: 14(4), 553–564. <https://doi.org/10.3920/WMJ2020.2646>

Aflatoxins are toxic and carcinogenic secondary metabolites, produced by *Aspergillus flavus* and *Aspergillus parasiticus*, which contaminate food and feed and threaten human and animal health. To assess the prevalence of aflatoxins in Tanzania, 180 groundnut and 200 maize samples were collected from 9 and 10 districts, respectively. Aflatoxin contamination was quantified using high performance liquid chromatography. Aflatoxins were detected in samples collected from all districts and prevalence ranged from 92 to 100% for groundnuts and 10 to 80% for maize. The mean aflatoxin level for groundnuts was 6.37 µg/kg and the highly contaminated sample had 40.31 µg/kg. For maize, the mean aflatoxin level was 12.47 µg/kg and the highly contaminated sample had 162.40 µg/kg. The estimated average probable daily intake (APDI) of aflatoxin B₁ (AFB₁) from groundnuts consumption was 1.88 ng/kg body weight/day, while for maize, it ranged between 151.98–272.89 ng/kg body weight/day. The APDI for both groundnut and maize exceeded the provisional maximum tolerable daily intake (PMTDI) of AFB₁ for adults (1 ng/kg body weight/day), bringing about health concerns for populations in Tanzania. Another alarming finding was that 75% of the farmers who provided samples for analysis were not aware of aflatoxins or the negative health impacts from consuming contaminated products. Results reported in this paper show that aflatoxin contaminated staple crops are widely distributed in Tanzania and that the risk of human exposure is high due to diet preferences. Awareness campaigns are required to inform and protect farmers and consumers.

Keywords: mycotoxin, *Aspergillus flavus*, aflatoxin exposure

4. Assessment of dietary diversity of mothers and children of 6–24 months from eastern and southern provinces of Zambia

Alamu, E. O., Gondwe, T., Eyinla, T., & Maziya-Dixon, B. (2019). Assessment of dietary diversity of mothers and children of 6–24 months from eastern and southern provinces of Zambia. *Journal of Nutrition and Metabolism*, 1049820). <https://doi.org/10.1155/2019/1049820>

In-depth information on dietary diversity and food consumption patterns in Zambian households is still scarce. This study, therefore, probed dietary intakes of mothers and their children living in households of two Zambian districts, Chipata and Monze, located in the eastern and southern provinces of Zambia, respectively. After assessing their diet, Dietary Diversity Scores (DDSs) were calculated and classified into low and high categories, while correlations were used to test determinants of DDS. The assessment revealed that the consumption of cereal-based products ranked highest in frequency. Specifically, the consumption of maize-based foods was highest in Chipata (55.43%) and then in Monze (43.56%) households. There was an observed low preference for mixed dishes that were not either maize or groundnut porridges. We also found positive and negative correlations of DDS with the educational level of household heads and age of mothers, respectively. We, therefore, suggest that increased nutrition education may improve dietary preferences, so also further investigation into other factors hindering low choices for mixed recipes will be useful in increasing overall diet quality.

5. Assessment of nutritional characteristics of products developed using soybean (*Glycine max* (L.) Merr.) Pipeline and improved varieties

Alamu, E. O., Gondwe, T., Mdziniso, P., & Maziya-Dixon, B. (2017). Assessment of nutritional characteristics of products developed using soybean (*Glycine max* (L.) Merr.) pipeline and improved varieties. *Cogent Food & Agriculture*, 3(1). <https://doi.org/10.1080/23311932.2017.1398042>

Breeding new varieties can introduce compositional differences in Soybean grains which could be caused by environment and climate factors, among other factors. Thus, there was need to evaluate these differences and also to investigate the applications of these varieties for product development at household level for improve nutrition. This study evaluated the nutritional, functional and pasting properties of pipeline and improved soybean varieties and of soy-based products. A total of six improved/pipeline soybean varieties and nine products were developed, which include six soy-fortified products using 80:20 wheat: soy flour blend and three soy-based products using 100% processed soybean grains, were milled and analyzed. The moisture, fat and protein contents ranged from 4.91–6.13/100 g; 13.77–19.82/100 g and 31.78–36.56/100 g fresh weight, respectively. The lowest water absorption capacity (WAC) was observed for D.AL/Z 7 having 180.43% while D.AL/Z 8 had the highest value at 285.94%. Pasting viscosity ranged from 1.65–9.63 RVU. The results also showed that the ash, fiber and fat contents of Soy yoghurt are significantly ($p < 0.05$) lower compared with Soy tofu and Salad cream. Soy Tofu had a significant ($p < 0.05$) higher level of protein content (30.7/100 g FW).

Keywords: soy products, nutritional properties, soy bread, soy cake, soy flour

6. Assessment of the chemical and trace metal composition of dried cassava products from Nigeria

Abass, A.B., Awoyale, W., & Alamu, E.O. (2018). Assessment of the chemical and trace metal composition of dried cassava products from Nigeria. *Quality Assurance and Safety of Crops & Foods*, 11(1), 43–52. <https://doi.org/10.3920/QAS2018.1273>.

The chemical and trace metal composition of six groups of commercial dried cassava products in Nigeria (gari, starch, tapioca, fufu, lafun and high-quality cassava flour) were evaluated

to ascertain quality standard compliance and safety for human consumption. In total, 340 samples of the dried products collected based on their popularity in the Humid forest (92), Derived savannah (234) and Southern Guinea savannah (14) agroecologies were analyzed using standard analytical methods. The moisture, cyanogenic potential (CNP), ash and crude fibre content of the samples were significantly different ($P < 0.05$). Product type or agroecology of the products did not have a significant influence on the acidity, pH or trace metal (copper (Cu), iron (Fe) and zinc (Zn)) content. Samples from the Humid forest exhibited the highest average moisture (12.80%), pH (6.62), Zn (5.01 mg/kg) and Cu (3.16 mg/kg) content; Southern Guinea savannah samples had the highest CNP (9.06 mg/kg), ash (2.03%) and Fe (35.38 mg/kg) content, while the samples from Derived savannah had the highest starch (61.11%) and crude fibre (2.87%) content. All the parameters analyzed were within the FAO/WHO standards for cassava products except for the Fe content which exceeded the threshold limit of 22 mg/kg, suggesting that iron-based processing machines release Fe that contaminate cassava during processing. Therefore, these machines should be made of stainless steel, and processors should adhere to the standard operating procedures that were established by the food regulatory agencies to reduce iron contamination of cassava products.

Keywords: processing, trace metals, composition, standards, cassava products

7. Assessment of the nutritional composition, physical properties and sensory quality of composite bread baked with high-quality cassava flour from biofortified and white-fleshed cassava roots

Awoyale, W., Abass, A., Amaza, P., Oluwasoga, O., & Nwaoliwe, G. (2019). Assessment of the nutritional composition, physical properties and sensory quality of composite bread baked with high-quality cassava flour from biofortified and white-fleshed cassava roots. *Preprints*, 2019, 2019060246. <https://doi.org/10.20944/preprints201906.0246.v1>

With proper processing and utilization, biofortified cassava may contribute to the nutritional status of the consumers, thus, the need for this study. High-quality cassava flour from white- (TME 419) and biofortified (TMS 01/1368) cassava varieties were produced at a commercial processing factory, after which the flour is composite with wheat flour to produce bread. The nutritional composition, physical properties and sensory quality of the composite bread were analyzed using standard methods. Results showed that composite bread from 20% biofortified cassava flour (20-YCF) had a higher value of total β -carotene (0.74 $\mu\text{g/g}$), moisture (37.83%) and ash (2.29%) contents. The fat (3.72%) and protein (12.83%) contents were higher in 20% white cassava flour (20-WCF) composite bread. The 20-YCF composite bread had the highest loaf volume (3286.2 cm^3), elasticity (6.32), chewiness (40.51 N) and gumminess (6.41), 20-WCF composite bread had higher specific volume (3.59 cm^3/g) and hardness (176.50 N). The 100% wheat bread had higher cohesiveness (0.10) and loaf weight (932.35 g). A significant negative correlation ($r = -0.98$, $p \leq 0.05$) exist between bread hardness and protein content. The composite bread compared favorably with the 100% wheat bread in terms of weight and aroma, but, the 100% wheat bread was more acceptable.

Keywords: white- and biofortified cassava flour, bread, nutritional composition, physical properties, sensory properties

8. Can the image processing technique be potentially used to evaluate quality of frying oil?

Udomkun, P., Innawong, B., & Sopa, W. (2019). Can the image processing technique be potentially used to evaluate quality of frying oil? *Journal of Food Quality*, 2019, 6580320. <https://doi.org/10.1155/2019/6580320>

The objective of this study was to investigate the feasibility of a computer vision system (CVS) for assessment contact angle of frying oil. The oil was used to fry carbohydrate- and protein-based foods for 40 h and the oil was collected for measuring free fatty acids (FFA), peroxide value (PV), total polar materials (TPMs), and FOS reading (dielectric constant). The results showed that FFA linearly increased with frying time ($R^2 > 0.95$), while the polynomial correlation between TPMs and FOS reading as a result of time was observed ($R^2 > 0.97$). The contact angle obtained from CVS was highly correlated with all chemical qualities ($R^2 > 0.94$), except PV. In addition, the contact angle models could be used to adequately predict FFA, TPMs, and FOS reading of frying oil ($R^2 > 0.91$). This result suggested that the image processing technique through CVS could be an appropriate alternative to chemical analysis, especially for small- and medium-industrial scales frying.

Keywords: frying, oils, French fries, Thailand, foods, materials

9. Changes in microstructure and functional properties of papaya as affected by osmotic pre-treatment combined with freeze-drying

Udomkun, P., Argyropoulos, D., Nagle, M., Mahayothee, B., Oladeji, AE., & Mueller, J. (2018). Changes in microstructure and functional properties of papaya as affected by osmotic pre-treatment combined with freeze-drying. *Journal of Food Measurement and Characterization*, 12(2), 1028–1037. <https://doi.org/10.1007/s11694-018-9718-3>

Freeze-drying represents a very effective method to significantly prevent loss of nutrients, especially heat-sensitive compounds. Moreover, osmotic dehydration is frequently applied prior to drying in order to facilitate moisture removal and improve quality. In the present study, the effect of osmotic pre-treatment combined with freeze-drying at different working pressures on microstructure, color, and functional properties such as carotenoid contents, total phenolic contents (TP) and antioxidant activity in papayas was investigated. Osmotic pretreatment prior to freeze-drying resulted in increased yellowness, apparent density, and solid density, while carotenoids, TP, and antioxidant activity were lower compared to untreated samples. SEM images clearly showed that the effect of working pressure on the characteristic of dried papaya structure. Samples dried at working pressure of 9 and 77 kPa showed higher deformation with large cavities and dense dry layer when compared with those at 28 kPa. In addition, samples were significantly higher in lightness, redness, color difference, and porosity when the working pressure was applied at 9 kPa. A reduction of working pressure had a negative effect on the retention of carotenoids, TP, and antioxidant activity in freeze-dried samples. It can be concluded that 28 kPa of pressure better conserved bioactive compounds and minimised structural deformation.

Keywords: drying, papaya, carotenoids, antioxidants, osmotic, freeze-drying, phenolics, bioactive compounds

10. Comparative study of physicochemical, nutritional, phytochemical, and sensory properties of bread with plantain and soy flours partly replacing wheat flour

Udomkun, P., Masso, C., Swennen, R., Romuli, S., Innawong, B., Fotso Kuate, A., Akin-Ikodu, P. E., Alakonya, A., & Vanlauwe, B. (2022). Comparative study of physicochemical, nutritional, phytochemical, and sensory properties of bread with plantain and soy flours partly replacing wheat flour. *Food Science & Nutrition*, 10(9), 3085–3097. <https://doi.org/10.1002/fsn3.2907>

Plantain flour (PLF) and soy flour (SF) were used to substitute wheat flour (10% and 20% w/w) in composite bread. Physicochemical, phytochemical, and sensory properties were investigated. Partial substitution by PLF significantly increased ($p < .05$) starch, amylose, ascorbic acid, and potassium content in bread samples. In contrast, a significant improvement ($p < .05$) in protein, fat, amylopectin, and calcium content was observed with SF substitution. Composite bread with PLF and SF together lowered the hydrolysis index (HI) and glycemic index (GI) as compared with whole wheat flour. The molar phytate to minerals (iron, zinc, and calcium) ratio in all composite loaves was lower than reported critical values, except for phytate to iron. Significant differences ($p < .05$) were found in color, specific volume, and texture characteristics of loaves made from partial substitution with PLF and SF. Sensory evaluation revealed that bread with 10% PLF exhibited better scores for appearance and willingness to pay than the control. In contrast, SF negatively affected ($p < .05$) the appearance, texture, color, overall acceptance, and willingness to pay. The trade-off analysis indicated that PLF can be utilized to produce bread that meets consumers' demands, while incorporating SF as an alternative high-nutrient density bread will be beneficial to health.

Keywords: bioactive compounds, bread, composite flour, consumer acceptance, glycemic index, nutritional value

11. Comparing characteristics of root, flour and starch of biofortified yellow-flesh and white-flesh cassava variants, and sustainability considerations: A review

Ayetigbo, O., Latif, S., Abass, A., & Müller, J. (2018). Comparing characteristics of root, flour and starch of biofortified yellow-flesh and white-flesh cassava variants, and sustainability considerations: A review. *Sustainability*, 10(9), 3089. <https://doi.org/10.3390/su10093089>

Cassava is a significant food security and industrial crop, contributing as food, feed and industrial biomass in Africa, Asia and South America. Breeding efforts have led to the development of cassava variants having desirable traits such as increased root, flour, and starch yield, reduced toxicity, reduced pest/disease susceptibility and improved nutrient contents. Prominent among those breeding efforts is the development of colored-flesh cassava variants, especially biofortified yellow-fleshed ones, with increased pro-vitamin A carotenoids, compared to the white-flesh variants. The concept of sustainability in adoption of biofortified yellow-flesh cassava and its products cannot be fully grasped without some detailed information on its properties and how these variants compare to those of the white-flesh cassava. Flour and starch are highly profitable food products derived from cassava. Cassava roots can be visually distinguished based on flesh color and other physical properties, just as their flours and starches can be differentiated by their macro- and micro-properties. The few subtle

differences that exist between cassava variants are identified and exploited by consumers and industry. Although white-flesh variants are still widely cultivated, value addition offered by biofortified yellow-flesh variants may strengthen acceptance and widespread cultivation among farmers, and, possibly, cultivation of biofortified yellow-flesh variants may outpace that of white-flesh variants in the future. This review compares properties of cassava root, flour, and starch from white-flesh and biofortified yellow-flesh variants. It also states the factors affecting the chemical, functional, and physicochemical properties; relationships between the physicochemical and functional properties; effects of processing on the nutritional properties; and practical considerations for sustaining adoption of the biofortified yellow-flesh cassava.

Keywords: yellow cassava, sustainability, cassava variants, cassava processing, carotenoids retention, amylose

12. Comparing characteristics of root, flour, and starch of biofortified yellow-flesh and white-flesh cassava variants, and sustainability considerations: A review

Ayetigbo, O., Latif, S., Abass, A., & Muller, J. (2018). Comparing characteristics of root, flour, and starch of biofortified yellow-flesh and white-flesh cassava variants, and sustainability considerations: A review. *Sustainability*, 10, 3089. <https://doi.org/10.3390/su10093089>

Cassava is a significant food security and industrial crop, contributing as food, feed and industrial biomass in Africa, Asia and South America. Breeding efforts have led to the development of cassava variants having desirable traits such as increased root, flour, and starch yield, reduced toxicity, reduced pest/disease susceptibility and improved nutrient contents. Prominent among those breeding efforts is the development of colored-flesh cassava variants, especially biofortified yellow-fleshed ones, with increased pro-vitamin A carotenoids, compared to the white-flesh variants. The concept of sustainability in adoption of biofortified yellow-flesh cassava and its products cannot be fully grasped without some detailed information on its properties and how these variants compare to those of the white-flesh cassava. Flour and starch are highly profitable food products derived from cassava. Cassava roots can be visually distinguished based on flesh color and other physical properties, just as their flours and starches can be differentiated by their macro- and micro-properties. The few subtle differences that exist between cassava variants are identified and exploited by consumers and industry. Although white-flesh variants are still widely cultivated, value addition offered by biofortified yellow-flesh variants may strengthen acceptance and widespread cultivation among farmers, and, possibly, cultivation of biofortified yellow-flesh variants may outpace that of white-flesh variants in the future. This review compares properties of cassava root, flour, and starch from white-flesh and biofortified yellow-flesh variants. It also states the factors affecting the chemical, functional, and physicochemical properties; relationships between the physicochemical and functional properties; effects of processing on the nutritional properties; and practical considerations for sustaining adoption of the biofortified yellow-flesh cassava.

Keywords: yellow cassava, sustainability, cassava variants, cassava processing, carotenoids retention, amylose

13. Compositional and functional dynamics of dried papaya as affected by storage time and packaging material

Udomkun, P., Nagle, M., Argyropoulos, D., Mahayothee, B., Latif, S., & Müller, J. (2015). Compositional and functional dynamics of dried papaya as affected by storage time and packaging material. *Journal of Food Chemistry*, 196, 712–719. <https://hdl.handle.net/10568/76375>

Papaya has been identified as a valuable source of nutrients and antioxidants, which are beneficial for human health. To preserve the nutritional properties after drying, appropriate storage specifications should be considered. This study aimed to investigate the quality and stability of air-dried papaya in terms of quality dynamics and behavior of bio-active compounds during storage for up to 9 months in two packaging materials: aluminium laminated polyethylene and polyamide/polyethylene. Samples with moisture content (MC) of 0.1328 g g⁻¹ and water activity (aw) of 0.5 were stored at 30 °C and relative humidity (RH) of 40-50%. The MC, aw, degree of browning (DB) and 5-hydroxymethylfurfural (HMF) content were found to notably increase as storage progressed. On the contrary, there was a significant decrease in antioxidant capacity (DPPH, FRAP and ABTS), total phenolic content (TP) and ascorbic acid (AA) content. Packaging in aluminium laminated polyethylene under ambient conditions was found to better preserve bio-active compounds and retard increases in MC, aw and DB, when compared to polyamide/polyethylene.

Keywords: browning, phenolics, vitamin C, antioxidative compounds

14. Computer vision coupled with laser backscattering for non-destructive colour evaluation of papaya during drying

Udomkun, P., Nagle, M., Argyropoulos, D., Wiredu, A.N., Mahayothee, B., & Mueller, J. (2017). Computer vision coupled with laser backscattering for non-destructive colour evaluation of papaya during drying. *Journal of Food Measurement and Characterization*, 11(4), 2142–2150. <https://doi.org/10.1007/s11694-017-9598-y>

Color change is a common physical phenomenon observed during drying, which need to be controlled since it directly affects consumer acceptance of dried products. This study aimed to investigate the feasibility of using computer vision, combined with laser light backscattering analysis at 650 nm in order to predict color changes of papaya during drying. The results revealed that each image-processing factor obtained can potentially be used to describe every color attribute change, except for chroma value. The multivariate correlations of measured backscattering parameters as well as the digital image properties were found to yield the best fitting for color validations. Interestingly, the use of computer vision technique coupled with laser backscattering methods provides a reliable tool for quality control based on a rapid, consistent, and non-intrusive method for in-line quality measurement in established fruit drying processes.

Keywords: color change, laser backscattering, computer vision system, quality control, drying, papaya

15. Computer vision system (CVS) for color and surface oil measurements of durian chips during post-frying

Udomkun, P., Innawong, B., & Jeepetch, K. (2019). Computer vision system (CVS) for color and surface oil measurements of durian chips during post-frying. *Journal of Food Measurement and Characterization*, 13, 2075–2081. <https://doi.org/10.1007/s11694-019-00128-1>

This study aimed to investigate the feasibility of using the computer vision system (CVS) for monitoring color and surface oil content of durian chips during post-frying cooling. The results revealed the browning index values increased with cooling time, while surface oil content decreased. A high linear correlation of browning index as well as surface oil content and cooling time was observed ($R^2 > 0.92$). The image-processing technique can effectively be used to describe browning index and surface oil content of fried durian chips as it yielded a very high correlation ($R^2 > 0.94$). This technology exhibits great potential as a reliable, rapid, consistent, and non-destructive tool for process optimization and quality control of fried products.

Keywords: browning index, glossy surface area, image analysis, quality control, frying, durian

16. Determinants of aflatoxin exposure in young children from Benin and Togo, West Africa: the critical role of weaning

Gong, Y., Egal, S., Hounsa, A., Turner, P., Hall, A., Cardwell, K., & Wild, C. (2003). Determinants of aflatoxin exposure in young children from Benin and Togo, West Africa: the critical role of weaning. *International Journal of Epidemiology*, 32, 556–562. <https://doi.org/10.1093/ije/dyg109>

Background: Dietary exposure to high levels of the fungal toxin, aflatoxin, occurs in West Africa, where long-term crop storage facilitates fungal growth.

Methods: We conducted a cross-sectional study in Benin and Togo to investigate aflatoxin exposure in children around the time of weaning and correlated these data with food consumption, socioeconomic status, agro-ecological zone of residence, and anthropometric measures. Blood samples from 479 children (age 9 months to 5 years) from 16 villages in four agro-ecological zones were assayed for aflatoxin-albumin adducts (AF-alb) as a measure of recent past (2–3 months) exposure.

Results: Aflatoxin-albumin adducts were detected in 475/479 (99%) children (geometric mean 32.8 pg/mg, 95% CI: 25.3–42.5). Adduct levels varied markedly across agro-ecological zones with mean levels being approximately four times higher in the central than in the northern region. The AF-alb level increased with age up to 3 years, and within the 1–3 year age group was significantly ($P = 0.0001$) related to weaning status; weaned children had approximately twofold higher mean AF-alb adduct levels (38 pg AF-lysine equivalents per mg of albumin [pg/mg]) than those receiving a mixture of breast milk and solid foods after adjustment for age, sex, agro-ecological zone, and socioeconomic status. A higher frequency of maize consumption, but not groundnut consumption, by the child in the preceding week was correlated with higher AF-alb adduct level. We previously reported that the prevalence of stunted growth (height

for age Z-score HAZ) and being underweight (weight for age Z-score WAZ) were 33% and 29% respectively by World Health Organization criteria. Children in these two categories had 30–40% higher mean AF-alb levels than the remainder of the children and strong dose–response relationships were observed between AF-alb levels and the extent of stunting and being underweight.

Conclusions: Exposure to this common toxic contaminant of West African food increases markedly following weaning and exposure early in life is associated with reduced growth. These observations reinforce the need for aflatoxin exposure intervention strategies within high-risk countries, possibly targeted specifically at foods used in the post-weaning period.

Keywords: aflatoxin, dietary exposure, biomarkers, child growth, weaning

17. Determinants of child nutritional status in the eastern province of Zambia: the role of improved maize varieties

Manda, J., Gardebreek, C., Khonje, M. G., Alene, A. D., Mutenje, M., & Kassie, M. (2016). Determinants of child nutritional status in the eastern province of Zambia: the role of improved maize varieties. *Food Security*, 8(1), 239–253. <https://doi.org/10.1007/s12571-015-0541-y>

Using household survey data from a sample of 810 households, this paper analyzes the determinants of children’s nutritional status and evaluates the impacts of improved maize varieties on child malnutrition in eastern Zambia. The paper uses an endogenous switching regression technique, combined with propensity score matching, to assess the determinants of child malnutrition and impacts of improved maize varieties on nutritional status. The study finds that child nutrition worsens with the age of the child and improves with education of household head and female household members, number of adult females in the household, and access to better sanitation. The study also finds a robust and significant impact of improved maize varieties on child malnutrition. The empirical results indicate that adoption of improved maize varieties reduces the probability of stunting by an average of about 26%.

Keywords: household, nutritional status, impact, improved maize varieties, malnutrition, endogenous switching regression technique, propensity score matching, education, Zambia

18. Determinants of nutritional status of preschool children from rural households in Kaduna and Kano States, Nigeria

Ojiako, I. A., Manyong, V., & Ikpi, A (2009). Determinants of nutritional status of preschool children from rural households in Kaduna and Kano States, Nigeria. *Pakistan Journal of Nutrition*, 8(9), 1497–1505. <https://dx.doi.org/10.3923/pjn.2009.1497.1505>

The study evaluated the nutritional status of preschool children; identified the influencing factors and estimated the degree of responsiveness of nutritional status index to changes in causal variables. Conducted in five villages selected from Kaduna and Kano States of northern Nigeria, the study used data from selected rural households and anthropometric measurements of preschool children resident therein. Household data were collected using

structured questionnaire administered by trained enumerators. The relevant software was used to calculate nutritional status indexes while a two-limit tobit regression analysis, in which the long-term index of height-for-age entered as a dependent variable, was conducted to assess the influence of the explanatory variables on nutritional status. Tobit decomposition framework was used to estimate the elasticities. Results revealed that the proportions of children with either moderate or severe nutritional problems were 61, 17 and 40% using the height-for-age, weight-for-height and weight-for-age measures respectively. Soybean consumption ($p < 0.01$), mother's education ($p < 0.01$), mother's position among housewives ($p < 0.05$) and child's height ($p < 0.01$) were positively related to the child's nutritional status. Also, mother's age ($p < 0.01$), child's age ($p < 0.01$) and dependency ratio ($p < 0.05$) had negative influence on nutritional status. A 10% increase in dependency ratio and child's mother's age would result to a 1.70 and 0.46% increases in total elasticity of children malnutrition. Proportionate percentage increases in mother's position among wives in the household, mother's level of education and household's consumption of soybean-related food would elicit a total of 0.03, 1.15 and 0.26% decreases respectively in elasticity of malnutrition. Decomposition of the elasticity coefficients revealed that marginal changes in all factors would increase or decrease the probability of intensity of children malnutrition more than they would increase or decrease the probability of prevalence. Policy options that would promote formal education for women, home use of soybean and reduction in dependency ratio are recommended to achieve meaningful improvement in nutritional status.

Keywords: determinants, nutritional status, preschool children, rural households, Nigeria

19. Development and sensory evaluation of Soyamusa: A soybean-plantain baby food

Ogazi, P. O, Oyewusi, F. A, Ozumba, A. U, Ogundipe, H. O., Osifo, B. O. A, & Lukambi, F. A.* (2000). Development and sensory evaluation of Soyamusa: A soybean-plantain baby food. *Acta Horticulturae*, 540, 575–582. https://www.ishs.org/ishs-article/540_63

Appropriate technologies were used to process plantain and soybean into flour which were used for the formulation of 'Soyamusa', a soybean-plantain baby food that requires little cooking. Extruded and non-extruded soybean grits were produced and mixed with plantain flour in varying proportions to determine the blend that would give the required energy and protein level in baby foods. A mixture of sugar, vitamins and minerals was added to improve the taste and to meet the recommended daily vitamin and mineral requirements for babies. The final blend was subjected to nutritional and sensory evaluations. The sensory test was to determine the acceptability of the two products of 'Soyamusa' and compare them with other popular market brands. It was found that a mixture of 60% plantain flour, 32% soybean grit and 8% sugar produced a blend whose proximate analysis showed 15.8% protein, 8.0% fat, and 72.8% carbohydrate with an energy content of 457.4 kcal per 100g. The sixteen weaning Wister rats on 'Soyamusa' had normal growth, packed cell volume and white blood cell count. Hemagglutination test did not indicate any immunological reaction against 'Soyamusa'. Results of the comparative assessment of the two samples for color, flavor, consistency, mouthful, taste and overall acceptability did not show any significant difference ($P > 0.05$). However, the samples differ significantly in all attributes ($P < 0.01$) from the two popular market brands but were equally acceptable.

20. Dietary aflatoxin exposure and impaired growth in young children from Benin and Togo: cross-sectional study

Gong, Y., Cardwell, K., Hounsa, A., Egal, S., Turner, P., Hall, A., & Wild, C. (2002). Dietary aflatoxin exposure and impaired growth in young children from Benin and Togo: cross-sectional study. *British Medical Journal*, 325, 20–21. <https://doi.org/10.1136/bmj.325.7354.20>

Fetal and early childhood environment, including the nutritional status of the pregnant mother and the infant, are considered critical for growth and risk of disease in later life. Many people in developing countries are not only malnourished but also chronically exposed to high levels of toxic fungal metabolites (mycotoxins). One family of mycotoxins, the aflatoxins, are carcinogenic and immunotoxic and cause growth retardation in animals. Aflatoxins contaminate staple foods in West Africa, particularly maize and groundnuts, as a result of hot, humid storage conditions that promote fungal growth. High exposure to aflatoxins occurs throughout childhood in the region, suggesting that growth and development could be critically affected. We assessed exposure to aflatoxins in relation to anthropometric measures in children in Benin and Togo. We studied 480 children (aged 9 months to 5 years) from 16 villages in four geographic zones (four in each zone): Sudan savannah, north Guinea savannah, south Guinea savannah, and coastal savannah. The Ministries for Health in Benin and Togo gave ethical approval, and parents gave informed consent. We determined weight for age, height for age, and weight for height z scores, according to the median value of a World Health Organization reference population. A z score ≤ -2 is classified as malnutrition, and ≤ -3 represents severe malnutrition. We also determined weaning status and the socioeconomic status of the mother and family. We assessed aflatoxin exposure over the previous two to three months by measuring aflatoxin bound to albumin in blood. We detected aflatoxin-albumin adducts in 475/479 (99%) samples (one sample missing), with a geometric mean concentration of 32.8 (range 5-1064) pg/mg albumin. Aflatoxin-albumin concentration increased with age up to 3 years, after which it reached a plateau. In the 302 children aged 3 years or under, the mean concentration was 2.5-fold higher in fully weaned children (45.6 pg/mg; 95% confidence interval 38.8 to 53.7) than in those still partially breast fed (18.0 pg/mg; 15.2 to 21.3). In a multivariable model adjusting for age, sex, socioeconomic status, and agro-ecological zone, weaning status was significantly associated with aflatoxin-albumin concentration ($P=0.0001$). Prevalence of malnutrition was 33% for stunting (height for age z score ≤ -2), 29% for being underweight (weight for age z score ≤ -2), and 6% for wasting (weight for height z score ≤ -2). Children with stunting or who were underweight had 30-40% higher mean aflatoxin-albumin concentrations. After adjustment as above, the negative correlation between individual aflatoxin-albumin concentration and each of the three growth parameters was highly significant ($P=0.001$ for height for age, $P=0.005$ for weight for age, and $P=0.047$ for weight for height). In a categorical analysis, the association with aflatoxin-albumin concentration was again significant, with clear dose-response relations with height for age and weight for age z scores

21. Dietary exposure to aflatoxin from maize and groundnut in young children from Benin and Togo, West Africa

Egal, S., Hounsa, A., Gong, Y., Turner, P., Wild, C., Hall, A., Hell, K., & Cardwell, K. (2005). Dietary exposure to aflatoxin from maize and groundnut in young children from Benin and Togo, West Africa. *International Food Microbiology*, 104(2), 215–224. <https://doi.org/10.1016/j.ijfoodmicro.2005.03.004>

Aflatoxins are a family of fungal toxins that are carcinogenic to man and cause immunosuppression, cancer and growth reduction in animals. We conducted a cross-sectional study among 480 children (age 9 months to 5 years) across 4 agro-ecological zones (SS, NGS, SGS and CS) in Benin and Togo to identify the effect of aflatoxin exposure on child growth and assess the pattern of exposure. Prior reports on this study showed that aflatoxin exposure among these children is widespread (99%) and that growth faltering is associated with high blood aflatoxin-albumin adducts (AF-alb adducts), a measure of recent past exposure. The present report demonstrates that consumption of maize is an important source of aflatoxin exposure for the survey population. Higher AF-alb adducts were correlated with higher *A. flavus* (CFU) infestation of maize ($p=0.006$), higher aflatoxin contamination (ppb) of maize ($p<0.0001$) and higher consumption frequencies of maize ($p=0.053$). The likelihood of aflatoxin exposure from maize was particularly high in agro-ecological zones where the frequency of maize consumption (SGS and CS), the presence of aflatoxin in maize (SGS) or the presence of *A. flavus* on maize (NGS and SGS) was relatively high. Socio-economic background did not affect the presence of *A. flavus* and aflatoxin in maize, but better maternal education was associated with lower frequencies of maize consumption among children from the northernmost agro-ecological zone (SS) ($p=0.001$). The impact of groundnut consumption on aflatoxin exposure was limited in this population. High AF-alb adduct levels were correlated with high prevalence of *A. flavus* and aflatoxin in groundnut, but significance was weak after adjustment for weaning status, agro-ecological zone and maternal socio-economic status (resp. $p=0.091$ and $p=0.083$). Ingestion of *A. flavus* and aflatoxin was high in certain agro-ecological zones (SS and SGS) and among the higher socio-economic strata due to higher frequencies of groundnut consumption. Contamination of groundnuts was similar across socio-economic and agro-ecological boundaries. In conclusion, dietary exposure to aflatoxin from groundnut was less than from maize in young children from Benin and Togo. Intervention strategies that aim to reduce dietary exposure in this population need to focus on maize consumption in particular, but they should not ignore consumption of groundnuts.

Keywords: *Aspergillus flavus*, aflatoxin, dietary exposure, maize, groundnut, children

22. Does crop diversity contribute to dietary diversity? Evidence from integration of vegetables into maize-based farming systems

Rajendran, S., Afari-Sefa, V., Shee, A., Bocher, T., Bekunda, M., Dominick, I., & Lukumay, P. J. (2017). Does crop diversity contribute to dietary diversity? Evidence from integration of vegetables into maize-based farming systems. *Agriculture & Food Security*, 6(50), 1–13. <https://doi.org/10.1186/s40066-017-0127-3>

Background: Maize is the most important staple crop for food security and livelihood of smallholder farmers in many parts of sub-Saharan Africa, but it alone cannot ensure food security. Cropping patterns must be diversified to ensure an adequate supply and economic access to greater variety of foods for smallholder farm households. This study measured the effect of crop diversification on household dietary diversity in a selected study locale using a survey of 300 randomly stratified farm households in 10 villages located in the Babati, Kongwa and Kiteto districts of Tanzania.

Results: Based on multiple regression analysis, the study found that simply increasing Simpson's Index does not influence dietary diversity of farm households due to the presence of interaction effect between Simpson's Index and crop income. It is much more critical and significant to increase the revenue generated from diversified crops along with other socioeconomic endowment and behavioral characteristics of farm households. This is particularly applicable to poorer smallholder farmers who receive crop income less than US\$85 per sales transaction and per season. Particularly, marginal and smallholders might be exposed to the effects of crop diversification and crop income toward increasing in their household dietary diversity score.

Conclusion: Under average crop income scenarios, households that diversify their crop production tend to increase their dietary diversity from their existing dietary diversity score at a decreasing rate. However, under below average crop income threshold scenarios, farmers tend to increase their dietary diversity score from their existing score at an increasing rate when they diversify into high-value crops that attract relatively high farm gate values and accrue higher net revenues from the market. Monthly food expenditure also tends to positively influence household dietary diversity, indicating that farm households that spend more on market-purchased food have consistent increases in their dietary diversity scores at the household level. This study concludes that improving economic access to variety of foods at the smallholder household level by diversifying diets through increased crop diversification should be encouraged within maize-based farming systems of the study locale, through integration of micronutrient-rich foods such as vegetables.

23. Effect of husk and harvesting time on the carotenoids and acceptability of roasted orange maize hybrids

Alamu, E. O., Menkir, A., Maziya-Dixon, B., & Olaofe, O. (2014). Effect of husk and harvesting time on the carotenoids and acceptability of roasted orange maize hybrids. *Food Science & Nutrition*, 2(6), 811–820. <http://dx.doi.org/10.1002/fsn3.179>

Vitamin A deficiency (VAD) is a major public health problem in many developing countries. Orange maize is preferred as green maize and consumed roasted on the cob, especially in Nigeria. This research work was to evaluate the effects of harvest time and husk on the carotenoid contents and sensory properties of roasted orange maize hybrids. The results showed that husk (roasting forms) and harvesting time had significant effects ($P \leq 0.001$) on the carotenoids and the sensory properties. There was general increase in β -carotene and provitamin A (PVA) values as the harvesting time increases. The β -carotene and PVA values for roasted orange maize hybrids with husk were higher than those for roasted without husk. Hybrid 5 had the highest β -carotene concentration and PVA value at 27 days after pollination (DAP) and 34DAP when unprocessed and roasted without husk. This information can help researchers in choosing proper roasting methods to increase the retention of high levels of β -carotene and PVA in orange maize that can be delivered to consumers through nutrition education.

Keywords: harvesting time, husk, sensory evaluation, orange maize, provitamin A, roasting, β -carotene

24. Effect of pre-treatment processes on physicochemical aspects of vacuum fried banana chips

Udomkun, P., & Innawong, B. (2018). Effect of pre-treatment processes on physicochemical aspects of vacuum fried banana chips. *Journal of Food Processing and Preservation*, 42(8), e13687. <https://doi.org/10.1111/jfpp.13687>

The objective of this study was to investigate the influence of various pre-treatments on the physico-chemical and sensory characteristics of the vacuum fried (VF) banana chips (120°C, 41.3 kPa) and consequently compare them to the atmospheric fried (AF) banana chips (170°C). Pre-treatments comprised osmotic dehydration with sucrose solution (ODSu), osmotic dehydration with salt solution (ODSa), microwave heating (MV), and hot air-drying (HD). The moisture content, oil content, L*, b*, and index of firmness of all pre-treated banana chips were significantly decreased whereas values for a*, volume shrinkage, and hardness were increased when compared to those without pre-treatment. The ODSu sample provided the lowest oil content. The highest volume shrinkage was obtained from HD and MV treatments. Sensory evaluation revealed that VF chips exhibited the highest scores in color, crispiness, and oiliness when compared to AF chips. ODSu and ODSa samples positively affected the color, crispiness, and taste properties.

25. Effect of soybean (*Glycine max* (L.) Merr.) flour inclusion on the nutritional properties and consumer preference of fritters for improved household nutrition

Alamu, E. O., Popoola, I., & Maziya-Dixon, B. (2018). Effect of soybean (*Glycine max* (L.) Merr.) flour inclusion on the nutritional properties and consumer preference of fritters for improved household nutrition. *Food Science & Nutrition*. 6(7),1811–1816. <https://doi.org/10.1002/fsn3.751>

Diets in populations of most developing countries are often deficient in protein, carbohydrates, and fat, leading to protein–energy malnutrition (PEM). Diet–based strategies are the most promising approach for a sustainable control of PEM. This study aimed to investigate the effects of soy flour inclusion on the nutritional properties, consumer preference, purchase intent, and willingness to pay for wheat–based fritters. The proximate composition of both types of fritters was determined using standard methods, Consumer preference survey on organoleptic properties was carried out among 291 participants (93 men, 198 women) in Chipata, Katete, and Lundazi districts of Eastern Zambia. The soy–fortified fritters had significantly higher ($p < 0.05$) levels of ash, fat, amylose, crude fiber, and protein than the unfortified fritters. Protein, crude fiber, amylose, and ash contents of soy–fortified fritters were considerably increased by 55.5%, 18.9%, 98%, and 30.6%, respectively. The overall preference showed no significant difference ($p > 0.05$) between unfortified and soy–fortified fritters. A larger percentage of participants in Katete (38%) and Chipata (41%) preferred the soy–fortified fritters to the nonfortified one. In addition, no significant difference ($p > 0.05$) was also observed for intention to purchase between both types of fritters across the three locations. In conclusion, incorporating 20% soybean flour into fritters, which showed better nutrients quality, could be used to alleviate PEM among fritters consuming populations of developing countries, particularly in Sub–Saharan Africa.

Keywords: consumption intent, protein, proximate composition, sensory properties, soy fritters, malnutrition, Zambia

26. Effects of calcium chloride and calcium lactate applications with osmotic pretreatment on physicochemical aspects and consumer acceptances of dried papaya

Udomkun, P., Mahayothee, B., Nagle, M., & Müller, J. (2014). Effects of calcium chloride and calcium lactate applications with osmotic pretreatment on physicochemical aspects and consumer acceptances of dried papaya. *International Journal of Food Science and Technology*, 49, 1122–1131. <https://doi.org/10.1111/ijfs.12408>

This study explored the effects of calcium chloride (CaCl₂) and calcium lactate (Ca-L) pretreatments prior to osmotic dehydration on physicochemical characteristics and consumer acceptance of dried papaya. Three different calcium concentrations [0.5, 1.5 and 2.5% (w/v)] were applied to samples before they were soaked in a 30° Brix sucrose solution and subsequently dried at 70°C. The results showed that the dried samples treated with calcium exhibited significantly lower moisture content, water activity, apparent density and shrinkage, while volume was higher when compared to the control. Calcium applications did not obviously influence sugar content of samples and maintained the quality of dried papaya in terms of color and textural characteristics. Calcium chloride at 2.5% (w/v) was found to particularly impart undesirable bitterness to the dried papaya. In contrast, using 2.5% (w/v) Ca-L provided the best acceptance scores. Thus, the use of Ca-L could be an alternative to CaCl₂ in the pretreatment of fruits prior to drying as it offers improved quality.

Keywords: calcium pretreatments, drying, osmotic dehydration, papaya, sensory analysis

27. Effects of husk and harvesting time on provitamin A activity and sensory properties of boiled fresh orange maize hybrids

Alamu, E. O., Maziya-Dixon, B., Menkir, A., & Olaofe, O. (2015). Effects of husk and harvesting time on provitamin A activity and sensory properties of boiled fresh orange maize hybrids. *Journal of Food Quality*, 38(6), 387–395. <http://dx.doi.org/10.1111/jfq.12158>

Boiled fresh maize on the cob is a nutritious food staple among Nigerians. This study evaluated the effect of husk and harvesting time on the β -carotene, provitamin A (PVA) activity and sensory properties of boiled orange maize hybrids. Eight freshly harvested cobs of orange maize hybrids were boiled with and without husk using an atmospheric cooking method and evaluated for PVA carotenoids. Sensory evaluation was carried out on the boiled samples within 24 h after harvesting. Husk and harvesting time had highly significant effects ($P \leq 0.001$) on the carotenoid components. The best harvesting time to boil fresh orange hybrids for higher β -carotene and PVA is 20 days after pollination (DAP) for boiled maize with husk and 27 DAP for boiled maize without husk. Hybrid variety and harvesting time were very important factors in rating sensory properties of boiled orange maize hybrids, and the sensory properties that determined the acceptance/likeness were found to be aroma, chewiness and taste.

Keywords: boiled fresh maize, food staple, sensory evaluation, husk, maize hybrids, Nigeria

28. Effects of traditional processing techniques on the nutritional and microbiological quality of four edible insect species used for food and feed in East Africa

Nyangena, D. N., Mutungi, C., Imathiu, S., Kinyuru, J., Affognon, H., Ekesi, S., Nakimbugwe, D., & Fiaboe, K. K. M. (2020). Effects of traditional processing techniques on the nutritional and microbiological quality of four edible insect species used for food and feed in East Africa. *Foods*, 9(5), 574. <https://doi.org/10.3390/foods9050574>

Edible insects are increasingly being considered as food and feed ingredients because of their rich nutrient content. Already, edible insect farming has taken-off in Africa, but quality and safety concerns call for simple, actionable hazard control mechanisms. We examined the effects of traditional processing techniques—boiling, toasting, solar-drying, oven-drying, boiling + oven-drying, boiling + solar-drying, toasting + oven-drying, toasting + solar-drying—on the proximate composition and microbiological quality of adult *Acheta domesticus* and *Ruspolia differens*, the prepupae of *Hermetia illucens* and 5th instar larvae of *Spodoptera littoralis*. Boiling, toasting, and drying decreased the dry matter crude fat by 0.8–51% in the order: toasting > boiling > oven-drying > solar-drying, whereas the protein contents increased by 1.2–22% following the same order. Boiling and toasting decreased aerobic mesophilic bacterial populations, lowered *Staphylococcus aureus*, and eliminated the yeasts and moulds, Lac+ enteric bacteria, and *Salmonella*. Oven-drying alone marginally lowered bacterial populations as well as yeast and moulds, whereas solar-drying alone had no effect on these parameters. Oven-drying of the boiled or toasted products increased the aerobic mesophilic bacteria counts but the products remained negative on Lac+ enteric bacteria and *Salmonella*. Traditional processing improves microbial safety but alters the nutritional value. Species- and treatment-specific patterns exist.

Keywords: entomophagy, processing, traditional knowledge, food/feed safety, nutrition

29. Enumeration of the microbiota and microbial metabolites in processed cassava products from Madagascar and Tanzania

Abass, A. B., Adegoke, G. O., Awoyale, W., Gaspar, A., Mlingi, N., Andrianavalona, V., Randrianarivelo, R., Sulyok, M., Mneney, A., & Ranaivoson, L.R. (2019). Enumeration of the microbiota and microbial metabolites in processed cassava products from Madagascar and Tanzania. *Food Control*, 99: 164–170. <https://doi.org/10.1016/j.foodcont.2018.12.025>

Cassava processing practices vary among communities and countries with implications for food safety. The study examined the microbiota and microbial metabolite profiles of 126 samples of sun-dried cassava products: grits, improved chips, improved flour, *kivunde*, and *makopa* from Tanzania, and *mangahazo maina* from Madagascar. All samples were free of *Salmonella* spp. Only 12.5% *makopa*, 6.7% of mechanically processed flour, and 25% of chips conformed to yeast/mold regulatory limits (10^3 cfu/g). Among the most agriculturally important mycotoxins, aflatoxins (B1, B2, G1, and M1) were detected in 6.3–11.9%, fumonisins (B1, B2 and B3) in 3.2–41.3%, and zearalenone in 41.3% of the samples. A few samples of improved chips, improved flour, and *makopa* contained high aflatoxin B1 content. Some emerging mycotoxins: emodin, beauvericin, moniliformin, sterigmatocystin, alternariol methyl ether, nivalenol, mycophenolic acid, enniatin B, and enniatin B1 were detected. The most prevalent microbial metabolites were emodin (75.4%), tryptophol (67.5%), equisetin (61.9%),

and beauvericin (51.6%), at mean concentrations of 8.8 µg/kg, 794.1 µg/kg, 277.2 µg/kg, and 29.5 µg/kg, respectively. Emodin and Beauvericin are the only emerging mycotoxins in this group and the mean concentrations are the lowest. Nevertheless, regular surveillance along the cassava food chain is recommended for early detection of emerging mycotoxins to prevent health problems associated with ingestion of unexpected toxins in foods.

Keywords: cassava, sun-drying, microbial metabolites, mycotoxins, regulatory standards

30. Evaluation of harvesting time and husk effects on retention of nutritional properties of boiled fresh orange maize hybrids

Alamu, E. O., Maziya-Dixon, B., Olaofe, O, & Menkir, A. (2016). Evaluation of harvesting time and husk effects on retention of nutritional properties of boiled fresh orange maize hybrids. *Ciencia e Tecnica Vitivinicola*, 31(6), 114–143. <https://hdl.handle.net/10568/76986>

This study evaluated the effects of harvesting time and husk on the proximate composition of boiled orange maize hybrids. Eight fresh orange maize hybrids were boiled with and without intact husk at 100°C using atmospheric cooking method and evaluated for proximate components. The results of analysis of variance [ANOVA] revealed that maturity [harvesting time] and method had significant effects [$p \leq 0.001$] on all proximate components. There was a general decrease in dry matter [DM], ash and total sugar contents across harvest maturity stages. Protein and fat increased at 20DAP and 27DAP and then decreased at 34DAP. The unprocessed maize had optimum sugar content at 20DAP and optimum protein and fat contents at 27DAP. The optimum sugar and protein contents were found at 20DAP and 34DAP respectively for boiled maize without husk, while optimum sugar and protein contents were found at 20DAP for boiled maize with husk. Boiled maize with husk had higher retention of protein, total sugars and starch at 20DAP than boiled maize without husk. Thus, the best harvesting time to consume boiled maize is at 20DAP for optimum protein and sugar contents and it must be boiled with husk.

Keywords: husk, harvesting time, proximate, orange maize, hybrids

31. Evaluation of nutritional properties, and consumer preferences of legume-fortified cassava leaves for low-income households in Zambia

Alamu, E. O., Prisca, C, Olaniyan, B., Omosebi, M. O, Adegunwa, M, Chikoye, D., & Maziya-Dixon, B. (2021). Evaluation of nutritional properties, and consumer preferences of legume-fortified cassava leaves for low-income households in Zambia. *Cogent Food & Agriculture*, 7(1), 1885796. <https://doi.org/10.1080/23311932.2021.1885796>

Cassava leaves have the potential to improve dietary diversity, the intake of protein and micronutrient of members of low-income households. The study aimed at evaluating nutritional properties, and consumer preferences of legume-fortified cassava leaves (soybean and groundnut fortified products) using plain leaves as control. The nutritional and anti-nutritional properties of the samples were determined using standard laboratory methods, and a structured questionnaire was used to assess consumer preferences. There were significant ($P < 0.05$) increase in the nutritional properties and the product type had a strong significant

($P < 0.05$) effect on the anti-nutritional properties (tannins, phytate, and cyanogenic potential (CNP)). Respondents from Kaoma and Serenje districts have a higher preference for soy-fortified over groundnut-fortified variant. In contrast, Kasama and Mansa districts preferred both soybean and groundnut in the fortification of cassava leaves. The Willingness to pay (WTP) is significantly ($P < 0.05$) correlated with the taste and texture of the cassava leaf products.

Keywords: cassava leaves, fortification, nutritional characteristics, consumer acceptability, willingness-to-pay, WTP

32. Evaluation of proximate composition and pasting properties of high-quality cassava flour (HQCF) from cassava genotypes (*Manihot esculenta* Crantz) of β -carotene-enriched roots

Alamu, E. O., Maziya-Dixon, B., & Dixon, G.A. (2017). Evaluation of proximate composition and pasting properties of high-quality cassava flour (HQCF) from cassava genotypes (*Manihot esculenta* Crantz) of β -carotene-enriched roots. *LWT – Food Science and Technology*, 86, 501–506. <http://dx.doi.org/10.1016/j.lwt.2017.08.040>

Cassava farmers are yet to fully exploit its full potential in terms of improvement of livelihood. Forty-five genotypes of cassava genotypes were processed into High Quality Cassava Flour (HQCF). These genotypes were planted in two sets, set 1 comprised 22 clones of β -carotene enriched roots and 3 check clones of white roots and set 2 comprised 18 clones and 2 check clones. The effects of variety on the proximate composition and pasting profile of the flour were investigated. The starch content ranged between 67.1 g/100 g (for 01/1663) and 82.4 g/100 g (for 30572) in set 1 and between 69.6 (01/1560) to 77.8 g/100 g (for Z97/0474) in set 2. Peak viscosity values ranged between 295.6 RVU (rapid visco unit) (30572) and 467.0 RVU (01/1115) across clones in set 1 while for set 2, it ranged from 271.9 RVU (for 01/1404) to 471.3 RVU (for 01/1417). Significant differences ($P < 0.05$) existed in the proximate composition and pasting properties of the flour from different cassava genotypes investigated. The high peak viscosity exhibited by most genotypes is indicative that the flour may be suitable for products requiring high gel strength and elasticity. The proximate composition compares competitively with values obtainable from conventional clones.

Keywords: cassava, chemical properties, cassava roots, cassava processing, pasting properties, livelihoods, genotypes

33. Food processing technologies and value addition for improved food safety and security

Alamu, E. O., & Mooya, A. (2017). Food processing technologies and value addition for improved food safety and security. In Nhamo, N., Chikoye, D., & Gondwe, T. (eds) *Smart Technologies for Sustainable Smallholder Agriculture*, pp. 201–210. Academic Press. <https://doi.org/10.1016/B978-0-12-810521-4.00010-4>

Food processing and value addition are key steps in the food value chain. Developing food

processing technologies that are environmentally friendly and efficient can substantially contribute to the food value chain and to mitigating the energy crisis that the Southern African region is experiencing. Some methods of food processing have been challenged in the recent years but food processing cannot be circumvented entirely because of the ever-growing human population that has to be nourished. The increase in global population during the past two centuries has made food processing one of the most deliberated subjects in the food value chain. The need for processed food is expected to increase even further when the global population increases further. Environmental concerns related to food processing that require consideration, such as the use of fossil fuels and the disposal of residual matters of food processing, will have to be reviewed. This chapter will provide strategies that can be used by industries to enhance the use of environmentally friendly technologies for food processing and enhance value addition.

34. Household hunger, poverty, and childcare in 5 States of Nigeria and their impacts on nutritional outcomes in preschool children

Manyong, V., Abdoulaye, T., Ojide, M., Ogundapo, A., Ayoola Gbolagade, B., Dashiell, K., & Okike, I. (2021). Household hunger, poverty, and childcare in 5 States of Nigeria and their impacts on nutritional outcomes in preschool children. *Food and Nutrition Bulletin*, 42(2). <https://doi.org/10.1177/03795721211009482>

This article presents findings from baseline surveys in 5 states of Nigeria to assess the nutritional outcomes on target groups on attaining the UN Sustainable Development Goal 2. The augmented regression technique was applied to analyze data from a sample of 1642 households with at least 1 child under the age of 5 years (U5) and their mothers or caregivers out of a total of 2500 households that were drawn from the 250 enumeration areas of the Nigeria Bureau of Statistics in the 5 states. The results support the growing evidence base that poverty and household hunger are pervasive. The incidence of poverty highlights inequalities among states. The combination of poverty and hunger was mirrored in the damning extent to which all forms of malnutrition coexisted in children U5, particularly during the second year of infancy and among poor households. Evidence from this study points to poor dietary quality of complementary food rather than other childcare practices as majorly responsible for child malnutrition. Child wellness was positively affected by maternal health-seeking behavior but negatively by the poverty probability index of the household. Notably, maternal health-seeking behavior played a more relevant role in child wellness than mothers' educational attainment.

Keywords: hunger, poverty, child malnutrition, anthropometry, feeding practices, zero hunger

35. How cost-effective is biofortification in combating micronutrient malnutrition? An ex ante assessment

Meenakshi, J., Johnson, N., Manyong, V., De Groote, H., Javelosa, J., Yanggen, D. R., Naher, F.*, Gonzalez, C., Garcia, J., & Meng, E. (2009). How cost-effective is biofortification in combating micronutrient malnutrition? An ex ante assessment. *World Development*, 38(1), 64–75. <https://doi.org/10.1016/j.worlddev.2009.03.014>

Biofortification is increasingly seen as an additional tool to combat micronutrient malnutrition. This paper estimates the costs and potential benefits of biofortification of globally important staple food crops with provitamin A, iron, and zinc for twelve countries in Africa, Asia, and Latin America. Using a modification of the Disability-Adjusted Life Years framework we conclude that overall, the intervention can make a significant impact on the burden of micronutrient deficiencies in the developing world in a highly cost-effective manner. Results differ by crop, micronutrient, and country; and major reasons underlying these differences are identified to inform policy.

Keywords: biofortification, micronutrient malnutrition, cost-effectiveness, DALYs

36. Impact of novel far-infrared frying technique on quality aspects of chicken nuggets and frying medium

Udomkun, P., Niruntasuk, P., & Innawong, B. (2019). Impact of novel far-infrared frying technique on quality aspects of chicken nuggets and frying medium. *Journal of Food Processing and Preservation*, 43(5), e13931. <https://doi.org/10.1111/jfpp.13931>

In this study the impact of far-infrared and conventional heaters on heat distribution and physico-chemical qualities of chicken nuggets and frying medium were investigated. For chicken nuggets, moisture content, fat content, color (L^* , a^* , and b^*), and texture (hardness, index of firmness, and displacement) were determined, while free fatty acid (FFA), peroxide value (PV), total polar materials (TPMs), and color were used to measure the quality of frying oil. A higher heating rate and more uniform heat distribution were observed in the far-infrared frying when compared to conventional frying. In addition, physico-chemical qualities of chicken nugget were not significantly influenced by type of heater, except the fat content in the crust was significantly higher in far-infrared fried samples. The FFA, TPM, and color values of frying oil were better in far-infrared frying. The results of this research indicate the feasibility of using far-infrared technology in the deep-fat frying process.

37. Incidence and farmers' knowledge of aflatoxin contamination and control in Eastern Democratic Republic of Congo

Udomkun, P., Wossen, T., Nabahungu, N. L., Mutegi, C., Vanlauwe, B., & Bandyopadhyay, R. (2018). Incidence and farmers' knowledge of aflatoxin contamination and control in Eastern Democratic Republic of Congo. *Food Science and Nutrition*, 6, 1607–1620. <https://dx.doi.org/10.1002%2Ffsn3.735>

Despite efforts to reduce aflatoxin contamination and associated mycotoxin poisoning, the phenomenon continues to pose a public health threat in food and feed commodity chains. In this study, 300 samples of cassava, maize, and groundnut were collected from farmers' households in Eastern DRC and analyzed for incidence of aflatoxins. In addition, the farmers' level of knowledge of the causes and consequences of contamination and the measures for prevention were also examined by administering questionnaires to a cross-section of 150 farmers. The results showed the presence of aflatoxins in all samples, with levels ranging from 1.6 to 2270 $\mu\text{g}/\text{kg}$. In 68% of all samples, total aflatoxin contamination was above 4 $\mu\text{g}/\text{kg}$, the

maximum tolerable level set by the European Union. Farmers ranked high humidity, improper storage practices, and poor soils as potential causes of aflatoxin contamination and changes in color, smell, and taste, and difficulty in selling crops as consequences. They identified crop management practices as the most effective way to control contamination. The results also revealed that most farmers apply pre-harvest crop management practices as a means of controlling contamination. More educated households were more knowledgeable about aflatoxins. Female-headed and married households were less likely to be willing to pay for aflatoxin control. About 28% of farmers claimed to be willing to allocate resources to seed intervention while a smaller proportion agreed to pay for training and information services. The result further suggests that an adoption of pre- and post-harvest technologies together with awareness creation is still required to reduce aflatoxin contamination in the country.

Keywords: aflatoxin contamination, awareness, farmers, Kendal's concordance, perception

38. Influence of air drying properties on non-enzymatic browning, major bio-active compounds and antioxidant capacity of osmotically pretreated papaya

Udomkun, P., Nagle, M., Mahayothee, B., Nohr, D., Koza, A., & Müller, J. (2015). Influence of air drying properties on non-enzymatic browning, major bio-active compounds and antioxidant capacity of osmotically pretreated papaya. *LWT – Food Science and Technology*, 60(2), 914–922. <https://doi.org/10.1016/j.lwt.2014.10.036>

This study aimed to investigate the effect of air drying parameters such as temperature, specific humidity and velocity, on non-enzymatic browning behavior and on bio-active compounds and antioxidant properties of osmotically pretreated papayas. Convection drying was conducted under through-flow mode at four temperatures (50, 60, 70, 80 °C), three air velocities (0.2, 0.5, 0.7 m/s) and two specific humidity levels (10, 25 g/kg dry air). Higher drying temperatures resulted in a significant decrease in moisture content and polyphenol oxidase activity, while degree of browning and 5-hydroxymethylfurfural increased. The antioxidant activity and total phenolic compounds increased with temperature and as well with decreasing air velocity. In contrast, specific humidity did not have a major effect on quality attributes of dried samples, except for carotenoid contents. This study has shown that drying parameters can decompose and/or enhance carotenoids contents in dried papayas. To obtain the product with highest level of bio-active compounds and lowest possible melanoid formation, treatment with temperature of 70 °C, specific humidity of 10 g/kg dry air and velocity of 0.2 m/s proved to be the most suitable option. Based on these results, optimization of the process, particularly drying temperature, should be considered with respect to preserving product color and biochemical properties.

Keywords: dehydration, browning, antioxidant activity, carotenoids, papaya

39. Influence of time of harvest on the yield and sensory attributes of white yam (*Dioscorea rotundata*) in Southwest Nigeria

Akinwande, B.*, Asiedu, R., Adeyemi, I.*, & Maziya-Dixon, B. (2007). Influence of time of harvest on the yield and sensory attributes of white yam (*Dioscorea rotundata*) in Southwest Nigeria. *Journal of Food, Agriculture & Environment*, 5(2), 179–184. <https://cgspace.cgiar.org/handle/10568/91340>

Effect of time of harvest of yam tubers on selected food quality characteristics was investigated to determine when yam tuber is due for harvesting. Setts from five land race varieties of white yam (*Dioscorea rotundata*) at their post-dormant stage were planted at the beginning of the rainy season in 2003 at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Harvesting was done at monthly intervals from three to seven months after vine emergence (MAVE) to determine the best time to harvest these varieties with respect to yield and food quality. Fresh and dry tuber yields increased steadily over the harvesting period till six MAVE and decreased thereafter. Mean tuber yields increased from 0.33 and 0.08 kg per plant at three MAVE to 1.21 and 0.41 kg per plant at seven MAVE, on fresh and dry weight basis respectively, while highest values of 1.37 and 0.42 kg per plant were obtained at six MAVE. The mean weight of tubers increased consistently in all varieties till five MAVE but there was variation from five to seven MAVE. The varieties differed in the number of tubers obtained per plant but time of harvest did not influence this attribute. For all mean yield values, significant inter-varietal differences occurred only from three to five MAVE. Mean sensory evaluation results on boiled yam (for mealiness, taste and general acceptability) and pounded yam (for smoothness, consistency and general acceptability) showed little variation from four till seven MAVE. Best scores for sensory evaluation was obtained at six MAVE before final foliage senescence occurred, which coincided with the time that highest tuber yield occurred. Yam tubers could thus be said to be ready for harvesting at six MAVE.

Keywords: yam tubers, harvesting, food quality, *Dioscorea rotundata*, yield, boiled yam, pounded yam

40. Innovative technologies to manage aflatoxins in foods and feeds and the profitability of application – A review

Udomkun, P., Wiredu, A. N., Nagle, M., Mueller, J., Vanlauwe, B., & Bandyopadhyay, R. (2017). Innovative technologies to manage aflatoxins in foods and feeds and the profitability of application – A review. *Food Control*, 76, 127–138. <https://doi.org/10.1016/j.foodcont.2017.01.008>

Aflatoxins are mainly produced by certain strains of *Aspergillus flavus*, which are found in diverse agricultural crops. In many lower-income countries, aflatoxins pose serious public health issues since the occurrence of these toxins can be considerably common and even extreme. Aflatoxins can negatively affect health of livestock and poultry due to contaminated feeds. Additionally, they significantly limit the development of international trade as a result of strict regulation in high-value markets. Due to their high stability, aflatoxins are not only a problem during cropping, but also during storage, transport, processing, and handling steps. Consequently, innovative evidence-based technologies are urgently required to minimize aflatoxin disclosure. Thus far, biological control has been developed as the most potential innovative technology of controlling aflatoxin contamination in crops, which uses competitive exclusion of toxigenic strains by non-toxigenic ones. This technology is commercially applied in groundnuts maize, cottonseed, and pistachios during pre-harvest stages. Some other effective technologies such as irradiation, ozone fumigation, chemical and biological control agents,

and improved packaging materials can also minimize post-harvest aflatoxins contamination in agricultural products. However, integrated adoption of these pre- and post-harvest technologies is still required for sustainable solutions to reduce aflatoxins contamination, which enhances food security, alleviates malnutrition, and strengthens economic sustainability.

Keywords: aflatoxins, agricultural crops, public health, pre-harvest management, post-harvest management, technology adoption

41. Maize storage practices and their influence on aflatoxin contamination in stored grains in four agroecological zones in Benin, West Africa

Hell, K., Cardwell, K., Sétamou, M., & Poehling, H. (2000). Maize storage practices and their influence on aflatoxin contamination in stored grains in four agroecological zones in Benin, West Africa. *Journal of Stored Products Research*, 36, 365–382. <https://hdl.handle.net/10568/99884>

Aflatoxin levels in 300 farmers' stores in four agro-ecological zones in Benin, a West African coastal country, were determined over a period of 2 years. A sampling questionnaire was used to evaluate maize storage practices. Farmers were asked what storage structure they used, their storage form, storage period, pest problems in storage and what was done against them. Beninese farmers often changed their storage structures during the storage period, transferring the maize from a drying or temporary store to a more durable one. Most of the farmers complained about insects damaging stored maize. Often, storage or cotton insecticides were utilized against these pests. Regression analysis identified those factors that were associated with increased or reduced aflatoxin. Maize samples in the southern Guinea and Sudan savannas were associated with higher aflatoxin levels and the forest/savanna mosaic was related to lower toxin levels. Factors associated with higher aflatoxin were: storage for 3-5 months, insect damage and use of *Khaya senegalensis*-bark or other local plants as storage protectants. Depending on the agroecological zone, storage structures that had a higher risk of aflatoxin development were the "Ago", the "Secco", the "Zingo" or storing under or on top of the roof of the house. Lower aflatoxin levels were related to the use of storage or cotton insecticides, mechanical means or smoke to protect against pests or cleaning of stores before loading them with the new harvest. Fewer aflatoxins were found when maize was stored in the "Ago" made from bamboo or when bags were used as secondary storage containers.

Keywords: aflatoxins, farmers, storage structures, pests

42. Minerals content of extruded fish feeds containing cricket (*Acheta domesticus*) and black soldier fly larvae (*Hermetia illucens*) fractions

Irungu, F. G., Mutungi, C. M., Faraj, A. K., Affognon, H., Tanga, C., Ekesi, S., Nakimbugwe, D., & Fiaboe, K. K. M. (2018). Minerals content of extruded fish feeds containing cricket (*Acheta domesticus*) and black soldier fly larvae (*Hermetia illucens*) fractions. *International Aquatic Research*, 10(2), 101–113. <https://doi.org/10.1007/s40071-018-0191-8>

Animal food sources provide human beings with minerals considerably in adequate quantities. Fish is an indispensable reliable source of nutrients, as aquaculture is a sector that is fast growing and which provides 50% of the world's fish production. However, fish production is hampered by the increasing costs of feeds due to the ever-rising cost of fish meal, an integral component of fish feeds. Substituting fish meal with cheap, yet highly nutritious ingredients in fish feeds is therefore paramount. This study investigated the effects of substituting fish meal with adult cricket meal (ACM) and black soldier fly meal (BSFM) on minerals content of extruded fish feeds, where four levels of substitution (0, 25, 50 and 75%) were used. The effect of feed moisture content on minerals was also studied where 20 and 30% feed moisture levels were used. Leaching effects of the pellets were studied as well. The results showed a significant increase ($P < 0.05$) in the levels of phosphorus and potassium as the level of fish meal substitution increased from 0 to 75%. On the other hand, iron and sodium levels reduced significantly ($P < 0.05$) as the level of fish meal substitution increased. Magnesium content increased with increasing level of substitution with BSFM, but decreased with increasing level of substitution with ACM. Copper, zinc and manganese were not greatly influenced by levels of fish meal substitution. Diets that had zero substitution showed higher leaching effect for most minerals than diets that were substituted with 75% ACM or BSFM. This study found that both ACM and BSFM can be used to substitute fish meal in fish feeds and obtain adequate mineral profile and low leaching effect.

Keywords: fish meal, substitution, cricket, black soldier fly larvae, minerals, extrusion

43. Moisture adsorption properties and shelf-life estimation of dried and pulverised edible house cricket *Acheta domesticus* (L.) and black soldier fly larvae *Hermetia illucens* (L.)

Kamau, E., Mutungi, C., Kinyuru, J., Imathiu, S., Tanga, C., Affognon, H., Ekesi, S., Nakimbugwe, D., & Fiaboe, K. K. M. (2018). Moisture adsorption properties and shelf-life estimation of dried and pulverised edible house cricket *Acheta domesticus* (L.) and black soldier fly larvae *Hermetia illucens* (L.). *Food Research International*, 106, 420–427. <https://doi.org/10.1016/j.foodres.2018.01.012>

Edible insects are part of the diets of a significant proportion of rural populations in the tropics especially Africa and Asia, and their use as source of key nutrients for better nutrition is re-emerging. Indigenously, elemental methods are used to process the insects before they are consumed or sold in retail outlets. In recent years, better knowledge of processing, packaging and storage has become necessary because of commercialization needs. A common processing approach involves drying after a brief heat-treatment step, and then milling into a powdered product which is sold to manufacturers or consumers as ingredient for processing final products. The hydration properties of dried powders of edible house cricket and black soldier fly larvae (BSFL) were studied with the aim of predicting shelf-life stability under typical packaging and storage temperatures experienced in the tropics. Moisture adsorption isotherms were determined gravimetrically at 25, 30 and 35 °C, over 0.11–0.97 water activity (a_w) range, and the data fitted to various models. Sorption isotherms were of type II according

to Brunauer classification indicating monolayer-multilayer sorption behavior. Cricket powder exhibited higher hydration capacity, and a_w of this product was less sensitive to temperature variation as compared to BSFL powder. In the two products, water exhibited transitions from bound- to free- state at ~5 g/100 g moisture content. Based on Heiss-Eichner model, a shelf-life of 7 months at 25 °C can be achieved if the cricket and BSFL powders are dried to ca. 5 g/100 g moisture content and packaged in 80 µm thick polyethylene films. At 35 °C the shelf-life of the cricket product is shortened three- to four-fold whereas the BSFL powder is unable to store.

Keywords: edible insects, processing, storage, water activity, sorption isotherm, isosteric heat

44. Multi-sensor approach to improve optical monitoring of papaya shrinkage during drying

Udomkun, P., Nagle, M., Argyropoulos, D., Mahayothee, B., & Mueller, J. (2016). Multi-sensor approach to improve optical monitoring of papaya shrinkage during drying. *Journal of Food Engineering*, 189, 82–89. <https://doi.org/10.1016/j.jfoodeng.2016.05.014>

This study aimed to assess the feasibility of a multi-sensor approach for predicting shrinkage of papaya during drying using computer vision methods in combination with optical scattering analysis of light at 650 nm. The top-side area and total surface area derived from computer vision were analyzed, while the illuminated area and light intensity from optical scattering images were used to interpret photon migration in the fruit tissue. The relationship between moisture content and shrinkage in terms of volume and area reduction during drying was satisfactorily explained by a linear model. The results demonstrated that the prediction of papaya shrinkage during drying from top and total surface areas of the sample was possible, but can potentially be improved. Multivariate correlations of computer vision parameters and optical scattering properties showed the enhanced performance for shrinkage prediction. This multi-sensor approach could possibly be applied as a fast, accurate and non-invasive technique for in-line quality control to monitor shrinkage in the production of dried fruits.

Keywords: food properties, computer vision, laser backscattering, post-harvest technology, dehydration, *Carica*

45. Mycotoxins in Sub-Saharan Africa: Present situation, socio-economic impact, awareness, and outlook

Udomkun, P., Wiredu, A. N., Nagle, M., Bandyopadhyay, R., Mueller, J., & Vanlauwe, B. (2016). Mycotoxins in Sub-Saharan Africa: Present situation, socio-economic impact, awareness, and outlook. *Food Control*, 72, 110–122. <https://doi.org/10.1016/j.foodcont.2016.07.039>

Many studies have reported the occurrence of mycotoxin in human foods and animal feeds in Sub-Saharan Africa (SSA). Aflatoxins, ochratoxins, fumonisins, and zearalenone are among the most hazardous mycotoxins produced by fungal species, mainly in the genera *Aspergillus*, *Penicillium*, and *Fusarium*. Due to their high stability, mycotoxins are a cause of

concern not only during crop production, but also in storage, transport, processing, and post-processing steps. Mycotoxin contamination is one factor that reduces the competitiveness of agricultural commodities from SSA for export. Moreover, these impurities negatively impact the health of humans and livestock which affects household security, livelihood, productivity, and income leading to significant costs and economic losses for the producing countries. Limited knowledge or awareness of most actors along the food and feed chain is considered to be one of the major problems which delay effective counter measures. In the last decades, various accurate and sensitive analytical methods have been developed to detect levels and composition of mycotoxins on food and feed samples such as HPLC, LC-MS, immuno-based assays, and optical methods. Nevertheless, immuno-based techniques are still the most useful for identifying mycotoxins in the field and farm levels as they can be conducted onsite. Although tolerable limits for mycotoxins have been established in many SSA countries, most contamination still exceeds maximum thresholds and continues to pose considerable risk to public health. To address mycotoxin problems in SSA, therefore, possible intervention strategies should provide support for capacity building and supply chain coordination, increased public awareness, and knowledge through education and extension, as well as improved incentives for management of fungal species.

Keywords: mycotoxin, fungal species, agricultural commodities, immuno-based, public health, fungal contamination, food safety, Sub Saharan Africa

46. Nutrient and aflatoxin contents of traditional complementary foods consumed by children of 6–24 months

Alamu, E. O., Gondwe, T., Akello, J., Sakala, N., Munthali, G., Mukanga, M., & Maziya-Dixon, B. (2018). Nutrient and aflatoxin contents of traditional complementary foods consumed by children of 6–24 months. *Food Science & Nutrition*, 6(4), 834–842. <https://doi.org/10.1002/fsn3.621>

The nutrient composition and safety of complementary foods have recently become areas of concern, especially with regard to aflatoxin contamination which has been found to adversely affect health outcomes. This study presents the nutrient and aflatoxin contents of complementary foods consumed by children (6–24 months) and infants and young child feeding practices of mothers from two districts in eastern and southern Zambia. A total of 400 mother–child pairs were recruited from Monze and Chipata districts, and data on breastfeeding and complementary feeding practices were collected twice at 3-month interval using a structured questionnaire. Samples of two traditional complementary foods (Maize Nshima and Maize porridge) were collected from the mothers and analyzed for nutrient contents and aflatoxin contamination. The results showed that there is a high level of awareness on exclusive breastfeeding among mothers. Fat, protein, carbohydrate, and ash contents of Maize nshima from Chipata were significantly lower ($p < .05$) compared to those from Monze district except for starch and sugar. Monze mothers preferred to prepare a thicker Maize nshima and Maize porridge compared to their Chipata counterparts. The aflatoxin contamination showed that the Maize porridge samples from Chipata were the most contaminated with mean aflatoxin content of 5.8 ± 15.93

mg/100 g, while Maize nshima was the most contaminated of the two complementary foods from Monze districts with mean aflatoxin level of 3.8 ± 6.41 mg/100 g. There were significant ($p < .05$) positive correlations between fat and aflatoxin contents for Chipata samples ($r = .12409$) and for Monze samples ($r = .13666$). The traditional complementary foods studied were found to be low in fat and protein and high in aflatoxin contamination. Thus, it is imperative that best practices and interventions are designed and introduced to reduce the possible lethal health implications of consumption of such complementary foods by children under 5 years.

Keywords: aflatoxin, breastfeeding, complementary foods, porridge

47. Nutritional and sensory properties: Snack food made from high-quality cassava flour and legume blend

Maziya-Dixon, B., Alamu, E. O., Popoola, I.O., & Yomeni, M. (2017). Nutritional and sensory properties: Snack food made from high-quality cassava flour and legume blend. *Food Science & Nutrition*, 5(3), 805–881. <http://dx.doi.org/10.1002/fsn3.464>

The nutritional benefits of grain legumes such as cowpea and soybean in sub-Saharan Africa have not been fully utilized to alleviate problem of protein-malnutrition in this region. This study aimed to evaluate and compare the nutritional properties and sensory evaluation of snack food made from high-quality cassava flour (HQCF) and soybeans (50:50), and HQCF and cowpea (50:50). Sensory evaluation was conducted among panellists in Nigeria and DR Congo. Results showed that the soy variant of the snack contained significantly higher protein than the cowpea variant. There was cross-cultural difference in snack preference between panellists in Nigeria and DR Congo. Panellists in DR Congo preferred the aroma of the unboiled soy variant, whereas panellists in Nigeria preferred the boiled soy variant more. This study showed the potential of legumes and cassava in the snack food sector not only as a partial substitute for wheat flour but as a major ingredient and also form basis for the new product development in the snacks food industry. The developed product could be possibly used to alleviate the protein-malnutrition among the vulnerable groups of most developing countries.

Keywords: grain legumes, cowpea, soybean, protein-malnutrition, sensory evaluation, antinutrients, cassava flour, consumer acceptance, snack foods, Nigeria, DR Congo

48. Nutritional evaluation and consumer preference of legume fortified maize-meal porridge

Alamu, E. O., Maziya-Dixon, B., Popoola, I., Gondwe, T., & Chikoye, D. (2016). Nutritional evaluation and consumer preference of legume fortified maize-meal porridge. *Journal of Food and Nutrition Research*, 4(10), 664–670. <https://cgspace.cgiar.org/handle/10568/77484>

Maize-meal porridge is commonly consumed meal for the adults as breakfast food and for the children as complementary food. Food-to-food fortification was employed in order to improve the protein content of maize-meal porridge using soy flour and local groundnut paste. The study was aimed at evaluating the nutritional properties and consumer preference of the attributes of the unfortified porridge, legume-fortified porridge, and powdered milk-fortified porridge. The

influence of consumers' knowledge of the type of fortificant added to the porridge was also investigated. Soy-fortified porridges provide comparable ash, crude fibre and fat contents to powdered milk- fortified porridge but with higher protein than powdered milk-fortified porridge. Soy flour raised the protein and ash content of the porridge by 90% and 63% respectively, the groundnut paste raised the protein and ash content by 88% and 41% and the powdered milk by 87% and 65% respectively. The unfortified porridge was the least preferred while the milk-fortified porridge was the most preferred. There was no significant difference between preference for some of the attributes of the groundnut paste fortified-porridge and the soy flour-fortified. There was no significant difference between consumption intent for the soy flour and groundnut paste-fortified porridge. Soy-fortified porridges provide comparable ash, crude fibre and fat contents to powdered milk- fortified porridge but with higher protein than powdered milk-fortified porridge. Soy-flour has shown to be a good substitute for powdered milk as a protein-fortificant for porridge and soy-fortified porridge could be a possible means of alleviating Protein-energy malnutrition among low income populations.

Keywords: maize-meal porridge, porridge fortificant, legume fortified porridge, Eastern Zambia

49. Nutritional evaluation of four optimized cassava-based complementary foods

Onabanjo, O. O., Oguntona, C, Maziya-Dixon, B., Olayiwola, I. O, Oguntona, B. E, & Dixon, A. (2008). Nutritional evaluation of four optimized cassava-based complementary foods. *African Journal of Food Science*, 2(12), 136–142. www.researchgate.net/publication/228483277

Complementary foods were formulated and their nutritional composition analyzed from three yellow and one white cassava varieties. The composites were analyzed for proximate, mineral, fatty acids and amino acids. The mean values for the proximate composition of the diets are moisture (41.4 g kg⁻¹) wet weight, ash (47.4 g kg⁻¹), crude protein (145.8 g kg⁻¹), crude fat (106.7 g kg⁻¹), crude fiber (21.1 g kg⁻¹), total carbohydrate (633.5 g kg⁻¹), and energy (409.2 kcal). The diets supplied adequate amounts of most minerals, except iron (about 65% of the standard). The composites contained all the essential amino acids with adequate chemical score for most amino acids. The complementary diets contained moderate to high proportions of α -linolenic acids (18:3n3) and a high proportion of linoleic acid (18:2n6), which resulted in a high total n-6/total n-3 ratio and a high linoleic/ α -linolenic acids ratio. Micronutrient improved cassava varieties can be effectively used to formulate complementary food as acceptable micronutrients supplement.

Keywords: micronutrient-improved, cassava, complementary foods, children

50. Nutritional quality of complementary food prepared from unmalted and malted maize fortified with cowpea using extrusion cooking

Obatolu, V. A, Cole, H. A, & Maziya-Dixon, B. (2000). Nutritional quality of complementary food prepared from unmalted and malted maize fortified with cowpea using extrusion cooking. *Journal of the Science of Food and Agriculture*, 80(6), 646–650. <https://pubmed.ncbi.nlm.nih.gov/29345783/>

The nutritional quality of extruded unmalted or malted maize fortified with cowpea as complementary food was assessed based on its proximate analysis, amino acid composition and results from rat feeding with the blends. Results indicated a slight decrease and increase in protein content due to malting and extrusion respectively. The changes in fat, crude fibre and ash content were not significant. The blends were a good source of energy, ranging from 1831 to 2045 kJ per 100 g. Extrusion significantly increased the amino acid content of the blends, while malting had a varied effect on each of the amino acids. There was no significant difference in the protein efficiency ratio (PER), net protein ratio (NPR) and weight gain of rats fed the blends when compared with the control (casein diet). The present study shows that malting improved the nutritional quality of the blends. Rats fed the casein diet had higher values for total digestibility (TD) and net protein utilization (NPU). There was no significant difference ($P > 0.05$) in the internal organ weights of rats fed all blends except the protein-free diet.

Keywords: complementary; extrusion; malted; processing; protein quality

51. Nutritional quality of fritters produced from fresh cassava roots, high-quality cassava and soy flour blends, and consumer preferences

Alamu, E. O., Maziya-Dixon, B., Ntawuruhunga, P., Chileshe, P., Mukuka, I., & Olaniyan B. (2019). Nutritional quality of fritters produced from fresh cassava roots, high-quality cassava and soy flour blends, and consumer preferences. *Cogent Food & Agriculture*, 5(1), 1677129. <https://doi.org/10.1080/23311932.2019.1677129>

Fritters are flour-based snacks made from wheat flour, but a cheaper alternative is needed in a developing economy, such as Zambia, owing to the high cost of wheat. This study aimed at evaluating fritters produced from different sources: fresh cassava roots, high-quality cassava flour (HQCF), and a composite (80:20) of HQCF and high-quality soy flour (HQSF) using 100% wheat flour as the control. The nutritional and anti-nutritional properties were analyzed with standard laboratory methods. A structured questionnaire was used to analyze consumer preferences. There were significant ($P < 0.05$) differences in the proximate parameters of the fritters samples. In HQCF fritters, amylose increased by 12.26%, sugar by 11.12%, and starch by 27.91%. There were no significant ($P > 0.05$) differences in the antinutritional properties among cassava and wheat fritters except for the composite cassava–soybean fritters. Among respondents from Kaoma, Kasama, and Serenje, the sensory characteristics showed no significant ($P > 0.05$) differences for appearance and aroma of all the fritters samples. The results showed that HQCF fortified with HQSF could be used as a cheaper alternative to wheat flour in the production of nutritious and acceptable fritters.

Keywords: fritters, sensory attributes, proximate composition, consumer preferences

52. Occurrence of aflatoxin in agricultural produce from local markets in Burundi and Eastern Democratic Republic of Congo

Udomkun, P., Mutegi, C., Wossen, T., Atehkeng, J., Nabahungu, N. L., Njukwe, E., Vanlauwe, B., & Bandyopadhyay, R. (2018). Occurrence of aflatoxin in agricultural produce from local markets in Burundi and Eastern Democratic Republic of Congo. *Food Science and Nutrition*, 6(8), 2227–2238. <https://doi.org/10.1002/fsn3.787>

Aflatoxins are noxious secondary metabolites, of certain fungal species, found in food and feed. Contamination of a commodity with aflatoxins is associated with production and storage losses, and subsequently less food availability. Aflatoxins can also pose human health risks and represent a barrier to the development of trade, in both domestic and international markets. In this study, samples of cassava, maize, groundnut, beans, soybean, sorghum and milk, and their processed products were collected from local markets in Burundi and Eastern DRC. In order to investigate the levels of aflatoxin, crop samples were analyzed using a single step lateral flow immunochromatographic assay (Reveal Q+), while enzyme-linked immune-sorbent assay (ELISA) was used to analyze aflatoxin-M₁ in milk, yogurt, and cheese samples. The results revealed the presence of aflatoxins in all samples from both countries, with levels ranging from 1.3 to 2410 µg/kg. Samples collected from Burundi contained relatively higher (p>0.05) levels of aflatoxins. In 51% of all the crops samples, total aflatoxin contamination was above the EU maximum tolerable level of 4 µg/kg. Processed products, particularly from groundnut, maize and sorghum, had the highest levels of aflatoxin contamination when compared to unprocessed grain. With regards to milk and dairy products, the level of aflatoxin-M₁ ranged from 4.8 to 261.1 ng/kg. Approximately 29% of milk and yogurt samples had aflatoxin-M₁ higher than the EU regulatory limit of 50 ng/kg, whereas 20% of cheese samples were found to be contaminated at levels higher than the maximum limit of 250 ng/kg. These results can serve as the basis for pre- and post-harvest approaches to reduce aflatoxin contamination in agricultural commodities in Burundi and Eastern DRC in order to reduce health risk, avoid reduced production in livestock, and open up export markets.

Keywords: aflatoxins, Central Africa, crops, fungi, milk and dairy products

53. Occurrence of regulated mycotoxins and other microbial metabolites in dried cassava products from Nigeria

Abass, A. B., Awoyale, W., Sulyok, M., & Alamu, E.O. (2017). Occurrence of regulated mycotoxins and other microbial metabolites in dried cassava products from Nigeria. *Toxins (Basel)*, 9(7), 207. www.ncbi.nlm.nih.gov/pmc/articles/PMC5535154/

Dried cassava products are perceived as one of the potential sources of mycotoxin ingestion in human foods. Processing either contributes to the reduction of toxins or further exposes products to contamination by microorganisms that release metabolic toxins into the products. Thus, the prevalence of microbial metabolites in 373 processed cassava products was investigated in Nigeria. With the use of liquid chromatography tandem-mass spectrometry (LC-MS/MS) for the constituent analysis, a few major mycotoxins (aflatoxin B₁ and G₁, fumonisin B₁ and B₂, and zearalenone) regulated in food crops by the Commission of the European Union were found at concentrations which are toxicologically acceptable in many other crops. Some bioactive compounds were detected at low concentrations in the cassava products. Therefore, the exposure of cassava consumers in Nigeria to regulated mycotoxins was estimated to be minimal. The results provide useful information regarding the probable safety of cassava products in Nigeria.

Keywords: dried cassava, mycotoxin, food safety, food standards, human exposure, microbial metabolite, regulated mycotoxins, Nigeria

54. Opportunities and challenges for biofortification of cassava to address iron and zinc deficiency in Nigeria

Okwuonu, I. C., Narayanan, N. N., Egesi, C., & Taylor, N. (2021). Opportunities and challenges for biofortification of cassava to address iron and zinc deficiency in Nigeria. *Global Food Security*, 28, 100478. <https://doi.org/10.1016/j.gfs.2020.100478>

Nigeria is the world's largest producer of cassava (*Manihot esculenta*), and its production is important to the country's economy. Cassava's edible storage roots act as a critical staple food for over 180 million Nigerians. Micronutrient deficiency presents a major public health issue in Nigeria and correlates with cassava consumption level across six agro-ecological zones within the country. Though high in caloric value, cassava roots are deficient in minerals, placing populations that rely on this crop at risk of hidden hunger. Micronutrient deficiencies, especially iron and zinc, affect an estimated 6 million children in Nigeria under five years old. Supplementation, fortification and food-based diversification are being employed to tackle micronutrient deficiencies. However, in order to achieve wider impact and sustainability, biofortification of staple foods such as cassava is also being explored. Conventional breeding of cassava is unlikely to achieve elevated storage root mineral content at nutritionally significant levels due to lack of genetic diversity for these traits within the existing germplasm. Biofortification by genetic modification provides a potential solution to this challenge. Proof of concept has demonstrated that transgenic biofortification is a reality and can produce foodstuffs with increased mineral content that could beneficially impact the health of consumers in Nigeria and elsewhere. This review is targeted toward understanding the dynamics of micronutrient deficiency across Nigeria and addresses opportunities and challenges for deploying iron and zinc biofortified cassava.

Keywords: micronutrient deficiency, Nigeria, biofortification, cassava, iron, zinc

55. Optimal physicochemical properties of dried litchis for Thai consumers

Precoppe, M., Nagle, M., Mahayothee, B., Udomkun, P., Janjai, S., & Müller, J. (2014). Optimal physicochemical properties of dried litchis for Thai consumers. *International Journal of Agricultural and Biological Engineering*, 7(5), 103–110. <https://ijabe.org/index.php/ijabe/article/view/1151/0>

The litchi is a fruit essential for the economies of several Southeast Asian countries, but markets regularly reject it, mainly due to spoilage. Drying extends the shelf-life of litchis, but in Thailand the optimal characteristics of the dried product have not yet been determined. The purpose of this study was to determine the optimum physicochemical properties of dried litchis – those suitable for Thai consumers. The dried fruits were submitted to physicochemical measurement and consumer evaluation, with datasets subsequently integrated using circular ideal-point regression analysis. Response surface methodology was then used to predict the optimum physicochemical properties of the fruits. It was found that Thai consumer preferences with regard to dried litchis are for the fruits to be of golden-yellow color (L^* ranging around 54; H ranging around 79°), to have a soft flesh (SMF ranging between 13 and 14 kN/100 g) and

to have a sweet taste (TSS:TA ranging between 25 and 28). The results may be used in the future to prescribe pretreatments and drying conditions.

Keywords: consumer preference, response surface methodology, circular ideal-point regression, product optimization, market acceptance, lychee

56. Optimization of extruder cooking conditions for the manufacture of fish feeds using response surface methodology

Irungu, F. G., Mutungi, C., Faraj, A., Affognon, H., Ekesi, S., Nakimbugwe, D., & Fiaboe, K. K. M. (2019). Optimization of extruder cooking conditions for the manufacture of fish feeds using response surface methodology. *Journal of Food Process Engineering*, 42(2), e12980. <https://doi.org/10.1111/jfpe.12980>

A composite blend consisting of sunflower cake, maize germ, wheat bran, fresh water shrimps and cassava flour was extruded using a single-screw extruder to produce expanded fish feed pellets. The effects of temperature (80–120 °C), die diameter (2–4 mm), and feed pre-conditioning time (50–150 s; steam 400 kPa) on properties of the pellets (expansion ratio, bulk density, floatability, durability, water absorption, water solubility, water stability, and in-vitro protein digestibility) were investigated using response surface methodology. Regression equations describing the effect of each variable on the product responses were obtained. The pellets extruded using a factor combination of 120 °C extruder barrel temperature, 2 mm die diameter, and 100 s of feed pre-conditioning time gave most desirable pellet floatability (100%), durability index (99%), expansion ratio (2.64), water absorption index (4.12), water solubility index (9.31), water stability (87%), bulk density (479 g/L), and in vitro protein digestibility (69.97%) with a composite desirability of 0.88.

Practical applications: Extrusion is a modern feed processing method whose use is fast gaining popularity among small feed processors in developing countries. However, extrusion is a process that involves many parameters that need to be optimized for desirable end properties. These findings guide fish feed manufacturers on the optimum conditions for single screw extruders for production of feeds with desirable properties especially for the fish types that are top feeders. In addition, the results offer important insights on how temperature, die diameter, and feed pre-conditioning, may be manipulated to influence properties of extruded aquafeed when using simple low-cost small-scale extruders.

57. Perception of food quality in yams among some Nigerian farmers

Otegbayo, B., Samuel, F. O., Kehinde, A. L., Sangoyomi, T. E., & Okonkwo, C. C. (2010). Perception of food quality in yams among some Nigerian farmers. *African Journal of Food Science*, 4(8), 541–549. https://academicjournals.org/article/article1380729831_Otegbayo%20et%20al.pdf

Yam, a staple and ceremonial crop is intimately integrated into the socio-cultural, economic and religious customs of several West African communities. This study presents a qualitative investigation of the perception of food quality in yams by farmers. Food quality in the yam

tuber is significant in determining its utilization (both at subsistence and industrial level) and acceptability of yam's food products by farmers, processors and consumers to ensure sustainable food security. Focus group discussion (FGD) was used to collect data from farmers in two major yam-growing ecological zones of Nigeria namely: Federal Capital Territory (FCT-Abuja) and Oyo North in Oyo State. Results showed that farmers do not have definite food quality indicators in the yam tubers that can determine or predict the quality of the product. Indigenous knowledge such as pattern of leaf foliage, smoothness and shape of the tubers are used to identify species and varieties rather than for predicting food quality. Farmers' perception of food quality in yams is mainly determined by the sustainable income derivable from cultivating particular species or varieties and also, on the sensorial quality of the yam product (textural quality). There is need for researchers to involve farmers in food quality studies as a form of holistic approach in achieving improved food quality.

Keywords: yam, food quality indicators, perception, culture, food security

58. Physical and Sensory Properties of Biofortified Fresh Yellow Maize

Alamu, E. O., Maziya-Dixon, B., & Olaofe, O. (2015). *Physical and Sensory Properties of Biofortified Fresh Yellow Maize*. LAP LAMBERT Academic Publishing. www.researchgate.net/publication/308309813

The effects of processing and harvesting time on the physical and sensory characteristics of micronutrient biofortified yellow maize varieties have been investigated using standard procedures. Freshly harvested eight biofortified yellow maize hybrids and eight open pollinated varieties (OPV) with various endosperm textures were used for this research. Selected fresh harvested yellow maize ears at three maturity stages (20, 27 and 34 days after pollination) were boiled and roasted with or without husk and sensory evaluation was carried out on the boiled and roasted fresh yellow maize samples. Physical characteristics determinations were carried out on the grain of fresh yellow maize samples. The maize samples for color properties were freeze-dried, pulverized and sieved to pass through 500 μ m sieve. The fresh yellow maize flour samples were analyzed for color properties (L^* , a^* and b^*). The results of the physical characteristic of fresh yellow hybrid and OPV maizes showed highly significant ($P < 0.001$) for the variety and maturity, while only kernel weight, kernel volume, bulk density, kernel size index (KSI), showed significant differences for both fresh yellow hybrid and OPV maizes. There was highly significant effect ($P < 0.001$) for variety, maturity and processing methods (boiling and roasting), on the color properties for fresh yellow hybrid and OPV maizes. There were increase in the mean values of L^* , a^* and b^* across the maturity stages for fresh yellow hybrid and OPV maizes. The results of the sensory characteristics showed that methods of processing and maturity were important factors in the rating of the sensory attributes of fresh yellow hybrid and OPV maizes. Optimum overall acceptability rating was attained at 20DAP and had the best maturity stages. Consumers slightly preferred boiled OPV maize with husk to that boiled OPV maize without husk. However, consumers showed little or no difference in likeness for boiled hybrid maize with or without husk. However, roasted maize without husk was preferred to roasted maize with husk for fresh yellow hybrid and OPV maizes. There were significant

($P < 0.001$) effects of variety and methods of processing on the antioxidant activity for both fresh yellow hybrid maizes but maturity had no significant effect. The results of the present study could be used by the Maize breeders to further improve the physical characteristics of the maize hybrids and OPVs, and by the consumers to know the best harvest time to consume boiled and roasted maize hybrids.

Keywords: processing, harvesting, yellow maize, hybrid, popcorn, breeding, biofortified, physical properties, sensory properties

59. Physico-chemical properties of extruded aquafeed pellets containing black soldier fly (*Hermetia illucens*) larvae and adult cricket (*Acheta domesticus*) meals

Irungu, F. G., Mutungi, C. M., Faraj, A. K., Affognon, H., Kibet, N., Tanga, C., Ekesi, S., Nakimbugwe, D., & Fiaboe, K. K. M. (2018). Physico-chemical properties of extruded aquafeed pellets containing black soldier fly (*Hermetia illucens*) larvae and adult cricket (*Acheta domesticus*) meals. *Journal of Insects as Food and Feed*, 4(1), 19–30. <https://doi.org/10.3920/JIFF2017.0008>

Fish farming is faced with the challenge of high cost of feeds because of the cost of high quality protein needed for formulation of the feeds. Thus, there is urgent need for alternative protein sources. The effects of substituting freshwater shrimp meal (FWSM) with black soldier fly larvae meal (BSFM) or adult cricket meal (ACM) on physico-chemical properties of hot-extruded fish feed pellets were investigated. The FWSM protein in a 26 g/100 g protein fish feed formulation was substituted at 0, 25, 50 and 75%, and moisture content of the formulated blends adjusted to 10, 20 or 30 g/100 g prior to extrusion. Floatability, expansion rate, bulk density, durability index, water absorption index, water solubility index, and water stability of extruded pellets were determined. Sinking velocity and the total suspended and dissolved solids in water were determined for the optimal pellets. Pellet floatability was not influenced by the type of insect meal but the interaction between level of inclusion and moisture content of the feed at extrusion. Pellets with high floatability >90% were produced from all feed blends at 30 g/100 g moisture content. Expansion ratio was not influenced by type of insect meal or the level of inclusion but by the moisture content whereby feed blends extruded at 30 g/100 g moisture gave pellets with high expansion ratio ~60%. Bulk density was influenced by the interaction of the three factors. Pellet durability and water absorption indices were not influenced by the investigated factors or their interactions. Processed pellets were generally highly durable (99%) out of water, but the stability in water was significantly influenced by the interaction of type of insect meal level of inclusion and moisture content at extrusion. Water solubility increased with increasing extrusion moisture. Overall, it was possible to process good quality extruded pellets with 75% BSFM or 75% ACM at 30 g/100 g feed moisture.

Keywords: aquafeed, extrusion, edible insects, processing

60. Post-harvest processes of edible insects in Africa: A review of processing methods, and the implications for nutrition, safety and new products development

Mutungi, C., Irungu, F. G., Nduko, J., Mutua, F., Affognon, H., Nakimbugwe, D., Ekesi, S., & Fiaboe, K. K. M. (2019). Post-harvest processes of edible insects in Africa: A review of processing methods, and the implications for nutrition, safety and new products development. *Critical Reviews in Food Science and Nutrition*, 59(2), 276–298. <https://doi.org/10.1080/10408398.2017.1365330>

In many African cultures, insects are part of the diet of humans and domesticated animals. Compared to conventional food and feed sources, insects have been associated with a low ecological footprint because fewer natural resources are required for their production. To this end, the Food and Agriculture Organization of the United Nations recognized the role that edible insects can play in improving global food and nutrition security; processing technologies, as well as packaging and storage techniques that improve shelf-life were identified as being crucial. However, knowledge of these aspects in light of nutritional value, safety, and functionality is fragmentary and needs to be consolidated. This review attempts to contribute to this effort by evaluating the available evidence on post-harvest processes for edible insects in Africa, with the aim of identifying areas that need research impetus. It further draws attention to potential post-harvest technology options for overcoming hurdles associated with utilization of insects for food and feed. A greater research thrust is needed in processing and this can build on traditional knowledge. The focus should be to establish optimal techniques that improve presentation, quality and safety of products, and open possibilities to diversify use of edible insects for other benefits.

Keywords: entomophagy, traditional knowledge, shelf-life, packaging, storage, functionality

61. Pre-harvest management is a critical practice for minimizing aflatoxin contamination of maize

Mahuku, G., Nzioki, H. S., Mutegi, C., Kanampiu, F., Narrod, C., & Makumbi, D. (2019). Pre-harvest management is a critical practice for minimizing aflatoxin contamination of maize. *Food Control*, 96, 219–226. <https://doi.org/10.1016/j.foodcont.2018.08.032>

Maize, the main dietary staple in Kenya, is one of the crops most susceptible to contamination by aflatoxin. To understand sources of aflatoxin contamination for home grown maize, we collected 789 maize samples from smallholder farmers' fields in Eastern and South Western, two regions in Kenya representing high and low aflatoxin risk areas, respectively, and determined aflatoxin B1 (AFB1) using ELISA with specific polyclonal antibodies. AFB1 was detected in 274 of the 416 samples from Eastern Kenya at levels between 0.01 and 9091.8 $\mu\text{g kg}^{-1}$ (mean 67.8 $\mu\text{g kg}^{-1}$). In South Western, AFB1 was detected in 233 of the 373 samples at levels between 0.98 and 722.2 $\mu\text{g kg}^{-1}$ (mean 22.3 $\mu\text{g kg}^{-1}$). Of the samples containing AFB1, 153 (55.8%) from Eastern and 102 (43.8%) from South Western exceeded the maximum allowable limit of AFB1 (5 $\mu\text{g kg}^{-1}$) in maize for human consumption in Kenya. The probable daily intake (PDI) of AFB1 in Eastern Kenya ranged from 0.07 to 60612 ng kg^{-1}

bw day⁻¹ (mean 451.8 ng kg⁻¹ bw day⁻¹), while for South Western, PDI ranged from 6.53 to 4814.7 ng kg⁻¹ bw day⁻¹ (mean 148.4 ng kg⁻¹ bw day⁻¹). The average PDI for both regions exceeded the estimated provisional maximum tolerable daily intake of AFB₁, which is a health concern for the population in these regions. These results revealed significant levels of preharvest aflatoxin contamination of maize in both regions. Prevention of preharvest infection of maize by toxigenic *A. flavus* strains should be a critical focal point to prevent aflatoxin contamination and exposure.

Keywords: maize, pre-harvest, aflatoxins, exposure, Kenya

62. Promoting the use of locally produced crops in making cereal-legume-based composite flours: An assessment of nutrient, antinutrient, mineral molar ratios, and aflatoxin content

Udomkun, P., Tirawattanawanich, C., Ilukor, J., Sridonpai, P., Njukwe, E., Nimbona, P., & Vanlauwe, B. (2019). Promoting the use of locally produced crops in making cereal-legume-based composite flours: An assessment of nutrient, antinutrient, mineral molar ratios, and aflatoxin content. *Food Chemistry*, 286, 651–658. <https://doi.org/10.1016/j.foodchem.2019.02.055>

Cassava, rice, and banana flours were used individually to replace wheat flour in cereal–legume-based composite flours. The proximate composition, mineral content, antinutritional effect, mineral molar ratios, and aflatoxin level were investigated. Replacing wheat flour with rice flour significantly improved protein, fat, potassium, and phosphorus content in samples. The molar ratios of phytate or oxalate to minerals (calcium and zinc) in all composite flours were lower than the reported critical values, except phytate to iron. However, all samples, except full replacement by rice flour, might not provide adequate zinc bioavailability when the effect of calcium and phytate on zinc absorption was collectively considered. Although all composite flours were contaminated with aflatoxins, only the control composed of wheat flour did not meet the EU regulatory threshold (4.0 µg/kg) for total aflatoxins. The findings showed that nutritional properties and aflatoxin content of composite flours can be improved by replacement with local crops.

Keywords: functional properties, mineral availability, antinutrient, composite flour, indigenous crops

63. Proximate composition and in vitro protein digestibility of extruded aquafeeds containing *Acheta domesticus* and *Hermetia illucens* fractions

Irungu, F. G., Mutungi, C. M., Faraj, A. K., Affognon, H., Ekesi, S., Nakimbugwe, D., & Fiaboe, K. K. M. (2018). Proximate composition and in vitro protein digestibility of extruded aquafeeds containing *Acheta domesticus* and *Hermetia illucens* fractions. *Journal of Insects as Food and Feed*, 4(4), 275–284. <https://doi.org/10.3920/JIFF2017.0089>

Major protein sources for feed manufacture have become costly, and this has led to increased cost of products such as aquafeeds. This has dampening effect on fish production especially

in developing countries, and has necessitated a search for alternative protein sources in processed feeds. The effects of extrusion on aquafeed blends containing fractions of adult cricket (*Acheta domesticus*) meal (ACM) or black soldier fly (*Hermetia illucens*) pre-pupae meal (BSFM) on proximate composition and in vitro protein digestibility were investigated. Extrusion resulted in higher contents of protein and nitrogen free extract, and lower contents of ether extract and crude fibre as compared to the non-extruded feed. These observations were mainly associated with denaturation of proteins leading to increase in solubility, solubilisation of fibre due to the shearing forces at high temperature resulting in higher nitrogen free extract, and formation of starch-lipid complexes leading to lower ether extract. Our findings indicate that ACM or BSFM can be used to substitute fresh water shrimp meal up to 75 g/100 g level and still achieve highly nutritious processed fish feed.

Keywords: aquafeed, processing, edible insects, extrusion, nutritional value

64. Public sector soybean (*Glycine max*) breeding: Advances in cultivar development in the African tropics

Chigeza, G., Boahen, S., Gedil, M., Agoyi, E., Mushoriwa, H., Denwar, N., Gondwe, T., Tesfaye, A., Kamara, A., Alamu, E.O., & Chikoye, D. (2019). Public sector soybean (*Glycine max*) breeding: Advances in cultivar development in the African tropics. *Plant Breeding*, 138(4), 455–464. <https://doi.org/10.1111/pbr.12682>.

Formal public sector soybean breeding in Africa spans over four decades, and it was initiated by the International Institute of Tropical Agricultural (IITA). As the demand of soybean continues to outstrip production, strategic projects such the Tropical Legume (TL) were initiated, in which the main goal was to enhance the productivity of soybean in the farmers' fields in Sub-Saharan Africa. One of the strategies to enhance the productivity of soybean in the farmers' fields is through developing and deploying improved soybean varieties in the target countries. Through the TL I and TL II projects, a number of varieties were released in the target countries, Kenya, Nigeria, Malawi and Mozambique by employing participatory variety selection (PVS). This review provides highlights of the achievements made by IITA breeding program and insights of what needs to be done to enhance yield improvement for soybean in Africa using demand-driven breeding approaches.

Keywords: soya beans, production, yield gap, climate change, breeding, soybean breeding

65. Quantitation of multiple mycotoxins and cyanogenic glucosides in cassava samples from Tanzania and Rwanda by an LC-MS/MS-based multi-toxin method

Sulyok, M., Beed, F., Boni, S., Abass, A., Mukunzi, A.*, & Krska, R. (2015). Quantitation of multiple mycotoxins and cyanogenic glucosides in cassava samples from Tanzania and Rwanda by an LC-MS/MS-based multi-toxin method. *Food Additives & Contaminants: Part A*, 32(4), 488–502. www.tandfonline.com/doi/abs/10.1080/19440049.2014.975752?journalCode=tfac20

A multi-mycotoxin method based on liquid chromatography/tandem mass spectrometry (LC-MS/MS) was used for a mycotoxin survey in 627 samples of processed cassava collected from different districts across Tanzania and Rwanda after the method performance for this matrix had been determined. Matrix effects as well as extraction efficiencies were found to be similar to most other previously investigated matrices with the exception of distinct matrix effects in the negative ionisation mode for early eluting compounds. Limits of detection were far below the regulatory limits set in the European Union for other types of commodities. Relative standard deviations were generally lower than 10% as determined by replicates spiked on two concentration levels. The sample-to-sample variation of the apparent recoveries was determined for 15 individually spiked samples during three different analytical sequences. The related standard deviation was found to be lower than 15% for most of the investigated compounds, thus confirming the applicability of the method for quantitative analysis. The occurrence of regulated mycotoxins was lower than 10% (with the exception of zearalenone) and the related limits were exceeded only in few samples, which suggests that cassava is a comparatively safe commodity as regards mycotoxins. The most prevalent fungal metabolites were emodin, kojic acid, beauvericin, tryptophol, 3-nitropropionic acid, equisetin, alternariol methylether, monocerin, brevianamide F, tenuazonic acid, zearalenone, chrysophanol, monilifomin, enniatins, apicidin and macrosporin. The related concentrations exceeded 1 mg kg⁻¹ only in few cases. However, extremely high levels of cyanogenic plant toxins, which had been previously added to the method, were observed in few samples, pointing out the need for improved post-harvest management to decrease the levels of these compounds.

Keywords: multi-mycotoxin determination, cyanogenic glucosides, matrix effects

66. Reducing child undernutrition through dietary diversification, reduced aflatoxin exposure, and improved hygiene practices: The immediate impacts in central Tanzania

Anitha, S., Muzanila, Y. C.*, Tsusaka, T. W., Kachulu, L., Kumwenda, N., Musoke, M., Swai, E.*, Shija, J.*, Siambi, M., Monyo, E., Bekunda, M., & Okori, P. (2019). Reducing child undernutrition through dietary diversification, reduced aflatoxin exposure, and improved hygiene practices: The immediate impacts in central Tanzania. *Ecology of Food and Nutrition*, 59(3), 243–262. <https://doi.org/10.1080/03670244.2019.1691000>

The study aimed to quantify the immediate effects of dietary diversification, food safety, and hygiene interventions on child undernutrition in four rural villages in Kongwa district of central Tanzania. One hundred mothers with their children of less than 24 months old were recruited for this study. The difference-in-difference (DID) method was used to assess the effects of intensive intervention through a learning-by-doing process on the topic of aflatoxin free diversified food utilization and improved hygiene practices. Periodic anthropometric measurements were conducted on the 0th, 7th, 14th, and 21st days, and DID estimator showed the significant and positive average marginal effects of the intervention on Z-Scores being 0.459, 0.252, and 0.493 for wasting, stunting, and underweight, respectively. Notably, at the end of the study, the mean aflatoxin M₁ level in urine samples decreased by 64% in the intervention group, while it

decreased by 11% in the control group. The study provides quantitative evidence on intensive 21-day training for mothers incorporating integrated technologies yielded positive impacts on their children's nutritional outcomes.

Keywords: undernutrition, complementary food, aflatoxin exposure, difference in difference

67. Relationship between agricultural biodiversity and dietary diversity of children aged 6–36 months in rural areas of northern Ghana

Saaka, M, Osman, S. M, & Hoeschle-Zeledon, I. (2017). Relationship between agricultural biodiversity and dietary diversity of children aged 6–36 months in rural areas of northern Ghana. *Food & Nutrition Research*, 61(1), 1–10. <https://doi.org/10.1080/16546628.2017.1391668>

In this study, we investigated the relationship between agricultural biodiversity and dietary diversity of children and whether factors such as economic access may affect this relationship. This paper is based on data collected in a baseline cross-sectional survey in November 2013. The study population comprising 1200 mother-child pairs was selected using a two-stage cluster sampling. Dietary diversity was defined as the number of food groups consumed 24 h prior to the assessment. The number of crop and livestock species produced on a farm was used as the measure of production diversity. Hierarchical regression analysis was used to identify predictors and test for interactions. Whereas the average production diversity score was 4.7 ± 1.6 , only 42.4% of households consumed at least four food groups out of seven over the preceding 24-h recall period. Agricultural biodiversity (i.e. variety of animals kept and food groups produced) associated positively with dietary diversity of children aged 6–36 months but the relationship was moderated by household socioeconomic status. The interaction term was also statistically significant [$\beta = -0.08$ (95% CI: $-0.05, -0.01$, $p = 0.001$)]. Spearman correlation (ρ) analysis showed that agricultural biodiversity was positively associated with individual dietary diversity of the child more among children of low socioeconomic status in rural households compared to children of high socioeconomic status ($r = 0.93$, $p < 0.001$ versus $r = 0.08$, $p = 0.007$). Socioeconomic status of the household also partially mediated the link between agricultural biodiversity and dietary diversity of a child's diet. The effect of increased agricultural biodiversity on dietary diversity was significantly higher in households of lower socioeconomic status. Therefore, improvement of agricultural biodiversity could be one of the best approaches for ensuring diverse diets especially for households of lower socioeconomic status in rural areas of Northern Ghana.

Keywords: agrobiodiversity, preschool children, socioeconomic status, causal mediation, interaction, Northern Ghana

68. Relationship between serum aflatoxin concentrations and the nutritional status of children aged 6–24 months from Zambia

Alamu, E. O., Gondwe, T., Akello, J., Maziya-Dixon, B., & Mukanga, M (2019). Relationship between serum aflatoxin concentrations and the nutritional status of children aged 6–24 months from Zambia. *International Journal of Food Sciences and Nutrition*, 71(5), 593–603. <https://doi.org/10.1080/09637486.2019.1689547>

In Zambia, mothers/caregivers feed their children cereal-based complementary foods that are prone to aflatoxin contamination. This study evaluated the relationship between exposure to aflatoxins and the nutritional status of young children. It covered 400 mothers with children aged 6–24 months. Their nutritional status assessed by measuring weight and height using standard procedures. Serum samples analyzed for aflatoxin B1-lysine (AFB1-lys), a reliable biomarker of aflatoxin exposure. Child sickness and age, exposure to aflatoxin in foods, and albumin-normalised AFB1-lys level were found to be significantly ($p < .05$) associated with child stunting except for child age that was not significant at $p = .05$. Children with an increase in the blood serum aflatoxin B1 lysine adduct are more likely to be stunted. These results have shown that dietary exposure to aflatoxin could lead to an increase in serum aflatoxin concentrations, both of which are associated with stunting.

Keywords: aflatoxin, complementary foods, children, dietary exposure, nutritional status, serum

69. Retention of iron and zinc in yam flour and boiled yam processed from white yam (*D. rotundata*) varieties

Maziya-Dixon, B., Alamu, E. O., Wireko-Manu, F. D., & Asiedu, R. (2016). Retention of iron and zinc in yam flour and boiled yam processed from white yam (*D. rotundata*) varieties. *Food Science & Nutrition*, 5, 662–668. <http://dx.doi.org/10.1002/fsn3.445>

This study investigated the impact of processing on retention of iron and zinc in *D. rotundata*. Fresh tubers were processed into boiled yam and yam flour and analyzed for zinc, iron, and physicochemical properties. Percent true retention (%TR) was assessed using paired samples and a formula that compensated for loss or gain of moisture and soluble solids. The retention of iron ranged from 55.5% to 98.7% in boiled yam and 25.2% to 54.9% in yam flour; retention of zinc ranged from 49.3% to 97.5% in boiled yam and 18.9% to 43.1% in yam flour. The amount of iron retained in boiled yam correlated with the amount in the fresh samples ($r = .79$), likewise in yam flour ($r = .82$). A similar trend was observed for zinc. From our study, we conclude that retention of iron and zinc is dependent on the variety and processing method used. The information from this study can be used by food scientists and nutritionists in choosing the appropriate processing to increase the retention of high levels of micronutrient in yams and by the yam breeders to adjust their germplasm breeding activities.

Keywords: fresh tubers, yam flour, zinc, iron, true retention

70. Retention of pro-vitamin A carotenoid in composite bread baked with high quality cassava flour from yellow fleshed cassava root

Awoyale, W., Abass, A., & Maziya-Dixon, B. (2018). Retention of pro-vitamin A carotenoid in composite bread baked with high quality cassava flour from yellow fleshed cassava root. *Functional Foods in Health and Disease*, 8(9), 438–446. <https://doi.org/10.31989/ffhd.v8i9.534>

As one of the most widely consumed foods, bread is one of the most important agricultural products. Bread made from high-quality cassava flour is consumed in some parts of Sub-Saharan Africa (SSA). The bread has no pro-vitamin A carotenoids (pVAC) due to the use of

artificial colorants. Consequently, there is a need for the use of pVAC rich foods for bread production. Foods that are rich with pro-vitamin A carotenoids can be converted into retinol in the human body and whose bioconversion contributes to the reduction of vitamin A deficiency diseases (VAD). VAD has caused annual loss of life in SSA, especially in Nigeria. The yellow-fleshed cassava root might contribute to the reduction of this disease. The high quality yellow cassava flour (YHQCF) produced from yellow-fleshed cassava root may contribute to the pVAC composition of bread. As a result, there is a need for the evaluation of the retention of pVAC in composite bread baked with high quality cassava flour from yellow-fleshed cassava roots.

Keywords: high quality cassava flour, composite flour, bread, pro-vitamin A carotenoid, nutrition

71. Screening of some cassava starches for their potential applications in custard and salad cream productions

Akinwale, T. E., Niniola, D. M., Abass, A. B., Shittu, T. A., Adebawale, A. A., Awoyale, W., Awonorin, S. O., Adewuyi, S., & Eromosele, C. O. (2017). Screening of some cassava starches for their potential applications in custard and salad cream productions. *Journal of Food Measurement and Characterization*, 11(1), 299–309. <https://doi.org/10.1007/s11694-016-9397-x>

Custard powder and salad cream are two food products commercially manufactured using different quantities of corn starch. This study aimed at determining the physicochemical properties of some starches extracted from some white and yellow root cassava varieties. The prospective applicability of the cassava starches in custard powder and salad cream production was also determined. The physical, chemical and functional properties of eight cassava starches were determined using standard analytical procedures. Sensory acceptability of the products was also determined using untrained consumer group. Products made from corn starch were used as the reference samples. The physical, chemical and functional properties of the cassava starches varied significantly ($p < 0.05$). The results of multivariate data analysis (principal component and cluster analyses) showed that it was difficult to completely discriminate starches from the yellow fleshed and white fleshed cassava roots. Texture was the most important sensory attribute determining the two products' acceptability. Starch powder dispersibility was found to have significant influence ($p < 0.05$) on the sensory acceptability of the two products. However, starch from a yellow fleshed root (TMS 01/1368) was the most preferred for salad cream making while starch from a white fleshed root (TMS 30572) was the most preferred for making custard powder. The starches showed high potential to replace corn starch for the respective product manufacture.

72. Single layer drying kinetics of papaya amidst vertical and horizontal airflow

Udomkun, P., Argyropoulos, D., Nagle, M., Mahayothee, B., Janjai, S., & Müller, J. (2015). Single layer drying kinetics of papaya amidst vertical and horizontal airflow. *LWT – Food Science and Technology*, 64, 67–73. <http://dx.doi.org/10.1016/j.lwt.2015.05.022>

The impact of airflow direction, namely through-flow and over-flow modes, on drying kinetics of osmotically-pretreated papayas was investigated in a convective-type dryer under varied conditions (temperature, humidity and velocity). The Newton model was used to describe thin-layer drying characteristics and the dependence of drying air parameters on the drying constant (k) was expressed by an Arrhenius-type relationship. It was found that a more uniform airflow distribution in the through-flow chamber resulted in higher product temperature as well as faster drying rate, especially during the initial stage of drying. For both airflow modes, drying kinetics was most significantly influenced by temperature and velocity of the air, whereas the specific humidity had less effect on the drying rate. The value of k increased in parallel with temperature and velocity of the drying air, whereas it was reduced by increasing humidity. A model incorporating the conditions of drying air was developed for each airflow mode, which can help with optimization of practical drying operations.

Keywords: air distribution, drying rate, convective drying, through-flow, over-flow

73. Snack food from unripe plantain and orange vesicle composite flour: nutritional and sensory properties

Adegunwa, M. O., Fafiolu, O. F., Adebowale, A. A., Bakare, H. A., & Alamu, E. O. (2019). Snack food from unripe plantain and orange vesicle composite flour: nutritional and sensory properties. *Journal of Culinary Science & Technology*, 17(6), 491–506. <https://doi.org/10.1080/15428052.2018.1491917>

This study investigated the potential of unripe plantain (UP) and orange vesicle (OV) composite flour for cookies production. Proximate composition, functional properties, vitamins and mineral composition of the composite flour were carried out. Data obtained was subjected to Analysis of Variance. The addition of OV flour to UP flour increased protein (5.59–7.50%), fat (0.67–1.25%), ash (2.67–4.40%) and fibre (0.56–7.19%) contents, while moisture (9.10–7.43%), carbohydrate (81.05–72.39%) and energy (380.43–360.84 calories) contents decreased. Swelling capacity, solubility index and water absorption capacity increased while dispersibility decreased with OV flour inclusion. Addition of OV flour enhanced the minerals and Vitamin C contents of the flour blends and the resultant cookies produced. Overall sensory acceptability of the cookies from the flour blends showed that it was slightly preferred by the sensory panelist. It can be concluded that (UP-OV) composite flours could be used up to 60:40 ratios for producing cookies.

Keywords: orange vesicle, unripe plantain, flour blend, cookies, nutritional properties

74. Sorption behavior of papaya as affected by compositional and structural alterations from osmotic pretreatment and drying

Udomkun, P., Argyropoulos, D., Nagle, M., Mahayothee, B., & Müller, J. (2015). Sorption behavior of papaya as affected by compositional and structural alterations from osmotic pretreatment and drying. *Journal of Food Engineering*, 157, 14–23. <http://dx.doi.org/10.1016/j.jfoodeng.2015.01.022>

Moisture sorption dynamics and isotherms of fresh, osmotically-pretreated and dried papayas at temperatures of 30, 50 and 70 °C and water activity in the range of 0.113-0.907 were investigated. Chemical composition as well as volume, density, porosity and microstructure of the fruits were analyzed. Results showed that the time required to reach equilibrium moisture content was mainly dependent on temperature, water activity level and processing method. The difference in moisture sorption characteristics between fresh, pretreated and dried papayas was attributed to i) changes in the contents of sugars after osmotic dehydration and ii) structural modifications caused by drying, which were corroborated by examination of micrographs. The differences in sorption were also proven by the selected isotherm models. The modified Halsey equation described the sorption behavior of the pretreated and dried papayas, whereas the untreated, fresh samples were better predicted by the modified Oswin equation. Further indication that osmotic pretreatment and drying influenced the interaction between the sorption sites and water molecules was imparted by the values of isosteric heat of sorption (Q_{st}) for fresh and dried papayas at different temperatures.

Keywords: sorption isotherms, sorption heat, Halsey model, microstructure

75. Soymilk yield and quality as affected by soybean varieties and processing techniques

Ogundipe, H., Dashiell, K., & Osho, S. (1989). Soymilk yield and quality as affected by soybean varieties and processing techniques. *Tropical Grain Legume Bulletin*, 36, 12–14. <https://hdl.handle.net/10568/98666>

Grains of nine soybean varieties were processed into soybean milk, and their milk yield and protein (%) were determined, followed by sensory evaluations. In another experiment, grains of five soybean varieties were made into soybean milk, using five different processing techniques. In the first experiment, there was a significant difference among the varieties for milk yield and the sensory evaluation characters, but no significant difference for protein (%). In the second experiment, processing techniques. Variety and the processing technique x variety interaction all had a significant effect on milk yield.

Keywords: soybeans, milk, sensory evaluation, proteins, techniques

76. The effect of processing on the nutrient content of cassava (*Manihot esculenta* Crantz) leaves

Achidi, A. *, Ajayi, O. A. *, Maziya-Dixon, B., & Bokanga, M. (2008). The effect of processing on the nutrient content of cassava (*Manihot esculenta* Crantz) leaves. *Journal of Food Processing and Preservation*, 32(3), 486–507. <https://ifst.onlinelibrary.wiley.com/doi/10.1111/j.1745-4549.2007.00165.x>

Leaves of two varieties of cassava (*Manihot esculenta* Crantz) – TME1 (local) and TMS30572 (improved) – were subjected to African household processing (heat-treated, pounded and cooked and crushed, ground and cooked) and compared for proximate composition, minerals, vitamins and antinutritional factors. The processing methods had no effect on ash, lipids,

protein, fiber, total carbohydrate, carotene, calcium, magnesium, potassium, sodium, phosphorus, copper, zinc and manganese but produced diminution in free sugars (23.2% reduction), ascorbic acid (77.7% reduction), thiamine (37.1% reduction), cyanogenic potential (>99% reduction) and tannin (55.2% reduction;) levels. On the contrary, iron level increased three- to fivefold with grinding but not with the pounding process. This study showed that adequate processing practically detoxifies cassava leaves with considerable nutrient retention, thus enhancing utilization of cassava leaves for human consumption.

Practical applications: This study has clearly shown that cassava leaves are very nutritious. However, they also have anti-nutrients which can render them toxic. This is responsible for the fear exhibited in the consumption of cassava leaves because of anticipated poisoning. This study shows that African processing methods tremendously reduce the ant-nutrients with minimal loss in the nutrients. There should therefore be no fear in the utilization of cassava leaves either for animal feed formulation or man's own direct consumption as a good source of leafy vegetables. The food quality of processed cassava leaves renders them a potential source of raw material for the animal feed industry as well as for the formulation of weaning foods especially for the underdeveloped world.

77. Utilization of mixed adsorbents to extend frying oil life cycle in poultry processing

Udomkun, P., Innawong, B., Siasakul, C., & Okafor, C. (2018). Utilization of mixed adsorbents to extend frying oil life cycle in poultry processing. *Food Chemistry*, 248, 225–229. <https://hdl.handle.net/10568/108198>

The effects were studied of two different adsorbent combinations (com I; bentonite: activated carbon: celite = 3:4:1 and com II; bentonite: activated clay: celite = 3:4:1 + 1% citric acid) on the physico-chemical changes of oil used continuously for deep-fat frying of chicken drumsticks. The results showed that the % FFA was reduced by 44.3, PV by 50.2, and FOS reading by 40.1% in com I whereas reductions of 41.6, 44.9, and 32.8%, respectively, were found in com II. The oil treated with com II exhibited a lighter color than with com I. The changes of oil color in com I were L* 30.7, a* 1.7, and b* 31.9%; in com II they were 53.2, 19.1, and 39.5% respectively. The higher the L* observed, the better the oil quality obtained because of the bleaching ability of adsorbents. Therefore, the use of such adsorbents is recommended for poultry processing.

Keywords: adsorbents, frying, shelf life, poultry

78. Variability of provitamin A carotenoids in plantain: Influence of cultivar, bunch type, maturation stage, and location

Udomkun, P., Masso, C., Swennen, R. L., Wossen, T., Amah, D., Fotso, A., Lienou, J., Adesokan, M., Njukwe, E., & Vanlauwe, B. (2020). Variability of provitamin A carotenoids in plantain: Influence of cultivar, bunch type, maturation stage, and location. *Journal of Food Composition and Analysis*, 94, 103636. <https://doi.org/10.1016/j.jfca.2020.103636>

In this study, the effect of ripening stage (R), cultivar (C), bunch type (T), and location (L) on the variability of provitamin A carotenoids (pVACs) in 16 plantain cultivars grown in Cameroon and Gabon was investigated. For the sixteen plantain cultivars, fruits were collected at stages 1 (unripe), 5 (ripe), and 7 (overripe) from three different bunch types (French, False Horn, and True Horn) across 13 locations in Cameroon and Gabon. For all cultivars, the highest concentration of carotenoids was found in ripe pulp ($p < 0.05$). For bunch type, a higher level of pVACs was observed in the French type compared with the False Horn and True Horn types at all ripening stages. In addition, the concentration of pVACs at each ripening stage varied greatly across locations. In both countries, the interaction between the four factors, particularly between $R \times C$, $R \times T$, $R \times L$, $R \times C \times L$, and $R \times T \times L$, contributed significantly ($p < 0.05$) to the variability of pVACs in plantain. Daily consumption of 100 g of ripe plantain could meet 36.2–101.7 % of the dietary reference intakes (DRIs) for children 1–5 years old, 20.7–58.1 % for adult women, and 16.1–45.2 % for adult men. These findings can serve as a guide to reducing vitamin A deficiency (VAD) in Africa.

79. Variation in the evaluation of *cis*- and *trans*- β -carotene in yellow-fleshed cassava (*Manihot esculenta* Cranz) varieties as a function of the storage root portion and sampling method

Maziya-Dixon, B., Alamu, E. O., & Dixon, G. A. (2016). Variation in the evaluation of *cis*- and *trans*-carotene in yellow-fleshed cassava (*Manihot esculenta* Cranz) varieties as a function of the storage root portion and sampling method. *LWT – Food Science and Technology*, 70, 296–301. <http://dx.doi.org/10.1016/j.lwt.2016.03.002>

Providing correct estimates of the carotenoid content of cassava varieties is very important in any cassava-breeding program for improving vitamin A intakes in sub-Saharan Africa especially among high-risk groups. The effect of different sampling methods – sampling with cork-borer (SPM1) and sampling without cork-borer (SPM2) – on *cis*- and *trans*- β -carotene in yellow-fleshed storage roots of cassava was investigated with 40 elite cassava varieties (comprises of 2 trials), grown in 2004/2005 growing season in replicated field trials (Randomized Complete Block Design) and harvested at 12 months after planting. The *cis*- and *trans*- isomers of β -carotene of the varieties of SPM1 and SPM2 was determined using HPLC. Result showed significant genotypic differences ($P < 0.001$) for both *cis*- and *trans*- β -carotene contents among the varieties. The mean *cis*- and *trans*- β -carotene contents were generally highest in the proximal portions and lowest in the distal portion of cassava storage roots. There was no significant difference ($P > 0.05$) in the two sampling methods and there was also positive correlation between the *cis*- and *trans*- β -carotene contents for both trials 1 and 2. This study provides information on β -carotene distribution and the appropriateness of SPM2 as an alternative and easy sampling method for carotenoid contents in yellow-fleshed cassava varieties.

Keywords: cassava roots, varieties, sampling method, yellow-fleshed, β -carotene

80. Varietal and harvesting time effects on physical characteristics and sensory attributes of boiled fresh yellow maize hybrids

Alamu, E. O., Olaofe, O.*, Maziya-Dixon, B., & Menkir, A. (2014). Varietal and harvesting time effects on physical characteristics and sensory attributes of boiled fresh yellow maize hybrids. *Journal of Applied Biosciences*, 82, 7347–7358. <https://doi.org/10.4314/jab.v82i1.3>

Objective: The present study evaluated the effect of varieties and harvesting time on the physical characteristics and acceptability of boiled fresh yellow maize hybrids.

Methodology and Results: Freshly harvested cobs from eight biofortified yellow maize hybrids, at three harvesting time (20, 27 and 34 days after pollination (DAP)), were used for the present study. The fresh yellow maize ears at each of the harvesting time were boiled without husk in water at 100oC for averagely 15mins (20DAP), 25mins (27DAP) and 32mins (34DAP) respectively using atmospheric cooking method. Sensory evaluation was carried out on the boiled fresh yellow maize samples within 24 hours after harvesting. The physical characteristics of the fresh maize grains were also determined. Variety and harvesting time had significant effects ($P < 0.001$) on most of the physical properties, except porosity. The optimum harvest maturity stage to consume boiled maize hybrids was found to be 20DAP. There was negative but significant correlation between the physical characteristics and the sensory properties except color that showed positive correlation.

Conclusions and application of findings: Differences in kernel characteristics caused by genetic inheritance and harvesting time can influence the processing, utilization and consumer appreciation of maize. The information from this study could used by the Maize breeders to further improve the physical characteristics of the maize hybrids and by the maize consumers to know the best harvest time to consume boiled maize hybrids.

Keywords: yellow maize, hybrids, harvesting time, boiled, physical characteristics acceptability

Situation and context analysis (59)

1. Adaptation strategies to climate change and impacts on household income and food security: Evidence from Sahelian region of Niger

Zakari, S., Ibro, G., Moussa, B., & Abdoulaye, T. (2022). Adaptation strategies to climate change and impacts on household income and food security: Evidence from Sahelian region of Niger. *Sustainability*, 14(5), 2847. <https://doi.org/10.3390/su14052847>

Sahelian countries, particularly Niger, are more vulnerable to climate change due to the high dependence of most of their populations on rain-fed agriculture and limited capacities to respond to climate variability and change. This paper examines the factors influencing climate change adaptation strategies and the impacts on household income and food security in rural Niger. For this purpose, we collected data from 1783 valid rural households in four main agricultural regions of Niger. The results showed that crop diversification (72.74%), income diversification (67.97%) and changing planting times (55%) are the main adaptation strategies adopted by households. The majority of respondents had noticed changes in rain patterns (93.21%), in the amount of rain (91.25%) and in the intensity of rain (81.82%) during the last five years.

We categorized these adaptation strategies into six major groups namely climate-resilient crop varieties, improved agronomic practices, irrigation and water conservation practices, crop diversification, income diversification, and agroforestry. We ran logit regression to identify the determinants of each individual group. The results show mixed effects of independent variables on these categories of adaptation strategies. Using matching techniques, we found adaptation strategies have positive and significant impact on both household income and food security. The farmers who adopt climate change adaptation strategies are more likely to increase household income by 7721.526 FCFA compared to those households with zero adaptation strategies. Similarly, the farmers have 7% to 9% more chance to be food secure compared to those who did not adopt strategies. These results suggest that strengthening the awareness of the effects of climate change on farmers and the choice of appropriate adaptation strategies are necessary to enhance household resilience. Strengthening institutional factors such as access to credit and market, extension services, and using drought-resilient crop varieties would surely improve agricultural production.

2. A land management-based approach to integrated *Striga hermonthica* control in sub-Saharan Africa

Berner, D., Carsky, R., Dashiell, K., Kling, J., & Manyong, V. (1996). *Outlook on Agriculture*, 25(3), 157–164. <https://journals.sagepub.com/doi/10.1177/003072709602500304>

Striga hermonthica, an obligate root parasite of grasses, is one of the most severe constraints to cereal production in sub-Saharan Africa. In the recent past, prior to increased production pressure on land, *S. hermonthica* was controlled in African farming systems by prolonged crop rotations with bush fallow. Because of increasing need for food and concomitant changes in land management practices, however, these fallow rotations are no longer extensively used. Shorter crop rotations and fallow periods have also led to declines in soil fertility which present a very serious threat to African food production. A sustainable solution will be an integrated approach that simultaneously addresses both of these major problems. An integrated program that replaces traditional bush fallow rotation with non-host nitrogen-fixing legume rotations, using cultivars selected for efficacy in germinating *S. hermonthica* seeds, is outlined. The program includes use of *S. hermonthica*-free planting material, biological control, cultural control to enhance biological suppressiveness, host-plant resistance, and host-seed treatments.

Keywords: *Striga hermonthica*, roots, parasites, cereals, farming systems, crop rotation, bush fallowing, soil fertility, food production, legumes

3. Are farmers using cropping system intensification technologies experiencing poverty reduction in the Great Lakes Region of Africa?

Dontsop Nguetzet, P. M., Ainembabazi, J. H., Alene, A., Abdulaye, T., Feleke, S., Nziguheba, G., Khonje, M., Mignouna, D., Okafor, C., Njukwe, E., Van Asten, P., Mapatano, S., Vanlauwe, B., & Manyong, V. (2020). Are farmers using cropping system intensification technologies experiencing poverty reduction in the Great Lakes Region of Africa? *Food and Energy Security*, 9(3), e205. <https://onlinelibrary.wiley.com/doi/10.1002/fes3.205>

This study evaluated the poverty reduction impact of the adoption of cropping system intensification (CSI) technologies using the endogenous switching regression (ESR) model in the Great Lakes region of Africa that comprises Burundi, eastern DR Congo, and Rwanda. The study data came from a household survey of 1,495 sample households interviewed between October and December 2014. Results indicated that the adoption of the CSI technologies had increased crop yield, crop income, and per capita consumption expenditure in the region, resulting in poverty reduction. Among the three countries, eastern DR Congo witnessed the highest poverty reduction (13% points) followed by Rwanda (6% points) and Burundi (2% points). Considering the adoption rate and size of the target population in each country at baseline, an estimated 180 thousand poor individuals had escaped poverty due to the adoption of the CSI technologies. This presents important evidence in favor of promoting CSI technologies as part of poverty reduction strategy. Given the large population size that remains poor even after adoption, we suggest that research-based poverty reduction strategies such as the CSI technologies should be complemented with development interventions.

Keywords: adoption, Africa, cropping system intensification technologies, Great Lakes region, impact, poverty

4. Assessing climate smart agriculture and its determinants of practice in Ghana: A case of the cocoa production system

Akrofi-Atitianti, F., Speranza, C. I., Bockel, L., & Asare, R. (2018). Assessing climate smart agriculture and its determinants of practice in Ghana: A case of the cocoa production system. *Land*, 7(1), 1–21. <https://doi.org/10.3390/land7010030>

Agriculture in Africa is not only exposed to climate change impacts but is also a source of greenhouse gases (GHGs). While GHG emissions in Africa are relatively minimal in global dimensions, agriculture in the continent constitutes a major source of GHG emissions. In Ghana, agricultural emissions are accelerating, mainly due to ensuing deforestation of which smallholder cocoa farming is largely associated. The sector is also bedevilled by soil degradation, pests, diseases and poor yields coupled with poor agronomic practices. Climate Smart Agriculture (CSA) thus offers a way to reduce the sector's GHG emissions and to adapt the sector to the adverse impacts of climate change. This study assesses the potential of CSA vis-à-vis conventional cocoa systems to enhance production, mitigate and/or remove GHG emissions and build resilience, in addition to understanding key determinants influencing CSA practices. Using a mixed methods approach, data was collected in Ghana's Juabeso and Atwima Mponua districts through semi-structured household questionnaires administered to 80 household heads of cocoa farms, two focus group discussions and expert interviews. A farm budget analysis of productivity and economic performance for both scenarios show that CSA practitioners had a 29% higher income per ha compared to the conventional farmers. Estimations using the FAO Ex-Ante Carbon-Balance Tool (EX-ACT) indicate CSA practices preserve forest resources without which the effect on carbon balance as presented by conventional farming would remain a source of GHG emissions. Farm tenure, age of farmers, location of farm, residential status and access to extension services were the main determining

factors influencing CSA practices among cocoa farmers. An in-depth understanding of these indicators can help identify ways to strengthen CSA strategies in the cocoa sector and their contributions to climate change mitigation and resilience.

Keywords: climate smart agriculture, resilience, carbon balance, cocoa, mitigation, Ghana, Ex-ACT, agroforestry

5. Assessing farm-level limitations and potentials for organic agriculture by agro-ecological zones and development domains in northern Nigeria of West Africa

Olayide, O, Ikpi, A, Alene, A., & Akinyosoye, V (2011). Assessing farm-level limitations and potentials for organic agriculture by agro-ecological zones and development domains in northern Nigeria of West Africa. *Journal of Human Ecology*, 34(2), 75–85. <https://doi.org/10.1080/09709274.2011.11906371>

Farm-level use of organic fertilizer could be influenced by development domains that comprise human population density and markets access. Analysis of 320 farm households from 16 geo-referenced villages provided the basis for assessing farm-level limitations and potentials for organic agriculture by agro-ecological zones and development domains in northern Nigeria of West Africa. The analysis was based on four identified development domains. The development domains were clusters of population and market access which are: low population density, low market access (LPLM); low population density, high market access (LPHM); high population density, low market access (HPLM); and high population density, high market access (HPHM). It was found that cereal-legume based cropping systems accounted for 74 % of the total share of organic fertilizer used on the farm. The actual and potential use of organic fertilizer revealed that the current levels of organic fertilizer use as share of the minimum requirements for take-off for organic agriculture in Nigeria was low (37 %) despite its potentials. Based cost effectiveness of livestock ownership, the development domains of HPLM and HPHM in the northern Guinea savanna revealed best potential for take-off of organic agriculture in Nigeria.

Keywords: organic fertilizer, geographic information system, development domains, potentials, Nigeria

6. Assessing the use of a drought-tolerant variety as adaptation strategy for maize production under climate change in the savannas of Nigeria

Tofa, A., Kamara, A., Babaji, B. A, Akinseye, F. M., & Bebeley, J. F. (2021). Assessing the use of a drought-tolerant variety as adaptation strategy for maize production under climate change in the savannas of Nigeria. *Scientific Reports*, 11, 8983. <https://doi.org/10.1038/s41598-021-88277-6>

The Decision Support System for Agricultural Technology Transfer (DSSAT) was used to quantify the impact of climate change on maize yield and the potential benefits of the use of drought-tolerant maize variety over non-drought tolerant variety in savanna ecological zones of Nigeria. Projections of maize yields were estimated for three locations representing different agro-climatic zones and soil conditions, in the mid-century (2040–2069) and end-

century (2070–2099) under representative concentration pathways scenarios (RCP 4.5 and 8.5) against the baseline period (1980–2009). Relative to the baseline period, the ensemble Global Circulation Models (GCMs) predicted significant increase in minimum and maximum temperatures and seasonal rainfall across the sites. In the mid-century, ensemble GCMs predicted temperatures increase between 1.7–2.4 °C for RCP4.5 and 2.2–2.9 °C for RCP8.5. By end-century, the temperature increases between 2.2–3.0 °C under RCP4.5 and 3.9–5.0 °C under RCP8.5. Predicted seasonal rainfall increase between 1.2–7% for RCP4.5 and 0.03–10.6% for RCP8.5 in the mid-century. By end of century, rainfall is expected to increase between 2–6.7% for RCP4.5 and 3.3–20.1% for RCP8.5. The DSSAT model predictions indicated a negative impact on maize yield in all the selected sites, but the degree of the impact varies with variety and location. In the mid-century, the results showed that the yield of the non-drought tolerant maize variety, SAMMAZ-16 will decline by 13–19% under RCP4.5 and 19–28% under RCP8.5. The projection by end-century indicates a decline in yield by 18–26% under RCP4.5 and 38–47% under RCP8.5. The yield of the drought-tolerant variety is projected to decline by 9–18% for RCP4.5 and 14–25% for RCP8.5 in the mid-century and 13–23% under RCP4.5 and 32–43% under RCP8.5 by the end-century. The higher temperatures by both emission scenarios (RCP 4.5 and 8.5) were primarily shown to cause more yield losses for non-drought-tolerant variety than that of the drought-tolerant variety. There will be 1–6% less reduction in yield when drought-tolerant variety is used. However, the higher yield reductions in the range of –13 to –43% predicted for the drought-tolerant variety by the end of the century across the study areas highlighted the need to modify the maize breeding scheme to combine both tolerances to drought and heat stresses in the agro-ecological zones of northern Nigeria.

7. Assessment of farmers' crop management practices influencing *Striga hermonthica* infestation and grain yield of sorghum (*Sorghum bicolor*)

Dugje, I, Kamara, A., & Omoigui, L. (2007). Assessment of farmers' crop management practices influencing *Striga hermonthica* infestation and grain yield of sorghum (*Sorghum bicolor*). *Nigerian Journal of Weed Science*, 20, 25–35. <https://cgspace.cgiar.org/handle/10568/93022>

Striga hermonthica (L.) Moench, a parasitic weed species, is a major constraint to sorghum production in the savanna zones of north-eastern Nigeria. The aim of this study was to assess the influence of farmer practices on *Striga* infestation of sorghum fields in the region. Random sampling technique and semi-structured questionnaires were used to sample 54 sorghum fields and assess farmer-practices in nine communities of Borno State in north-eastern Nigeria. About 39% of the farmers had continuously cultivated their farmlands for more than 10 years, 60% planted in June, and 41% practiced sorghum-legume rotation, 45% practiced sorghum+legumes relay intercropping, 58% applied nitrogen fertilizer and 43% conducted hoe-weeding three times. In northern and southern Guinea savannas, prolonged period of land cultivation, early planting, and inadequate nitrogen fertilization promoted *Striga* infestation as these practices were positively associated with *Striga* counts. However, late planting, sorghum-cowpea or groundnut rotation, and increased weeding frequency reduced infestation as these were negatively correlated with *Striga* counts. Relay intercropping reduced grain yield ha⁻¹

($r = -0.52^*$) in northern Guinea savanna, but sorghum-legume rotation, weeding frequency, and increased nitrogen fertilizer rate increased grain yield as these were positively associated with grain yield ha^{-1} in both zones. In Sudan savanna, *Striga* counts were reduced by relay intercropping of sorghum with legumes, as the practice was negatively associated with *Striga* count, while inadequate weeding promoted infestation ($r = 0.44^*$). However, grain yield ha^{-1} was positively associated with nitrogen fertilizer rate and weeding frequency. Thus prolonged period of land use, continuous cropping of sorghum, inadequate nitrogen fertilization and early planting or less than 3 hoe-weedings promote *Striga* infestation, while sorghum-legume rotation, sorghum + legume intercropping or 3 hoe-weeding reduced infestation and increased grain yield of sorghum in the three zones.

Keywords: sorghum, farmer participation, *Striga hermonthica*, grain, yield, savannas

8. Baseline simulation for global wheat production with CIMMYT mega-environment specific cultivars

Gbegbelegbe, S., Cammarano, D., Asseng, S., Robertson, R., Chung, U., Adam, M., Abdalla, O., Payne, T., Reynolds, M., Sonder, K., Shiferaw, B., & Nelson, G. (2017). Baseline simulation for global wheat production with CIMMYT mega-environment specific cultivars. *Field Crops Research*, 202, 122–135. <https://doi.org/10.1016/j.fcr.2016.06.010>

Climate change is expected to impact global food supply and food security by affecting growing conditions for agricultural production. Process-based dynamic growth models are important tools to estimate crop yields based on minimum inputs of climate, soil, crop management, and crop cultivar parameters. Using region-specific cultivar parameters is critical when applying crop models at a global scale because cultivars vary in response to climate conditions, soils, and crop management. In this study, parameters were developed for modern cultivars representing all 17 CIMMYT wheat Mega Environments (MEs) using field experimental data and genetic cultivar relationships for the CROPSIM-CERES model in DSSAT v 4.5 (Decision-Support System for Agrotechnology Transfer). Cultivar performance was tested with independent CIMMYT breeding trial field experiments across several locations. Then crop simulations were carried out at $0.5 \times 0.5^\circ$ pixels for global wheat-growing areas, using cultivars representing MEs, soil information, region-specific crop management, and initial soil conditions. Aggregated simulated wheat yields and production were compared to reported country yields and production from Food and Agriculture Organization (FAO) statistics, resulting in a Root Mean Square Error (RMSE) of 1.3t/ha for yield and 2.2Mt/country for country production. Some of the simulated errors are relatively large at country level because of uncertainties in pixel information for climate, soil, and crop management input and partly because of crop model uncertainties. In addition, FAO yield statistics have uncertainties because of incomplete farm reports or poor estimates. Nevertheless, this new cultivar-specific, partially-validated global baseline simulation enables new studies on issues of food security, agricultural technology, and breeding advancement impacts combined with climate change at a global scale.

Keywords: climate change, food security, agricultural production, crop yields, FAO, global wheat production, geo-spatial crop modeling

9. Baseline study of *Striga* control using IR maize in western Kenya

Manyong, V., Alene, A., Olanrewaju, A., Ayedun, B., Rweyendela, V., & Wesonga, A. S. (2006). *Baseline study of Striga control using IR maize in western Kenya*. Nairobi: African Agricultural Technology Foundation. <https://hdl.handle.net/10568/90752>

This report presents the results of the baseline study undertaken to assess the status of *Striga* damage, the general livelihoods and livelihood strategies of the rural poor in western Kenya. A stratified random sampling method led to the selection of 8 districts, 16 sub-locations, 32 villages and 800 households. A combination of techniques for data collection was used, including literature review, GPS recordings, focus group discussions and interview of individual households. Various econometric models were also developed and estimated for data analyses. A stochastic frontier production function was used to measure the technical efficiency of maize production. A logistic regression model of poverty was estimated to examine the determinants and correlates of poverty in western Kenya. The study revealed that households are small in size and the dependency ratio is high. There were about 26% of households headed by females. The level of education is low for the heads of households and all members of farm families. Households are endowed with a multitude of assets for their livelihoods. However, the level of assets was found to be low or of very poor quality. Maize is the major food crop and a source of cash income. Farmers grow both local and improved (hybrid) maize varieties, but the productivity is low. There is a considerable gap between potential and actual maize yields. Major factors constraining crop production include *Striga* infestation on maize, low soil fertility, drought and erratic rainfall. *Striga* is the major threat to livelihoods of smallholders and its economic importance has increased over the past three decades. Traditional methods of *Striga* control include uprooting, burning and manuring, which have proved to be ineffective. Alternative technologies exist but they have not been adopted and used as they should because the level of awareness is very low. Analysis of the determinants of poverty revealed that the poverty status of a household in western Kenya is significantly related to *Striga* damage, *Striga* control, dependency ratio, age, education, technology adoption, land per capita, farm assets, off-farm work, cash crop production, and location. More than 70% of the sampled households experience food shortage lasting as long as five months every year. Coping strategies include off-farm short-term jobs, disposal of assets, and informal safety nets especially through remittances received from relatives. The anthropometric Z scores calculated on children indicate that about 30% were wasting, 50% were underweight and 48% were stunted. Similarly, the results on body mass index (BMI) on women showed that 36% were underweight while 18% were overweight. One of the possible strategies to reduce poverty and vulnerability is to increase the efficiency in maize production. Considerable variation in maize production efficiency was found among the sample maize farmers. The results point to the possibility of increasing maize production through improved efficiency and best local practices adopted by the most efficient farmers in the sample, such as integrated *Striga* control. While technical efficiency increases with educational attainment, it has a significant non-linear relationship with farm size where it first increases but eventually declines with farm size. The direct farm size-efficiency relationship for smaller holdings coupled with the fact that most farmers in western Kenya cultivate tiny plots of land suggests that re-

allocation of more land to maize would enhance farmer efficiency. Increased efficiency could be achieved through, for instance, more optimal application of inputs and greater intensity of adoption of improved maize varieties. Therefore, efforts must be made to enhance adoption of both hybrid maize and *Striga* control technologies to help increase maize production. Maize yields in Kenya have continued to decline despite increased use of new maize varieties, largely due to lack of effective *Striga* control technologies. Promoting both high-yielding varieties and *Striga* control technologies should thus be an important goal for research and extension in Kenya.

10. Benefits of legume–maize rotations: Assessing the impact of diversity on the productivity of smallholders in Western Kenya

Ojiem, J. O., Franke, A. C., Vanlauwe, B., de Ridder, N., & Giller, K. E. (2014). Benefits of legume–maize rotations: Assessing the impact of diversity on the productivity of smallholders in Western Kenya. *Field Crops Research*, 168, 75–85. <https://doi.org/10.1016/j.fcr.2014.08.004>

Agricultural intensification of farming systems in sub-Saharan Africa is a prerequisite to alleviate rural poverty and improve livelihoods. Legumes have shown great potential to enhance system productivity. On-farm experiments were conducted in different agro-ecological zones (AEZ) in Western Kenya to assess the agronomic and economic benefits of promising legumes. In each zone, trials were established in fields of high, medium and low fertility to assess the effect of soil fertility heterogeneity on legume productivity and subsequent maize yield. Common bean, soybean, groundnut, lima bean, lablab, velvet bean, crotalaria, and jackbean were grown in the short rains season, followed by maize in the long rains season. Alongside, continuous maize treatments fertilized at different rates were established. AEZs and soil fertility gradients within these zones greatly affected crop productivity, returns to land and labor of rotations, as well as the relative performance of rotations. Poorer soil fertility and AEZs with lower rainfall gave smaller legume and maize yields and consequently, smaller returns to land and labor. The cultivation of legumes increased maize yields in the subsequent long rains season compared with continuous maize receiving fertilizer at a similar rate, while the increase of maize after green manure legumes was stronger than that after grain legumes. Maize yield responded strongly to increasing amounts of N applied as legume residues with diminishing returns to legume-N application rates above 100 kg N ha⁻¹. In the low potential zones, factors other than improved N availability likely also stimulated maize yield. Rotations with grain legumes generally provided better returns than those with green manures. Intercropping bean with maize in the long rains season provided an additional bean yield that did not come at the expense of maize yield and improved returns to land and labor, but more so in the high potential zones. The results demonstrate the strong impact of biophysical diversity on the productivity of the legumes and suggest the need for careful targeting of legume technologies to the different biophysical conditions.

Keywords: agro-ecological zones, soil fertility gradients, legumes, rotations, economic analysis, technology niches

11. Charcoal production and household welfare in Uganda: a quantile regression approach

Ainembabazi, J. H., Shively, G., & Angelsen, A. (2013). Charcoal production and household welfare in Uganda: a quantile regression approach. *Environment and Development Economics*, 18(5), 537–558. <https://doi.org/10.1017/S1355770X1300017X>

Previous research suggests that forest-dependent households tend to be poorer than other groups, and that extreme reliance on forest resources might constitute a poverty trap. We provide an example in which a non-timber forest product – charcoal – appears to be providing a pathway out of poverty for some rural households in Uganda. Data come from households living adjacent to natural forests, some of whom engage in charcoal production. We use a semi-parametric method to identify the determinants of participation in charcoal production and a quantile regression decomposition to measure the heterogeneous effect of participation on household income. We find that younger households and those with few productive assets are more likely to engage in charcoal production. We also show that, as a result of their participation, charcoal producers are better off than non-charcoal producers in terms of income, even though they are worse off in terms of productive assets.

12. Circular bioeconomy research for development in sub-Saharan Africa: Innovations, gaps, and actions

Feleke, S., Cole, S. M., Sekabira, H., Djouaka, R., & Manyong, V. (2021). Circular bioeconomy research for development in sub-Saharan Africa: Innovations, gaps, and actions. *Sustainability*, 13(4), 1926. <https://doi.org/10.3390/su13041926>

The International Institute of Tropical Agriculture (IITA) has applied the concept of ‘circular bioeconomy’ to design solutions to address the degradation of natural resources, nutrient-depleted farming systems, hunger, and poverty in sub-Saharan Africa (SSA). Over the past decade, IITA has implemented ten circular bioeconomy focused research for development (R4D) interventions in several countries in the region. This article aims to assess the contributions of IITA’s circular bioeconomy focused innovations toward economic, social, and environmental outcomes using the outcome tracking approach, and identify areas for strengthening existing circular bioeconomy R4D interventions using the gap analysis method. Data used for the study came from secondary sources available in the public domain. Results indicate that IITA’s circular bioeconomy interventions led to ten technological innovations (bio-products) that translated into five economic, social, and environmental outcomes, including crop productivity, food security, resource use efficiency, job creation, and reduction in greenhouse gas emissions. Our gap analysis identified eight gaps leading to a portfolio of five actions needed to enhance the role of circular bioeconomy in SSA. The results showcase the utility of integrating a circular bioeconomy approach in R4D work, especially how using such an approach can lead to significant economic, social, and environmental outcomes. The evidence presented can help inform the development of a framework to guide circular bioeconomy R4D at IITA and other research institutes working in SSA. Generating a body of evidence on what works, including the institutional factors that create enabling environments for circular bioeconomy approaches

to thrive, is necessary for governments and donors to support circular bioeconomy research that will help solve some of the most pressing challenges in SSA as populations grow and generate more waste, thus exacerbating a changing climate using the linear economy model.

Keywords: circular bioeconomy, sustainability, agriculture, outcome tracking, gap analysis, sub-Saharan Africa

13. Climate change and agricultural technology adoption: the case of drought tolerant maize in rural Nigeria

Tambo, J. A., & Abdoulaye, T. (2012). Climate change and agricultural technology adoption: the case of drought tolerant maize in rural Nigeria. *Mitigation and Adaptation Strategies for Global Change*, 17(3), 277–292. <https://doi.org/10.1007/s11027-011-9325-7>

Climate change is a major problem undermining agricultural production in Africa. Consequently, efforts are being made to provide farmers with adaptation technologies, but little empirical research exists on the determinants of adopting such technologies. This article addresses this research gap, using the case of drought tolerant maize (DTM) technology in Nigeria. With survey data from 200 farm households and econometric techniques, we explore the determinants of whether to invest and how much to invest in adaptation technology by smallholder farmers. Results from the study indicate that among the key determinants of adoption are access to the technology, complementary inputs, extension services, and climate change information. We also show that off-farm income and wealth status of a household play a significant role in adoption, implying capital constraints; hence, it can be difficult for resource-poor farmers to adopt the technology. Moreover, the farmers identified cost of the technology and complementary inputs, particularly fertilizer as major constraints to adoption. We conclude that while the DTM technology is suitable and important in helping smallholder maize farmers to continue to produce under a changing climate, more support is needed for them to invest in the technology and overcome adoption constraints. Necessary interventions include improving access to information about climate change and the available adaptation technology, timely access to the technology and complementary inputs, and improving access to credit, particularly for the resource-poor farm households.

Keywords: adoption, climate change, double hurdle, drought tolerant, maize, Nigeria, Smallholder farmers

14. Climate change impacts and potential benefits of heat-tolerant maize in south Asia

Tesfaye, K., Zaidi, P., Gbegbelegbe, S., Boeber, C., Rahut, D. B., Getaneh, F., Seetharam, K., Erenstein, O., & Stirling, C. (2017). Climate change impacts and potential benefits of heat-tolerant maize in south Asia. *Theoretical and Applied Climatology*, 130, 959–970. <https://doi.org/10.1007/s00704-016-1931-6>

Maize is grown by millions of smallholder farmers in South Asia (SA) under diverse environments. The crop is grown in different seasons in a year with varying exposure to weather extremes, including high temperatures at critical growth stages which are expected to increase with

climate change. This study assesses the impact of current and future heat stress on maize and the benefit of heat-tolerant varieties in SA. Annual mean maximum temperatures may increase by 1.4–1.8 °C in 2030 and 2.1–2.6 °C in 2050, with large monthly, seasonal, and spatial variations across SA. The extent of heat stressed areas in SA could increase by up to 12% in 2030 and 21% in 2050 relative to the baseline. The impact of heat stress and the benefit from heat-tolerant varieties vary with the level of temperature increase and planting season. At a regional scale, climate change would reduce rainfed maize yield by an average of 3.3–6.4% in 2030 and 5.2–12.2% in 2050 and irrigated yield by 3–8% in 2030 and 5–14% in 2050 if current varieties were grown under the future climate. Under projected climate, heat-tolerant varieties could minimize yield loss (relative to current maize varieties) by up to 36 and 93% in 2030 and 33 and 86% in 2050 under rainfed and irrigated conditions, respectively. Heat-tolerant maize varieties, therefore, have the potential to shield maize farmers from severe yield loss due to heat stress and help them adapt to climate change impacts.

Keywords: maize, smallholder farmers, high temperatures, rain-fed, climate change, South Asia

15. Can smallholder farmers adapt to climate variability, and how effective are policy interventions? Agent-based simulation results for Ethiopia

Berger, T., Troost, C., Wossen, T., Latynskiy, E., Tesfaye, K., & Gbegbelegbe, S. (2017). *Agricultural Economics*, 48(6), 693–706. <https://doi.org/10.1111/agec.12367>

Climate variability with unexpected droughts and floods causes serious production losses and worsens food security, especially in Sub-Saharan Africa. This study applies stochastic bioeconomic modeling to analyze smallholder adaptation to climate and price variability in Ethiopia. It uses the agent-based simulation package Mathematical Programming-based Multi-Agent Systems (MPMAS) to capture nonseparable production and consumption decisions at household level, considering livestock and eucalyptus sales for consumption smoothing, as well as farmer responses to policy interventions. We find the promotion of new maize and wheat varieties to be an effective adaptation option, on average, especially when accompanied by policy interventions such as credit and fertilizer subsidy. We also find that the effectiveness of available adaptation options is quite different across the heterogeneous smallholder population in Ethiopia. This implies that policy assessments based on average farm households may mislead policy makers to adhere to interventions that are beneficial on average albeit ineffective in addressing the particular needs of poor and food insecure farmers.

Keywords: climate variability, droughts, food security, stochastic bioeconomic, Sub-Saharan Africa, Ethiopia

16. Climate smart agriculture rapid appraisal (CSA-RA): A tool for prioritizing context-specific climate smart agriculture technologies

Mwongera, C., Shikuku, K. M., Twyman, J., Läderach, P., Ampaire, E., Van Asten, P., Twomlow, S., & Winowiecki, L. A. (2017). Climate smart agriculture rapid appraisal (CSA-RA): A tool for

prioritizing context-specific climate smart agriculture technologies. *Agricultural Systems*, 151, 192–203. <https://doi.org/10.1016/j.agsy.2016.05.009>

Approaches that aim to identify and prioritize locally appropriate climate smart agriculture (CSA) technologies will need to address the context-specific multi-dimensional complexity in agricultural systems. The climate smart agriculture rapid appraisal (CSA-RA) is a mixed method approach that draws on participatory bottom-up, qualitative, and quantitative tools to assess the heterogeneity of local contexts, and prioritize context-specific CSA options. This is an imperative if countries are to respond to the COP21 agreement and meet their intended nationally determined contributions (INDCs). The CSA-RA is designed to assess biophysical including climatic, socio-cultural, economic and technological characteristics at the household, farm and community/regional level. The CSA-RA employs gender-disaggregated methods, including gender differences in perceptions of climate change and its impacts. The CSA-RA combines common participatory rural appraisal (PRA) and rapid rural appraisal (RRA) tools into one methodology, that disaggregates the gender dimension, and includes resource mapping; climate calendars; historical calendars; cropping calendars; organization mapping; transect walks; key informant interviews; farmer interviews; and pairwise ranking matrix. The tool collects qualitative and quantitative data from various stakeholders (farmers, local leaders, researchers, local-level agricultural experts, private sector actors, donor organizations, and policy implementers), allowing expansive analysis, triangulation and validation. Application of the CSA-RA in Tanzania and Uganda reveals heterogeneity across the sites in terms of vulnerability, constraints and CSA priorities among different social groups (gender) and agro-ecological zones. Thus, the CSA-RA allows stakeholders to simultaneously take into account biophysical and socio-economic aspects to target and implement CSA.

Keywords: climate smart agriculture, prioritization, context-specific, participatory, mixed-method approach

17. *Coffea arabica* yields decline in Tanzania due to climate change: Global implications

Craparo, A. C. W., Van Asten, P. J. A., Läderach, P., Jassogne, L. T. P., & Grab, S. W. (2015). *Coffea arabica* yields decline in Tanzania due to climate change: Global implications. *Agricultural and Forest Meteorology*, 207, 1–10. <https://doi.org/10.1016/j.agrformet.2015.03.005>

Coffee is the world's most valuable tropical export crop. Recent studies predict severe climate change impacts on *Coffea arabica* (*C. arabica*) production. However, quantitative production figures are necessary to provide coffee stakeholders and policy makers with evidence to justify immediate action. Using data from the northern Tanzanian highlands, we demonstrate for the first time that increasing night time (T_{min}) temperature is the most significant climatic variable responsible for diminishing *C. arabica* yields between 1961 and 2012. Projecting this forward, every 1°C rise in T_{min} will result in annual yield losses of $137 \pm 16.87 \text{ kg ha}^{-1}$ ($P=1.80 \times 10^{-10}$). According to our ARIMA model, average coffee production will drop to $145 \pm 41 \text{ kg ha}^{-1}$ ($P=8.45 \times 10^{-9}$) by 2060. Consequently, without adequate adaptation strategies and/or substantial external inputs, coffee production will be severely reduced in the Tanzanian highlands in the near future. Attention should also be drawn to the arabica growing regions

of Brazil, Colombia, Costa Rica, Ethiopia and Kenya, as substantiated time series evidence shows these areas have followed strikingly similar minimum temperature trends. This is the first study on coffee, globally, providing essential time series evidence that climate change has already had a negative impact on *C. arabica* yields.

Keywords: agriculture, minimum temperature, phenology, adaptation

18. Conservation Agriculture in mixed crop–livestock systems: Scoping crop residue trade-offs in Sub-Saharan Africa and South Asia

Valbuena, D., Erenstein, O., Homann-Kee Tui, S., Abdoulaye, T., Claessens, L., Duncan, A. J., Gérard, B., Rufino, M. C., Teufel, N., van Rooyen, A., & van Wijk, M. T. (2012). Conservation Agriculture in mixed crop–livestock systems: Scoping crop residue trade-offs in Sub-Saharan Africa and South Asia. *Field Crops Research*, 132, 175–184. <https://doi.org/10.1016/j.fcr.2012.02.022>

Conservation Agriculture (CA) is being advocated to enhance soil health and sustain long term crop productivity in the developing world. One of CA's key principles is the maintenance of soil cover often by retaining a proportion of crop residues on the field as mulch. Yet smallholder crop–livestock systems across Africa and Asia face trade-offs among various options for crop residue use. Knowledge of the potential trade-offs of leaving more residues as mulch is only partial and the objective of this research is to address some of these knowledge gaps by assessing the trade-offs in contrasting settings with mixed crop–livestock systems. The paper draws from village surveys in 12 sites in 9 different countries across Sub-Sahara Africa and South Asia. Sites were clustered into 3 groups along the combined population and livestock density gradients to assess current crop residue management practices and explore potential challenges to adopting mulching practices in different circumstances. Results show that although high-density sites face higher potential pressure on resources on an area basis, biomass production tends to be more substantial in these sites covering demands for livestock feed and allowing part of the residues to be used as mulch. In medium-density sites, although population and livestock densities are relatively lower, biomass is scarce and pressure on land and feed are high, increasing the pressure on crop residues and their opportunity cost as mulch. In low-density areas, population and livestock densities are relatively low and communal feed and fuel resources exist, resulting in lower potential pressure on residues on an area basis. Yet, biomass production is low and farmers largely rely on crop residues to feed livestock during the long dry season, implying substantial opportunity costs to their use as mulch. Despite its potential benefit for smallholder farmers across the density gradient, the introduction of CA-based mulching practices appears potentially easier in sites where biomass production is high enough to fulfill existing demands for feed and fuel. In sites with relatively high feed and fuel pressure, the eventual introduction of CA needs complementary research and development efforts to increase biomass production and/or develop alternative sources to alleviate the opportunity costs of leaving some crop residues as mulch. Keywords: biomass use, mulching, feed, sustainability, intensification, human population density, livestock density

19. COVID-19 outbreak and rural household food security in the Western Democratic Republic of the Congo

Manyong, V., Bokanga, M., Akonkwa Nyamuhirwa, D.-M., Bamba, Z., Adeoti, R., Mwepu, G., Cole, S. M., & Dontsop Nguetzet, P. M. (2022). COVID-19 outbreak and rural household food security in the Western Democratic Republic of the Congo. *World Development Perspectives*, 28, 100469. <https://doi.org/10.1016/j.wdp.2022.100469>

Although global assessments of the initial impacts of the coronavirus disease (COVID-19) have focused on income, jobs, and health conditions, this study constitutes one of the first studies that assessed the impact of COVID-19 on food security in DRC and established the short-term implications of the COVID-19 outbreak on rural households' food security in DRC. In addition, the study recommendations contributed to shaping government interventions toward the pandemic in the Country. The study used data from four western provinces of the country on 1339 households. Our results show that 80% of households experienced an increase in food prices, 61% a noticeable decrease in the availability of food, and 54% a decrease in their dietary diversity. Due to changes in food availability, dietary diversity, and food accessibility imposed by the COVID-19 outbreak, >70% of households experienced either a decrease in the consumption of meat, milk, fish, and cereals or an increase in their consumption of traditional vegetables. In addition, COVID-19 significantly affected food security dimensions in larger households, households with a greater number of members aged 35 years and above, households headed by women, households where members participate in associations or cooperatives, households that depend on crop sales as the major source of income, and in poorer households. These findings highlight the significant implications of the COVID-19 outbreak on household food security in western DRC and underscore the need for emergency interventions to strengthen the resilience of rural people and accelerate their recovery and other long-term measures toward sustainable and inclusive development.

20. Do commercial forest plantations reduce pressure on natural forests? Evidence from forest policy reforms in Uganda

Ainembabazi, J. H., & Angelsen, A. (2014). Do commercial forest plantations reduce pressure on natural forests? Evidence from forest policy reforms in Uganda. *Forest Policy and Economics*, 40, 48–56. <https://doi.org/10.1016/j.forpol.2013.12.003>

This paper investigates if and how the establishment of private commercial forest plantations in degraded forest reserves can conserve natural forests in Uganda. It uses difference-in-difference and decomposition analyses on household data collected from intervention and control villages in the neighborhood of forest reserves. We find that commercial forest plantations are weakly effective in conserving natural forests. The reduction in forest use is unevenly distributed across households depending on location and resource endowments such as farmland and livestock. The results suggest that the conservation effectiveness can be enhanced by complementary interventions that change characteristics that reduce forest use, such as more education for forest users.

Keywords: forest policy, commercial forest plantations, extraction, conservation

21. Does crop–livestock integration lead to improved crop production in the savanna of West Africa?

Franke, A., Berkhout, E., Iwuafor, E.*, Nziguheba, G., Dercon, G., Vandeplas, I., & Diels, J. (2010). Does crop–livestock integration lead to improved crop production in the savanna of West Africa? *Experimental Agriculture*, 46(4), 439–455. <https://doi.org/10.1017/s0014479710000347>

Integrated crop–livestock farming in the Guinea savanna of West Africa is often assumed to lead to synergies between crop and livestock production, thereby improving the overall productivity and resilience of agricultural production. Whether these synergies actually occur remains poorly studied. On-farm trials were conducted in northern Nigeria over a period of four years to assess the agronomic and economic performance of maize-legume systems with and without the integration of livestock (goats). Groundnut-maize rotations with livestock achieved the highest carry-over of nutrients as manure from one season to the next, covering approximately one-third of the expected N, P and K uptake by maize and reducing the demand for synthetic fertilizers. However, the advantage of lower fertilizer costs in rotations with livestock was offset by higher labor costs for manure application and slightly lower values of maize grain. Overall, no clear agronomic or economic benefits for crop production were observed from the combined application of manure and synthetic fertilizer over the application of synthetic fertilizer only, probably because the amounts of manure applied were relatively small. Legume-maize rotations achieved higher cereal yields, a better response to labor and fertilizer inputs, and a higher profitability than maize-based systems with no or only a small legume component, irrespective of the presence of livestock. Livestock at or near the farm could nevertheless make legume cultivation economically more attractive by increasing the value of legume haulms. The results suggested that factors other than crop benefits, e.g. livestock providing tangible and non-tangible benefits and opportunities for animal traction, could be important drivers for the ongoing integration of crop and livestock production in the savanna.

22. Ecological and socio-economic factors affecting agricultural intensification in the West African savannas: Evidence from northern Nigeria

Okike, I., Jabbar, M., Manyong, V., & Smith, J. W. (2005). Ecological and socio-economic factors affecting agricultural intensification in the West African savannas: Evidence from northern Nigeria. *Journal of Sustainable Agriculture*, 27(2), 5–37. http://dx.doi.org/10.1300/J064v27n02_03

Agricultural intensification in West Africa is at an early stage and the process is taking place through various pathways. Population pressure and market access are generally considered as major factors driving intensification and crop–livestock interaction. In this paper both ecology and economic factors and their interactions are hypothesised as driving forces in intensification and crop–livestock interaction. Analyses of a survey involving farming households in Nigeria confirm the hypothesis and show that the degree of intensification is higher in the Sudan savanna than the Northern Guinea savanna. Intensification is occurring mostly through higher land and labor use intensity, higher livestock stocking rates and application of more manure

per hectare. It is concluded that policies to enhance market access will facilitate the process and that different technological options need to be pursued in the two agroecological zones to facilitate intensification.

Keywords: agricultural intensification, crop-livestock interaction, northern Guinea savanna, Sudan savanna

23. Ex-ante economic analysis of biological control of coconut mite in Benin

Oleke, J.M., Manyong, V., Mignouna, D.B., Isinika, A., Mutabazi, K.D., Hanna, R., Sabelis, M. 2013. *AgBioForum*, 16(2), 161–169. <https://agbioforum.org/wp-content/uploads/2021/02/AgBioForum-16-2-161.pdf>

The coconut mite, *Aceria guerreronis* Keifer, has been identified as one of the pests that pose a threat to the coconut industry in Benin using a standard economic surplus model. The study presents the simulation results of the economic benefits of the biological control of coconut mites in Benin. In the least optimistic scenario, the economy would derive an overall net-gain of US\$155,213.40. Considered at a discount rate of 12% for the period 2008–2027, net present value was about US\$207,721, while the internal rates of return or break-even discount rates are high at 13.21%. It is therefore recommended that contemporaneous with the release of natural predators of the coconut mite, plans should be underway for improving research and extension services to coconut farmers in Benin.

Keywords: *Aceria guerreronis*, biological control, Benin, ex ante economics, Tanzania

24. The contributions of climate change mitigating policies to poverty reduction in the Sahel Region

Labintan, A. C., Mignouna, D. B., & Ituma, C. C. (2012). The contributions of climate change mitigating policies to poverty reduction in the Sahel Region. In Walter, L. F. (ed.) *Climate Change and Disaster Risk Management*, pp. 217–235. Springer. https://doi.org/10.1007/978-3-642-31110-9_14

Although there is a relationship between climate change and poverty reduction, some countries in the Sahel region of Africa are yet to incorporate a climate change risk management strategy into their poverty reduction program. The aim of this research is therefore to evaluate the subjective and quantitative analysis of climate change risk management strategies in all the nine countries that constitute the Sahel region. Both a qualitative and a quantitative approach were used in the investigation. The qualitative approach was used to make a subjective analysis of the climate change mitigating framework with regard to poverty reduction issues at country level. It was based on a scoring system methodology by assessing the following criteria:

- The consideration of climate change scenarios and the vulnerabilities of the countries;
- The analysis of poverty-climate links;
- The climate change institutional framework of each country.

The quantitative approach was based on Data Envelopment Analysis (DEA). This was done by applying DEA Solver to evaluate the efficiency of climate change mitigating frameworks and their impact on poverty reduction. The results of the investigation revealed that none of the Sahel countries, excluding Burkina Faso, included climate change risk management in their Poverty Reduction Strategy and Policies (PRSP). Burkina Faso's National Adaptation Policies Action (NAPA) performs well. Burkina Faso is considered a model country which has included climate change policies in its PRSP. However, as with most countries in the region, the Burkina Faso climate change risk management policy is not comprehensive. This is a result of inadequate climate change risk management projects, exclusion of real needs and other exogenous parameters. However, in Senegal, more efforts are required in response to climate change risk management in order to reduce poverty. This is paramount for the following reasons: the inclusion of climate change risk management into PRSP important in increasing its understanding several challenges require to be addressed for good implementation and to ensure a good monitoring system. Stakeholders in the sector will be more effective and efficient in developing action plans for climate change management strategies and poverty reduction programs.

Keywords: Sahel, climate change, poverty reduction, adapted strategy

25. Economic impact of biological control of water hyacinth in southern Benin

De Groote, H., Ajuonu, O., Attignon, S., Djessou, R., & Neuenschwander, P. (2003). Economic impact of biological control of water hyacinth in southern Benin. *Ecological Economics*, 45, 105–117. [http://dx.doi.org/10.1016/S0921-8009\(03\)00006-5](http://dx.doi.org/10.1016/S0921-8009(03)00006-5)

A biological control program of water hyacinth was undertaken in Southern Benin between 1991 and 1993. It consisted of the release of three natural enemies, two weevil species and one moth, that feed exclusively on water hyacinth. In 1999, a survey of 365 men and women from 192 households in 24 villages in the target area, using participatory and quantitative methods, revealed that water hyacinth, although not eliminated, was perceived by the villagers as having been reduced from a serious pest to one of minor or moderate importance. According to their estimates of the impacts they perceived, at the peak of the infestation water hyacinth had reduced the yearly income of this population of about 200 000 by approximately US\$84 million. Lost revenues for men were mostly in fishing, while women experienced lost revenues in trade, primarily food crops and fish. The reduction of water hyacinth cover through biological control was credited with an increase in income of US\$30.5 million per year. The total cost of the control program is estimated at a present value of US\$2.09 million. Assuming the benefits are to stay constant over the next 20 years, a most conservative assumption, the accumulated present value would be US\$260 million, yielding a respectable benefit cost ratio of 124:1. This ratio is calculated for direct economic effects on the people of Southern Benin only, and does not take into account indirect benefits or the benefits of the project to other countries were the biological control agents were successfully introduced. Other effects mentioned, but not measured, included an increase of water quality and of human health.

Keywords: biological control, impact assessment, water hyacinth, Benin, fishing, *Neochetina* spp.

26. Economic perspectives of the diversity of risks among crop farmers in the Northern Guinea Savanna of Nigeria

Olarinde, L.* , Akintola, J.* , & Manyong, V. (2011). Economic perspectives of the diversity of risks among crop farmers in the Northern Guinea Savanna of Nigeria. *The Social Sciences*, 6(4), 262–268. <https://doi.org/10.3923/sscience.2011.262.268>

In this study, we examine the diversity of risks that affect farming in the Northern Guinea Savanna of Nigeria. We also investigate the perspectives of these risks in relation to their economic implications on the farming enterprises. We also show that through reorganization of these risks, some derived factors have the ability to present themselves whether as corresponding to existing categorization of the variables or not and also to enable us know which of the factors is more important than the other. Gross margin and factor analytical methods were used in computing the estimated results on a cross sectional sample of 348 farming households. Results show that farmers who were grouped under natural risk incurred the least mean production cost of ₦11,115.61 while the highest mean production cost of ₦15,998.18 was incurred by farmers grouped under production risks. The highest mean revenue of ₦18,998.16 was recorded by farmers under production risk which translated into a mean gross margin of ₦65,999.85. Verifying whether some derived factors would correspond to the existing categorization of 14 risk types (from five sources) which the farmers faced, results from the factor analysis and the consequent F-test from ANOVA show no marked or significant differences among the identified factors and the existing risk sources. Consequently, the individual effect or importance of the original 14 risk types that the sampled farmers considered important can be dully represented and effectively regrouped into five sources (factors) as natural, technical, social, ecosocial and biochemical.

27. Economics of biological control of cassava mealybug in Africa

Zeddies, J., Schaab, R. P., Neuenschwander, P., & Herren, H. R. (2001). Economics of biological control of cassava mealybug in Africa. *Agricultural Economics*, 24(2), 209–219. <https://www.sciencedirect.com/science/article/abs/pii/S0169515000000645>

Pest populations of the cassava mealybug *Phenacoccus manihoti* Mat.-Ferr. (Homoptera: Pseudococcidae) were reduced successfully by the biological control agent *Apoanagyrus (Epidinocarsis) lopezi* De Santis (Hymenoptera: Encyrtidae) throughout most of sub-Saharan Africa. The economics of the project were evaluated based on data from field trials, socio-economic surveys, published results, and financial information provided by the International Institute of Tropical Agriculture (IITA) and the national programs. Costs and benefits for the biological control of *P. manihoti* were calculated over 40 years (1974–2013) for 27 African countries, for four different scenarios, taking into account that impact by *A. lopezi* and speed of the impact differ between ecological zones. A reasonable calculation considering compounded interest resulted in a benefit cost ratio of about 200 when cassava was costed at world market prices, and of about 370–740 when inter-African prices were considered.

Keywords: economics of biological control, *Phenacoccus manihoti*, *Apoanagyrus lopezi*, cassava, Africa

28. Ecoregional research in Africa: Learning lessons from IITA's benchmark area approach

Douthwaite, B., Baker, D., Weise, S., Gockowski, J., Manyong, V., & Keatinge, J. (2005). Ecoregional research in Africa: Learning lessons from IITA's benchmark area approach. *Experimental Agriculture*, 41(3), 271–298. <https://doi.org/10.1017/S0014479705002681>

Ecoregional research has the potential to help address some of the huge challenges facing agriculture in developing countries by developing technologies that work under different agro-ecological conditions, and the processes by which these technologies can be adapted to work in other areas with similar conditions. The CGIAR system has been developing ecoregional research as a new paradigm for over a decade. In this paper we evaluate one of the most ambitious of these initiatives called the Benchmark Area Approach (BAA) pioneered by the International Institute of Tropical Agriculture. We evaluate the BAA against nine good practice criteria for ecoregional research and finding that the approach is delivering, or has the potential to deliver, on all nine. Many of the lessons learnt from this evaluation will be relevant to current and future attempts to undertake co-ordinated multi-locational research for development.

29. Effective dimensionality and factors affecting crop-livestock integration in West African savannas: a combination of principal component analysis and tobit approaches

Manyong, V., Okike, I., & Williams, T. (2006). Effective dimensionality and factors affecting crop-livestock integration in West African savannas: a combination of principal component analysis and tobit approaches. *Agricultural Economics*, 35(2), 145–155. <http://dx.doi.org/10.1111/j.1574-0862.2006.00148.x>

Crop-livestock integration (CLI) to improve natural resource management for increased productivity is evolving in Nigeria and West Africa. Processes in the evolution and factors that influence it still need to be well understood. This article proposes and tests a new framework for measuring the multiple dimensionality of CLI. The framework derives a CLI index using the principal components of its most common single measures; it develops geographic information systems (GIS)-based village-level ecological and market factors; and it estimates parameters of factors affecting CLI using the derived index as the dependent variable in a Tobit model. The framework is tested using empirical data from 634 farm households in 11 geo-referenced villages in the Sudan savanna (SS) and northern Guinea savanna (NGS), Nigeria. Along a north–south (SS to NGS) axis, CLI initially increases, peaking around 11.2°N, and then declines. This latitude probably identifies the boundary below which disease challenge constrains traditional livestock production and CLI. This polynomial pattern of CLI is contrary to an expected linear increase along lines of perceived potentials for rain-fed crop production. Household resources, GIS-derived village-level market factors, and institutional factors also significantly affect CLI. Ecological and institutional factors have most impact on the probability of adoption and use intensities of CLI. The incorporation of GIS-derived market factors with household and institutional variables in an econometric model offers new opportunities for assessing patterns of evolution of CLI, comparing results across sites, and targeting recommendation domains objectively. A comparison with results from more common

methods of running independent models for individual indicators of CLI shows that this new framework is an effective way of reducing the multiple dimensionality of CLI to gain quicker, well-focused knowledge of the processes of agricultural intensification.

30. Efficiency of traditional maize storage and control methods in rural grain granaries: a case study from Senegal

Gueye, M.* , Goergen, G., Ndiaye, S.* , Asiedu, E., Wathelet, J., Lognay, G., & Seck, D.* (2013). Efficiency of traditional maize storage and control methods in rural grain granaries: a case study from Senegal. *Tropicultura*, 31(2), 39–46. www.researchgate.net/publication/258343194

Maize storage and pest control method as practiced in traditional clay granaries in the Kédougou region in eastern Senegal were evaluated under rural conditions during two successive years. Three storage modes, i.e. maize cobs, winnowed and non-winnowed maize grains, were tested in seven granaries where the insecticidal plants *Hyptis spicigera* or *H. suaveolens* were either incorporated in the store structure or deposited as layers intermittently with maize. At the beginning of the storage period, all granaries were artificially infested with 7 pairs *Tribolium castaneum* and *Sitophilus zeamais*. No damage, losses or live insects were observed during 7 months of storage when maize cobs were placed between layers of *H. spicigera*. Compared with the control, incorporation of insecticidal plants within the granary bottom had no significant effect on the damage and loss level irrespective of the storage mode. Non-winnowed maize always suffered less damage and losses than the winnowed variant. In all granaries depredation, insect abundance and moisture content were highest toward the end of storage period between June and July.

Keywords: maize, granary, insecticidal plants, storage modes, damage, losses, Senegal

31. Evaluating maize yield variability and gaps in two agroecologies in northern Ghana using a crop simulation model

MacCarthy, D. S, Adiku, S. G. K, Freduah, B. S, Kamara, A., Narh, S, & Abdulai, A. L.* (2018). Evaluating maize yield variability and gaps in two agroecologies in northern Ghana using a crop simulation model. *South African Journal of Plant and Soil*, 35(2), 137–147. <https://doi.org/10.1080/02571862.2017.1354407>

The yield gap and variability in maize under smallholder systems in two agroecologies in northern Ghana were evaluated using a decision support system for agrotechnology transfer (DSSAT). The model was used to assess (1) the potential yield of maize (YPOT), (2) water-limited exploitable maize yield (YWEX), (3) nitrogen-limited yield (YNI), (4) farmer practice maize yield (YCFP) and (5) proposed enhanced nutrient use yield (enhanced farmer practice; YEFP). Effect of supplementary irrigation was also assessed on YCFP and YEFP conditions. Yield gaps were determined as the difference between YPOT and YCFP or YEFP on the one hand, and between YWEX and YCFP or YEFP on the other hand. The yield gap based on potential yield ranged from 59% to 75% under CFP and narrowed to between 29% and 59% under EFP. With water-limited exploitable yields, the yield gap ranged from 53% to 65% under CFP, reducing to between 22% and 42% under EFP. The use of supplementary irrigation further reduced the yield gap. Improved fertilizer use and supplementary irrigation have the

potential to increase yield and hence reduce the yield gap if effective policies and institutional structures are in place to provide farmers with credit facilities and farm inputs.

Keywords: crop simulation model, fertilizer use, maize, yield variability

32. Evaluating sustainable intensification of groundnut production in northern Ghana using the sustainable intensification assessment framework approach

Rahman, N. A., Larbi, A., Kotu, B. H., Kizito, F., & Hoeschle-Zeledon, I. (2020). Evaluating sustainable intensification of groundnut production in northern Ghana using the sustainable intensification assessment framework approach. *Sustainability*, 12(15), 5970. <https://doi.org/10.3390/su12155970>

The sustainable intensification of crop production system requires the efficient use of resources. A 3-year on-farm experiment was conducted to determine the sustainability of plant density for groundnut production in Northern Ghana using the sustainable intensification assessment framework (SIAF). The SIAF allows the assessment of the sustainable intensification potential of the agricultural system in five domains: productivity, economics, environment, human, and social. The experiment was laid out in a strip plot design with six groundnut varieties (early maturity type: Chinese, Yenyewoso, and Samnut 23, and late maturity type: Azivivi, Mani pinta, and Samnut 22) as the horizontal plot factor and four plant densities (22, 15, 11, and 9 plant/m²) as the vertical plot factor. Using the SIAF as a guide, data on grain and fodder yield (productivity), net income and benefit cost ratio (economic), vegetative cover at 30, 40, and 50 days after planting and harvesting and biological nitrogen fixation (environment), calorie and protein production (human), and technology rating by gender (social) were recorded to calculate the sustainability indices of the treatments. The results showed that the sustainability indices for the Yenyewoso and Mani pinta groundnut varieties were above 1 in all the regions, indicating that both groundnut maturity types are sustainable for cultivation in the Northern regions of Ghana. Planting both groundnut maturity types at a density of 22 plant/m² increased the sustainability index threefold compared with the farmer practice (9 plant/m²) and 79% compared with the 11 and 15 plant/m². This suggests that planting groundnut at a density of 22 plant/m² will sustainably intensify groundnut production in Northern Ghana and similar agro-ecologies across West Africa.

Keywords: *Arachis hypogaea*, plant density, SIAF, savanna

33. Evaluating the environmental-technology gaps of rice farms in distinct agro-ecological zones of Ghana

Asravor, J., Wiredu, A. N., Siddig, K., & Onumah, E. E. (2019). Evaluating the environmental-technology gaps of rice farms in distinct agro-ecological zones of Ghana. *Sustainability*, 11(7), 20727. <https://doi.org/10.3390/su11072072>

Rice (*Oryza sativa*) is an important food staple and a cash crop, which is cultivated in all the ten regions of Ghana under varying agro-ecological conditions. These conditions also reflect the production technologies used and the total farm output. In an attempt to determine the potential

sources of production shortfalls on rice farms in Ghana, this paper estimates the production efficiency and the environmental-technology gaps of rice-producing households in the forest-savannah transition and guinea savannah agro-ecological zones of Ghana. The paper adopts the stochastic metafrontier framework, which permits technology-related inefficiency effects to be extricated from managerial inefficiency effects for appropriate policy formulation. In contrast to past studies, the empirical findings reveal that farms in the two agro-ecological zones adopt heterogeneous production technologies due to differences in their production environments. This is indicated by the estimated mean environmental-technology gap ratios of 0.95 and 0.50, and mean metafrontier technical efficiencies of 0.56 and 0.42 for farms in the forest-savannah transition and guinea savannah zones, respectively. These findings call for agricultural policy formulation in Ghana to be targeted at the prevailing environmental conditions of the various agro-ecological zones rather than being all-inclusive in addressing the extant inefficiencies in the rice production systems of Ghana.

Keywords: environmental-technology gaps, stochastic metafrontier framework, agro-ecological zones, rice production, Ghana

34. Evaluation of integrated weed management practices in maize in northern Nigeria

Chikoye, D., Schulz, S., & Ekeleme, F. (2004). Evaluation of integrated weed management practices in maize in northern Nigeria. *Crop Protection*, 23(10), 895–900. <https://doi.org/10.1016/j.cropro.2004.01.013>

Field trials were conducted in 1999 and 2000 in the northern Guinea savanna of Nigeria to evaluate the potential of several weed management practices to reduce early weed competition in maize. The treatments were different combinations of the herbicide mixture metolachlor + atrazine at 5 L ha⁻¹, the cover crop velvetbean (*Mucuna cochinchinensis*), hoe weeding at 2, 4, and 6 weeks or at 4 and 8 weeks after planting (WAP) maize, maize density: high (60,000 plants ha⁻¹), medium (40,000 plants ha⁻¹), low (25,000 plants ha⁻¹) and a farmer's control consisting of a single weeding at 4 WAP and low maize density. Results showed that maize grain yield was significantly higher in the treatment in which either the herbicide mixture or velvetbean was combined with 40,000 maize plants ha⁻¹ and weeded thrice. The lowest maize grain yield was obtained with the farmer's control. Weed dry matter was 60% more in the farmer's control than in velvetbean combined with 40,000 maize plants ha⁻¹ and weeded three times. The farmer's control was higher in weed species diversity with *Setaria pallide-fusca*, *Vernonia galamensis*, and *Boerhavia erecta* as the dominant species. *Sporobolus pyramidalis* and *Thelepogon elegans* were the dominant weeds in the herbicide treatment and velvetbean plots, respectively. Herbicide or velvetbean in combination with medium maize density and weeding three times (2, 4, and 6 WAP) is recommended for weed management in the northern Guinea savanna.

35. Factors influencing implementation of bylaws on sustainable crop intensification: Evidence from potatoes in southwestern Uganda

Makuma-Henry, M, Kibwika, P, Nampala, P, Manyong, V., & Yami, M (2020). Factors influencing implementation of bylaws on sustainable crop intensification: Evidence from potatoes in

southwestern Uganda. *Cogent Social Sciences*, 6, 1841421. <https://doi.org/10.1080/23311886.2020.1841421>

The study examined the factors for the successful implementation of bylaws on sustainable crop intensification. The study used the new institutionalism theory to examine the implementation of bylaws in the potato cropping system in southwestern Uganda. A mixed model featuring both qualitative and quantitative approaches was used in the study. This involved analysis of primary data. The primary sources were key informants, focus group discussions, and face to face interviews with individual farmers, as well as secondary data sources. Factors influencing the effective implementation of bylaws on sustainable crop intensification at community level included awareness of existing bylaws, availability of extension agents to sensitize and train farmers on bylaws, power relations and conflicts among farmers, and availability of financial resources for procurement of agro-inputs. The factors influencing implementation of bylaws on sustainable crop intensification at the individual level included farmers' knowledge on bylaws ($P = 0.03$), farmers' participation in activities organized by government agencies ($P = 0.01$), the farmers' village/location ($P = 0.03$), farmers' gender ($P = 0.001$), farmers' other occupations ($P = 0.01$), and income earnings ($P = 0.02$), support of local councils and technical persons to implement bylaws ($P = 0.01$), and knowledge on soil and water conservation laws ($P = 0.03$). Thus, there is need to protect land rights (regardless of gender), create awareness on best practices and bylaws among farmers, and mobilize resources to strengthen formal and informal farmer groups to enhance sustainable crop intensification and economic development of the potato sector.

Keywords: bylaws implementation, local policies, improved and quality seed, soil and water conservation, market access, sustainable crop intensification, potatoes

36. Farmers, food and climate change: ensuring community-based adaptation is mainstreamed into agricultural programmes

Wright, H., Vermeulen, S., Laganda, G., Olupot, M., Ampaire, E., & Jat, M. L. (2014). Farmers, food and climate change: ensuring community-based adaptation is mainstreamed into agricultural programmes. *Climate and Development*, 6(4), 318–328. <https://doi.org/10.1080/17565529.2014.965654>

Climate change creates widespread risks for food production. As climate impacts are often locally specific, it is imperative that large-scale initiatives to support smallholder farmers consider local priorities and integrate lessons from successful autonomous adaptation efforts. This article explores how large-scale programs for smallholder adaptation to climate change might link effectively with community-led adaptation initiatives. Drawing on experiences in Bangladesh, Mozambique, Uganda and India, this article identifies key success factors and barriers for considering local priorities, capacities and lessons in large-scale adaptation programs. It highlights the key roles of extension services and farmers' organizations as mechanisms for linking between national-level and community-level adaptation, and a range of other success factors, which include participative and locally driven vulnerability assessments,

tailoring of adaptation technologies to local contexts, mapping local institutions and working in partnership across institutions. Barriers include weak governance, gaps in the regulatory and policy environment, high opportunity costs, low literacy and underdeveloped markets. The article concludes that mainstreaming climate adaptation into large-scale agricultural initiatives requires not only integration of lessons from community-based adaptation, but also the building of inclusive governance to ensure smallholders can engage with those policies and processes affecting their vulnerability.

Keywords: climate change, community-based adaptation, mainstreaming, agriculture, adaptation

37. Farmers' preferences for sustainable intensification attributes in sorghum-based cropping systems: evidence from Mali

Badolo, F., Kotu, B. H., Oyinbo, O., Sanogo, K., & Birhanu, B. Z. (2022). Farmers' preferences for sustainable intensification attributes in sorghum-based cropping systems: evidence from Mali. *Renewable Agriculture and Food Systems*, 37(6), 695–706. <https://doi.org/10.1017/S1742170522000345>

Sorghum plays a crucial role in the rural economy and nutrition of rural households in Mali. Yet the productivity of this crop is constrained by limited adoption of agricultural intensification technologies, which could be partly because technology development does not properly consider farmers' preferences. This study with smallholder farmers in southern Mali aimed to assess farmers' preferences for different attributes of sorghum technologies through the lens of sustainable intensification. The study used a discrete choice experiment, a method which involves asking individuals to state their preference over hypothetical alternative scenarios, goods or services. We considered six attributes corresponding to different domains of sustainable intensification: grain yield, risk of yield loss, soil fertility, nutrition, labor requirement and fodder yield. We analyzed the data using the mixed logit model, while considering the multinomial logit model as a robustness check. The findings revealed that smallholder farmers are strongly interested in transitioning from their existing sorghum-based cropping systems to those that closely align with these domains of sustainable intensification. However, there were diverse preferences among all the smallholder farmers studied, and between distinct sub-groups of smallholder farmers characterized by their social networks and agroecological zones, which yield relevant policy implications. Overall, these results support the growing research and development prioritization and policy interests toward scaling sustainable intensification among farmers, with a particular focus on human nutrition.

38. Identifying and managing plant health risks for key African crops: yam, taro and cocoyam

Mignouna, B. D., Kumar, P. L., Coyne, D., Bandyopadhyay, R., Ortega-Beltran, A., Bhattacharjee, R., & Koeyer, D. de. (2019). Identifying and managing plant health risks for key African crops: yam, taro and cocoyam. In Neuenschwander, P., & Tamò, M. (eds) *Critical Issues in Plant Health: 50 Years of Research in African Agriculture*. Burleigh Dodds. <https://cgspace.cgiar.org/handle/10568/104022>

A large proportion of the world's yams, which are mostly indigenous to Africa, and the exotic taro and cocoyam are grown in West and Central Africa by resource-poor farmers. Surveys demonstrate recycling and build-up of pathogens and nematodes from one generation to the next because of their vegetative mode of propagation. Miniset techniques, organ culture, vine cuttings and so on, and the use of botanic seeds can alleviate these problems. The main pests are two types of nematodes, among which root-knot nematodes have increased recently, yam beetles, fungi and viruses, but many fungal pathosystems remain unexplored. Marker-assisted resistance breeding, particularly against yam mosaic virus, is using next-generation sequencing techniques and robust phenotypic screening. Virus-free material can be obtained by hot water treatment of seed tubers. There is a huge prospect of using genomics and transgenic approaches to accelerate the rate of improvement without affecting production and productivity.

Keywords: food security, yams, taro, plant condition, plant diseases, viruses, plant health

39. Impact of climate change, weather extremes, and price risk on global food supply

Haile, M. G., Assfaw Wossen, T., Tesfaye, K., & von Braun, J. (2017). Impact of climate change, weather extremes, and price risk on global food supply. *Economics of Disasters and Climate Change*, 1(1), 55–75. <https://doi.org/10.1007/s41885-017-0005-2>

We analyze the determinants of global crop production for maize, wheat, rice, and soybeans over the period 1961–2013. Using seasonal production data and price change and price volatility information at country level, as well as future climate data from 32 global circulation models, we project that climate change could reduce global crop production by 9% in the 2030s and by 23% in the 2050s. Climate change leads to 1–3% higher annual fluctuations of global crop production over the next four decades. We find strong, positive and statistically significant supply response to changing prices for all four crops. However, output price volatility, which signals risk to producers, reduces the supply of these key global agricultural staple crops—especially for wheat and maize. We find that climate change has significant adverse effects on production of the world's key staple crops. Especially, weather extremes—in terms of shocks in both temperature and precipitation—during crop growing months have detrimental impacts on the production of the abovementioned food crops. Weather extremes also exacerbate the year-to-year fluctuations of food availability, and thus may further increase price volatility with its adverse impacts on production and poor consumers. Combating climate change using both mitigation and adaptation technologies is therefore crucial for global production and hence food security.

40. Improving Smallholder Farmer Adoption of Climate-Smart Agriculture Practices

Margiotta, S., & Giller, O. (2018). *Improving Smallholder Farmer Adoption of Climate-Smart Agriculture Practices*. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). <https://cgspace.cgiar.org/handle/10568/97664>

The International Institute of Tropical Agriculture (IITA), as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), with CIAT, Sustainable Food Lab and Rainforest Alliance, are promoting increased smallholder coffee farmer adoption of Climate Smart Agriculture (CSA) practices in Uganda. Initial IITA research on coffee began in 2010 and has subsequently expanded across 17 districts, 899 farmers, 51 on-farm field trials and 26 demonstration sites. IITA collaborates with Hanns R. Neumann Stiftung (HRNS) in Robusta coffee in Luwero and Olam, Kawacom and Great Lakes Coffee in Arabica coffee growing regions in Uganda. CSA practices in coffee are practices such as planting shade trees and soil and water conservation structures, that are finetuned to the local context. Research concluded that CSA adoption is hindered, in part, due to limited resources and differing levels of entrepreneurship amongst smallholder coffee farmers in Uganda. In addition, farmer limitations and aspirations, farming systems, and climate change impact vary from site to site. Enablers of CSA adoption therefore need to be contextually specific to ensure they relate to local needs. A suite of studies have been conducted to explore the diversity in Uganda's smallholder coffee farmers, their ranking of constraints to implementing CSA practices, and land use mapping to identify different ecological zones within a district.

Keywords: climate change, agriculture, food security

41. Increasing cassava root yield on farmers' fields in Nigeria through appropriate weed management

Ekeleme, F., Dixon, A., Atser, G., Hauser, S., Chikoye, D., Korie, S., Olojede, A. O, Agada, M, & Olorunmaiye, P (2021). Increasing cassava root yield on farmers' fields in Nigeria through appropriate weed management. *Crop Protection*, 150, 105810. <https://doi.org/10.1016/j.cropro.2021.105810>

Weed competition is the major biological stress affecting cassava production in smallholder farms in West and Central Africa, where yields are low compared with those in Asia and Latin America. Options for improved weed management are crucial in increasing productivity. Selected pre- and post-emergence herbicides, integrated with appropriate tillage and plant spacing, were tested in 96 sites in four locations in Nigeria, 24 in 2016 and 72 in 2017. Trials were split plots with six pre-emergence herbicides and no post-emergence treatment as main plots. Subplot treatments were four post-emergence herbicides, weeding with a motorized rotary weeder, short- and long-handled hoes, and no post-emergence weed control, i.e., regardless of pre-emergence treatments. Indaziflam-based treatments, irrespective of post-emergence treatment, and flumioxazin + pyroxasulfone applied pre-emergence followed by one weeding with a long-handled hoe provided >80% control of major broadleaf and grass weeds. Compared with herbicide use, farmer control practices (53%) were not efficient in controlling weeds. The highest root yield was produced where (1) s-metolachlor was combined with atrazine, and one weeding with a long-handled hoe or clethodim with lactofen, and (2) indaziflam + isoxaflutole was combined with glyphosate. An increase in root yield from 3.41 to 14.2 t ha⁻¹ and from 3.0 to 11.99 t ha⁻¹ was obtained where herbicides were used compared

with farmers' practice and manual hoe weeding. Our results showed that integrating good agronomic practices with safe and effective use of appropriate herbicides can result in root yield $>20 \text{ t ha}^{-1}$. i.e., twice the national average root yield of $8\text{--}12 \text{ t ha}^{-1}$, with $>50\%$ net profit. The use of appropriate herbicides can reduce the amount of manual labor required and improve livelihoods, specifically for women and children. Smallholder cassava farmers would require continuous training on the safe use and handling of herbicides to improve efficiency and prevent adverse effects on humans and the environment.

Keywords: on-farm trials, herbicide, manual hoe weeding, cassava root yield, net profit

42. Influence of farmers' crop management practices on *Striga hermonthica* infestation and grain yield of maize (*Zea mays* L.) in the savanna zones of northeast Nigeria

Dugje, I.* , Kamara, A., & Omoigui, L. (2008). Influence of farmers' crop management practices on *Striga hermonthica* infestation and grain yield of maize (*Zea mays* L.) in the savanna zones of northeast Nigeria. *Journal of Agronomy*, 7(1), 33–40. <http://dx.doi.org/10.3923/ja.2008.33.40>

The aim of this study was to assess the influence of farmers' crop management practices on *Striga* infestation and maize grain yield. Sixty farmers' fields were randomly selected in nine communities across three savanna zones. About 35% of the farmers had cultivated their fields for over 10 years, 48% grew the *Striga* resistant variety 97 TZL Comp-1-W, 68% planted maize in mid-June and 60% practiced legume-maize rotation. About 33% intercropped maize + cowpea, 42% applied 100 kg N ha^{-1} and 87% conducted 2 to 3 hoe weedings. The *Striga* resistant maize variety reduced *Striga* count and host damage score and increased grain yield ha^{-1} in northern and southern Guinea savannas. However, the varieties grown in Sudan savanna increased *Striga* count ha^{-1} ($R = 0.56^{**}$) and *Striga* damage (0.59^{**}) because they were not resistant to *Striga*. Planting maize in mid-July reduced *Striga* infestation in northern Guinea, but grain yield ha^{-1} was highest when maize was planted in mid-June in all three zones. Soybean-maize or groundnut-maize rotation reduced *Striga* count in all the agro-ecosystems. Relay intercropping of cowpea into maize reduced *Striga* count in northern Guinea. Higher nitrogen fertilizer rate reduced *Striga* count and score and significantly increased grain yield in the three zones. Two or three hoe weedings reduced *Striga* count in the three zones and *Striga* score in Sudan savanna. Thus, the farmers' practices sampled significantly influenced *Striga* infestation of maize fields in the three agro-ecosystems. The *Striga* resistant maize variety, Soybean-maize rotation, 100 kg N ha^{-1} and three hoe weedings could serve as component technologies in an integrated package for combating *Striga* menace in the region.

43. Informal institutions as mechanisms to address challenges in communal grazing land management in Tigray, Ethiopia

Yami, M., Vogl, C., & Hauser, M. (2011). Informal institutions as mechanisms to address challenges in communal grazing land management in Tigray, Ethiopia. *International Journal of Sustainable Development & World Ecology*, 18(1), 78–87. <https://doi.org/10.1080/13504509.2010.530124>

The role of institutions providing rules, norms and regulations, in addressing challenges in communal resources management has been debated for several decades. This article

analyzes the role of informal institutions for addressing shortage of grazing land, conflicts among users of communal grazing land and resistance among users to shift from free grazing to zero grazing in Tigray, Ethiopia. We used in depth interviews and focus group discussions for data collection. We argue that informal institutions are important mechanisms for addressing the challenges in communal grazing land management. The contributions of informal institutions for addressing challenges in communal grazing lands varied with type of challenge and were influenced by distances from markets and Wereda towns. Although the informal institutions were crucial in reversing the shortage of grazing land by regulating access to communal grazing land and enhancing controlled use of grass, they did not contribute to resolving conflicts that arose from unequal allocation of benefits in the village far from a market and Wereda town. Incorporating zero-grazing practices in informal institutions was hindered by disagreements among users and the top-down approach used by development agents when introducing zero grazing. To enhance effectiveness of informal institutions, the increasing grazing pressure should be addressed using more efficient schemes for harvesting grass. Moreover, creating awareness of the need for fewer but more productive cattle breeds is crucial. Consideration of well-performing informal institutions in policy and development interventions is essential to maximise the benefits of communal grazing lands to improve livelihoods of users.

Keywords: communal resource management, conflicts, free grazing, rules, Wereda, zero grazing

44. Institutional challenges to climate change adaptation: A case study on policy action gaps in Uganda

Ampaire, E., Jassogne, L., Providence, H., Acosta, M., Twyman, J., Winowiecki, L., & Van Asten, P. (2017). Institutional challenges to climate change adaptation: A case study on policy action gaps in Uganda. *Environmental Science and Policy*, 75, 81–90. <https://doi.org/10.1016/j.envsci.2017.05.013>

Despite the considerable progress made in the last decade toward building governance systems for climate change adaptation in Africa, implementation still limits positive responses. This study applies an iterative process of field assessments and literature reviews across multiple governance levels and spatial scales to identify constraints to effective formulation and implementation of climate change related policies and strategies in Uganda. Data was collected through sex-segregated participatory vulnerability assessments with farming communities in Rakai district, policy document reviews, and interviews with policy actors at national and district levels. Findings reveal that the key challenges to effective policy implementation are diverse and cut across the policy development and implementation cycle. Policies are mainly developed by central government agencies; other actors are insufficiently involved while local communities are excluded. There is also a communication disconnect between national, district, and community levels. Coupled with limited technical capacity and finances, political interference, and absence of functional implementation structures across these levels, climate change adaptation becomes constrained. We propose strategies that enhance

linkages between levels and actors, which will improve policy formulation, implementation and ultimately adaptation by smallholders.

Keywords: policy formulation, policy implementation, implementation constraints, smallholder vulnerabilities, local institutions, climate change adaptation, Uganda

45. Institutional perspectives of climate-smart agriculture: A systematic literature review

Totin, E, Segnon, A. C., Schut, M., Affognon, H., Zougmore, R., Rosenstock, T. S., & Thornton, P. (2018). Institutional perspectives of climate-smart agriculture: A systematic literature review. *Sustainability*, 10, 1–20. <https://doi.org/10.3390/su10061990>

Climate-smart agriculture (CSA) is increasingly seen as a promising approach to feed the growing world population under climate change. The review explored how institutional perspectives are reflected in the CSA literature. In total, 137 publications were analyzed using institutional analysis framework, of which 55.5% make specific reference to institutional dimensions. While the CSA concept encompasses three pillars (productivity, adaptation, and mitigation), the literature has hardly addressed them in an integrated way. The development status of study sites also seems to influence which pillars are promoted. Mitigation was predominantly addressed in high-income countries, while productivity and adaptation were priorities for middle and low-income countries. Interest in institutional aspects has been gradual in the CSA literature. It has largely focused on knowledge infrastructure, market structure, and hard institutional aspects. There has been less attention to understand whether investments in physical infrastructure and actors' interaction, or how historical, political, and social context may influence the uptake of CSA options. Rethinking the approach to promoting CSA technologies by integrating technology packages and institutional enabling factors can provide potential opportunities for effective scaling of CSA options.

Keywords: climate-smart agriculture, institutions, adaptation, mitigation, systematic review

46. Integrated soil fertility management: from concept to practice in Eastern DR Congo

Lambrecht, I., Vanlauwe, B., & Maertens, M. (2016). Integrated soil fertility management: From concept to practice in Eastern DR Congo. *International Journal of Agricultural Sustainability*, 14(1), 100–118. <https://doi.org/10.1080/14735903.2015.1026047>

Many paradigms on sustainable agricultural intensification promote a combination of different agricultural technologies. Whether such a paradigm survives in practice depends on how farmers combine these technologies on their fields. We focus on integrated soil fertility management (ISFM) and investigate how the concept is put into practice in South Kivu, Eastern DR Congo. ISFM includes the use of improved germplasm, organic inputs and mineral fertilizer, and emphasizes the complementarities and synergies that arise when technologies are jointly applied. We investigate whether different ISFM components are applied jointly, sequentially or independently, and whether that matters for the long-term use of the technology. We use

original survey data from 420 farms, and combine a descriptive statistical analysis and a factor analysis. We find that few farmers in the area have reached 'full ISFM', and technology application occurs sequentially rather than simultaneously. Two technology subsets can be distinguished: more resource-intensive and less resource-intensive technologies. These subsets behave as supplements rather than as complements, and adoption within and among each subset is more sequential than simultaneous. Our results imply that there is a disconnect between the theoretical arguments in the agronomic ISFM literature, and the actual patterns of ISFM application on farmers' fields.

Keywords: sustainable intensification, complementary agricultural technologies, application patterns, integrated soil fertility management, sub-Saharan Africa, Eastern DR Congo

47. Irrigation projects in Ethiopia: what can be done to enhance effectiveness under 'challenging contexts'?

Yami, M. (2016). Irrigation projects in Ethiopia: what can be done to enhance effectiveness under 'challenging contexts'? *International Journal of Sustainable Development & World Ecology*, 23(2), 132–142. <https://doi.org/10.1080/13504509.2015.1057628>

Investment in small scale irrigation (SSI) is crucial to sustain food security and livelihoods of smallholders. In Ethiopia, the government and development partners show a growing interest in developing irrigation projects. The success of irrigation projects is determined by governance and socio-cultural contexts. Yet the lack of thorough understanding of the challenging contexts undermines the efforts to achieve sustainability outcomes in irrigation projects. This article identifies the challenging contexts to irrigation projects, examines how the challenging contexts influence the effectiveness of irrigation projects, and indicates ways of improving the effectiveness of irrigation projects under the existing challenging contexts. Data were collected between April and December 2011 in three regional states of Ethiopia using in-depth interviews and focus group discussions. The lack of governance capacity and accountability are critical challenges for the sustainability of the irrigation projects. In addition, the poor consideration of local knowledge and the use of top-down approaches in planning and implementing the irrigation projects, and lack of equitable access to the irrigation schemes result in poor ownership of projects among farmers. Improving the funding scheme to support long-term capacity building at national and local levels, and in understanding the socio-cultural contexts of the intervention areas; planning irrigation projects with due consideration of the existing challenging contexts, and with active engagement of the local community, are important for the long-term viability and sustainability of irrigation projects.

Keywords: Ethiopia, governance, institution, irrigation, livelihoods, sustainability

48. Linking agricultural adaptation strategies, food security and vulnerability: evidence from West Africa

Douxchamps, S., van Wijk, M. T., Silvestri, S., Moussa, A. S., Quiros, C., Ndour, N. Y. B., Buah, S., Some, L., Herrero, M., Kristjanson, P., Ouedraogo, M., Thornton, P., Van Asten, P., Zougmore, R., & Rufino, M. (2016). Linking agricultural adaptation strategies, food security

and vulnerability: evidence from West Africa. *Regional Environmental Change*, 16, 1305–1317. <http://dx.doi.org/10.1007/s10113-015-0838-6>

Adaptation strategies to reduce smallholder farmers' vulnerability to climate variability and seasonality are needed given the frequency of extreme weather events predicted to increase during the next decades in sub-Saharan Africa, particularly in West Africa. We explored the linkages between selected agricultural adaptation strategies (crop diversity, soil and water conservation, trees on farm, small ruminants, improved crop varieties, fertilizers), food security, farm household characteristics and farm productivity in three contrasting agro-ecological sites in West Africa (Burkina Faso, Ghana and Senegal). Differences in land area per capita and land productivity largely explained the variation in food security across sites. Based on land size and market orientation, four household types were distinguished (subsistence, diversified, extensive, intensified), with contrasting levels of food security and agricultural adaptation strategies. Income increased steadily with land size, and both income and land productivity increased with degree of market orientation. The adoption of agricultural adaptation strategies was widespread, although the intensity of practice varied across household types. Adaptation strategies improve the food security status of some households, but not all. Some strategies had a significant positive impact on land productivity, while others reduced vulnerability resulting in a more stable cash flow throughout the year. Our results show that for different household types, different adaptation strategies may be 'climate-smart'. The typology developed in this study gives a good entry point to analyze which practices should be targeted to which type of smallholder farmers, and quantifies the effect of adaptation options on household food security. Subsequently, it will be crucial to empower farmers to access, test and modify these adaptation options, if they were to achieve higher levels of food security.

49. Prioritizing international agricultural research investments: lessons from a global multi-crop assessment

Pemsl, D. E., Staver, C., Hareau, G., Alene, A. D., Abdoulaye, T., Kleinwechter, U., Labarta, R., & Thiele, G. (2022). Prioritizing international agricultural research investments: lessons from a global multi-crop assessment. *Research Policy*, 51(4), 104473. <https://doi.org/10.1016/j.respol.2022.104473>

Investments in international agricultural research have proven very successful at an aggregated level over the past decades. Decision makers, however, face the tough question of how best to allocate limited public funds across increasingly diverse research areas to achieve the largest impacts. Simultaneously, donors demand more accountability from research institutions with regards to use of funds and resulting impacts on food and nutrition security, the environment, gender equality and poverty reduction. From 2012–2014, the CGIAR Research Program on Roots, Tubers and Bananas (RTB) undertook a systematic, quantitative ex-ante priority assessment across five key crops to inform its strategic research portfolio decisions. In-depth studies were conducted for cassava, banana, potato, sweet potato, and yams with a harmonized methodological framework. The assessments comprised: 1) elicitation of major production constraints and research opportunities through global expert surveys; 2)

identification of priority research interventions; 3) ex ante estimation of costs and benefits for two adoption scenarios using partial equilibrium economic surplus models; and 4) poverty impact simulations. Results suggest substantial, although variable benefits for all assessed potential research investments and provide a range of impact indicators (adoption area, number of beneficiaries, net present value, internal rate of return, and poverty reduction). The findings have since informed the research portfolio development of RTB and were critical for continued program funding in the second phase. This paper presents the methodology and results and then focuses on the policy implications and lessons learned to strengthen future priority assessments in agricultural research.

50. Responding to food supply shocks through global partnerships in technology development and transfer: the case of the IITA-led biological control of cassava mealybug in sub-Saharan Africa

Alene, A., Manyong, V., & Coulibaly, O. (2006). Responding to food supply shocks through global partnerships in technology development and transfer: the case of the IITA-led biological control of cassava mealybug in sub-Saharan Africa. *Outlook on Agriculture*, 35(4), 255–261. <https://hdl.handle.net/10568/91765>

Partnerships involving national agricultural research systems (NARS), the Consultative Group on International Agricultural Research (CGIAR), universities, advanced research institutes, the private sector, civil society, non-governmental organizations, farmer organizations, and international investors represent a global capacity to provide solutions to strategic problems and to fulfill the overall objective of combating rural poverty and food insecurity. Drawing on the experiences and achievements of the IITA-led biological control of the cassava mealybug in Sub-Saharan Africa, this paper gives an account of the role of global partnerships in technology development and transfer in addressing food security challenges. It concludes with implications for national and international agricultural research centers for efficient, demand-driven technology development and delivery.

51. Response of speargrass (*Imperata cylindrica*) to cover crops integrated with handweeding and chemical control in maize and cassava

Chikoye, D., Manyong, V. M., Carsky, R. J., Ekeleme, F., Gbehounou, G., & Ahanchede, A. (2002). Response of speargrass (*Imperata cylindrica*) to cover crops integrated with handweeding and chemical control in maize and cassava. *Crop Protection*, 2(21), 145–156. <https://www.sciencedirect.com/science/article/abs/pii/S0261219401000783>

Speargrass [*Imperata cylindrica* (L.) Raeuschel] is a noxious weed widespread in most tropical zones of the world. Studies were conducted in the savannah of West Africa from 1997 to 1999 to evaluate crop yield, speargrass control, and net benefit from the use of cover crops integrated with handweeding and chemical control in maize and cassava. Glyphosate and handweeding were main treatments. Subplot treatments were type of cover crop [velvetbean, *Mucuna cochinchinensis* (Lour.) A. Chev., kudzu, *Pueraria phaseoloides* (Roxb.) Benth, and velvetbean intercropped with kudzu] and plots without cover crops. Weeding five times or

applying glyphosate was more effective than weeding twice in preventing crop yield losses and suppressing speargrass. Plots that received glyphosate or those weeded five times had 28-59% higher crop yields than plots weeded twice at all locations. In maize, subplots without cover crop had 30% more maize grain yield than plots with cover crops. In cassava, subplots without cover crops at Ezillo and plots where kudzu was intercropped with velvetbean at Ogoja had the lowest cassava tuber yields. Speargrass was more effectively suppressed in plots with cover crops than in plots without cover crops. Across all main treatments, velvetbean nearly eliminated rhizomes of speargrass within 2 years of treatment application at Avrankou. It was cheaper to use glyphosate than handweeding for speargrass control in both crops. Cover crops generally gave better economic benefit in cassava while in maize an opposite trend was observed.

Keywords: speargrass, cover crops, small-scale farms

52. Situational analyses on cowpea value chain in Zambia: the case of an untapped legume

Mwila, N. M., Munyinda, K., Mwala, M., Kamfwa, K., Kambikambi, T., Siyunda, A., Sinyangwe, S., Kanenga, K., Alamu, E. O., & Rubaihayo, P. (2022). Situational analyses on cowpea value chain in Zambia: the case of an untapped legume. *Cogent Food & Agriculture*, 8(1: 2094060), 1-18. <https://doi.org/10.1080/23311932.2022.2094060>

Cowpea (*Vigna unguiculata* (L.) Walp) is a vital legume crop for Zambia's urban and rural households. The crop is an important legume used as human and animal food and as a component of the agricultural production system, which improves the fertility of many depleted soils because of its ability to fix atmospheric nitrogen. Government through the ministries of health and agriculture recommend its' use. Despite the importance of cowpea in the nation, there is limited information on the crop along with its' value chain components. This review aims to assemble pertinent information on cowpea and its value chain components in Zambia. A critical look through the food system from production to consumption reveals the prevailing gaps in knowledge and output. The information covered here touches on crop breeding, production, marketing, processing, and consumption. This paper delves into various literature, bringing out the salient issues that are not commonly discussed about on the crop. It is a situation analysis focusing on finding solutions to improving the relevance and appreciation of the crop. There is a need for agricultural policies to promote cowpea production and use with the active participation of relevant actors. This would create a conducive environment for determining user needs, and leading to the development of beneficial impact-related activities at various stages. The country needs to begin incorporating a variety of crops within the food system to complement maize to improve nutrient intake, contribute to climate-smart practices, and sustainability of agricultural practices within communities in Zambia.

Keywords: crop diversity; seed development; black-eyed pea; value chain; markets; end-user; policy; research.

53. Socioeconomic baseline study of Ogoniland in the Niger Delta Region of Nigeria

Ojide, M. (2015). Socioeconomic baseline study of Ogoniland in the Niger Delta Region of Nigeria. *Journal of Economics.*, 3(1), 8–15. https://www.researchgate.net/publication/274672074_Socioeconomic_Baseline_Study_of_Ogoniland_in_the_Niger_Delta_Region_of_Nigeria

Crude oil is one of the natural resources accessible for development of Nigeria economy which also poses great environmental challenges. As a result, the impacts of oil exploration activities on the wellbeing of host communities, like Ogoniland, have been of concern to Nigerian government. This paper, therefore, presents a baseline study of Ogoniland in the light of oil exploration in the community. Primary data used in this study were collected through a survey of 400 households using a multistage sampling technique. Data collected include information on socioeconomic and environment as well as marginal willingness to pay and accept pay. The findings reveals that about 65% of the households were within the average monthly income of N50,000 (about US\$317.88) and below with an average household size of 6. In addition, about 75% of the surveyed households were involved in agricultural productivity. Only 37% of the households involved in agriculture indicated that they lost their produce due to oil spoilage within the last two years.

Keywords: socio-economics, environment, baseline, Ogoniland, Nigeria

54. Smallholder farmers in eastern Africa and climate change: a review of risks and adaptation options with implications for future adaptation programmes

Gbegbelegbe, S., Serem, J, Stirling, C., Kyazze, F, Radeny, M., Misiko, M., Tongruksawattana, S., Nafula, L, Gakii, M, & Sonder, K. (2018). Smallholder farmers in eastern Africa and climate change: a review of risks and adaptation options with implications for future adaptation programmes. *Climate and Development*, 10(4), 289–306. <https://doi.org/10.1080/17565529.2017.1374236>

This article reviews the published evidence of the climatic risks faced by smallholder farmers in eastern Africa and the adaptation strategies these farmers have so far adopted. In addition, the study draws on two detailed case studies in Kenya for a better understanding of the nuances of climate adaptation, requiring a range of measures to be adopted and institutions working together. Findings from the study reveal that the most consistent observation among farmers is that eastern Africa is experiencing increased temperature and decreased rainfall across all its agro-ecological zones. In response to their perceived climatic risks, smallholder farmers in the region are using both short-term and long-term strategies, with the former mainly consisting of coping mechanisms against climate chocks. In addition, the adaptation strategies implemented by the farmers are influenced by agro-ecological conditions which shape their farming systems and institutional settings including proximity to a major city and markets. The case studies highlight the importance of collaborative efforts between key local and external stakeholders in supporting adaptation to climate change. Key lessons are drawn from this study for the development of future adaptation programs.

Keywords: climate change, eastern Africa, Kenya, Ethiopia, Uganda, Tanzania, risks, adaptation strategies, barriers to adaptation

55. Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna

Tambo, J. A., & Abdoulaye, T. (2013). Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. *Regional Environmental Change*, 13(2), 375–388. <https://doi.org/10.1007/s10113-012-0351-0>

The savanna region of Africa is a potential breadbasket of the continent but is severely affected by climate change. Understanding farmers' perceptions of climate change and the types of adjustments they have made in their farming practices in response to these changes will offer some insights into necessary interventions to ensure a successful adaptation in the region. This paper explores how smallholder farmers in the Nigerian savanna perceive and adapt to climate change. It is based on a field survey carried out among 200 smallholder farm households selected from two agro-ecological zones. The results show that most of the farmers have noticed changes in climate and have consequently adjusted their farming practices to adapt. There are no large differences in the adaptation practices across the region, but farmers in Sudan savanna agro-ecological zone are more likely to adapt to changes in temperature than those in northern Guinea savanna. The main adaptation methods include varying planting dates, use of drought tolerant and early maturing varieties and tree planting. Some of the farmers are facing limitations in adapting because of lack of information on climate change and the suitable adaptation measures and lack of credit. The study then concludes that to ensure successful adaptation to climate change in the region, concerted efforts are needed to design and promote planned adaptation measures that fit into the local context and also to educate farmers on climate change and appropriate adaptation measures.

56. Spatial patterns of biological constraints to cassava and yam production in West and Central Africa: Implications for technology development and transfer

Manyong, V., & Oyewole, B. (1997). Spatial patterns of biological constraints to cassava and yam production in West and Central Africa: implications for technology development and transfer. *African Journal of Root and Tuber Crops*, 3, 15–21. https://biblio.iita.org/documents/Spatial_patterns_of_biological_constraints_to_cassava_and_yam.pdf-f659a01bda78eff961192e925cadcf9e.pdf

A broad-level survey was conducted in the major cassava and yam growing areas of 14 countries in West and Central Africa. The resulting georeferenced data on crops were entered into Geographical Information Systems (GIS) to produce maps showing features of the study area. Overlaying single maps corresponding to either physical factors or socioeconomic factors with maps featuring infested areas on crops has resulted in the identification of factors affecting the development and economic incidence of biotic stresses (or risk factors) on yam and cassava. Corresponding areas to all single risk factors using GIS were then quantified for the main biotic constraints as follows: 59% and 65% for African Cassava Mosaic Virus (CMV);

62% and 25% for Cassava Mealybug (CM); and 8% and 28% for Cassava Green Mite (CGM) of the cassava growing area in West and Central African respectively. The high risk area for nematodes infestation on yam was estimated to be about 45% of the yam growing area in West Africa and 4% in Central Africa.

Keywords: cassava, yam, biotic stresses, socioeconomics, GIS

57. Structural approaches to modeling the impact of climate change and adaptation technologies on crop yields and food security

Islam, S., Cenacchi, N., Sulser, T. B., Gbegbelegbe, S., Hareau, G., Kleinwechter, U., Mason-D'Croz, D., Nedumaran, S., Robertson, R., Robinson, S., & Wiebe, K. (2016). Structural approaches to modeling the impact of climate change and adaptation technologies on crop yields and food security. *Global Food Security*, 10, 63–70. <https://doi.org/10.1016/j.gfs.2016.08.003>

Achieving and maintaining global food security is challenged by changes in population, income, and climate, among other drivers. Assessing these threats and weighing possible solutions requires a robust multidisciplinary approach. One such approach integrates biophysical modeling with economic modeling to explore the combined effects of climate stresses and future socioeconomic trends, thus providing a more accurate picture of how agriculture and the food system may be affected in the coming decades. We review and analyze the literature on this structural approach and present a case study that follows this methodology, explicitly modeling drought and heat tolerant crop varieties. We show that yield gains from adoption of these varieties differ by technology and region, but are generally comparable in scale to (and thus able to offset) adverse effects of climate change. However, yield increases over the projection period are dominated by the effects of growth in population, income, and general productivity, highlighting the importance of joint assessment of biophysical and socioeconomic drivers to better understand climate impacts and responses.

Keywords: structural approach, agricultural productivity, yields, climate change, adaptation

58. Sustainable intensification: What is its role in climate smart agriculture?

Campbell, B., Thornton, P., Zougmore, R., Van Asten, P., & Lipper, L. (2014). Sustainable intensification: What is its role in climate smart agriculture? *Current Opinion in Environmental Sustainability*, 8, 39–43. <https://doi.org/10.1016/j.cosust.2014.07.002>

The 'sustainable intensification' (SI) approach and 'climate-smart agriculture' (CSA) are highly complementary. SI is an essential means of adapting to climate change, also resulting in lower emissions per unit of output. With its emphasis on improving risk management, information flows and local institutions to support adaptive capacity, CSA provides the foundations for incentivizing and enabling intensification. But adaptation requires going beyond a narrow intensification lens to include diversified farming systems, local adaptation planning, building responsive governance systems, enhancing leadership skills, and building asset diversity. While SI and CSA are crucial for global food and nutritional security, they are only part of a

multi-pronged approach that includes reducing consumption and waste, building social safety nets, facilitating trade, and enhancing diets.

59. The contributions of climate change mitigating policies to poverty reduction in the Sahel Region.

Labintan A. C., Mignouna D.B, & Ituma C.C. (2012). The contributions of climate change mitigating policies to poverty reduction in the Sahel Region. In Leal Filho, W. (ed.) *Climate Change and Disaster Risk Management*, pp. 217–235. Berlin, Heidelberg: Springer. http://dx.doi.org/10.1007/978-3-642-31110-9_14

Although there is a relationship between climate change and poverty reduction, some countries in the Sahel region of Africa are yet to incorporate a climate change risk management strategy into their poverty reduction program. The aim of this research is therefore to evaluate the subjective and quantitative analysis of climate change risk management strategies in all the nine countries that constitute the Sahel region. Both a qualitative and a quantitative approach were used in the investigation. The qualitative approach was used to make a subjective analysis of the climate change mitigating framework with regard to poverty reduction issues at country level. It was based on a scoring system methodology by assessing the following criteria: The consideration of climate change scenarios and the vulnerabilities of the countries; The analysis of poverty-climate links; The climate change institutional framework of each country. The quantitative approach was based on Data Envelopment Analysis (DEA). This was done by applying DEA Solver to evaluate the efficiency of climate change mitigating frameworks and their impact on poverty reduction. The results of the investigation revealed that none of the Sahel countries, excluding Burkina Faso, included climate change risk management in their Poverty Reduction Strategy and Policies (PRSP). Burkina Faso's National Adaptation Policies Action (NAPA) performs well. Burkina Faso is considered a model country which has included climate change policies in its PRSP. However, as with most countries in the region, the Burkina Faso climate change risk management policy is not comprehensive. This is a result of inadequate climate change risk management projects, exclusion of real needs and other exogenous parameters. However, in Senegal, more efforts are required in response to climate change risk management in order to reduce poverty. This is paramount for the following reasons: the inclusion of climate change risk management into PRSP important in increasing its understanding several challenges require to be addressed for good implementation and to ensure a good monitoring system. Stakeholders in the sector will be more effective and efficient in developing action plans for climate change management strategies and poverty reduction programs.

Keywords: Sahel, climate change, poverty reduction, adaptation strategy, biosketches.

Value chain analysis (58)

1. A study of spatial price efficiency of food grain marketing in north-eastern Nigeria

Nuhu, H. S., Amaza, P., & Gaya, H (2007). A study of spatial price efficiency of food grain marketing in north-eastern Nigeria. *Agriculture, Business and Technology Journal*, 5, 71–79. <https://hdl.handle.net/10568/91466>

The study examined spatial aspects of marketing efficiency in urban marketing system for maize, sorghum and cowpea in north eastern Nigeria. The data for the study were obtained from both secondary and primary sources. Primary data was obtained through the use of structured questionnaires, interviews and market surveys on transportation/handling cost. Four markets (Maiduguri, Damaturu, Gombe and Yola) known for marketing of cereal grains and pulses were selected purposely for the study.

Keywords: spatial efficiency, food grain, marketing, maize, sorghum, cowpeas

2. A two-stage empirical analysis of market participation in yam-growing areas of West Africa

Mignouna, D.B., Abdoulaye, T., Akinola, A.A., Alene, A., Oparinde, A., Manyong, V.M., Maroya, N., & Asiedu, R. (2017). A two-stage empirical analysis of market participation in yam-growing areas of West Africa. *Tropicicultura*, 35(4), 262–274. https://www.researchgate.net/publication/322029014_A_two-stage_empirical_analysis_of_market_participation_in_yam-growing_areas_of_West_Africa

Participation in agricultural markets could be a viable channel to transform agriculture thereby lifting millions of poor farmers out of hunger and poverty traps. Unfortunately, most of the potential beneficiaries are hindered by several factors in their quest to participate in yam market. This study, thus, investigated the underpinning drivers of market participation among small-scale farmers in yam belt of West Africa. Using a multistage random sample of 1400 households from Nigeria and Ghana, the study tests the hypothesis that factors affecting farmers' decisions to participate are not necessarily the same as those affecting the extent of participation. Non-price constraints played a significant role in determining decisions on market participation. Consideration should therefore be given to creation of enabling environment and strengthening social institutions to generate adequate marketable surplus to make market participation possible and valuable.

Keywords: two-stage empirical analysis, market participation, yam, Nigeria, Ghana

3. Adding value through the mechanization of post-harvest cassava processing, and its impact on household poverty in north-eastern Zambia

Abass, A., Amaza, P., Bachwenkizi, B., Alenkhe, B., Mukuka, I., & Cromme, N. (2017). Adding value through the mechanization of post-harvest cassava processing, and its impact on household poverty in north-eastern Zambia. *Applied Economics Letters*, 24(9), 579–583. <https://doi.org/10.1080/13504851.2016.1213356>

This article investigates the impact of adopting a mechanized cassava processing system on household poverty levels in Zambia. A Foster, Greer and Thorbecke (FGT) poverty measure was used to compare poverty levels among households using a mechanized cassava processing system against those households using a nonmechanized process. Based on the FGT poverty measure's specifications, a significantly lower poverty status of 49% was found

among households using the mechanized process when compared to the 58% found among households using the nonmechanized process. The significant factors contributing to these differences in poverty levels include whether households are using a mechanized process or not, the number of years' schooling among household members, the number of years' farming experience, household income and membership of associations. The study concludes that the mechanization of cassava processing, particularly if done on the right scale, can transform primary production activities, in turn leading to higher incomes and reduced poverty levels in rural villages. Thus, policies should be introduced aimed at encouraging the promotion of mechanized post-harvest cassava processing technologies among rural households, so as to enhance crop productivity and household income levels, as well as reduce poverty among rural households.

Keywords: value addition, poverty, impact, cassava, mechanized

4. An overview of African traditional cassava processing and utilization

Hahn, S. (1989). An overview of African traditional cassava processing and utilization. *Outlook on Agriculture*, 18(3), 110–118. <https://cgspace.cgiar.org/handle/10568/98610>

Cassava is grown in 31 African countries and consumption per capita averages just over 100 kg/year. This article reviews traditional cassava processing and utilization as now practised by small-scale farmers and processors in Africa, and examines the opportunities for improving post-harvest operations in the African continent.

Keywords: cassava, farmers, marketing, harvesting, nutrition, food crops

5. Analyse de quelques aspects du système de production légumière et perception des producteurs de l'utilisation d'extraits botaniques dans la gestion des insectes ravageurs des cultures maraîchères au Sud du Togo

Moneddji, A. D., Nyamador, W. S., Amevoin, K., Adéoti, R., Abbey, G. A., Ketoh, G. K., & Glitho, I. A. (2015). Analyse de quelques aspects du système de production légumière et perception des producteurs de l'utilisation d'extraits botaniques dans la gestion des insectes ravageurs des cultures maraîchères au Sud du Togo. *International Journal of Biological and Chemical Sciences*. <https://doi.org/10.4314/ijbcs.v9i1>.

L'une des contraintes liée à la production maraîchère, est la pression exercée par les insectes ravageurs. Cette étude analyse quelques aspects du système de production légumière ainsi que la perception des producteurs de l'utilisation d'extraits botaniques dans la gestion des insectes ravageurs des cultures maraîchères. Elle a été réalisée à travers une enquête menée auprès de 217 maraîchers au Sud du Togo. L'analyse descriptive des données a révélé que plus d'hommes (72%) que de femmes (28%) pratiquent le maraîchage. Seul 33% a suivi une fois une formation en maraîchage. La contrainte majeure dans la production maraîchère est le problème de ravageurs et de maladies dont les principaux sont des insectes, des nématodes et des champignons. La lutte chimique constitue la principale méthode de lutte contre ces

ravageurs. Néanmoins, les maraîchers connaissent des dangers induits par l'utilisation des pesticides de synthèse et sont au courant de l'utilisation des pesticides botaniques en maraîchage. Cependant, très peu les utilisent dans la gestion des ravageurs. Mais, ils sont disposés à utiliser les pesticides botaniques si ceux-ci sont disponibles, accessibles, efficaces et pas trop chers pour pallier les effets néfastes des pesticides de synthèse à la santé et à l'environnement.

Keywords: Maraîchage, perception des producteurs, extraits botaniques, Sud du Togo

6. Analysis of gender and governance of value chain-based systems on rice and vegetable crops in southern Benin and Mali

Adétonah, S., Coulibaly, O., Ahoyo, R., Sessou, E., Dembélé, U., Huat, J., Houssou, G., Vodouhe, G., & Loko, J. (2015). Analysis of gender and governance of value chain-based systems on rice and vegetable crops in southern Benin and Mali. *Open Journal of Social Sciences*, 3(6), 134–141. <https://doi.org/10.4236/jss.2015.36020>

This present study analyzes gender and governance in the rice and vegetable-based value chain systems in 3 lowlands of southern Benin and 2 lowlands in Southern Mali. A sample of 243 farmers, 1 modern processing unit, 18 traditional processors, 76 traders and 8 national institutions were interviewed in Benin and Mali. Descriptive statistics and Harvard analytical framework were used for the analysis of governance and gender respectively in the value chains. The majority of farmers have access to the use of land. Women produce up to 80% of basic foods for household consumption and sale. However they don't have the control of these resources (capital and land). Decision making in relation to resources (land, water labor, credit) is under the control of men and natives. The governance analysis showed that the products of lowlands are not subject to quality control, with no public inspection for health and product quality. There is no input subsidy for actors in both countries. There are informal contracts between actors of the rice based systems in Mali and Benin. The markets are open for all the products and credit systems do exist. Some structures are involved in upstream and downstream chain components for training in various activities.

Keywords: value chain, gender, governance, Benin, Mali

7. Analysis of relationships between production of yam [*Dioscorea* spp.] and its determinants in Nigeria: a cointegration approach

Ojiako, I. A., Tarawali, G., Akwarandu, B., Okechukwu, R., & Idowu, A.* (2013). Analysis of relationships between production of yam [*Dioscorea* spp.] and its determinants in Nigeria: a cointegration approach. *African Journal of Root and Tuber Crops*, 10(1), 1–8. <https://hdl.handle.net/10568/76678>

The associations between the production and some of the variously-debated factors that have the tendency to influence it, including cultivated land area, yield, and climatic conditions, were investigated for yams (*Dioscorea roundata*), a leading tuber crop in Nigeria. Secondary data collected from two reliable sources covering the 1961-2008 periods were used for the study.

Data were analyzed using advanced econometric cointegration technique. Results of the unit roots tests revealed that production, land area, and yield of yams were each integrated of order one, $I(1)$, compelling their use for cointegration analysis. However, the two included climatic factors, rainfall and temperature integrated only at levels, $I(0)$, making them unsuitable for use in cointegration tests and were consequently dropped. Results showed further that cointegration existed between production and land area on the one hand and yield on the other. The resultant trace- and maximum eigenvalue statistics were 29.83 ($p < 0.01$) and 29.22 ($p < 0.01$) respectively for test involving production and land area, and 29.85 ($p < 0.01$) and 29.23 ($p < 0.1$) respectively for test of production with yield. The Bivariate Granger causality tests could not reveal any causality either from land area to production or vice versa. Also, although causality could not be revealed from yield to production, an inverse, but weak, causality ($F = 2.83$; $p < 0.05$) was observed from production to yield. The implication of the finding is that past values of cultivated land area and yield could not be used as reliable indicators for predicting the future values of yam production in Nigeria. A lot more other factors had contributed to past fluctuations in yam production and there was need to adopt an across-the-board approach in the development of the yams sector in Nigeria.

Keywords: yams, production, cultivated land area, yield, weather conditions, cointegration, Nigeria

8. Assessing the performance of the grain legume marketing system in northern Ghana

Aidoo, R, Mensah, J, Opoku, A, & Abaidoo, R. (2013). Assessing the performance of the grain legume marketing system in northern Ghana. *International Journal of AgriScience*, 3(10), 787–795.

The main objective of this study was to examine costs, returns and efficiency levels associated with the activities of key players in the grain legume marketing chain in northern Ghana. A total of 140 market participants comprising 93 retailers, 39 wholesalers and eight (8) assemblers/aggregators were selected from major and satellite markets in the three Northern Regions of Ghana through a multi-stage sampling approach. Data for the study was obtained through personal interviews with the use of structured questionnaire. In addition to descriptive statistics, gross marketing margin, net margin and marketing efficiency analyses were performed using field data. The study identified a long chain of greater than four different channels/pathways through which grain legumes moved from farm gate to final consumers. Marketing of grain legumes in the study Districts was found to be profitable, as only 18% of gross marketing margin was spent as marketing costs, with the remaining amount retained as net marketing margin. The study further showed that net marketing margins were not equitably distributed among different trading partners along the marketing chain. Generally, net marketing margin for assemblers/aggregators was far higher than that received by wholesalers and retailers. Marketing activities by all traders in the grain legume value chain were performed efficiently, with efficiency ratios far in excess of 100%. Trading in groundnut was far more profitable than trading in cowpea and soybean. The main constraints identified by grain legume traders were

limited access to credit, high cost of transportation, poor road network and inadequate storage facilities.

Keywords: grain legumes, marketing margins, marketing efficiency, Ghana

9. Assessment of the potential industrial applications of commercial dried cassava products in Nigeria

Awoyale, W., Abass, A. B., Ndavi, M., Maziya-Dixon, B., & Sulyok, M. (2017). Assessment of the potential industrial applications of commercial dried cassava products in Nigeria. *Journal of Food Measurement and Characterization*, 11(2), 598–609. <https://doi.org/10.1007/s11694-016-9428-7>

Variations in the functional and pasting properties of four groups of commercial dried cassava product in Nigeria were evaluated in this study, to explore their potential for use as industrial raw materials. In total, 692 products were analyzed using standard analytical methods. The functional and pasting properties of the samples were found to vary significantly ($p < 0.05$). Toasted cassava was found to have the highest water absorption capacity, at 467.42%, and dried cassava the lowest, at 252.57%. Conversely, dried cassava was found to have the highest peak and breakdown viscosities, and toasted cassava the lowest. A significant ($p < 0.01$) positive correlation was found to exist between dispersibility and the swelling power ($r = -0.93$) and solubility index ($r = -0.84$) of the cassava products. Meanwhile, the correlation between dispersibility and the peak ($r = -0.75$) and breakdown ($r = -0.72$) viscosities was positive and significant ($p < 0.05$). Therefore, the authors of this study conclude that user industries such as the food, paper, adhesives, textiles and plywood sectors might require information on the pre-processing of cassava-based feedstock, so as to predetermine the technical usability of such raw materials within their industrial processes.

Keywords: cassava products, processing methods, functional properties, pasting properties, Nigeria

10. Banana and plantain-based foods consumption by children and mothers in Cameroon and Southern Nigeria: A comparative study

Honfo, F. G., Tenkouano, A., & Coulibaly, O. (2011). Banana and plantain-based foods consumption by children and mothers in Cameroon and Southern Nigeria: A comparative study. *African Journal of Food Science*, 5(5), 287–291. www.researchgate.net/publication/268342624

Bananas and plantains (*Musa* spp.) play an important role in the diet of people in Central and West Africa. In Cameroon and Southern Nigeria, a comparative study was carried out in 480 households to assess the frequencies and levels of consumption of banana and plantain-based foods commonly consumed by children under five years-old and their mothers. The results revealed some degree of similarities in the areas of boiled, roasted and fried banana or plantain between the two countries. Consumption frequencies of banana and plantain-based foods and consumption levels were higher among the respondents in Cameroon compared

to Southern Nigeria surveyed. The daily consumption levels of boiled plantain, fried plantain and ripe banana were 225, 136 and 145 g respectively for children from Cameroon, while in Nigeria, the figure were 112, 82 and 80 g respectively. The daily consumption levels of the same recipes among the Cameroonian mothers were 402, 300 and 304 g respectively whereas among the Nigerian mothers, there were 265, 158 and 165 g. The study showed that banana and plantain-derived food were more consumed in Cameroon than in Southern Nigeria.

Keywords: *Musa* spp., plantain-based foods, consumption frequency, level of consumption

11. Cassava flour and starch: Processing technology and utilization

Shittu, T. A., Alimi, B. A., Wahab, B., Sanni, L. O., & Abass, A. B. (2016). Cassava flour and starch: Processing technology and utilization. In Sharma, H. K., Njintang, N. Y., Singhal, R. S., & Kaushal, P. (eds) *Tropical Roots and Tubers: Production, Processing and Technology*, pp. 415–450. John Wiley & Sons. <https://doi.org/10.1002/9781118992739.ch10a>

This chapter describes the existing and emerging cassava processing technologies and utilization of cassava flour and starch. Fresh cassava roots are subjected to size reduction operations like chipping, mincing and grating to enhance subsequent unit operation like dewatering, drying, fermentation and starch extraction. Adhesives mainly used by the paper, textile and packaging industries are originally made from corn starch and imported to many developing economies. Modification of starch improves its industrial application and enhances its utilization as a substitute for fossil-derived resources. Modified starches find important applications in paper, textile and thermoplastic industries. The paper industry is the main user of modified starch; each tonne of paper requires 55 kg of starch. Cationic modified starch is widely used in large-scale paper industries to increase tensile fold and bursting strength of the paper.

Keywords: cassava, production, processing, technology, starch, flours, utilization

12. Cassava processing among small-holder farmers in Cameroon: opportunities and challenges

Njukwe, E., Onadipe, O. O., Amadou Thierno, D., Hanna, R., Kirscht, H., Maziya-Dixon, B., Araki, S., Mbairanodji, A, & Ngue-Bissa, T (2014). Cassava processing among small-holder farmers in Cameroon: opportunities and challenges. *International Journal of Agricultural Policy and Research*, 2(4), 113–124. <https://cgspace.cgiar.org/handle/10568/75905>

The study was conducted in three regions (Southwest and Littoral, South and Centre, West and Northwest) of Cameroon to document cassava processed products and to assess processing constraints among small-holder farmers. A total of twelve small-scale processing units and five marketer groups with six fabricators were contacted and interviewed. In addition, two operational and two non-operational medium-scale processing factories was visited. Key informant interviews and focused group discussions was conducted to collect information on

their activities. Results indicate that 68.75% of women and 31.25% of men are involved in cassava processing and marketing activities with Bamenda recording (100%) in gari processing and Ebolowa (100%) in baton processing. The percentage score for all products is in the order; fufu (95.00%), chips (86.25%), gari (72.50%), baton (62.50%) and flour (18.75%) with cassava flour having the least score in the entire antenna; Ebolowa (10.71%), Douala (20:00%) and Bamenda (25.93%). Apart from baton (steamed fermented cassava paste wrapped and tied in leaves) that was reported processed among groups, other products were processed at individual and household levels. The profit margins of these processed products are small due to poor quality products, although labor investments are high compared with those of medium and large-scale processing factories. Market linkage needs strengthening among the stakeholders and national sensitization on cassava processing could help create awareness and get the attention of the government for policy drive.

Keywords: Cameroon, cassava, indigenous foods, processing, smallholder farmers.

13. Cassava processing in sub-Saharan Africa: the implications for expanding cassava production

Nweke, F. I. (1994). Cassava processing in sub-Saharan Africa: the implications for expanding cassava production. *Outlook on Agriculture*, 23(3), 197–205. <https://doi.org/10.1177/003072709402300307>

Cassava makes an important contribution to improving food security and rural incomes in sub-Saharan Africa, as it is tolerant of drought and poor soil and its cultivation does not require much labor. However, the fresh roots are bulky and perishable and need to be processed before they can be marketed; processing also removes the cyanogens which make many varieties poisonous in their raw form. Cassava roots are turned into granules, flours, pastes and chips, with a wide range of flavor and appearances for different areas and markets. Many different processing techniques are used, some of which make intensive use of fuel wood while others require a plentiful water supply. These requirements, as well as the need for a good transport and marketing infrastructure, limit the expansion of cassava production in sub-Saharan Africa, but technical solutions are being found.

14. Cassava production and processing characteristics in southern Cameroon: An analysis of factors causing variations in practices between farmers using Principal Component Analysis (PCA)

Essono, G. G, Ayodele, M., Akoa, A, Foko, J, Gockowski, J., & Olembo, S (2008). Cassava production and processing characteristics in southern Cameroon: An analysis of factors causing variations in practices between farmers using Principal Component Analysis (PCA). *African Journal of Agricultural Research*, 3(1), 49–59. www.researchgate.net/publication/299078415

A questionnaire-based survey study was carried out during a 3 month period, from January to April 1998, in 45 villages belonging to three locations (Yaounde, Mbalmayo, and Ebolowa) of southern Cameroon. The survey was aimed at collecting constraints and processing practices

related information from farmers growing cassava and transforming it into chips. Information in the questionnaire contained some characteristics associated with cassava chips production (processing methods, forms of chips produced, their end uses, drying and storage facilities used, the major problems associated with their production) and cassava cultivation (cassava varieties, harvesting periods of these varieties, and their preferred attributes). A total of 225 farmers were interviewed and the results obtained showed that farmers in Yaounde and Mbalmayo processed and stored chips in similar ways. Similarly, harvesting periods after planting also differed between Ebolowa and both Yaounde and Mbalmayo. Storage methods and storage facilities were mainly related to the different forms of chips produced. Chips' discoloration frequently reported by the majority of farmers (87%) was as a result of their insufficient drying. Principal component analysis was implemented to determine those factors accounting for differences observed in farmers' practices. Eleven principal components were derived from the variables used in analysis. Five principal components accounting for 72.75% of the total variations were associated with the data set collected in Yaounde and Mbalmayo. An equal number expressing 78.2% of the overall variance was likewise obtained at Ebolowa. For a number of reasons such as traditional patterns of nutrition, market purposes, the relative proximity with the nearest city, these components suggested that storage methods, end uses, and production constraints were differently perceived by the respondents. They also showed that the different forms of chips produced were more market oriented, and that a number of constraints experienced by farmers were closely related to the way they managed their fields, or market outlets.

15. Cassava value chain development through partnership and stakeholders' platform in Cameroon

Njukwe, E., Hanna, R., Sarr, S., Shigeru, A., Kirscht, H., Mbairanodji, A, Ngue-Bissa, T, & Tenkouano, A. (2014). Cassava value chain development through partnership and stakeholders' platform in Cameroon. *International Journal of Agricultural Policy and Research*, 2(11), 383–392. <https://doi.org/10.15739/ijapr.011>

In order to understand product flows of cassava and actors along its value chain, a study was conducted in three out of the five antennas of National Program for Roots and Tuber Development (PNDRT); South and Centre, West and North West and East regions in Cameroon with the aid of structured questionnaires, interviewing producers, processors, transporters, marketers and consumers. It was observed that the major challenge affecting cassava enterprise development were age (60.84%) above 45 and education status (76.67%) below primary including poor organization and planning while women represent 65.83%. Transportation is dominated by head or back-load (60%) while 32.5% of cassava is consumed fresh and 51.67% of the product is sold in village market. In a partnership agreement between the International Institute of Tropical Agriculture (IITA) and PNDRT to enhance cassava production, IITA adopted the value chain approach in research-for-development that guarantees the coverage of production to consumption and considers all groups from farmers to consumers and developed a variety of cassava processing techniques to broaden the range of products derived from cassava. To

achieve successful partnership, collaboration is formalized through appropriate agreements that clearly define responsibilities and expectations and required for a specific level of product based on partner's category, status, geographic location, years of experience, current activities and capacity.

Keywords: actors, Cameroon, cassava, stakeholders, platform, value chain

16. Consumption trends of white cassava and consumer perceptions of yellow cassava in Ghana

Duah, E. A, Parkes, E., Baah, R. O, Acquatey-Mensah, A, Danquah, E, Kirscht, H., Kulakow, P., & Steiner-Asiedu, M. (2016). Consumption trends of white cassava and consumer perceptions of yellow cassava in Ghana. *Journal of Food and Nutrition Research*, 4(12), 814–819. <http://article.foodnutritionresearch.com/pdf/JFNR-4-12-8.pdf>

Vitamin A deficiency has been one of the major nutritional problems for many countries where cassava is eaten as a major source of energy. In an attempt to help reduce the incidence of vitamin A deficiency, bio-fortified cassava which contains more pro-vitamin A carotenoids than the white cassava, has been introduced to such areas. This study therefore endeavored to find out how often Ghanaians ate cassava and its products, as well as what Ghanaian consumers knew about bio-fortified cassava and their willingness to consume it. A survey was done between the month of January and March using 287 participants in the Greater Accra Region of Ghana which gathered information on their demographics, and their frequencies of the consumption of cassava and its products. Data on the knowledge of the participants on yellow flesh cassava, and their willingness to accept it were also gathered. Logistic regression was used to determine the relationship between some demographic characteristics and knowledge and 'willingness-to-accept' biofortified cassava. The cassava product which was mostly consumed by the participants was gari. Sixty-three % of the participants had no knowledge of bio-fortified cassava. About half of them were willing to accept the biofortified cassava, and more than half of the participants perceived that yellow cassava could be used for some white cassava products. Providing nutritional information and sensitizing consumers on the benefits of biofortified cassava can enhance its consumption in Ghana.

Keywords: bio-fortified cassava, willingness-to-accept, knowledge, gari

17. Contribution of maize-based products to the livelihood of smallholder processors in rural northern Nigeria

Makuachukwu, O. G., Busie, M.-D., & Tahirou, A. (2022). Contribution of maize-based products to the livelihood of smallholder processors in rural northern Nigeria. *International Journal of Rural Management*, 18(2), 167–183. <https://doi.org/10.1177/0973005221998244>

In the smallholder value chains of maize, diversification of utilization is an essential strategy toward enhancing the benefits drivable from the increase in maize production. This article identifies the contribution of maize-based products on poverty level among smallholder

processors. The study, which was conducted in 30 rural communities in northern Nigeria, involved Focus Group Discussions and survey of 300 smallholder processors of maize-based products. Descriptive and inferential analyses were used. The results show that average annual profit among the interviewed smallholder processors of maize-based products was approximately N425,506 (about US\$1,400). These processors faced several constraints which tend to keep them under poverty trap (vicious cycle of poverty). The result of the estimated two-step Tobit model shows that, with necessary interventions, profit from maize-based products has the capacity of keeping these processors out of poverty trap. The result indicates that as profit from maize-based products increases, the poverty probability index that household is not below poverty line of \$1.90/day at 2011 purchase–power parity increases ($p < 0.05$). Thus, household poverty among rural smallholder processors of maize-based product could be reduced drastically through interventions targeted at mitigating the identified constraints.

18. Cooking banana consumption patterns in the plantain-growing area of southeastern Nigeria

Tshiunza, M., Lemchi, J., Onyeka, U. P., & Tenkouano, A. (2001). Cooking banana consumption patterns in the plantain-growing area of southeastern Nigeria. *Tropicultura*, 19(3), 135–140. <https://hdl.handle.net/10568/92709>

Cooking bananas (*Musa* spp., ABB genome) were introduced into Southeastern Nigeria by the International Institute of Tropical Agriculture (IITA) in the mid-1980s as an interim measure to reduce the incidence of black sigatoka disease (caused by the fungus *Mycosphaerella fijiensis* Morelet) on plantain. However, the people of this region were not familiar with their utilization methods. To address this lack of the knowledge and thereby sustain cooking banana cultivation, IITA, in collaboration with the Shell Petroleum Development Company (SPDC) and the Nigeria Agip OU Company (NAOC) commenced a training campaign on cooking banana processing methods. This study examined the patterns of utilization of cooking bananas ten years after the training took place and compared them with plantain. About 95% of the households interviewed are consuming cooking banana, indicating a broad acceptance of the crop in the region. Overall, two ripening stages termed green and ripe are the most popular ripening stages for the consumption of both plantain and cooking banana, followed by partially ripe maturity stage. The most common forms of consumption for green plantain are, in decreasing order of importance, pottage, boiled, roasted, and fried. Green cooking banana is also mostly eaten in pottage and boiled forms, and less frequently in fried and pounded forms. Ripe plantain is mostly eaten in fried and pottage forms, while ripe cooking banana is mostly eaten in fried and raw forms. Partially ripe plantain is mostly eaten in pottage, fried, boiled, and roasted forms, while partially ripe cooking banana is eaten in fried, pottage and boiled forms. These results indicate that the consumption patterns of plantain and cooking banana are very similar. This similarity has greatly contributed to the rapid integration of cooking banana within the existing plantain consumption and cropping systems.

19. Cowpea market participation, food security and income: evidence from northern Nigeria

Manda, J., Arega, A. D., Abdoulaye, T., Tufa, A. H., & Manyong, V. (2019). Cowpea market participation, food security and income: Evidence from northern Nigeria. Presented at African Association of Agricultural Economists (AAAE) Sixth International Conference, September 23–26, 2019, Abuja, Nigeria. <https://doi.org/10.22004/ag.econ.295815>

This article evaluates the impact of cowpea market participation on household food security and income in northern Nigeria. Using household survey data from a representative sample of over 1,500 farm households and applying a combination of instrumental variable techniques and dose–response functions, we found that cowpea market participation had a statistically significant positive impact on household food security and income. Cowpea market participation increased food expenditure by 1.6% and household income by 0.7% with a 10 unit increase in the quantity of cowpea sold. These results underscore the importance of cowpea market participation for household food security and income improvement. We also found that selling cowpea to rural and urban traders significantly increased household income, food expenditure, and food security. Results show that selling cowpea to rural and urban traders increased household income by 17% and 13%, respectively. The results point to the need for an enabling policy environment and public infrastructure to enhance market participation of farmers and traders. Public infrastructure investments in the form of feeder road construction and maintenance in the distant villages are encouraged, which in the long run can translate into improved cowpea productivity and welfare of smallholder farmers.

Keywords: cowpea market participation, cowpea, rural traders, urban traders, food security, income, northern Nigeria

20. Determinants of food demand among rural households in Borno state, Nigeria

Amaza, P., & Fregene, T (2008). Determinants of food demand among rural households in Borno state, Nigeria. *Empirical Economics Letters*, 7(6), 607–613. <https://biblio.iita.org/documents/amaza-determinants-2008.pdf-75dd9a61f67cb662e5368aaa3ed490f6.pdf>

This study uses a food consumption survey of rural households to examine the determinants of food demand in Borno State, Nigeria. The Linear-Approximate Almost Idea Demand System (LA/AIDS) model was used in analysis of data. Results showed that the income elasticities (expenditure) for animal protein and fat & oil are positive but greater than one, while those of cereals, legumes, roots & tubers and vegetables & fruits were less than one but positive. The policy implication of this finding is that due to the high cost of animal protein, it is important to introduce new recipe of legume-based food in order to supplement protein intake.

Keywords: food, demand, rural households, Nigeria.

21. Determinants of intensity of biomass utilization: Evidence from cassava smallholders in Nigeria

Adeyemo, T. A, Amaza, P, Okoruwa, V, Akinyosoye, V, Salman, K. K, & Abass, A. (2019). Determinants of intensity of biomass utilization: Evidence from cassava smallholders in Nigeria. *Sustainability*, 11, 2516. <https://doi.org/10.3390/su11092516>

The paradigm shift from value chains to value webs in the emerging bioeconomy has necessitated a review on how agricultural systems transit to value web production systems. This study examines how smallholders in the cassava system in Nigeria have been able to increase utilization of biomass in their production systems. Using a sample of 541 households, the study employed cluster analysis and ordered probit regression to examine the intensity of cassava utilization and the determinants of the intensity of utilization. The study found that over 50% of the respondents were classified as low-intensity utilization households, while ~13% were high-intensity utilization households. Land, social capital, farming experience, and asset ownership increased the probability of intensifying cassava utilization among smallholders. The study recommends strengthening assets acquisition, improving land quality and encouraging social capital development among smallholders.

Keywords: biomass utilization, intensity, cassava smallholders, Nigeria

22. Determinants of market production of cooking banana in Nigeria

Tshiunza, M., Lemchi, J., & Tenkouano, A. (2001). Determinants of market production of cooking banana in Nigeria. *African Crop Science Journal*, 9(3), 537–547. <https://doi.org/10.4314/acsj.v9i3.27600>

The factors that influence farmers' decisions to produce cooking banana for market in southeast Nigeria were examined. Data were collected from a random sample of 217 farmers through the use of a structured questionnaire. Results of the study indicate that about 80% of the farmers interviewed produce cooking banana both for household consumption and for sale. The proportion of cooking banana sold ranged from 10% to 90% with an average of 45%. Thus, cooking banana performs the dual role of providing food for the households, as well as being an additional source of cash income. Tobit regression analysis revealed that the price and the ripening stage at sale of cooking banana, as well as the presence of middlemen in the marketing chain were the most important determinants of the proportion of cooking banana planted for market. This indicates that cooking banana growers readily respond to market forces. Age and gender ownership of cooking banana also influenced the proportion of the crop planted for market. Increased involvement of wholesalers and processors in the marketing chain of the crop will probably enhance its market in the region.

Keywords: marketing, farmers' decision, market factors, *Musa* spp. ABB, production decision

23. Determinants of market value for fresh yam (*Dioscorea* species) tubers in two consumption centers in Togo

Amegbeto, N. K., Manyong, V., Coulibaly, O., & Asiedu, R. (2007). Determinants of market value for fresh yam (*Dioscorea* species) tubers in two consumption centers in Togo. *Annales des Sciences Agronomiques du Benin*, 9(2), 29–48. <https://doi.org/10.4314/asab.v9i2.43245>

This study examined the dynamics of fresh yam tuber prices and applied a hedonic pricing model to estimate the market values of tuber characteristics in two consumption centers in Togo. Real prices were modeled as a function of variables measuring yam species, physical attributes of tuber, origin of production, market location, and time of the year as well as damage from pests, diseases, and handling. Estimations were based on a sample of 9958 tubers described, calibrated, and priced at six markets between August 2001 and July 2002. Results show that real prices of yam were erratic. *Dioscorea rotundata* (white yam) prices exhibited a steady decline from August to September which corresponds to its milking time, a slight increase in weeks preceding Christmas, an apparent stability from late December through January in Lomé (March in Sokodé), and a steady increase from February in Lomé (March in Sokodé) into late July. *Dioscorea alata* (water yam) tubers appeared on the markets in December and their prices remained more or less stable throughout January, declined to their lowest level in February, and increased steadily thereafter. Results also suggest the existence of price premium to producers and retailers for growing /selling early maturing *D. rotundata* compared to late maturing varieties. In contrast, *D. alata* varieties were substantially discounted on the markets. Characteristics of tuber size, tuber shape, yellowish flesh color, and few supply sources had statistically significant and positive market values. Among symptoms of damage caused by diseases, pests, and handling, only rotting and mealybugs inflicted a discount on tuber value in Lomé and Sokodé respectively. Time factors were the most important variables affecting real prices. The period from April to July when time premiums are highest represents a market window for yam commercialization. Results can be used by yam producers in making appropriate decisions regarding cultivar selection, time of planting, harvesting, and marketing in order to increase farm incomes effectively.

24. Determinants of smallholder farmers' participation in banana markets in Central Africa: the role of transaction costs

Ouma, E., Jagwe, J., Obare, G. A., & Abele, S. (2010b). Determinants of smallholder farmers' participation in banana markets in Central Africa: the role of transaction costs. *Agricultural Economics*, 41(2), 111–122. <https://doi.org/10.1111/j.1574-0862.2009.00429.x>

A bivariate probit model was employed to jointly and separately estimate banana market participation decisions of buying and selling households in Rwanda and Burundi using household survey data. Selectivity bias was corrected for estimating the transacted volumes using Heckman's procedure. The results showed that transaction cost-related factors such as geographical location of households, market information sources, and travel time to the nearest urban center influence market participation. Non-price-related factors such as security

of land tenure, labor availability, off-farm income, gender of the household head, and years of farming experience had a significant influence on the transacted volumes. Output prices had a significant correlation with sales volume, indicating price incentives increased supply by sellers. Generally, the findings suggest that policies aimed at investments in rural road infrastructure, market information systems, collective marketing, and value addition of banana products may provide a potential avenue for mitigating transaction costs and enhancing market participation and production of marketed surplus by rural households.

Keywords: probit, market, survey, households, gender, income, banana, Rwanda, Burundi

25. Determinants of smallholder farmers' participation in rice value chains in Uganda

Rugema, S. H, Sseguya, H., & Kibwika, P (2018). Determinants of smallholder farmers' participation in rice value chains in Uganda. *Journal of Agricultural Extension*, 22(2), 62–71. <https://doi.org/10.4314/jae.v22i2.6>

This study explored the key determinants of smallholder farmers' participation in the One Stop Centre Farmer Association (OSCA) rice value chains in Uganda. Data were collected from 98 respondents in Luwero and Bugiri districts using focus group discussions and 20 key informant interviews, and analyzed with NVIVO software. The findings indicated that style of leadership, trust, cohesive networks and support services were key determinants of participation. Minimal participation of some members occurred due to unrealistic expectations and incompetent leadership. Further, addressing OSCA objectives can mitigate ensuing expectations. Along with this, strengthening the OSCA leadership to entrench transparency and establishment of business models for integration of value chain interventions into the wider livelihood strategies is important in order to cater for interests of all the members.

Keywords: participation, smallholder farmers, value chains, networks.

26. Dissemination and diffusion of cooking utilization methods in Nigeria

Lemchi, J., Tshiunza, M., Onyeka, U. P, & Tenkouano, A. (2005). Dissemination and diffusion of cooking utilization methods in Nigeria. *Nigerian Journal of Agricultural Technology*, 12, 56–73. www.researchgate.net/publication/228349983

As part of efforts in realizing her aim of introducing cooking banana into Nigeria, the International Institute of Tropical Agriculture (IITA) mounted training and awareness campaigns on its utilization in collaboration with Shell and Agip Oil companies between 1991 and 1997. This study looked into the adoption profile of the utilization methods and the factors that may have influenced it. Data were collected from a random sample of 232 respondents from 24 villages in southeast Nigeria. Results showed an overall adoption level of 79.5%. The highest adoption levels were obtained for those utilization methods similar to local and traditional methods of plantain consumption and lowest for non-traditional uses. The extent or intensity of adoption by the respondents ranged from 1 processing method to 7, with an average of 3. As a proportion of the number of utilization methods on which training was given, the intensity of adoption ranged

from 12.5% to 100% with a mean of 52.2%, meaning that the respondents have adopted more than 50% of the total number methods on which they received training. The major factors which have strongly influenced the adoption process were the level of educational attainment, social status, primary occupation, intensity of training received, availability of commercially-produced plantain products in the market/area, trialability as well as the number of desirable attributes of the utilization methods.

Keywords: cooking banana, adoption, processing methods

27. Does improved storage technology promote modern input use and food security? Evidence from a randomized trial in Uganda

Omotilewa, O. J., Ricker-Gilbert, J., Ainembabazi, J. H., & Shively, G. (2018). Does improved storage technology promote modern input use and food security? Evidence from a randomized trial in Uganda. *Journal of Development Economics*, 135, 176–198. <https://doi.org/10.1016/j.jdeveco.2018.07.006>

We use panel data from a randomized controlled trial (RCT) administered among 1200 smallholders in Uganda to evaluate input use and food security impacts of an improved maize storage technology. After two seasons, households who received the technology were 10 percentage points more likely to plant hybrid maize varieties that are more susceptible to insect pests in storage than traditional lower-yielding varieties. Treated smallholders also stored maize for a longer period, reported a substantial drop in storage losses, and were less likely to use storage chemicals than untreated cohorts. Our results indicate that policies to promote soft kernel high-yielding hybrid maize varieties in sub-Saharan Africa should consider an improvement in post-harvest storage as a complementary intervention to increase adoption of these varieties.

Keywords: post-harvest storage losses, improved storage technology, RCT, higher-yielding maize adoption, PICS hermetic bags, Uganda

28. Drivers of technical efficiency in cassava processing in Nigeria: Implications for a commercializing food sector

Abass, A., Olarinde, L., Okoruwa, V., Amaza, P., Awoyale, W., Alabi, T. R., & Ndavi, M. (2019). Drivers of technical efficiency in cassava processing in Nigeria: Implications for a commercializing food sector. *Tropicultura*, 37, 1–11. <https://doi.org/10.25518/2295-8010.573>

Most agriculture policies in Nigeria are aimed at integrating the rural poor into market economy. In the last decade, Nigeria witnessed significant private and public injection of capital into the promotion of small-medium scale cassava processing. This study uses a stochastic frontier function and inputs/outputs data to measure technical efficiencies (TE) of 274 small-medium cassava processing firms in Nigeria. Results showed that the cassava processing enterprises had a mean TE of 43 %, indicating that, a large proportion of output value (57%) is lost due to firm-specific inefficiencies. Cassava processing enterprises in the north-central area of Nigeria recorded a mean TE of 61% (highest), followed by South-east/South-west (42%) and South-

south (26%). TE values were below 80% for about 85% % of the sampled enterprises. Technical efficiencies were influenced by enterprise classification (small-medium, sole proprietorship or family ownership), social factors (interaction with other actors), economic (number of products, clients or orders received) and attendance of training workshop. It is recommended that government and institutions with statutory role to promote agricultural value chains should consider encouraging and promoting small-medium scale cassava processing the more with adequate impetus. Constant training workshops to improve the skills and efficiency of the cassava processors are also recommended.

Keywords: cassava processing, efficiency, normal/half, normal distribution, products value chain, Nigeria

29. Economics of maize, soybean and cowpea processing in the northern regions of Ghana

Akinola, A. A.*, Maziya-Dixon, B., Ayedun, B., & Abdoulaye, T. (2014). Economics of maize, soybean and cowpea processing in the northern regions of Ghana. *Journal of Food, Agriculture and Environment*, 12(2), 252–258. <https://cgspace.cgiar.org/handle/10568/75946?show=full>

Maize, soybean and cowpea are important staple food items in Ghana. However, there is paucity of information on the economics of the processing sector in the three northern regions of Ghana. Using survey data and applying budgetary technique, Foster-Greer-Thorbecke measures of poverty and Stochastic Production Frontier Function, this paper analyzed costs and returns to food processors, incidence, depth and severity of as well as technical efficiency of the processors in the sector. The results revealed that cost of materials processed represented the highest cost (>40%) items in all the regions. The net benefit was highest in the northern region, followed by upper east. An average processor has a net benefit per person per day of €4.30, €4.54 and €4.33 from processing Banku, Dawadawa and Kose, respectively. On a regional basis, an average processor of foodstuff has a net benefit of €6.32, €5.09 and €6.53 in the northern region. The figures for the upper west were lowest. Although, the results indicate positive net benefits in the study area, cost benefit ratios are not that high (<2) in all regions. The moderate poverty line for the whole northern region was €1381.00 while the core poverty line was €920.67. The moderate poverty line for northern Ghana, upper east and upper west were €1724.80, €1503.96 and €993.55, respectively. The two significant variables ($p < 0.1$) influencing amount of food processed were raw materials that represented the quantity of crop used in processing and amount spent on transport in the course of getting the food crop transported to point of sales. The study suggested the need for concerted efforts aimed at increasing awareness for improved access to credit facilities as well as better transport conditions in order to improve quantity and quality of processed food crops as ways to enhancing general livelihood of the processors in the three regions of Ghana.

Keywords: efficiency, poverty, processing, stochastic

30. Effect of transaction costs on market participation among smallholder cassava farmers in Central Madagascar

Okoye, B. C., Abass, A., Bachwenkizi, B., Asumugha, G., Alenkhe, B., Ranaivoson, R., Randrianarivelo, R., Rabemanantsoa, N., & Ralimanana, I. (2016). Effect of transaction costs on market participation among smallholder cassava farmers in Central Madagascar. *Cogent Economics & Finance*, 4(1), 1143597. <https://doi.org/10.1080/23322039.2016.1143597>

High transaction costs deter entry of small farmers into the market. With the data from 240 smallholder cassava farmers in Central Madagascar, this study identified strategies to promote successful smallholder commercialization. The coefficients for membership of cooperatives, native of community and farming experience, have a direct relationship with decision to participate in the market and which is significant at 1% level and road condition to the nearest town is good at 10% level. The coefficients for age, distance to the nearest town and distance from the farm to the market have an indirect relationship with decision to participate in the market and significant at 5, 10 and 1% levels, respectively. The results also show that the coefficients for personal means of transportation and marketing experience have a direct relationship with decision to sell cassava off-farm and at 10 and 1% level of significance, respectively, while distance to the nearest town and distance from the farm to the market had an indirect relationship with decision to sell off-farm at 5% level of significance each and cost of transportation at 1% level. The study raises policy issues which might reduce these transaction costs by providing more market outlets, better rural infrastructure and also bulking centers.

Keywords: rural infrastructure, triple hurdle and Heckman selection

31. Establishing the link between market orientation and agricultural commercialization: Empirical evidence from northern Ghana

Martey, E, Etwire, P. M, Wiredu, A., & Ahiabor, B. D (2017). Establishing the link between market orientation and agricultural commercialization: Empirical evidence from northern Ghana. *Food Security*, 9, 849–866. <http://dx.doi.org/10.1007/s12571-017-0688-9>

This paper established a positive relationship between market orientation and intensity of commercialization among rural farm households in northern Ghana. The IV Tobit regression estimate suggests that intensity of maize commercialization is significantly determined by education, agro-ecology, household size, total livestock units, farm size, access to formal markets and market orientation. In addition, a highly and unbiased significant positive effect is observed between market orientation and intensity of maize commercialization after controlling for endogeneity in market orientation. Intensity of maize commercialization increased by 0.86% for a 0.1 unit increase in the market orientation index. The empirical implications of the results are discussed.

Keywords: market orientation, intensity of commercialization, northern Ghana, truncated regression, Tobit

32. Evaluation of cassava processing and utilization at household level in Zambia

Alamu, E. O., Ntawuruhunga, P., Chibwe, T., Mukuka, I., & Chiona, M (2019). Evaluation of cassava processing and utilization at household level in Zambia. *Food Security*, 11, 141–150. <https://doi.org/10.1007/s12571-018-0875-3>

Cassava (*Manihot esculenta* Crantz) is the second most consumed staple food crop after maize in Africa and is the main food security crop after maize in Zambia. A study, aimed at analyzing cassava processing and utilization at household level in Zambia, was conducted. Surveys were conducted in five districts (Kasama, Samfya, Mansa, Serenje and Kaoma). A structured questionnaire was administered to a total of 300 randomly selected households. The percentage of households that were involved in processing were 4.3% for income, 34% for consumption and 58% for both income generation and consumption. Levels of awareness and usage of improved cassava processing methods across the districts were low, ranging between 20% and 26%. The only improved processing equipment that farmers used often (69%) was the hammer mill. Product development and utilization were still at a low level (ranging between 9% and 18%) in Zambia. Cassava is mostly consumed in its traditional form for its leaves, as a snack, and for preparing *nshima* (cassava flour alone or a mixture of cassava and maize meal, called maize-cassava *nshima*). The limited knowledge of cassava products' diversity and the low usage of improved equipment are challenges to the production of confectionery products that could lead to increased cassava consumption. There has been no significant change over the last two decades in cassava processing and product development, which could spur cassava development. This calls for more efforts to support Government policy in diversifying crop use and crop diversification in order to create wealth.

Keywords: cassava, food security, cassava processing, household level, confectionery products, product development, processing equipment

33. Expanding the application of cassava value chain technologies through UPoCA project

James, B., Bramel, P., Witte, E. R., Asiedu, R., Watson, D., & Okechukwu, R. (2011). Expanding the application of cassava value chain technologies through UPoCA project. *African Journal of Root and Tuber Crops*, 9(1), 38–49. <https://hdl.handle.net/10568/88171>

Cassava has long been expected to play a key role in rural economic growth in Africa, but are we there yet? Although research partnerships have produced elite cassava varieties with 50% more yielding potential and demonstrated technologies to boost processing and marketing of cassava, the sub-sector is constrained by low productivity and marketing difficulties. In DR Congo, Ghana, Malawi and Sierra Leone, for example, cassava value chain actors are yet to respond to 2007 estimated \$59 million trade opportunities through substitution of imported wheat flour with locally produced high quality cassava flour. Industrial pull for cassava would also aggravate hunger and poverty if yields do not increase from current national averages of 5 to 19t/ha to more than 25t/ha expected of released varieties under low input agriculture. In 2008, USAID and IITA initiated the project “Unleashing the Power of Cassava in Response

to Food Price Crisis (UPOCA) as a multi-country and inter-institutional partnership enabling cassava sub-sectors to realize their full potential in rural economies. UPoCA project covers DR Congo, Ghana, Malawi, Mozambique, Nigeria, Sierra Leone, and Tanzania. UPoCA project draws on prior research results to increase on-farm cassava productivity and value adding processing for markets. By end 2009, small holder beneficiaries associated with 55 partner organizations and 11 agricultural related firms established 306 community cassava stem multiplication sites and root production farms totalling 10,097ha with 58 improved varieties. Through experiential learning at 24 hands-on short-term courses, 345 men and 142 women learnt improved techniques in cassava production, processing, product development, and packaging/labelling and 8 technologies were introduced to rural communities. Seven other papers in this symposium, based on these evolving UPoCA achievements, show that a longer-term cassava research for development partnership platform of this nature will enable cassava sub-sectors to contribute significantly to rural economic growth in Africa.

Keywords: cassava, productivity, income, foods

34. Food intake among smallholder cassava value chain households

Samuel, F. O., Akinwande, B. A., Opasola, R. O., Azeez, L. A., & Abass, A. B. (2019). Food intake among smallholder cassava value chain households. *Nutrition & Food Science*, 49(6), 1051–1062. <https://doi.org/10.1108/NFS-11-2018-0310>

Purpose: The purpose of this study is to compare food consumption and dietary diversity in smallholder cassava value chain households (CVCHs) and non-cassava value chain households (non-CVCHs).

Design/methodology/approach: A total of 572 rural households were selected using multi-stage sampling from Oyo and Kwara states, Southwest Nigeria. Socio-demographic, 24 h dietary recall and food frequency questionnaires were used to collect data. Household Dietary Diversity Score (HDDS) and the Minimum Dietary Diversity for Women of Reproductive Age (MDD-W) were measured.

Findings: The mean age of respondents was 49.1 ± 17.3 years, 68.3 per cent were female, household sizes ranged from 2-20 with an average of 8 members. Most households consumed monotonous staple-based diets mainly from roots and tubers, cereals and legumes. There was no significant difference in HDDS (6.70 ± 1.37 and 6.77 ± 1.12 ; $p = 0.12$) and MDD-W (4.78 ± 1.12 and 4.95 ± 1.16 ; $p = 0.09$) for CVCH and non-CVCH respectively. About one-third of all women did not achieve the MDD-W score required for micronutrient adequacy, with the main dietary gap being vitamin A-rich fruits and vegetables.

Practical implications: the findings suggest that there was no influence of households' involvement in cassava value chain activities on their pattern of food consumption and dietary diversity.

Originality/value: While cassava value chain activities have potential for improved livelihoods among its actors, a nutrition-sensitive approach needs to be incorporated to translate this into their improved food consumption, dietary diversity and nutritional (particularly micronutrient) status.

35. Household characteristics and market participation competence of smallholder farmers supplying cassava to starch processors in Nigeria

Ojiako, I., Tarawali, G., Okechukwu, R., & Chianu, J. (2016). Household characteristics and market participation competence of smallholder farmers supplying cassava to starch processors in Nigeria. *International Journal of Agricultural Research, Innovation and Technology*, 6(2), 42–56. <http://dx.doi.org/10.22004/ag.econ.305410>

The household head characteristics of smallholder cassava farmers supplying raw materials to the major commercial starch processors in Nigeria were examined alongside their market participation categories. A multi-stage random sampling technique was used to select 96 farmers working in clusters in the eight cassava producing states. Data were analyzed using a combination of descriptive and inferential statistics, including the use of independent sample t-test technique to compare farmer's characteristics for the farmers' market participation categories. Results revealed that majority of the farmers were farming for subsistence with only 19.80% selling up to 50% of their farm produce as against 80.20% who sold less. Average mean values were found to be higher for the high market participants compared with the low participants for the age, farming experiences, education, farm size, gender, marital status, household size, training, season of harvesting and fertilizer use, but lower for use of credit, improved cassava variety, harvesting method, farming time devotion, and road access. Only farm size, gender and harvesting season at $p < 0.01$ level and training at $p < 0.05$ level were found to be statistically significant in distinguishing the high and low market participation categories. Policies and programs aimed at promoting market participation among cassava farmers in Nigeria should be more impactful if directed at these significant factors.

Keywords: household characteristics, cassava, smallholder farmers, market participation, starch, processors, training, Nigeria

36. Household utilization of manioc (*Manihot esculenta* Crantz) in Northern Mozambique

Muoki, P. N., & Maziya-Dixon, B. (2010). Household utilization of manioc (*Manihot esculenta* Crantz) in Northern Mozambique. *Ecology of Food and Nutrition*, 49(5), 337–356. <https://doi.org/10.1080/03670244.2010.507435>

Mozambique is ranked ninth of top manioc (*Manihot esculenta* Crantz) producing countries in the world. Manioc roots are a staple to people living in the northern part of the country. Despite this, information on production, utilization, post-harvest handling, and marketing is scarce. The purpose of this baseline study was to document selected information on manioc, from the production to marketing stage. To gather this information, 70 focus groups consisting of 1,724 participants purposely sampled from 10 districts were engaged in discussions using a

questionnaire. The results show that manioc is the most important crop in terms of contribution to household food security and income in the region. Both men and women participate in the delivery of manioc production chain. Typically, 5 to 15 varieties identified by local language can be found on most farms in the study area. Manioc leaves and roots are the parts of the plant used as human food. Sun dried manioc roots are principally marketed within the locality of production by individual farmers. This baseline study suggests the need for location-targeted interventions as the farmers reported varied challenges along the manioc production chain.

37. Improving seed potato quality in Ethiopia: a value chain perspective

Hirpa, A., Meuwissen, M. P. M., Lommen, W. J. M., Oude Lansink, A. G. J. M., Tsegaye, A., & Struik, P. C. (2016). Improving seed potato quality in Ethiopia: a value chain perspective. In Bijman, J., & Bitzer, V. (eds) *Quality and Innovation in Food Chains*, pp. 101–118. Wageningen Academic Publishers. https://doi.org/10.3920/978-90-8686-825-4_5

In Ethiopia, use of low-quality seed potatoes by the majority of potato growers is associated with underdevelopment of the seed potato value chains. Three seed potato systems are present in Ethiopia: the informal seed system, the alternative seed system and the formal seed system. This chapter analyzes the performance of seed potato value chains with respect to their ability to supply quality seed tubers to seed potato systems, by using the chain performance drivers enabling environment, technology, market structure, chain coordination, farm management, and inputs. Information obtained from literature review, secondary data and key informants' interviews were used for the analysis. In the informal seed system, seed potato value chains suffered from a poor enabling environment such as a low-quality technical support and lack of a seed quality control system; use of sub-optimal storage and transportation technologies, sub-optimal farm management practices; and little use of inputs. In the alternative seed system, main constraints were the lack of a seed potato quality control system, poor farm management practices, little use of inputs by seed potato growers, and a distorted seed potato market that resulted from involvement of institutional buyers. Chains in the formal seed potato system were characterized by little involvement of the private and public sectors in the production and supply of seed potatoes. Based on the analysis, improvement options for the three seed systems were identified.

Keywords: potatoes, value chain, seed quality, Ethiopia

38. Improving the production and utilization of cowpea as food and fodder

Singh, B., Ajeigbe, H., Tarawali, S., Fernandez-Rivera, S., & Abubakar, M. (2003). Improving the production and utilization of cowpea as food and fodder. *Field Crops Research*, 84(1–2), 169–177. [https://doi.org/10.1016/S0378-4290\(03\)00148-5](https://doi.org/10.1016/S0378-4290(03)00148-5)

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important food legume and an integral part of traditional cropping systems in the semi-arid regions of the tropics. The estimated worldwide area under cowpea is about 14 million ha of which West Africa alone accounts for about 9.3 million ha with annual production of about 2.9 Mt. Cowpea grains are consumed as food and

the haulms are fed to livestock as a nutritious fodder. Farmers often grow a short-duration spreading variety for grain and a long-duration spreading variety for fodder, but the grain and fodder yields are poor due to low yield potential of the spreading varieties and also due to early cessation of rains. Therefore, IITA in collaboration with ILRI has initiated a systematic program to develop medium-maturing, semi-erect, dual-purpose varieties with higher grain and fodder yields and with enhanced fodder quality. By crossing the late, traditional spreading varieties with improved early, semi-erect varieties, a semi-erect group of medium-maturing, dual-purpose varieties has been developed which yield over 1.5 t ha⁻¹ grain and 2.5 t ha⁻¹ haulms. Despite the high grain and fodder yields, the haulms of improved dual-purpose varieties have similar crude protein content (17–18%) and dry matter digestibility (64–71%) compared to the local varieties. Controlled sheep feeding experiments have shown an average live weight gain of about 80 g per animal per day with 200–400 g per day of cowpea haulms as a supplement to a basal diet of sorghum stover. This was 100% higher than the average live weight gain of animals fed sorghum fodder alone. These results indicate that improved dual-purpose varieties can play an important role in enhancing crop–livestock integration in West Africa.

Keywords: *Vigna unguiculata*, dual-purpose cowpea, fodder, haulms, crop–livestock systems

39. Least-cost seed potato production in Ethiopia

Hirpa Tufa, A., Meuwissen, M. P., Lommen, W. J., Tsegaye, A.* , Struik, P. C., & Lansink, A. O. (2015). Least-cost seed potato production in Ethiopia. *Potato Research*, 58(3), 277–300. <https://doi.org/10.1007/s11540-015-9309-1>

Improved potato varieties can increase potato yields of smallholders, and thus contribute to food security improvement in Ethiopia. However, the uptake of these varieties by farmers is very limited so far and this is one of the causes of insufficient seed quality in the seed potato system in Ethiopia. The low uptake may be related to the high costs of recommended production methods for these varieties. The objective of this study was to formulate least-cost seed potato production methods for farmers in Ethiopia. The paper used integer linear programming to determine these least-cost seed potato production methods, using published data on the perceived contributions to seed tuber yield and quality of different cultivation and post-harvest management options, and calculated seed potato production cost data for the different options. For the potato-growing districts Jeldu and Welmera, several seed potato production methods were formulated from which farmers can choose an affordable method that will enable them to produce seed potato with reasonable yield and quality levels. Results showed that yield and quality levels could be simultaneously improved at relatively low extra costs, for example, by applying recommended fertilizer rate combined with two fungicide applications. In both districts, most methods were robust to 50% increases in the rental values of land, prices of seed, wage rates, and prices of agrochemicals. Findings can be used by potato development practitioners to advise farmers on the adoption of seed potato technologies that are compatible with their financial resources.

Keywords: improved potato varieties, seed potato, smallholders, production methods, linear programming, least-cost production, Ethiopia

40. Manure marketing in the savannas of Nigeria: implications for sustainable food security

Olayide, O, Alene, A., Ikpi, A, & Nziguheba, G. (2009). Manure marketing in the savannas of Nigeria: Implications for sustainable food security. *Journal of Food, Agriculture and Environment*, 7(2), 540–545. <https://cgspace.cgiar.org/handle/10568/90194>

Achieving sustainable food security in Nigeria is feasible through organic farming. However, unavailability and resource constraints hamper the adoption of agricultural inputs; hence the market offers opportunity for use of purchased organic inputs. In assessing the importance of the market, the study developed and employed a socio-economic-ecological-modeling (SEEM) framework in its analyses. Using data from a sample of 320 farm households and manure agents, the study aimed at bridging the knowledge gap on the importance, nature, structure and performance of manure market in northern Nigeria. Results show that cereal-legume-based cropping systems accounted for major use of total manure applied on the farm; maize-based cropping systems received the highest amount of the total manure applied. There was asymmetric information flow in the manure market. The market concentration ratios show that none of the manure agents was sufficient in exercising monopoly power in the manure market. The Gini coefficients of the Lorenz curve analyses further showed considerable degrees of inequalities in the volume of manure marketed by different agents both across the agro-ecological zones and socio-economic domains. Manure marketing was found to be inefficient. Further, manure marketing in the study area is profitable with huge potentials for market development.

Keywords: manure, marketing, socio-economic ecological modeling, self-sufficiency, outsourcing, geographic information system, Savanna

41. Mapping cassava food value chains in Tanzania's smallholder farming sector: The implications of intra-household gender dynamics

Masamha, B., Thebe, V, & Uzokwe, V. N. E. (2018). Mapping cassava food value chains in Tanzania's smallholder farming sector: The implications of intra-household gender dynamics. *Journal of Rural Studies*, 58(1), 82–92. <https://doi.org/10.1016/j.jrurstud.2017.12.011>

A gendered mapping of the structure and coordination (functioning) of traditional cassava value chains is important for marginalized groups such as women in rural development. In contrast to global high value chains, traditional food value chains and associated gender relations as well as power dynamics within households have received little attention. We conducted a cross sectional study in Kigoma, Mwanza, the coastal region, and Zanzibar Island in Tanzania. Data were collected through structured interviews conducted with 228 farmers, combined with key informant interviews, direct observations, repeated household visits, and literature review. The results of the study revealed that there are weak linkages within the cassava value chain, which is highly gendered. While production and processing nodes of the chain, which commenced from villages, were dominated by women and children, women were not well-

integrated within high value nodes such as marketing in urban areas and cross-border trading, which were dominated by men. Transportation of cassava to highly lucrative markets was also dominated by men. Cassava processing was conducted at the household level as well as within small-scale cooperatives, with the major portion of this work being done by women. Supporting institutions were found to be involved in the supply of planting material, training, and the provision of processing equipment. In general, men played a prominent role in the control of resources, marketing, and income. In conclusion, the mapping of cassava value chains could help to identify avenues for understanding of poverty, enhancing food security, upgrading capacities, reducing gender inequality, and enhancing women's participation in marketing and income control in the cassava value chains.

Keywords: cassava value chain, gender, smallholder farmers, household

42. Market building for post-harvest technology through large-scale extension efforts

Baributsa, D., Abdoulaye, T., Lowenberg-DeBoer, J., Dabire, C, Moussa, B, Coulibaly, O., & Baoua, I (2014). Market building for post-harvest technology through large-scale extension efforts. *Journal of Stored Products Research*, 58, 59–66. <https://doi.org/10.1016/j.jspr.2014.02.012>

The Purdue Improved Cowpea Storage (PICS) technology has been disseminated in 30,896 villages in 10 different countries in West and Central Africa from 2007 to 2012. Extension and supply chain development efforts were required to make the PICS technology available to millions of farmers and other users. Several research and development organizations assisted in awareness building activities to develop the market and increase access. Thousands of village and market demonstrations were implemented by field technicians and supported by media activities. Supply chain development activities were led by the private sector with some support from the project. Overall, 40–70 adults attended demonstrations in each village, among which 38% were women. Large-scale extension activities substantially increased the demand for the technology and helped establish the supply chain. More than 2.4 million triple bags were sold in the first five years of the project. In some countries, up to 50% of bags ordered during the first year were bought by farmers; even though village demonstrations had not yet been completed. Market building activities helped convince the private sector that there were business opportunities in buying and selling PICS bags. Bags ordered by the private sector went from 0% in 2007 to 200% in 2010, proving that it is possible to commercialize a new agricultural technology in developing countries in a relatively short time.

Keywords: commercialization, ag-inputs, PICS bags, cowpea storage, West and Central Africa

43. Market participation, household food security, and income: The case of cowpea producers in northern Nigeria

Manda, J., Alene, A., Hirpa Tufa, A., Feleke, S., Abdoulaye, T., Omoigui, L., & Manyong, V. (2020). Market participation, household food security, and income: The case of cowpea producers in northern Nigeria. *Food and Energy Security*, 9(3), e211. <https://doi.org/10.1002/fes3.211>

This article evaluates the impact of cowpea market participation on household food security and income in northern Nigeria. Using household survey data from a representative sample of over 1,500 farm households and applying a combination of instrumental variable techniques and dose–response functions, we found that cowpea market participation had a statistically significant positive impact on household food security and income. Cowpea market participation increased food expenditure by 1.6% and household income by 0.7% with a 10 unit increase in the quantity of cowpea sold. These results underscore the importance of cowpea market participation for household food security and income improvement. We also found that selling cowpea to rural and urban traders significantly increased household income, food expenditure, and food security. Results show that selling cowpea to rural and urban traders increased household income by 17% and 13%, respectively. The results point to the need for an enabling policy environment and public infrastructure to enhance market participation of farmers and traders. Public infrastructure investments in the form of feeder road construction and maintenance in the distant villages are encouraged, which in the long run can translate into improved cowpea productivity and welfare of smallholder farmers.

44. On-farm comparison of different post-harvest storage technologies in a maize farming system of Tanzania Central Corridor

Abass, A. B., Fischler, M., Schneider, K., Daudi, S., Gaspar, A., Rüst, J., Kabula, E., Ndunguru, G., Madulu, D., & Msola, D. (2018). On-farm comparison of different post-harvest storage technologies in a maize farming system of Tanzania Central Corridor. *Journal of Stored Products Research*, 77, 55–65. <https://doi.org/10.1016/j.jspr.2018.03.002>

Seven methods for storing maize were tested and compared with traditional storage of maize in polypropylene bags. Twenty farmers managed the experiment under their prevailing conditions for 30 weeks. Stored grain was assessed for damage every six weeks. The dominant storage insect pests identified were the Maize weevil (*Sitophilus zeamais*) and the Red flour beetle (*Tribolium castaneum*). The moisture content of grain in hermetic conditions increased from $12.5 \pm 0.2\%$ at the start of storage to a range of 13.0 ± 0.2 to $13.5 \pm 0.2\%$ at 30 weeks. There was no significant difference ($F = 87.09$; $P < 0.0001$) regarding insect control and grain damage between hermetic storage and fumigation with insecticides. However, the insecticide treatment of polypropylene yarn (ZeroFly®) did not control the insect populations for the experimental period under farmers' management. Grain damage was significantly lower in hermetic storage and fumigated grain than ZeroFly® and polypropylene bags without fumigation. No significant difference in grain damage was found between airtight treatment alone and when combined with the use of insecticides. During storage, *S. zeamais* was predominant and could be of more economic importance than *T. castaneum* as far as maize damage is concerned. At 30 weeks, the germination rate of grain stored with insecticides or in hermetic storage ($68.5 \pm 3.6\%$ to $81.4 \pm 4.0\%$) had not significantly reduced from the rate before storage ($F = 15.55$; $P < 0.0001$) except in ZeroFly®, also in polypropylene bags without treatment. Even though such bags did not control storage pests, farmers still liked this cheap technology. Hermetic storage techniques can be recommended to farmers without the use of insecticides provided they are inexpensive, and the proper application of technologies is ensured.

Keywords: maize farmers, hermetic storage, grain damage, food loss, insect damage

45. Overcoming smallholder farmers' post-harvest constraints through harvest loans and storage technology: Insights from a randomized controlled trial in Tanzania

Channa, H., Ricker-Gilbert, J., Feleke, S., & Abdoulaye, T. (2022). Overcoming smallholder farmers' post-harvest constraints through harvest loans and storage technology: Insights from a randomized controlled trial in Tanzania. *Journal of Development Economics*, 157, 102851. <https://doi.org/10.1016/j.jdeveco.2022.102851>

Maintaining staple grains throughout the year and managing liquidity are two major challenges that smallholder farmers face at harvest. We implemented a randomized controlled trial in Tanzania that was designed to address these post-harvest constraints. First, we offered treated farmers two hermetic (airtight) storage bags, which helped preserve grain quantity and quality. Second, we offered other treated farmers a loan at harvest, which reduced the liquidity constraints they faced. Repayment was due with interest six months from harvest when maize prices were traditionally higher. We did not find a significant impact of the storage intervention. However, those offered the loan stored 29 percent more and sold 50 percent more maize on average in the lean season compared to farmers in the control group. Nevertheless, an unexpected maize export ban in Tanzania likely attenuated the outcomes of both interventions. This highlighted the challenges surrounding agricultural financial products in the developing world.

Keywords: randomized controlled trial, hermetic storage, microfinance, Tanzania, price seasonality, maize markets

46. Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania

Abass, A., Ndunguru, G., Mamiro, P., Alenkhe, B., Mlingi, N., & Bekunda, M. (2014). Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania. *Journal of Stored Products Research*, 57, 49–57. <https://doi.org/10.1016/j.jspr.2013.12.004>

An assessment of post-harvest handling practices and food losses in a maize-based farming system in semi-arid areas of Central and Northern Tanzania was carried out in 2012. Seventeen crops were mostly cultivated by the farmers in the surveyed areas; maize (32%), sunflower (16%), and pigeon peas (12%) were the most cultivated, while maize was the most stored. There are at least seven months between two harvest seasons of each crop; while farmers sold the crops soon after harvest to cater for household expenditure (54%) and school fees (38%), the market prices increased significantly ($P \leq 0.05$) within six months of storage. Most processing activities (winnowing, dehulling, drying, sorting, and shelling) were carried out manually, almost entirely by women, but mechanized processing for maize, sunflower, millet, and sorghum were commonly practiced. Quantitative post-harvest losses of economic importance occur in the field (15%); during processing (13–20%), and during storage (15–25%). The main storage pests responsible for the losses are larger grain borers (*Prostephanus truncatus*), grain weevils (*Sitophilus granarius*), and the lesser grain borer (*Rhyzopertha*

dominica). Most of the farmers considered changes in weather (40%), field damage (33%), and storage pests (16%) as the three most important factors causing poor crop yields and aggravating food losses. However, survey results suggest that the farmers' poor knowledge and skills on post-harvest management are largely responsible for the food losses. 77% of the surveyed farmers reported inadequate household foods and 41% received food aid during the previous year. Increasing farmers' technical know-how on adaptation of the farming systems to climate variability, and training on post-harvest management could reduce food losses, and improve poverty and household food security.

Keywords: smallholder farmers, post-harvest loss, processing, storage, food security

47. Post-harvest technology change in cassava processing: A choice paradigm

Adejumo, O, Okoruwa, V, Abass, A., & Salman, K. K (2020). Post-harvest technology change in cassava processing: A choice paradigm. *Scientific African*, 7, e00276. <https://doi.org/10.1016/j.sciaf.2020.e00276>

This study employed a choice model to examine the factors influencing the choice of post-harvest technologies in cassava starch processing, using a sample of five hundred and seventy (570) processors in the forest and guinea savanna zones of Nigeria. In addition, the profitability of various post-harvest technologies in the study area was assessed using the budgetary technique, while the impact of improved post-harvest technology on processors' revenue and output was analyzed using the average treatment effect model. Sex of the processor, processing experience, income, and cost of post-harvest technology, the capacity of post-harvest technology and access to credit, amongst others significantly influence the choice of post-harvest technologies. Although the use of improved post-harvest technology comes with a high cost, the net income from its use was higher than the other types of post-harvest technologies, suggesting that the use of improved techniques was more beneficial and profitable. In addition, using improved post-harvest technology had a positive and significant effect on output and income. These findings show that investment in improved post-harvest technologies by cassava starch processors and other stakeholders would increase income, thus, improving welfare.

Keywords: cassava starch, post-harvest technologies, profitability, treatment effect model

48. Post-harvest processes of edible insects in Africa: a review of processing methods, and the implications for nutrition, safety and new products development

Mutungi, C., Irungu, F. G, Nduko, J, Mutua, F, Affognon, H., Nakimbugwe, D, Ekesi, S., & Fiaboe, K. K. (2019). Post-harvest processes of edible insects in Africa: A review of processing methods, and the implications for nutrition, safety and new products development. *Critical Reviews in Food Science and Nutrition*, 59(2), 276–298. <https://doi.org/10.1080/10408398.2017.1365330>

In many African cultures, insects are part of the diet of humans and domesticated animals. Compared to conventional food and feed sources, insects have been associated with a low ecological foot print because fewer natural resources are required for their production. To this end, the Food and Agriculture Organization of the United Nations recognized the role that edible insects can play in improving global food and nutrition security; processing technologies, as well as packaging and storage techniques that improve shelf-life were identified as being crucial. However, knowledge of these aspects in light of nutritional value, safety, and functionality is fragmentary and needs to be consolidated. This review attempts to contribute to this effort by evaluating the available evidence on post-harvest processes for edible insects in Africa, with the aim of identifying areas that need research impetus. It further draws attention to potential post-harvest technology options for overcoming hurdles associated with utilization of insects for food and feed. A greater research thrust is needed in processing and this can build on traditional knowledge. The focus should be to establish optimal techniques that improve presentation, quality and safety of products, and open possibilities to diversify use of edible insects for other benefits.

Keywords: entomophagy, traditional knowledge, shelf-life, packaging, storage, functionality

49. Price transmission in Nigerian food security crop markets

Hatzenbuehler, P. L., Abbott, P. C., & Abdoulaye, T. (2017). Price transmission in Nigerian food security crop markets. *Journal of Agricultural Economics*, 68(1), 143–163. <https://doi.org/10.1111/1477-9552.12169>

This paper comprehensively examines price transmission from world, neighbor country, and internal commercial hub markets to Nigerian urban markets, as well as from urban to rural markets within the country, for seven key food security crops (maize, millet, sorghum, rice, cassava, yams and cowpeas). There are three key findings: (i) tradability matters for price transmission, but tradability varies across crops and regions. The strongest international linkages are with neighboring countries. Rice price transmission is high across all markets, while coarse grain price correspondence is low with world prices but high with neighbor country market prices; (ii) our results imply that local conditions matter for price transmission, and are relatively more important than trade for some crops (e.g. yams, cassava) than others (e.g. imported rice, maize); (iii) larger than expected long-run price transmission parameters in world and neighbor countries for rice and coarse grains suggest that, in these select markets, there are either large transactions costs or quality premiums that vary systematically with border prices, and/or mark-ups captured by traders with market power.

50. Regional Cassava Value Chains Analysis in West Africa: Case Study of Côte d'Ivoire

Coulibaly, O., Arinloye, D.-D. A. A., Faye, M., Abdoulaye, T., Calle-Goulivas, A., & Ahoyo, R. (eds) (2014). *Regional Cassava Value Chains Analysis in West Africa: Case Study of Côte d'Ivoire*. Ibadan: IITA. <http://dx.doi.org/10.13140/2.1.4476.3201>

Five countries were selected for the cassava chain analysis: Cote d'Ivoire, Ghana, Sierra Leone, Nigeria and Liberia. A two steps method was used to collect data: first a literature review on the cassava chain in the target countries accompanied by a desk study and in-depth surveys to collect primary data at each chain actor level. Our investigations showed that in all countries, the main actors in the cassava chains are the input dealers, the producers, the processors, the traders, the financial services providers, the transporters, the extension services, the research institutes, the NGOs and the policy makers. The main constraints cited by actors are: the high cost of transport, the high number of sellers, the unavailability of some inputs, the poor quality of some inputs, the high prices of imported inputs compared to locally-produced ones and the poor access to cash and/or input-tied credit. Opportunities are the expanded urban demand (Abidjan and other cities), the high potential of profit due to the high demand of some cassava products and the opportunity to get credit when for members of some cooperatives. Most of cassava producers are male and belong to a producer organization and have access to fertilizers, pesticides and other inputs compared to other target countries. However, cassava production system in Côte d'Ivoire remains extensive with a wide use of traditional and low-yielding varieties and low levels of fertilizers.

51. Research on yam production, marketing and consumption of Nupe farmers of Niger State, central Nigeria

Fu, R. H. Y., Kikuno, H., & Maruyama, M. (2011). Research on yam production, marketing and consumption of Nupe farmers of Niger State, central Nigeria. *African Journal of Agricultural Research*, 6(23), 5301–5313. http://www.academicjournals.org/app/webroot/article/article1380903959_Fu%20et%20al.pdf

Questionnaire survey was conducted to obtain information from lowland rice cultivation based Nupe farmers in Niger State, central Nigeria regarding the current practices of yam production, marketing and consumption. In order to intensify yam production in Africa, scientists have developed various technologies to control growth cycle of yams for dry season production on wetlands. With appropriate natural environment and tradition of wetland utilization, the Nupe farmers in Niger State are targeted for introducing the new technologies to initiate dry season yam cultivation. Farmers can harvest ware yams during months when market prices of yam tubers are high, which would improve their incomes. Cassava as the current major dry season crop in the region may be replaced by yams which have far higher market and nutrition values. This research thus attempts to obtain basic information for future project planning. The findings suggest that, although in small scale, yams have been incorporated into the cropping system of Nupe farmers. Yams were mainly cultivated for self-consumption, so it was not market-oriented, and resources inputs were limited. There were discrepancies between complex villages and upland villages in terms of production scale, variety, cultivating calendar and time pattern for sale and consumption.

Keywords: yams, Nupe, farming system, inland valley utilization, off-season production

52. Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya

Alene, A., Manyong, V., Omany, G, Mignouna, H., Bokanga, M., & Odhiambo, G. D (2008). Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya. *Food Policy*, 33, 318–328. <https://doi.org/10.1016/j.foodpol.2007.12.001>

This paper assessed the effects of transactions costs—relative to price and non-price factors—on smallholder marketed surplus and input use in Kenya. A selectivity model was used that accounts for the effects of transactions costs, assets, technology, and support services in promoting input use and generating a marketable surplus. Output supply and input demand responses to changes in transactions costs and price and non-price factors were estimated and decomposed into market entry and intensity. The results showed that while transactions costs indeed have significant negative effects on market participation, institutional innovations—such as group marketing—are also emerging to mitigate the costs of accessing markets. Output price has no effect on output market entry and only provides incentives for increased supply by sellers. On the other hand, both price and non-price factors have significant influence on adoption and intensity of input use. Overall, the findings suggest that policy options are available other than price policies to promote input use and marketed surplus. The paper concludes with implications for policy to induce greater input–output market participation among smallholders in Africa.

Keywords: commercialization; Kenya; Africa

53. Smallholder soybean farmers' supply response in northern Nigeria.

Ojiako, I. A., Manyong, V., & Ikpi, A (2008). Smallholder soybean farmers' supply response in northern Nigeria. *Journal of Agricultural and Food Economics*, 3(1–2), 43–53. <https://biblio1.iita.org/handle/20.500.12478/3448?show=full>

The supply response of the smallholder soybean growers was investigated using a sample of 307 farmers randomly-selected from Jive villages in Kaduna and Kano States of Nigeria. Different multivariate functional forms were experimented but the power Junction was chosen because of its obvious unique characteristics. The response of the farmers' marketed surplus is positive and significant to changes in cultivated area, own farm-gate price and physical yield of soybean but negative and significant to changes in price of beans. The degree of responsiveness is elastic for farmland area (1.7), physical yield (1.8) and cross-price of beans (1.6) and inelastic own-price of soybean (0.9). The study the need for promoting commercial rather than subsistence soybean farming and recommends policies capable of fostering increases in yield, more access to farmland, and creating price incentives for farmers since soybean production is market-driven.

54. Sustainable inclusion of smallholders in the emerging high quality cassava flour value chains in Africa: Challenges for agricultural extension services

Adebayo, K., Abayomi, L., Abass, A., Dziedzoave, N, Forsythe, L., Hillocks, R. J., Gensi, R, Gibson, R., Graffham, A. J., Ilona, P., Kleih, U. K., Lamboll, R. I., Mahende, G, Martin, A. M., Onumah, G. E., Orr, A. W., Posthumus, H., Sanni, L. O, Sandifolo, V, & Westby, A. (2010). Sustainable inclusion of smallholders in the emerging high quality cassava flour value chains in Africa: Challenges for agricultural extension services. *Journal of Agricultural Extension*, 14(1), 1–10. <https://doi.org/10.4314/jae.v14i1.64062>

Based on the premise that smallholders often get excluded as markets become more commercial, this paper draws lessons from the Cassava: Adding Value for Africa (C:AVA) Project by exploring the main issues and challenges facing extension service partners in five African countries (Nigeria, Ghana, Tanzania, Uganda and Malawi). These lessons include issues around competitiveness in the supply of raw material, assisting smallholders to produce value-added products competitively, working with a range of partners at different stages in the value chain to take pilot studies to scale, ensuring and maintaining quality, selecting appropriate technologies for different circumstances, anticipating negative effects of the market environment on smallholders and ensuring that strategies for ensuring benefits for women and other disadvantaged groups are incorporated into extension service operations. It concluded that one strategy does not work in all countries and, while positive government support for cassava development is helpful, the real challenge is in the need to target markets according to realizable capacities of the smallholder actors in the value chain.

55. The economics of post-harvest loss and loss-preventing technologies in developing countries

Ricker-Gilbert, J., Omotilewa, O., & Kado, D. (2022). The economics of post-harvest loss and loss-preventing technologies in developing countries. *Annual Review of Resource Economics*, 14(1), 243–265. <https://doi.org/10.1146/annurev-resource-111820-020601>

This article reviews the recent literature that has evaluated the effectiveness of post-harvest loss (PHL)-reducing technologies for grains among smallholder farmers and small-scale traders in sub-Saharan Africa. We also develop a conceptual framework for identifying and quantifying different types of PHL that include physical quantity losses along with quality losses that are both observable (e.g., discoloration, insect damage, mold growth, and odor) and unobservable (e.g., aflatoxin contamination, chemical residues, and nutrient content losses). The framework considers how PHL affects producers, consumers, and society as a whole. We find that although reducing post-harvest quantity losses often receives more attention from researchers, it is the loss of quality, particularly unobservable quality issues, that has a large effect on food safety and nutrition. A review of the literature suggests that cost-effective technologies to reduce PHL exist, but facilitating their adoption requires action from both the public and private sectors.

56. The role of smallholder bean farmers in determining farm gate prices for beans in Uganda

Jjagwe, G., Kibwika, P., Mazur, R., & Sseguya, H. (2022). The role of smallholder bean farmers in determining farm gate prices for beans in Uganda. *Agriculture & Food Security*, 11(1), 45. <https://doi.org/10.1186/s40066-022-00380-7>

Background: Like for other agricultural commodities, the bean value chain involves a series of actors including; farmers as producers, middlemen, retailers, wholesalers and exporters. The study explains the common bean (*Phaseolus vulgaris*) marketing constraints faced by smallholder bean farmers and other actors in the bean value market chain that need redress for efficient and effective bean marketing in Uganda. Specifically, the effect of farmer bean production and marketing modes, and limited knowledge about bean market requirements on the final prices received for their beans and their limited ability to demand better prices is explained by the study. A descriptive cross-sectional design was used to collect data from 127 farmers (in strata of trained and non-trained farmers), 34 traders, five input dealers and 40 consumers, using semi structured questionnaires, and interview guides. Quantitative and qualitative data were analyzed using SPSS and content analysis, respectively.

Results: Trained farmers produced more beans in the two seasons though the mean difference was not statistically significant from the non-trained farmers. Farmers determine the quantity of beans sold and not the prices. Both trained and non-trained farmers consider the price offered by traders through consultations. Most farmers individually sold their beans with little role in determining prices. Farmers formed groups to better access inputs and improve their bargaining power. Variety, price and quality influenced consumer purchase decisions. NABE 15 K132, NABE4, Yellow and white beans were preferred varieties. Trained farmers sold beans at a higher price of USD 0.505 per kilo gram, while non-trained farmers sold at USD 0.369 per kilo gram. The records kept by majority of the farmers pertain either to dates particular activities were executed or when they received visitors, and could neither be used in determining the bean prices nor costing production.

Conclusions: The constraints faced by the different bean actors provide a basis for developing bean marketing models. Addressing smallholders' marketing challenges will increase their incomes and boost production. Increase in income through increased prices for farmers will improve farmer living standards as they will be able to meet basic needs. The quantity increase in production will partly address the food insecurity problems through direct consumption and selling the excess to buy other desired foods.

57. Understanding market participation choices and decisions of maize and cowpea farmers in northern Nigeria

Mignouna, D., Abdoulaye, T., Akinola, A., Kamara, A., & Oluoch, M. (2016). Understanding market participation choices and decisions of maize and cowpea farmers in northern Nigeria. *Tropicultura*, 34(1), 26–39. <https://hdl.handle.net/10568/76355>

Alleviating poverty and reducing food insecurity have received close critical attention from many researchers in sub-Saharan Africa. Farmers' participation in agricultural markets has been seen as a potent strategy for improving their livelihoods. This paper applies econometrics to farm survey data from Bauchi and Kano states as major maize and cowpea growing areas hit by one of the most important root parasites known as *Striga* to determine the factors behind farmers' decisions about participation in the agricultural market and the volume of their output to be marketed. Relevant data was collected from 600 households in both states and results from the Double-Hurdle model indicated that price and non-price constraints played significant roles in determining decisions on participation in the markets for both maize and cowpea. Household and total farm sizes, price and ease of transportation through access to motorized equipment were positively related to decision to participate in the maize market. However, the volume of sale of traded produce was influenced by location-specific variable which underscores socio-economic and population-related factors favoring market access that are present more in Kano than in Bauchi. Age of the household head and total farm size were significantly related to decision to participate in the cowpea market while results of the second stage of the model indicate that access to mobile phone and location variable affect positively the volume of cowpea sold. The role of price was conspicuous in both produce markets as the main incentive for households' participation. The paper concludes with policy implications aimed at providing better market opportunities to farmers thereby improving their welfare in northern Nigeria and other areas with similar socio-economic and bio-physical conditions in West Africa.

58. Upscaling cassava processing machines and products in Liberia

Awoyale, W., Asiedu, R., Kawalawu, W. K, Kolawole, P., Diallo, T. A., Edet, M., & Adetunji, M(2020). Upscaling cassava processing machines and products in Liberia. *Croatian Journal of Food Science and Technology*, 12(1), 1–7. <https://doi.org/10.17508/cjfst.2020.12.1.04>

Cassava is produced by more than 80% of farming households and is an important contributor to gross domestic product (GDP) in Liberia. It is therefore important to assess the status of cassava processing into food and other products. A total of one hundred and sixty (160) well-structured questionnaires were used for the collection of information from eight counties, with twenty respondents from each county. It was found out that all the counties lack adequate modern cassava processing machines, with almost all cassava processing operations being done with rudimentary equipment. Gari and wet fufu are common products in Liberian markets, with no high-quality cassava flour (HQCF) or derivatives. Consequently, user and gender friendly processing machines were installed in six established modern cassava processing centers, and new cassava products, such as fufu powder, tapioca, and HQCF with its value-added products (10% bread and pastries), were introduced. This upscaling will enhance the cassava value chain in Liberia with improvement in livelihoods, especially for vulnerable women and unemployed youth.

Keywords: Liberia, cassava products, processing machines, livelihood, vulnerable group

Innovation platforms and policy advocacy (51)

1. A multi-level and multi-actor approach to risk governance: a conceptual framework to support policy development for *Ambrosia* weed control

Lansink, A. O., Schut, M., Kamanda, J., & Klerkx, L. (2018). A multi-level and multi-actor approach to risk governance: A conceptual framework to support policy development for *Ambrosia* weed control. *Journal of Risk Research*, 21(6), 780–799. <https://doi.org/10.1080/13669877.2016.1247376>

Invasive species such as *Ambrosia* (an annual weed) pose a biosecurity risk whose management depends on the knowledge, attitudes and practices of many stakeholders. It can therefore be considered a complex policy and risk governance problem. Complex policy problems are characterized by high uncertainty, multiple dimensions, interactions across different spatial and policy levels, and the involvement of a multitude of actors and organizations. This paper provides a conceptual framework for analyzing the multi-level and multi-actor dimensions of *Ambrosia* management. Potential and existing public, private and public–private management strategies are identified to address the interests and needs of different actor groups across different levels. We conclude that policies that promote a mix of public and private *Ambrosia* management strategies may respond better to the needs and interests of different actor groups across different levels than a one-size-fits-all approach. However, multiple policy strategies need to be aligned in order to lead to synergies and spreading coherent messages to the public. Collaboration may enhance the likelihood of biosecurity management and risk governance of *Ambrosia* being adequately implemented and enforced.

Keywords: common ragweed, innovation, multi-scale, participatory policy development, public–private partnerships

2. A review of policy acts and initiatives in plantain and banana innovation system in Nigeria

Faturoti, B., Madukwe, M. C., Tenkouano, A., & Agwu, A. E (2007). A review of policy acts and initiatives in plantain and banana innovation system in Nigeria. *African Journal of Biotechnology*, 6(20), 2297–2302. <https://doi.org/10.5897/AJB2007.000-2359>

Plantain and banana are among the most important staple food crops in humid forest zone of West and Central Africa. These has made the crop one of the key research mandates of International and national research institutes, both of which has developed many technologies aimed at improving the production of the crop and removing constraints posed by pest and diseases, marketing opportunities and perishability. Despite these efforts and research breakthrough the production of the crops has been on consistent downward trend in recent years. A ten years (1996–2005) production figure of the crops showed that land under plantain and banana production increased by 24.6% while yield reduction of 21.8% was recorded during the same period. This abysmal trend prompted a 40 years (1967–2006) review of policy

acts and initiatives on the crops, with an examination of various efforts in the areas of research, dissemination, utilization, production and marketing. Seven gaps of critical implications to production and commercialization were identified; these include government nonintervention, marketing and constraints to production, weak/fragile links among stakeholders, research-farmers dichotomy, project sustainability, lack of documentation and funding. Linkages among stakeholders were generally weak and without cohesion, objectives were at variance and unhealthy. The study concluded that stakeholder's cohesion and coordination of efforts is needed for increased production and commercialization. Also governmental intervention is needed in the areas of policy initiatives and acts that will go beyond the ad-hoc response which are usually triggered by natural disaster such as pest and diseases as is the case with black Sigatoka outbreak in mid 80s which was the only period government really intervened in plantain and banana production in Nigeria.

Keywords: plantain and banana, policy acts, initiatives, stakeholders

3. An innovation capacity analysis to identify strategies for improving plantain and banana (*Musa spp.*) productivity and value addition in the Democratic Republic of Congo

Mobambo, P, Staver, C., Hauser, S., Dhed'a, D. B, & Vangu, G (2010). An innovation capacity analysis to identify strategies for improving plantain and banana (*Musa spp.*) productivity and value addition in the Democratic Republic of Congo. *Acta Horticulturae*, 879, 821–828. <https://doi.org/10.17660/ActaHortic.2010.879.90>

The agricultural sector of the Democratic Republic of Congo continues to suffer from declining productivity after a decade of civil unrest and underinvestment. Plantain and banana (*Musa spp.*) are considered the second most important staple crop after cassava (*Manihot esculenta*). The Congo basin is a secondary center of plantain diversity in the world. The area planted with plantain/banana declined from over 400,000 ha in the early 90s to less than 150,000 ha presently. Yields are low and declining and plantain become too expensive for poor urban households. There are numerous political, economic, social and technological constraints to increase the contribution of banana and plantain to household, community and the national economy. A number of priorities for action were identified: (a) simple and low cost strategies to estimate production and planted areas and the extent of serious pest and disease threats to guide investment in areas with the greatest impact; (b) mapping of production potential based on soils, climate and water sources and ease of market access to prioritize investment in intensification; (c) piloting of clean seed systems to contain the spread and impact of *Banana bunchy top virus*, and *Xanthomonas* wilt, to multiply highly productive clones of preferred cultivars and to conserve plantain diversity; (d) technology for land productivity stabilization and improvement, depending on access to infrastructure and natural resource quality; (e) improving field access to information on new technologies to farmers and their associations, public extension and non-governmental organizations and rural school teachers; and (f) farmer and village marketing organizations to capture greater value from plantain and banana markets where clean seed and improved land productivity are piloted.

Keywords: *Musa* sector, multi-stakeholder, productivity

4. Analysing the prospect of the IAR4D's innovation platforms in improving the productive efficiencies of cereal-legume farmers in the Sudan Savanna of Nigeria

Olarinde, L, Abdoulaye, T., Kamara, A., Binam, J. N., & Adekunle, A. (2010). Analysing the prospect of the IAR4D's innovation platforms in improving the productive efficiencies of cereal-legume farmers in the Sudan Savanna of Nigeria. *Journal of Food, Agriculture and Environment*, 8(2), 813–820.

This paper analyzed the baseline productive efficiencies of the cereal legume farmers in the Sudan Savanna of Nigeria. The paper also investigated the factors that affected the technical efficiency of the sampled farmers. Baseline data collected on cereal-legume farmers who belong to four Innovation Platforms were used for analysis. Results showed that sorghum-legume farmers obtained higher crop output, which is higher than the average for the total sample. There is decreasing return-to-scale in farming operations in the study area, however, unit increases in cultivated area, seed use and fertilizer/chemical application will improve the output by 17%, 20% and 29%, respectively. The mean technical efficiencies for the maize-legume, sorghum-legume farmers and for the pooled sample were found to be 85%, 74% and 79%, respectively. The frequencies of occurrence of the predicted technical efficiencies indicate that the highest number of farmers (for the total sample) have technical efficiencies between 80% and 90%. The sample frequency distribution indicates a clustering of technical efficiencies in the region of 0.8-0.9 efficiency range, implying that the farmers are fairly efficient. Given the variation in the level of technical efficiency, there appears to be considerable room for effecting improvements in the technical efficiencies of the farmers in the study area. Factors influencing technical inefficiency of farmers in the study area are age of farmers, farming experience, credit access, extension contact and interaction with other farmers and farmer groups, implying that being an IP member will help improve productive efficiencies. The results of this study have clearly demonstrated that almost all the hypothesized factors affecting the productive efficiencies of the sampled farmers are significant; an improvement in farmer productivity will be recorded if a reinforcement of the IP activities that are aligned with the findings here is ensured. This will increase the potential of the IAR4D to help in improving the productive efficiencies of the farmers, which is one of its key objectives.

5. Assessing the performance of innovation platforms in crop-livestock agro-ecosystems in the Volta basin

Augustine, A. A., Kees, S., Hubert, S., & Pamela, P. (2016). Assessing the performance of innovation platforms in crop-livestock agro-ecosystems in the Volta basin. *African Journal of Agricultural Research*, 11(33), 3141–3153. <https://doi.org/10.5897/AJAR2016.11147>

To enhance integrated rainwater management in crop-livestock systems in the Volta basin of Burkina Faso, innovation platforms (IP) comprising of multiple stakeholders were established in the districts of Koubri and Ouahigouya. Quarterly IP meetings were organized to collectively identify and prioritize constraints and opportunities, and to design and implement strategies to address them. IP represents an example of putting the agricultural innovations systems'

perspective into practice. Several studies have evaluated the performance of IPs, but these are often based on external (mainly qualitative) assessments during mid-term and/or end evaluation. In this study we are interested in how key processes develop over time and how this is perceived by participants themselves, since this determines the participation and commitment of stakeholders and hence the success of the IP. To ensure adequate documentation of IP processes and activities, several monitoring and evaluation tools were developed. This paper focuses on the assessment of the IP performance in terms of consistency of participation across meetings and stakeholder groups, relevance of identified issues, information exchange, conflict resolution, participation in decision making, facilitation, and perceived benefits. For all the indicators used to assess the IP, the mean scores tended to increase with the lifespan of the IPs. This reaffirms that the IP is perceived as valuable by its members as a way to enhance agricultural development. At the same time though an IP is not a “quick-win”, but takes time to mature for it to become fully functional and achieve desired outcomes.

Keywords: agricultural development, innovation systems, crop-livestock systems, social learning, Volta basin

6. Attitudes toward risk among maize farmers in the dry savanna zone of Nigeria: some prospective policies for improving food production

Olarinde, L, Manyong, V., & Akintola, J. (2007). Attitudes toward risk among maize farmers in the dry savanna zone of Nigeria: some prospective policies for improving food production. *African Journal of Agricultural Research*, 2(8), 399–408. <http://www.academicjournals.org/AJAR>

This paper applies econometric analyses to quantitatively determine the individual risk attitudes of sampled maize farmers in the dry savanna zone of Nigeria. The extent of the risk attitudes are then made the basis for categorizing the farmers into three groups of low, intermediate and high risk averse maize farmers. This categorization now forms a necessary condition for improving the typology of the farmers, which is hypothesized to be influenced by socio-economic, demographic and other extrinsic “risk factor”. The typology is essentially made possible by discriminant analyses, which re-categorized the farmers into their appropriate risk groups. A four-stage sampling technique leading to the selection of a final sample of about 350 maize farmers was adopted. Results show that, about 8, 42% and 50% of the farmers are respectively lowly, intermediately and highly averse to maize risk. About 72% of the hypothesized variables were found to be responsible for the risk aversion among the sampled farmers. These variables are the basis of policy recommendation to address issues generated by four types of risks identified in maize production namely natural, social, economic and technical risks. These are important for harnessing crop technology and to alleviate hunger and poverty in Africa.

Keywords: risk attitudes and factors, dry savanna, Nigeria, econometric and discriminant analyses, crop technology

7. Blending “hard” and “soft” science: the “Follow-the-Technology” approach to analyzing and evaluating technology change

Douthwaite, B., De Haan, N., Manyong, V., & Keatinge, J. (2001). Blending “hard” and “soft” science: the “Follow-the-Technology” approach to analyzing and evaluating technology change. *Conservation Ecology*, 5(2), 13. <http://dx.doi.org/10.5751/ES-00335-050213>

The types of technology change catalyzed by research interventions in integrated natural resource management (INRM) are likely to require much more social negotiation and adaptation than are changes related to plant breeding, the dominant discipline within the system of the Consultative Group on International Agricultural Research (CGIAR). Conceptual models for developing and delivering high-yielding varieties have proven inadequate for delivering natural resource management (NRM) technologies that are adopted in farmers’ fields. Successful INRM requires tools and approaches that can blend the technical with the social, so that people from different disciplines and social backgrounds can effectively work and communicate with each other. This paper develops the “follow-the-technology” (FTT) approach to catalyzing, managing, and evaluating rural technology change as a framework that both “hard” and “soft” scientists can work with. To deal with complexity, INRM needs ways of working that are adaptive and flexible. The FTT approach uses technology as the entry point into a complex situation to determine what is important. In this way, it narrows the research arena to achievable boundaries. The methodology can also be used to catalyze technology change, both within and outside agriculture. The FTT approach can make it possible to channel the innovative potential of local people that is necessary in INRM to “scale up” from the pilot site to the landscape. The FTT approach is built on an analogy between technology change and Darwinian evolution, specifically between “learning selection” and natural selection. In learning selection, stakeholders experiment with a new technology and carry out the evolutionary roles of novelty generation, selection, and promulgation. The motivation to participate is a “plausible promise” made by the R&D team to solve a real farming problem. Case studies are presented from a spectrum of technologies to show that repeated learning selection cycles can result in an improvement in the performance of the plausible promise through adaptation and a sense of ownership by the stakeholders.

Keywords: actor-oriented approach, follow-the-technology approach, integrated natural resource management, learning selection approach, participatory technology development, social construction of technology

8. Can innovation platforms (IPs) improve rural women participation in maize value chain? Evidence from the eastern DR Congo

Mumbeya, P. N., Matungula, P. K., Masuki, K. K., Schut, M., & Okafor, C. (2020). Can innovation platforms (IPs) improve rural women participation in maize value chain? Evidence from the eastern DR Congo. *European Journal of Agriculture and Food Sciences*, 2(3). <https://doi.org/10.24018/ejfood.2020.2.3.16>

This study explored the potential of the Innovation Platform approach, in improving the participation of rural female farmers in Maize value chain. It intends to identify the peculiarities, in terms of challenges and opportunities related to its application to the rural women realities. The study collected data from 120 small scale maize producers in South Kivu province of the Democratic Republic of Congo (DRC) from 2015 to 2017, using individual interview and focus group discussion (FGD) for data confirmation. Data was analyzed using the Average Effect of Treatment of treated (ATT) and the propensity matching score to assess the effect of IP approach on rural women, who were randomly selected to participate in an innovation platform composed solely of women (100%) against those participating in a mixed innovation platform, made of 70% of men. The results show that the Innovation platform approach allowed women to address their basic challenges and improve their participation in the maize value chain. Average individual income from participation to the Innovation Platform increased from \$ 100 to \$ 300 per cropping season and the average earning of a women in a platform made of women solely was \$552.6 higher than that of women participating in mixed platform \$432.4. We hypothesized that the main benefits from the female IP would be increased maize yields. However, the analysis shows that although yield increased, the main effect was due to improved market access provided by the IP.” The implementation of the innovation platform process encountered several challenges, in particular: building a consensus when the interests of the groups in place have proven to be divergent, the barrier of social consideration (social stereotype), inability of smallholder’s farmers to learn quickly and fully play expected role, the traditional culture of learning, visioning the process. Despite these challenges, IPs offered small-scale maize producers many technical, organizational and material opportunities, including income generation, access to inputs and to lucrative markets, acquisition of diversified knowledge and skills, ability to work in a commercial environment, benefiting from the services of experts, accessing new sources of financing, they could not benefit otherwise. These findings imply that to be effective for rural women, an innovation platform should include individuals with no wide social disparity and diversify the sources of income, including livestock and others off farm activities

9. Can smallholder farmers adapt to climate variability, and how effective are policy interventions? Agent-based simulation results for Ethiopia

Berger, T., Troost, C., Wossen, T., Latynskiy, E., Tesfaye, K., & Gbegbelegbe, S. (2017). Can smallholder farmers adapt to climate variability, and how effective are policy interventions? Agent-based simulation results for Ethiopia. *Agricultural Economics*, 48(6), 693–706. <https://doi.org/10.1111/agec.12367>

Climate variability with unexpected droughts and floods causes serious production losses and worsens food security, especially in Sub-Saharan Africa. This study applies stochastic bioeconomic modeling to analyze smallholder adaptation to climate and price variability in Ethiopia. It uses the agent-based simulation package Mathematical Programming-based Multi-Agent Systems (MPMAS) to capture nonseparable production and consumption decisions at household level, considering livestock and eucalyptus sales for consumption

smoothing, as well as farmer responses to policy interventions. We find the promotion of new maize and wheat varieties to be an effective adaptation option, on average, especially when accompanied by policy interventions such as credit and fertilizer subsidy. We also find that the effectiveness of available adaptation options is quite different across the heterogeneous smallholder population in Ethiopia. This implies that policy assessments based on average farm households may mislead policy makers to adhere to interventions that are beneficial on average albeit ineffective in addressing the particular needs of poor and food insecure farmers.

Keywords: climate variability, droughts, food security, stochastic bioeconomic, sub-Saharan Africa, Ethiopia

10. Compositional dynamics of multilevel innovation platforms in agricultural research for development

Lamers, D., Schut, M., Klerkx, L., & van Asten, P. (2017). Compositional dynamics of multilevel innovation platforms in agricultural research for development. *Science and Public Policy*, 44(6), 739–752. <https://doi.org/10.1093/scipol/scx009>

Innovation platforms (IPs) form a popular vehicle in agricultural research for development (AR4D) to facilitate stakeholder interaction, agenda setting, and collective action toward sustainable agricultural development. In this article, we analyze multilevel stakeholder engagement in fulfilling seven key innovation system functions. Data are gathered from experiences with interlinked community and (sub)national IPs established under a global AR4D program aimed at stimulating sustainable agricultural development in Central Africa. Our findings show that all innovation systems functions required multilevel action, but that fulfillment of specific functions demands for strategic involvement of specific stakeholders at specific levels. We observed that a research- and dissemination-oriented sequence in the functions was prioritized in AR4D IPs and argue that such a sequence may be different in other types of (business) IPs. Our findings provide an incentive to think function oriented about compositional dynamics (stakeholder groups * levels) in innovation processes, rather than striving for equal stakeholder participation.

Keywords: technology transfer, data analysis, inclusive innovation, innovation systems, systemic instruments, transdisciplinary science, multilevel action, innovation platforms

11. Determinants of cocoa farmer's participation in the innovation platform of the humid tropics programme in southwestern Nigeria

Akinmusola, O, Soyebó, K. O, Farinde, A. J, Amujoyegbe, B. J, Idrissou, L., Gaya, H., Fatunbi, O.*, & Ilesanmi, R. Y.* (2016). Determinants of cocoa farmer's participation in the innovation platform of the humid tropics programme in southwestern Nigeria. *International Journal of Environmental & Agriculture Research*, 2(11), 1–11. <https://cgspace.cgiar.org/handle/10568/78153>

In an effort to determine factors influencing cocoa farmer's participation in innovation platform (IP) activities of the humid tropics program, data was collected from purposively selected 177 farmers using multistage technique sampling technique and was gathered through the use of structured interview schedule. Data were collected and analyzed with percentage, frequency counts, mean, standard deviation and factor analysis. The study shows the mean age of the cocoa farmers in the IP to be 51.16 ± 12.64 with about 52% aged above 50 years, female were only (23.73%), with more than 75th percentile literacy level and only about 31% of respondents generate annual income from farming above ₦50,000 while about 70% made below ₦40,000 extra income from other occupation. The mean farm size was 16.87 ± 16.04 acre, farming experience 25.42 ± 10.48 years and household size was 9.78 ± 5.52 . The six significant determinants of cocoa farmer's participation in IP arranged in order of magnitude are psychological factor ($\lambda = 3.158$), experience factor ($\lambda = 2.164$), community related factor ($\lambda = 1.697$) educational factor ($\lambda = 1.854$), economic factor ($\lambda = 1.438$) and internal factor ($\lambda = 1.113$). The summative effect of the identified factors accounted for 76.17 % variation observed in cocoa farmer's participation in the IP.

Keywords: innovation platform, humid tropics program, cocoa farmers, participation determinants

12. Digital platforms for smallholder credit access: The mediation of trust for cooperation in maize value chain financing

Agyekumhene, C., de Vries, J. R., van Paassen, A., Macnaghten, P., Schut, M., & Bregt, A. (2018). Digital platforms for smallholder credit access: The mediation of trust for cooperation in maize value chain financing. *NJAS: Wageningen Journal of Life Sciences*, 86/87(1), 77–88. <https://doi.org/10.1016/j.njas.2018.06.001>

Maize production is of critical importance to smallholder farmers in Ghana. Various factors limit the productivity of smallholder maize farming systems undergirded by the lack of capital for critical investments both at the farm and at national policy levels. Using a value chain approach, this diagnostic study explains how a complex configuration of actor interaction within an institutionally and agro-ecologically challenged value chain leads to the enduring absence of maize farming credit support. We find a cycle of credit rationing resulting from value chain challenges such as agro-ecological uncertainties, inadequate GAPs training, weak farmer groups and market insecurity. This condition is sustained by an interplay between mistrust, insufficient information across the value chain and inadequate control strategies in the maize credit system. We argue that Digital Platforms (DPs) show potential to help overcome some information and communication gaps and related uncertainties that impede traditional value chain credit arrangements. This is promising in terms of aiding awareness and coordinated responsiveness to agro-ecological farm conditions and the development of farming records databases. Thus, DPs could generate new networks and forms of cooperation in the maize value chain in this regard. As a tool for mediating trust in value chain credit cooperation, strategic use of these DP contributions could help initiate an entry point for recalibration of trust perceptions. Significant considerations and improvements are however needed to harness DPs effectively in mediating trust for maize credit provision, not least being farmer digital inclusion

in DP implementation, effective intermediation and network governance arrangements and digital contributions toward cost-effective agro-ecological controls in the erratic maize farming context. This approach to trust building should therefore not be viewed as a quick fix but as a process of trial and error, and learning by doing.

Keywords: trust, networks, ICT, agriculture finance, digital agriculture, Ghana

13. Do mature innovation platforms make a difference in agricultural research for development? A meta-analysis of case studies

Schut, M., Cadilhon, J.-J., Misiko, M., & Dror, I. (2018). Do mature innovation platforms make a difference in agricultural research for development? A meta-analysis of case studies. *Experimental Agriculture*, 54(1), 96–119. <https://doi.org/10.1017/S0014479716000752>

Innovation Platforms (IPs) have become a popular vehicle in agricultural research for development (AR4D). The IP promise is that integrating scientific and local knowledge results in innovations that can have impact at scale. Many studies have uncovered how IPs work in various countries, value chains and themes. The conclusion is clear: IPs generate enthusiasm and can bring together stakeholders to effectively address specific problems and achieve 'local' impact. However, few studies focus on 'mature' IPs and whether or not these achieve impact at a 'higher' scale: address systems trade-offs to guide decision making, focus on integration of multiple commodities, reach a large number of beneficiaries and learn from their failures. This study evaluates the impact of mature IPs in AR4D by analyzing the success factors of eight case studies across three continents. Although we found pockets of IP success and impact, these were rarely achieved at scale. We therefore critically question the use of IPs as a technology dissemination and scaling mechanism in AR4D programs that aim to benefit the livelihoods of many farmers in developing countries. Nevertheless, we do find that IPs can fulfill an important role in AR4D. If the IP processes are truly demand-driven, participatory and based on collective investment and action, they have the ability to bring together committed stakeholders, and result in innovations that are technically sound, locally adapted, economically feasible for farmers, and socially, culturally and politically acceptable. Several of our cases show that if these IPs are firmly embedded in other public and private extension mechanisms and networks, they can allow the technologies or other types of innovations to scale out beyond the original IP scope, geographical focus or target audience. We see a need for more rigorous, accurate and continuous measurement of IP performance which can contribute to adaptive management of IPs, better understanding of 'what works' in terms of process design and facilitation, as well as to cost-benefit analysis of IPs as compared to other approaches that aim to contribute to agricultural development.

14. Eco-efficiency and agricultural innovation systems in developing countries: Evidence from macro-level analysis

Grovermann, C., Wossen, T., Muller, A., & Nichterlein, K. (2019). Eco-efficiency and agricultural innovation systems in developing countries: Evidence from macro-level analysis. *PLOS ONE*, 14(4), e0214115. <https://doi.org/10.1371/journal.pone.0214115>

Agricultural innovation is an essential component in the transition to more sustainable and resilient farming systems across the world. Innovations generally emerge from collective intelligence and action, but innovation systems are often poorly understood. This study explores the properties of innovation systems and their contribution to increased eco-efficiency in agriculture. Using aggregate data and econometric methods, the eco-efficiency of 79 countries was computed and a range of factors relating to research, extension, business and policy was examined. Despite data limitations, the analysis produced some interesting insights. For instance public research spending has a positive significant effect for emerging economies, while no statistically significant effect was found for foreign aid for research. However, foreign aid for extension is important in less developed economies. These and other results suggest the importance of context-specific interventions rather than a “one size fits all” approach. Overall, the analysis illustrated the potential of a macro-level diagnostic approach for assessing the role of innovation systems for sustainability in agriculture.

15. Effect of ICT tools attributes in accessing technical, market and financial information among youth dairy agripreneurs in Tanzania

Okello, D. O., Feleke, S., Gathungu, E., Owuor, G., & Ayuya, O. I. (2020). Effect of ICT tools attributes in accessing technical, market and financial information among youth dairy agripreneurs in Tanzania. *Cogent Food & Agriculture*, 6(1). www.tandfonline.com/doi/abs/10.1080/23311932.2020.1817287

The purpose of this article is to determine the effect of Information and communications technology (ICT) tools' attributes in accessing technical, market and financial information among youthful dairy agripreneurs in Arumeru District, Tanzania. Data were collected through a standardized questionnaire from 347 farming households. Descriptive statistics and multivariate probit regression were used to analyze the data. The results of the study show that utilization of the various ICT tools (mobile phone, television (TV) and radio) is interrelated, whereas several factors, including extension contacts, installation of electricity, level of buyer trust, availability of market information and receiving of remittances, are found to affect the probability of ICT use. Findings also reveal that complementarity, accessibility, relevance and timeliness had a positive effect on ICT use, while the feedback attribute had a negative influence on ICT use. This finding underscores the need to consider ICT tools' attributes when designing a sustainable ICT-based information delivery model for dairy youth agripreneurs. An understanding of actual users' preference for ICT attributes can provide a blueprint for the ongoing ICT-based public- and private-sector initiatives that target youth-users more effectively.

Keywords: attributes, youth, dairy agripreneurs, information communication technology, Arumeru

16. Effects of multi-stakeholder platforms on multi-stakeholder innovation networks: Implications for research for development interventions targeting innovations at scale

Sartas, M., Schut, M., Hermans, F., Asten, P. van, & Leeuwis, C. (2018). Effects of multi-stakeholder platforms on multi-stakeholder innovation networks: Implications for research

for development interventions targeting innovations at scale. *PLOS ONE*, 13(6), e0197993. <https://doi.org/10.1371/journal.pone.0197993>

Multi-stakeholder platforms (MSPs) have been playing an increasing role in interventions aiming to generate and scale innovations in agricultural systems. However, the contribution of MSPs in achieving innovations and scaling has been varied, and many factors have been reported to be important for their performance. This paper aims to provide evidence on the contribution of MSPs to innovation and scaling by focusing on three developing country cases in Burundi, Democratic Republic of Congo, and Rwanda. Through social network analysis and logistic models, the paper studies the changes in the characteristics of multi-stakeholder innovation networks targeted by MSPs and identifies factors that play significant roles in triggering these changes. The results demonstrate that MSPs do not necessarily expand and decentralize innovation networks but can lead to contraction and centralization in the initial years of implementation. They show that some of the intended next users of interventions with MSPs – local-level actors – left the innovation networks, whereas the lead organization controlling resource allocation in the MSPs substantially increased its centrality. They also indicate that not all the factors of change in innovation networks are country specific. Initial conditions of innovation networks and funding provided by the MSPs are common factors explaining changes in innovation networks across countries and across different network functions. The study argues that investigating multi-stakeholder innovation network characteristics targeted by the MSP using a network approach in early implementation can contribute to better performance in generating and scaling innovations, and that funding can be an effective implementation tool in developing country contexts.

17. Estimating multidimensional poverty among cassava producers in Nigeria: patterns and socioeconomic determinants

Olarinde, L. O., Abass, A. B., Abdoulaye, T., Adepoju, A. A., Fanifosi, E. G., Adio, M. O., Adeniyi, O. A., & Wasiu, A. (2020). Estimating multidimensional poverty among cassava producers in Nigeria: Patterns and socioeconomic determinants. *Sustainability*, 12(13), 5366. <https://doi.org/10.3390/su12135366>

The scourge of poverty, including its correlates, has been witnessing an incremental sequence over the years in Nigeria despite the natural endowment of the country. Efforts by various stakeholders to address this problem have not yielded tangible results. Using cross-sectional data collected in 2015 on 775 cassava farmers spread across four geographical zones, this study estimates multidimensional poverty of cassava producers in Nigeria. This is to determine the factors responsible for poverty increase and contribution(s) of these factors to poverty. The study found that about 74% of the respondents were multidimensionally poor. Assets and public/housing utility were the main contributors to aggregate multidimensional poverty index (MPI), while education and health contributed most to poverty reduction. The results also showed major contributing indicators to MPI to be formal employment, school enrolment, years of schooling, frequency of hospital visits, and household assets' ownership. The South-east

zone of Nigeria had the highest adjusted headcount of poverty among cassava producers. The estimated coefficient of age, farming experience, years of schooling, household size, and access to informal credit were significant determinants of poverty in the study area. In conclusion, the results suggest that although Nigeria is a federation of more than 30 states that continue to rely on nation-wide policy initiatives of the central government, policies on cassava aiming to lift millions of people out of poverty should instead vary according to the peculiar poverty dimensions of each federation unit. We suggest reform in the agriculture sector that will emphasize facilitation and access to incentives (credits, training, extension, cooperate system, etc.) by younger farmers to engage in modern cassava farming, thereby, enhancing the chances of rural cassava growers to move out of poverty.

Keywords: multidimensional poverty index, cassava, intensity of poverty, young farmers, Nigeria

18. Extension agents' perception of participatory agricultural extension approaches adopted by Agricultural Development Programme (ADP) in Ondo State Nigeria

Ajayi, M. T, & Okafor, C. (2006). Extension agents' perception of participatory agricultural extension approaches adopted by Agricultural Development Programme (ADP) in Ondo State Nigeria. *International Journal of Agricultural and Biological Sciences*, 4(1), 20–25. <https://hdl.handle.net/10568/91748>

With recent emphasis on participatory approaches, seeking the perception of those who implement extension programs will be useful for effective implementation approaches. The study assessed the perception of extension agents on adopted participatory agricultural extension approaches as against Training and Visit (T&V). Data were collected through the use of structured questionnaire from all the 47 extension agents purposely selected from Ondo Central zone of Agricultural Development Project, Ondo state, Nigeria.

Keywords: extension agents perception, participatory approaches, agricultural development program

19. Factors influencing participation dynamics in research for development interventions with multi-stakeholder platforms: a metric approach to studying stakeholder participation

Sartas, M., Van Asten, P., Schut, M., McCampbell, M., Awori, M., Muchunguzi, P., Tenywa, M, Namazzi, S., Sole-Amat, A., Proietti, C., Devaux, A., & Leeuwis, C. (2019). Factors influencing participation dynamics in research for development interventions with multi-stakeholder platforms: A metric approach to studying stakeholder participation. *PLOS ONE*, 14(11), e0223044. <https://doi.org/10.1371/journal.pone.0223044>

Multi-stakeholder platforms have become mainstream in projects, programs and policy interventions aiming to improve innovation and livelihoods systems, i.e. research for development

interventions in low- and middle-income contexts. However, the evidence for multi-stakeholder platforms' contribution to the performance of research for development interventions and their added value is not compelling. This paper focuses on stakeholder participation as one of the channels for multi-stakeholder platforms' contribution to the performance of research for development interventions, i.e. stakeholder participation. It uses a quantitative approach and utilizes descriptive statistics and ARIMA models. It shows that, in three Ugandan multi-stakeholder platform cases studied, participation increased both in nominal and in unique terms. Moreover, participation was rather cyclical and fluctuated during the implementation of the research for development interventions. The study also shows that, in addition to locational and intervention factors such as type of the area along a rural–urban gradient targeted by the intervention and human resources provided for multi-stakeholder platform implementation, temporal elements such as phases of research for development intervention objectives and the innovation development process play significant roles in influencing participation. The study concludes that contribution of multi-stakeholder platforms to the performance of research for development projects, programs, policies and other initiatives is constrained by locational and temporal context and conditional on the participation requirements of the objectives pursued by research for development intervention.

20. How farmer videos trigger social learning to enhance innovation among smallholder rice farmers in Uganda

Karubanga, G., Kibwika, P., Okry, F., & Sseguya, H. (2017). How farmer videos trigger social learning to enhance innovation among smallholder rice farmers in Uganda. *Cogent Food & Agriculture*, 3(1), 1368105. <https://doi.org/10.1080/23311932.2017.1368105>

Information and Communication Technology (ICT) tools such as videos promoted to enhance farmer access to information to influence change in farming practices need to be situated in social learning processes. Farmers learn and innovate through social learning characterized by exchanges amongst farmers to contextualize knowledge and adapt technologies for relevance. This study assessed how a video-mediated extension approach (VMEA) triggers social learning to enhance innovation among rice farmers in Uganda using experiences of a Non-Government Organization, Sasakawa Global 2000 (SG 2000). A cross-sectional study was conducted among 100 farmers subjected to VMEA by SC 2000 in Kamwenge district. Semi-structured interviews, focus group discussions (FGDs), field observations and key informant interviews were used to collect the quantitative and qualitative data. Quantitative data were analyzed using Statistical Package for Social Sciences (SPSS) while thematic analysis was applied to the qualitative data. Results indicate that inherently, videos trigger conversational exchange between farmers including those who do not watch the videos. These interactions enable collective reflection, evaluation and validation of knowledge, which in turn motivate experimentation. In this study, videos significantly enhanced awareness, knowledge acquisition, uptake of technologies and innovation among rice farmers. However, the potential of videos in influencing farmer knowledge and behavioral change can be further exploited if the users can produce contextualized videos of farmer practices and innovations

for dissemination. Among other things, effective use of videos in extension requires excellent skills in facilitating social learning processes; and video documentation of farmer practices and innovations to aid scaling up and deepening learning.

Keywords: video-mediated extension approach, social learning, smallholder farmers, farmer innovation, rice, Uganda

21. Innovation intermediation in a digital age: Comparing public and private new-ICT platforms for agricultural extension in Ghana

Munthali, N., Leeuwis, C., van Paassen, A., Lie, R., Asare, R., van Lammeren, R., & Schut, M. (2018). Innovation intermediation in a digital age: Comparing public and private new-ICT platforms for agricultural extension in Ghana. *NJAS: Wageningen Journal of Life Sciences*, 86/87(1), 64–76. <https://doi.org/10.1016/j.njas.2018.05.001>

Agricultural extension in sub-Saharan Africa has often been criticised for its focus on linear knowledge transfer, and limited attention to systemic approaches to service delivery. Currently, the region is experiencing a new-ICT revolution and there are high expectations of new-ICTs to enhance interaction and information exchange in extension service delivery. Using an innovation systems perspective, we distinguish the roles demand-articulation, matching demand and supply, and innovation process management for innovation-intermediaries. The study explores literature on how new-ICT may support these roles, with specific interest in the possibilities of environmental monitoring and new forms of organization enabled by enhanced connectivity. In order to contribute to the understanding of this area, the paper reports on a comparative study of two new-ICT platforms embedded in Ghanaian public and private extension organizations respectively. We assess the roles that these platforms (aim to) support, and document achievements and constraints based on interviews with extension staff and farmers. The findings indicate that while both platforms aim to support innovation-intermediation roles the focus areas and level of detail differ due to diverging organizational rationales to service delivery. In addition, we see that new-ICTs' potential to support innovation-intermediation roles is far from realized. This is not due to (new) ICTs lacking the capacity to link people in new ways and make information accessible, but due to the wider social, organizational and institutional factors that define the realization of their potential. Therefore, more conventional modes of interaction around production advice and also credit provision continue to be dominant and better adapted to the situation. However, beyond the two platforms that were developed specifically by and for the extension organizations, there were indications that more informal and self-organized new-ICT initiatives can transform and enhance interaction patterns in innovations systems to achieve collective goals through standard virtual platforms such as WhatsApp and Telegram.

Keywords: information communication technology, ICT4D, ICT4Ag, agricultural extension, innovation intermediation

22. Innovation platforms and institutional change: the case of small-scale palm oil processing in Ghana

Adjei-Nsiah, S., & Klerkx, L. (2016). Innovation platforms and institutional change: the case of small-scale palm oil processing in Ghana. *Cahiers Agricultures*, 25(6), 65005. <https://doi.org/10.1051/cagri/2016046>

Oil palm is an important industrial, livelihood and food crop in Ghana. Smallholders produce the bulk of the palm fruits and small-scale processors, mainly women, produce most of the crude palm oil. Poor practices lead to a high proportion of free fatty acids in the crude palm oil and the processors thus cannot access remunerative national and international markets. Exploratory and diagnostic studies identified the absence of rules and regulations governing processing as a major factor. An innovation platform was convened and facilitated to remove the identified institutional constraints. Based on event tracing, this paper reports a study of the effects of the innovation platform's interventions and how these were achieved. Institutional entrepreneurs are shown to play important roles: they mobilised resources such as expertise, knowledge, access to information and high-level political power to influence small-scale processors to adopt alternative practices. The institutional changes observed are shown to arise in cooperation between traditional authorities (chiefs), the district legislature and authorities at the national level, who together institutionalized the experimental actions and processes taken in the study area. The institutional elements they most affected were: rules and regulations, the legitimacy of new practices and organizational arrangements, co-generation of knowledge, material resources, and the strategic and communication skills of key actors.

Keywords: oil palm, free fatty acids, smallholders, innovation platforms

23. Innovation platforms in agricultural research for development: ex-ante appraisal of the purposes and conditions under which innovation platforms can contribute to agricultural development outcomes

Schut, M., Kamanda, J., Gramzow, A., Dubois, T., Stoian, D., Andersson, J. A., Dror, I., Sartas, M., Mur, R., Kassam, S., Brouwer, H., Devaux, A., Velasco, C., Flor, R. J., Gummert, M., Buizer, D., McDOUGALL, C., Davis, K., Tui, S. H.-K., & Lundy, M. (2018). Innovation platforms in agricultural research for development: ex-ante appraisal of the purposes and conditions under which innovation platforms can contribute to agricultural development outcomes. *Experimental Agriculture*, 55(4), 575–596. <https://doi.org/10.1017/S0014479718000200>

Innovation platforms are fast becoming part of the mantra of agricultural research for development projects and programs. Their basic tenet is that stakeholders depend on one another to achieve agricultural development outcomes, and hence need a space where they can learn, negotiate and coordinate to overcome challenges and capture opportunities through a facilitated innovation process. Although much has been written on how to implement and facilitate innovation platforms efficiently, few studies support ex-ante appraisal of when

and for what purpose innovation platforms provide an appropriate mechanism for achieving development outcomes, and what kinds of human and financial resource investments and enabling environments are required. Without these insights, innovation platforms run the risk of being promoted as a panacea for all problems in the agricultural sector. This study makes clear that not all constraints will require innovation platforms and, if there is a simpler and cheaper alternative, that should be considered first. Based on the review of critical design principles and plausible outcomes of innovation platforms, this study provides a decision support tool for research, development and funding agencies that can enhance more critical thinking about the purposes and conditions under which innovation platforms can contribute to achieving agricultural development outcomes.

24. Innovation platforms: experiences with their institutional embedding in agricultural research for development

Schut, M., Klerkx, L., Sartas, M., Lamers, D., Campbell, M. M., Ogonna, I., Kaushik, P., Atta-Krah, K., & Leeuwis, C. (2016). Innovation platforms: experiences with their institutional embedding in agricultural research for development. *Experimental Agriculture*, 52(4), 537–561. <https://doi.org/10.1017/S001447971500023X>

Innovation Platforms (IPs) are seen as a promising vehicle to foster a paradigm shift in agricultural research for development (AR4D). By facilitating interaction, negotiation and collective action between farmers, researchers and other stakeholders, IPs can contribute to more integrated, systemic innovation that is essential for achieving agricultural development impacts. However, successful implementation of IPs requires institutional change within AR4D establishments. The objective of this paper is to reflect on the implementation and institutionalization of IPs in present AR4D programs. We use experiences from sub-Saharan Africa to demonstrate how the adoption and adaptation of IPs creates both opportunities and challenges that influence platform performance and impact. Niche-regime theory is used to understand challenges, and anticipate on how to deal with them. A key concern is whether IPs in AR4D challenge or reinforce existing technology-oriented agricultural innovation paradigms. For example, stakeholder representation, facilitation and institutional embedding determine to a large extent whether the IP can strengthen systemic capacity to innovate that can lead to real paradigm change, or are merely ‘old wine in new bottles’ and a continuation of ‘business as usual’. Institutional embedding of IPs and – more broadly – the transition from technology-oriented to system-oriented AR4D approaches requires structural changes in organizational mandates, incentives, procedures and funding, as well as investments in exchange of experiences, learning and capacity development.

25. Institutionalising dialogue in Rwanda through innovation platforms

Schut, M., Okafor, C., Hicintuka, C., Kagabo, D., Njukwe, E., Zawadi, S., Lamers, D., Ndayisaba, P. C., McCampbell, M., Sartas, M., Van Asten, P., & Vanlauwe, B. (2016). Institutionalising dialogue in Rwanda through innovation platforms. *Farming Matters*, 32(1), 32–33. <https://hdl.handle.net/10568/75999>

A platform of farmers, retailers and service providers, civil society organizations, NGOs, government officials, and researchers improves livelihoods in Rwanda. Through interaction and collaboration, these groups experiment with various technological and institutional innovations, thereby tackling local agricultural challenges. This experience illustrates the importance of institutionalizing a space where knowledge can be co-created.

Keywords: farmers, agricultural research, innovation

26. Institutionalizing the farming systems perspective in multi-commodity research institute: The role of systems-based research groups

Spencer, D. (1991). Institutionalizing the farming systems perspective in multi-commodity research institute: The role of systems-based research groups. *Experimental Agriculture*, 27(1), 1–9. <https://doi.org/10.1017/S0014479700019153>

Research institutes in Africa have had limited success in producing new technologies appropriate to the needs of small farmers because of an inadequate understanding of small farmers' goals and resource limitations and over-reliance on the transfer of technologies from other regions. Farming systems research (FSR) is an effective way of improving the focus of scientists on the problems farmers face. Vertically segmented thematic research programs make institutionalization of FSR difficult within multi-commodity research centers, particularly the International Agricultural Research Centers. The Farming Systems Research Group has proved effective at overcoming such difficulties at the International Institute of Tropical Agriculture. Its organization, operation and effects on the performance of the research programs are described.

Keywords: farming systems research, Africa, IITA

27. Intermediation capabilities of information and communication technologies (ICTs) in Ghana's agricultural extension system

Munthali, N., Lie, R., Van Lammeren, R., Van Paassen, A., Asare, R., & Leeuwis, C. (2021). Intermediation capabilities of information and communication technologies (ICTs) in Ghana's agricultural extension system. *African Journal of Information and Communication*, 28. <https://doi.org/10.23962/10539/32212>

Information and communication technologies (ICTs), specifically those that are digital and interactive, present opportunities for enhanced intermediation between actors in Ghana's agricultural extension system. To understand these opportunities, this study investigates the capabilities of ICTs in support of seven forms of intermediation in the context of agricultural extension: disseminating (information), retrieving (information), harvesting (information), matching (actors to services), networking (among actors), coordinating (actors), and co-creating (among actors). The study identifies the types of ICTs currently functioning in Ghana's agricultural system, and applies a Delphi-inspired research design to determine the consensus and dissensus of researchers, scientists, and practitioners about the potential of these ICTs to

support each of the seven intermediation capabilities. The findings reveal that experts reached consensus that interactive voice response (IVR) technologies currently have the highest potential to support disseminating, retrieving, harvesting, and matching. Meanwhile, social media messaging (SMM) technologies are currently seen as highly capable of supporting coordinating and, to a lesser extent, co-creating, but no consensus is reached on the potential of any of the technologies to support networking.

28. Linking innovations systems with participatory research and extension: MIRACLE experiences from Southern Africa

Ellis-Jones, J., & Gondwe, T. (2013). Linking innovations systems with participatory research and extension: MIRACLE experiences from Southern Africa. *Agriculture for Development*, 18(2), 13–17. <https://cgspace.cgiar.org/handle/10568/76648>

MIRACLE (“Making innovations work for smallholder farmers affected by HIV and AIDS in Southern Africa”) brings together key stakeholders in operational and strategic level innovation platforms. This paper outlines MIRACLE’s strategy for improving livelihoods through improved production, processing, consumption and marketing of nutritionally-enhanced crops. Operating in Malawi, Mozambique, Swaziland and Zambia, MIRACLE brings together researchers, NGOs, public extension, local leaders, community based organizations (CBOs), farmers and the private sector. MIRACLE’s four-stage Participatory Research and Extension Approach (PREA) involves community engagement and social mobilization, action planning, experimentation, learning and sharing experiences. The paper highlights early achievements and challenges and identifies key lessons. These include the need for building and supporting partnerships, strengthening farmer organizations to participate in research, accessing existing knowledge and fostering learning. A well organized private agri-business sector is essential for developing market opportunities, capacity building and engaging with the public and NGO sectors. Sustainability will be built on local ownership with effective back-up from R&D organizations in both private and public sectors. Scaling up successful pilot initiatives can be supported by strategic level innovation platforms (IPs) linked to and interacting with local operational IPs.

29. Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options

Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B. M., & Menkir, A. (2014). Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. *Weather and Climate Extremes*, 3, 67–79. <https://doi.org/10.1016/j.wace.2014.04.004>

Agriculture and the economies of Sub-Saharan Africa (SSA) are highly sensitive to climatic variability. Drought, in particular, represents one of the most important natural factors contributing to malnutrition and famine in many parts of the region. The overall impact of drought on a given country/region and its ability to recover from the resulting social, economic and environmental impacts depends on several factors. The economic, social and environmental impacts of

drought are huge in SSA and the national costs and losses incurred threaten to undermine the wider economic and development gains made in the last few decades in the region. There is an urgent need to reduce the vulnerability of countries to climate variability and to the threats posed by climate change. This paper attempts to highlight the challenges of drought in SSA and reviews the current drought risk management strategies, especially the promising technological and policy options for managing drought risks to protect livelihoods and reduce vulnerability. The review suggests the possibilities of several ex ante and ex post drought management strategies in SSA although their effectiveness depends on agro-climatic and socio-economic conditions. Existing technological, policy and institutional risk management measures need to be strengthened and integrated to manage drought ex ante and to minimize the ex post negative effects for vulnerable households and regions. A proactive approach that combines promising technological, institutional and policy solutions to manage the risks within vulnerable communities implemented by institutions operating at different levels (community, sub-national, and national) is considered to be the way forward for managing drought and climate variability.

Keywords: climate variability, drought, drought risk management, technology and policy options, sub-Saharan Africa

30. Multi-actor governance of sustainable biofuels in developing countries: The case of Mozambique

Schut, M., Cunha Soares, N., van de Ven, G., & Slingerland, M. (2014). Multi-actor governance of sustainable biofuels in developing countries: The case of Mozambique. *Energy Policy*, 65, 631–643. <https://doi.org/10.1016/j.enpol.2013.09.007>

This paper describes and analyzes the multi-actor governance process that made Mozambique the first African nation-state to develop a national policy framework for sustainable biofuels. The paper draws on findings from action research conducted in Mozambique between December 2008 and July 2012. We analyze interactions between the changing governance context, the course of the multi-actor governance process, and the choices in relation to governance framework characteristics and content for four successive stages of governance framework development. This provides the basis for reflection on the competences required for effective multi-actor sustainability governance, and a discussion about the role of the nation-state in sustainability governance of global economies such as biofuels. The governance framework for sustainable biofuels has contributed to a more transparent and secure investment climate for biofuels in Mozambique. Key factors for success were (1) the presence of different types of competences during the various stages of the governance framework development, (2) closing the gap between ‘licences to sell’ and ‘licences to produce’ across different governance levels, and (3) balancing between the short- and long-term objectives for biofuel production in Mozambique and requirements of global biofuel markets. Developing-country nation-states can provide an essential contribution to these success-factors for global governance of sustainable biofuels.

31. Multi-stakeholder process strengthens agricultural innovations and sustainable livelihoods of farmers in Southern Nigeria

Bisseleua, D. H. B., Idrissou, L., Olurotimi, P., Ogunniyi, A., Mignouna, D., & Bamire, S. A. (2018). Multi-stakeholder process strengthens agricultural innovations and sustainable livelihoods of farmers in Southern Nigeria. *Journal of Agricultural Education and Extension*, 24(1), 29–49. <https://doi.org/10.1080/1389224X.2017.1392992>

Purpose: In this paper, we explore the strategic role of Multi-stakeholder processes (MSP) in agricultural innovations and how it has impacted livelihood assets' (LAs) capital dynamics of stakeholders in platforms in West Africa.

Design/Methodology/Approach: We demonstrate how LA capitals and socio-economic dynamics induced by MSP can enhance cassava production efficiency but also create opportunities and challenges that influence platform dynamics and impacts. We use a multistage sampling procedure and sustainable livelihood model (e.g. stochastic frontier functions and Tobit regression) to analyze LA capital dynamics of the stakeholders.

Findings: We showed that the LA of the MSP participants (0.72) was found to be significantly higher ($\chi^2=3.732$, $p < .10$) than that of the non-participants (0.45). The results further revealed a remarkable increase from 0 to 0.77 and from 0.33 to 0.82 for human capital and social capital, respectively, as stakeholders participate in MSPs' activities.

Practical implications: We recommend the institutionalization of MSP in the Agricultural Research for Development (AR4D) with more extension follow-up services so as to adequately and appropriately unleash the potentials in social capital networks that enable the development, effective dissemination and adoption of agricultural innovations.

Theoretical implications: This study suggests that soft-transfer of technologies seems to dominate at MSP inception. But at maturity, the results of the struggle between researchers and farmers would lead to co-reaction and community-based research. Consequently, the knowledge and power dynamics that take place within the MSP should be considered the center of co-construction and platform dynamics.

Originality/Values: The study provided a practical experience on how MSP can be institutionalized in the AR4D programs to support agricultural innovation systems and foster pro-poor growth and livelihoods.

Keywords: agricultural innovation systems, livelihood asset capitals, demand-driven research, innovation system thinking, CGIAR research program on integrated systems for the humid tropics, humid tropics

32. Opportunities and pitfalls for researchers to contribute to the design of evidence-based agricultural policies: lessons from Uganda

Pali, P., Schut, M., Kibwika, P.*, Wairegi, L., Yami, M., Van Asten, P., & Manyong, V. (2018). Opportunities and pitfalls for researchers to contribute to the design of evidence-based

agricultural policies: lessons from Uganda. *International Journal of Agricultural Sustainability*, 16(3), 272–285. <https://doi.org/10.1080/14735903.2018.1471830>

Agricultural policies in sub-Saharan Africa have paid insufficient attention to sustainable intensification. In Uganda, agricultural productivity has stagnated with aggregate increases in crop production being attributed to expansion of cultivated land area. To enhance sustainable crop intensification, the Ugandan Government collaborated with stakeholders to develop agricultural policies using an evidence-based approach. Previously, evidence-based decision-making tended to focus on the evidence base rather than evidence and its interactions within the broader policy context. We identify opportunities and pitfalls to strengthen science engagement in agricultural policy design by analyzing the types of evidence required, and how it was shared and used during policy development. Qualitative tools captured stakeholders' perspectives of agricultural policies and their status in the policy cycle. Subsequent multi-level studies identified crop growth constraints and quantified yield gaps which were used to compute the economic analyses of policy options that subsequently contributed to sub-national program planning. The study identified a need to generate relevant evidence within a short time 'window' to influence policy design, power influence by different stakeholders and quality of stakeholder interaction. Opportunities for evidence integration surfaced at random phases of policy development due to researchers' 'embeddedness' within co-management and coordination structures.

Keywords: sub-Saharan Africa, stakeholder engagement, policy development process, agricultural service provision

33. Participatory action research, social networks, and gender influence soil fertility management in Tanzania

Mponela, P., Manda, J., Kinyua, M., & Kihara, J. (2023). Participatory action research, social networks, and gender influence soil fertility management in Tanzania. *Systemic Practice and Action Research*, 36, 141–163. <https://doi.org/10.1007/s11213-022-09601-3>

Transformation of knowledge systems and fostering learning among smallholder farmers such as through participatory action research (PAR) is key to agricultural growth in rural sub-Saharan Africa. We investigate how PAR influences uptake/use of integrated soil fertility management (ISFM) while accounting for gendered, bonding and bridging social capital. Stratified by engagement in a mother-baby PAR and by resource endowments, 607 smallholder farmers were sampled from northern Tanzania. Binary logistic and multinomial logit models revealed that full engagement in PAR was associated with early adoption of inorganic fertilizers, either as a dichotomous decision or an ISFM bundle with improved varieties, organic matter inputs and soil and water conservation. Bonding social capital through cooperatives, farmer groups, and farmer-farmer local networks supports soil and water conservation, especially among resource-poor farmers. Among the high-resource farmers, increased women's bargaining power in farm input purchases supports fertilizer and manure use while increased bargaining power in livestock tending supports crop residue incorporation. ISFM usage is constrained by

age of decision-makers and a higher number of dependents per worker while education level and farm sizes increase its likelihood. In the resource-constrained, with low extension and technical support, and men-dominated patrilineal farming systems of Africa, the study places PAR, social networks, and gender inclusivity as key approaches for improving smallholders' ISFM.

34. Participatory appraisal of institutional and political constraints and opportunities for innovation to address parasitic weeds in rice

Schut, M., Rodenburg, J., Klerkx, L., Hinnou, L. C.*, Kayeke, J.*, & Bastiaans, L. (2015). Participatory appraisal of institutional and political constraints and opportunities for innovation to address parasitic weeds in rice. *Crop Protection*, 74, 158–170. <https://doi.org/10.1016/j.cropro.2015.04.011>

Parasitic weeds in smallholder rice production systems, of which *Striga asiatica*, *Striga hermonthica* and *Rhaphicarpa fistulosa* are the main representatives, form an increasing problem for food and income security in sub-Saharan Africa (SSA). The objective of this paper is to identify institutional and political constraints and opportunities for innovation to address parasitic weed problems in rice. Constraints and opportunities for innovation were studied across three nested systems: the parasitic weed control system, the crop protection system, and the agricultural system. Multi-stakeholder workshops, interviews and surveys were held to gather data on key constraints faced by different stakeholder groups across three parasitic weed infested study sites in both Tanzania and Benin. The results demonstrate that in both countries, the majority of institutional and political constraints relate to the functioning of the broader crop protection and agricultural systems and not specifically to parasitic weeds. Although differences were observed between the two countries and the different stakeholder groups, the majority of constraints perceived by the stakeholders were caused by a lack of capabilities and resources and a limited access to credit. Awareness raising of parasitic weed problems among farmers, extension and crop protection officers at the local level, combined with improved input and service supply and enhanced agricultural education and training curricula at the national level, were identified as important elements for improvement. More structural collaboration between key stakeholder groups is expected to contribute to a better recognition of agricultural problems, like that of parasitic weeds in rice, and a more timely identification of feasible solutions.

Keywords: agricultural research for development (AR4D), Rapid Appraisal of Agricultural Innovation Systems (RAAIS), rain-fed agriculture, Orobanchaceae, *Oryza sativa* L.

35. Participatory on-farm evaluation of the performance of drought-tolerant maize varieties in the Guinea Savannas of Nigeria

Kamara, A., Kureh, I., Menkir, A., Kartung, P., Tarfa, B., & Amaza, P. (2006). Participatory on-farm evaluation of the performance of drought-tolerant maize varieties in the Guinea Savannas of Nigeria. *Journal of Food, Agriculture and Environment*, 4(1), 192–196. www.wflpublisher.com/Abstract/786

Maize is an important food crop in the Guinea savannas of Nigeria where it is gradually replacing the traditional cereal crops, such as sorghum and millet because of its high productivity. Despite its high yield potential, maize production is faced with numerous constraints. One of these is drought both at the beginning and during the growing season, which significantly reduces grain yield. Therefore early-maturing varieties that are tolerant to drought or extra-early maturing varieties that escape drought are desirable in these communities. Efforts are being made at IITA to develop or identify drought-tolerant maize varieties that are adapted to the Guinea savannas of West Africa. This study evaluated three maize varieties that have been identified either to tolerate or escape drought. The drought-tolerant maize varieties were evaluated on farmers' fields for two years in two Federal States of northern Nigeria. Generally, the on-farm yield of the maize varieties evaluated was higher than the average grain yield reported for northern Nigeria. Farmers differed in their preferred choice of varieties. In the relatively market-driven production systems in the communities in Borno State, the early-maturing and high-yielding drought-tolerant variety (TZE-COMP 3 DT) was popular. Since this variety attains physiological maturity in late September when rainfall is less, it can be harvested and processed for sale. It therefore has high potential for adoption in these communities. On the contrary, in the relatively resource-poor sorghum-based production systems in Kano State; extra-early maturing varieties (95TZEE-W and 95TZEE-Y) were preferred to provide food security during the period of food scarcity in August/September. The emphasis was therefore more on earliness of crop maturity than on high yields.

36. Policy and competitiveness of agroforestry-based technologies for maize production in Cameroon: an application of policy analysis matrix

Adesina, A., & Coulibaly, O. (1998). Policy and competitiveness of agroforestry-based technologies for maize production in Cameroon: an application of policy analysis matrix. *Agricultural Economics*, 19(1/2), 1–13. <https://cgspace.cgiar.org/handle/10568/95959>

Questions have been raised about the ecological consequences and economic sustainability of exclusive reliance on chemical fertilizers for the rapidly expanding maize production across sub-Saharan Africa. Alternative agroforestry-based natural resource management technologies have been developed for farmers. This paper applies the policy analysis matrix (PAM) to analyze the social profitability of agroforestry-based technologies for maize production in the highland savanna zone of Cameroon, and the impacts of policy shifts on the financial competitiveness of maize production under these technologies. The paper shows that maize production under agroforestry-based systems has high comparative advantage.

Keywords: agroforestry, Cameroon, policy analysis matrix

37. Policy support for sustainable crop intensification in eastern Africa

Yami, M., & Van Asten, P. (2017). Policy support for sustainable crop intensification in eastern Africa. *Journal of Rural Studies*, 55, 216–226. <https://doi.org/10.1016/j.jrurstud.2017.08.012>

Sustainable Crop Intensification (SCI) has been recognized as a means to increase crop productivity and improve rural livelihoods by governments and development partners in Sub

Saharan Africa. Designing and implementing policies that address the bottlenecks to SCI interventions is pertinent to address low crop productivity. However, little attention is geared toward analyzing the existing policies and examining their provision in addressing the key challenges to SCI. Based on analysis of policy documents and perception of key policy actors in Ethiopia, Kenya, and Uganda, this paper looks at the level of policy support for SCI in Eastern Africa. Results indicate that lack of incentives to invest in SCI, and poor capacity of agricultural extension system in technology development and dissemination constrain implementation of policies supporting SCI. Mistrust among policy actors over 'hidden' interest of international donors in Genetically Modified Organisms (GMOs) and failure to have open discussion to clarify the involvement of multinational companies in regional trade hamper the implementation of policies supporting SCI. Policies lack emphasis on protecting farmers' rights over land tenure and local varieties, posing a challenge to policy harmonization and regional trade. Therefore, developing incentive mechanisms for SCI, and strengthening the capacity of agricultural extension system to meet the requirements of SCI are required. Encouraging public dialogue over the national and regional interests over involvement of multinational companies in regional trade and on GMOs could enhance the acceptability of the policies supporting SCI by many of the agricultural actors. Strengthening farmer groups at different levels could also play important role in protecting farmers' rights in regional trade.

Keywords: agricultural productivity, incentive mechanisms, local varieties, policy harmonization, regional trade, sub-Saharan Africa

38. RAAIS: Rapid Appraisal of Agricultural Innovation Systems (Part I). A diagnostic tool for integrated analysis of complex problems and innovation capacity

Schut, M., Klerkx, L., Rodenburg, J., Kayeke, J., Hinnou, L. C., Raboanarielina, C. M., Adegbola, P. Y., van Ast, A., & Bastiaans, L. (2015). RAAIS: Rapid Appraisal of Agricultural Innovation Systems (Part I). A diagnostic tool for integrated analysis of complex problems and innovation capacity. *Agricultural Systems*, 132, 1–11. <https://doi.org/10.1016/j.agsy.2014.08.009>

This paper introduces Rapid Appraisal of Agricultural Innovation Systems (RAAIS). RAAIS is a diagnostic tool that can guide the analysis of complex agricultural problems and innovation capacity of the agricultural system in which the complex agricultural problem is embedded. RAAIS focuses on the integrated analysis of different dimensions of problems (e.g. biophysical, technological, socio-cultural, economic, institutional and political), interactions across different levels (e.g. national, regional, local), and the constraints and interests of different stakeholder groups (farmers, government, researchers, etc.). Innovation capacity in the agricultural system is studied by analyzing (1) constraints within the institutional, sectoral and technological subsystems of the agricultural system, and (2) the existence and performance of the agricultural innovation support system. RAAIS combines multiple qualitative and quantitative methods, and insider (stakeholders) and outsider (researchers) analyses which allow for critical triangulation and validation of the gathered data. Such an analysis can provide specific entry points for innovations to address the complex agricultural problem under study, and generic entry points for innovation related to strengthening the innovation capacity of agricultural system and the

functioning of the agricultural innovation support system. The application of RAAIS to analyze parasitic weed problems in the rice sector, conducted in Tanzania and Benin, demonstrates the potential of the diagnostic tool and provides recommendations for its further development and use.

Keywords: agricultural research for development (AR4D), farming systems research, integrated assessment, (participatory) research methods, system diagnostics, wicked problems

39. RAAIS: Rapid Appraisal of Agricultural Innovation Systems (Part II). Integrated analysis of parasitic weed problems in rice in Tanzania

Schut, M., Rodenburg, J., Klerkx, L., Kayeke, J., van Ast, A., & Bastiaans, L. (2015). RAAIS: Rapid Appraisal of Agricultural Innovation Systems (Part II). Integrated analysis of parasitic weed problems in rice in Tanzania. *Agricultural Systems*, 132, 12–24. <https://doi.org/10.1016/j.agsy.2014.09.004>

Parasitic weeds such as *Striga* spp and *Rhizophicarpa fistulosa* in smallholder rice production systems form an increasing problem for food and income security in sub-Saharan Africa. In this paper, we implement the Rapid Appraisal of Agricultural Innovation Systems (RAAIS) as a diagnostic tool to identify specific and generic entry points for innovations to address parasitic weeds in rain-fed rice production in Tanzania. Data were gathered across three study sites in Tanzania where parasitic weeds are eminent (Kyela, Songea Rural and Morogoro Rural districts). The results demonstrate that in Tanzania, weeds in general and parasitic weeds in particular receive little attention in agricultural research, training and education curricula. Crop protection policies mainly focus on the control of (insect) pest and diseases and there is relatively little attention for weed prevention, which is essential for addressing parasitic weed problems effectively. Specific entry points for innovation include increasing awareness of parasitic weed problems among farmers, extension and crop protection officers and policymakers. In regions where awareness is relatively high, participatory research approaches can provide a basis for developing locally adapted parasitic weed management strategies. Generic entry points for innovation include enhanced collaboration and interaction between stakeholders across different levels, for example in multi-stakeholder platforms. This can provide the basis for developing and implementing coherent policy and development strategies to address structural constraints in the agricultural system, including the promotion of clean local seed systems, investments in physical and knowledge infrastructure development, adequate backstopping of agricultural extension officers, agribusiness training for farmers, quality control of agricultural inputs, timely access to agricultural inputs, and improved access to markets for farmers. Together the specific and generic entry points can strengthen the innovation capacity of Tanzania's agricultural system to address parasitic weed problems, as well as other complex agricultural problems.

Keywords: agricultural research for development (AR4D), diagnostic studies, farming systems research (FSR), rain-fed agriculture, Orobanchaceae, *Oryza sativa* L.

40. Reforming the research policy and impact culture in the CGIAR: Integrating science and systemic capacity development

Leeuwis, C., Klerkx, L., & Schut, M. (2018). Reforming the research policy and impact culture in the CGIAR: Integrating science and systemic capacity development. *Global Food Security*, 16, 17–21. <https://doi.org/10.1016/j.gfs.2017.06.002>

This paper argues that the CGIAR—through its CGIAR Research Programs—is struggling to fulfill its international mandate of conducting strategic research that contributes to agricultural development and global food security. Ongoing reforms have resulted in a situation where the CGIAR is assessed as if it were a development organization. This leads the CGIAR to raise unrealistic expectations regarding the development impacts of the science conducted, resulting in ever growing distrust between the centers and the donor community. Moreover, its short-term funding cycle and current mode of safeguarding scientific quality are not conducive to doing strategic and potentially transformative research. The paper proposes changes in the CGIAR impact culture, driven by a shift in policies that govern the everyday implementation and assessment of research. In line with this, we suggest that the best way to combine the international ‘science’ and ‘development’ mandates is through scientific capacity development of staff belonging to national research and innovation systems. This simultaneously requires major changes in the time-horizon of donor funding, and in how research programs are selected and led.

Keywords: CGIAR reform, research policy, impact assessment; funding policy

41. Relevance of informal institutions for achieving sustainable crop intensification in Uganda

Yami, M., & Van Asten, P. (2018). Relevance of informal institutions for achieving sustainable crop intensification in Uganda. *Food Security*, 10, 141–150. <https://doi.org/10.1007/s12571-017-0754-3>

Informal institutions play an important role in the socio-cultural lives of rural communities in Uganda. However, little attention is given in research and development to understanding the influence of informal institutions in efforts to achieve Sustainable Crop Intensification (SCI). Such evidence is, however, pertinent to addressing low crop productivity by designing and implementing interventions that take into account the socio-cultural and institutional barriers and opportunities for SCI. This paper analyzes the influence of informal institutions on farmers’ access to land resources, financial resources, and farm inputs. The analysis is based on qualitative and quantitative data collected between January and May 2015 using 61 in-depth interviews, field surveys with 120 farmers and 18 gender-segregated focus group discussions in Eastern and Southwestern Uganda. Results indicate that informal institutions play a central role in enhancing farmers’ investment in SCI interventions by facilitating access to land through inheritance, land rentals, and labor sharing arrangements, although they are biased against non-clan members and female members of the communities. Informal institutions also enable access to financial resources by farmers at lower transaction cost compared to formal financial

institutions. Yet, the informal institutions face challenges related to poor rule enforcement and limited financial reserves. The contribution of informal institutions in improving farmers' access to (i) external farm inputs, (ii) serving as forums for knowledge sharing and (iii) regulating quality of farm inputs is minimal. Findings imply that development interventions could benefit from using informal institutions as entry points for investment in SCI and building on institutions' strengths in influencing access to land and financial resources. Policies and programs that promote the SCI approach need to recognize the role of informal institutions for increased implementation and impact.

42. Science of Scaling: Understanding and guiding the scaling of innovation for societal outcomes

Schut, M., Leeuwis, C., & Thiele, G. (2020). Science of Scaling: Understanding and guiding the scaling of innovation for societal outcomes. *Agricultural Systems*, 184, 102908. <https://doi.org/10.1016/j.agsy.2020.102908>

This Editorial to the Special Issue “Science of Scaling: connecting the pathways of agricultural research and development for improved food, income and nutrition security” presents the framing, overview and analysis of 10 articles focussed on scaling innovation in the agricultural research for development sector. The publications cut across three categories that focus on: (i) Understanding the scaling trajectory retrospectively from a longer term, systems perspective, (ii) Understanding scaling of innovation retrospectively as part of shorter term agricultural research for development interventions, and (iii) Conceptual or methodological approaches aimed at guiding scaling prospectively. Cross-cutting review of the publications leads to several insights and critically questions dominant ways of understanding and guiding scaling of innovation in the agricultural research for development sector. This provides a starting point for proposing more outcome-oriented scaling as a third wave of understanding and guiding scaling, beyond technology adoption (first wave) and the scaling of innovation (second wave). The Editorial proposes three Research Domains for the Science of Scaling: (1) ‘Understand the big picture of scaling innovation’ that can inform more realistic ideas about the factors, conditions and dynamics that affect innovation and scaling processes; (2) ‘Develop instruments that nurture efficient and responsible scaling’ that comprises new approaches, concepts and tools that can facilitate the development of evidence-based scaling strategies; and (3) ‘Create a conducive environment for scaling innovation’ that focusses on the institutional arrangements, partnership models, and monitoring and learning for scaling of innovation.

Keywords: agricultural innovation systems, adoption, impact at scale, agricultural research for development, CGIAR

43. Smallholder management of diverse soil nutrient resources in West Africa: Economics and policy implications

Berkhout, E., Franke, L., & Abdoulaye, T. (2015). Smallholder management of diverse soil nutrient resources in West Africa: Economics and policy implications. In Lal, R., & Stewart, B. A. (eds) *Soil-Specific Farming: Precision Agriculture*, pp. 127–154. Boca Raton: CRC

Press. <https://www.taylorfrancis.com/chapters/mono/10.1201/b18759-9/smallholder-management-diverse-soil-nutrient-resources-west-africa-economics-policy-implications-rattan-lal-stewart>

There exists widespread agreement on the need to raise agricultural productivity in West Africa. Yields are well below their theoretical potential and attainable levels and a combination of adequate technologies and policies are needed to enhance production. There equally exists a clear understanding that past blanket interventions have been largely unsuccessful due to the lack of incorporating heterogeneity. Heterogeneity exists at multiple levels: at the country level, implying comparative advantages between countries and regions, but also at the smallest field level. Such within farm variability in soil fertility, or the variability between farms within a small geographic area, is sometimes greater than the mean variation across districts. As a result, responses to new technologies and fertilizer differ across fields, with the least fertile fields often being unresponsive. Some recent studies suggest that the poorest households more frequently own such fields. For them, use of fertilizer or other inputs, such as labor for timely crop management, remain economically unattractive under current conditions.

44. Social network analysis of multi-stakeholder platforms in agricultural research for development: Opportunities and constraints for innovation and scaling

Hermans, F., Sartas, M., van Schagen, B., van Asten, P., & Schut, M. (2017). Social network analysis of multi-stakeholder platforms in agricultural research for development: Opportunities and constraints for innovation and scaling. *PLOS ONE*, 12(2), e0169634. <https://doi.org/10.1371/journal.pone.0169634>

Multi-stakeholder platforms (MSPs) are seen as a promising vehicle to achieve agricultural development impacts. By increasing collaboration, exchange of knowledge and influence mediation among farmers, researchers and other stakeholders, MSPs supposedly enhance their 'capacity to innovate' and contribute to the 'scaling of innovations'. The objective of this paper is to explore the capacity to innovate and scaling potential of three MSPs in Burundi, Rwanda and the South Kivu province located in the eastern part of Democratic Republic of Congo (DRC). In order to do this, we apply Social Network Analysis and Exponential Random Graph Modelling (ERGM) to investigate the structural properties of the collaborative, knowledge exchange and influence networks of these MSPs and compared them against value propositions derived from the innovation network literature. Results demonstrate a number of mismatches between collaboration, knowledge exchange and influence networks for effective innovation and scaling processes in all three countries: NGOs and private sector are respectively over- and under-represented in the MSP networks. Linkages between local and higher levels are weak, and influential organizations (e.g., high-level government actors) are often not part of the MSP or are not actively linked to by other organizations. Organizations with a central position in the knowledge network are more sought out for collaboration. The scaling of innovations is primarily between the same type of organizations across different administrative levels, but not between different types of organizations. The results illustrate the potential of Social Network Analysis and ERGMs to identify the strengths and limitations of MSPs in terms of achieving development impacts.

45. Stimulating innovations for sustainable agricultural practices among smallholder farmers: Persistence of intervention matters

Mellon Bedi, S., Kornher, L., von Braun, J., & Kotu, B. H. (2022). Stimulating innovations for sustainable agricultural practices among smallholder farmers: Persistence of intervention matters. *The Journal of Development Studies*, 58(9), 1651–1667. <https://doi.org/10.1080/00220388.2022.2043283>

As part of the dissemination of sustainable intensification (SI) of agricultural practices in northern Ghana, farmers were conditionally induced with inputs to adopt the SI practices. We study the effects of the conditional inducement on maize yield and net income of farmers under a quasi-randomised phase-out design. We examine the effects of the inducement by comparing continuous induced farmers with past induced and non-induced farmers. Our results indicate that the conditional inducement led to an increase in the maize yield and the net income of continuously induced farmers, on average. Estimates also suggest that the continuously induced farmers would have had their maize yields and net incomes decreased by about 64 per cent and 54 per cent, respectively if the inducement had been discontinued. Distributional analysis reveals that the inducement effects are heterogeneous and that past inducement impacted more on the maize yield and the net income of farmers at the lower quantiles. We conclude that appropriate conditional inducement can stimulate farmers' adoption. Besides, the duration of intervention matters and must not be overlooked in interventions that necessitate gaining experience and learning.

46. Successful innovations and lessons learnt in cassava improvement and deployment by IITA in Eastern African Region

Ntawuruhunga, P., Dixon, A., Kanju, E., Ssemakula, G., Okechukwu, R., Whyte, J., Obiero, H., Bigirimana, S., Gashaka, G., Lukombo, S., Mkamilo, G., Ndyetabula, I., Tata-Hangy, W., Otim Okello, F., & Schofield, J (2013). Successful innovations and lessons learnt in cassava improvement and deployment by IITA in Eastern African Region. *African Journal of Root and Tuber Crops*, 10(1), 41–54. <https://cgspace.cgiar.org/handle/10568/76664>

The International Institute of Tropical of Agriculture (IITA) established its East and Southern Africa Regional Research Centre (ESARC) in Uganda at the former Namulonge Agricultural and Animal Research Institute (NAARI), presently Namulonge Animal and Crops Research Institute (NaCRRI), to address issues of cassava, banana, and plantain development; coordinate all related activities, and work closely with the national agricultural research institutes (NARS). IITA-ESARC began extensive cassava germplasm development to counter the pandemic of African cassava mosaic disease (ACMD) in the region in 1995 through the Eastern Africa Root Crops Research Network (EARRNET). More than 100,000 seeds were evaluated through the conventional plant breeding scheme. Selected genotypes were kept in in-situ conservation from where the regional cassava national programs selected clones for further evaluation in their own countries. Burundi, Democratic Republic of Congo (DRC), Kenya, Rwanda, Tanzania, and Uganda benefited immensely. Through EARRNET, the region gained significantly from the large germplasm base to mitigate the scourge of ACMD and the production of cassava

was restored. A new joint effort that was established between Catholic Relief Services and IITA in collaboration with the NARS and other stakeholders promoted the adoption of improved germplasm through participatory variety selection. The breeding approach used enabled to reduce selection period for NARS to release new varieties to farmers as they received elite materials for evaluation. However, the spread of cassava brown streak disease (CBSD) in mid altitude threatened the achievements already made as the new disease attacked most of the ACMD-resistant and high yielding varieties. Its spread in the region calls for more effective collaborative action than before from IITA and its partners to develop new resistant materials to mitigate the effects of both ACMD and CBSD. The present paper attempts to summarize the breeding work efforts made and demonstrate how the germplasm development at this regional center has been useful to the region through effective partnership.

Keywords: cassava mosaic disease, cassava brown streak disease, germplasm development, exchange, partnership and participatory variety selection

47. Sustainable intensification of agricultural systems in the Central African Highlands: The need for institutional innovation

Schut, M., van Asten, P., Okafor, C., Hicintuka, C., Mapatano, S., Nabahungu, N. L., Kagabo, D., Muchunguzi, P., Njukwe, E., Dontsop-Nguezet, P. M., Sartas, M., & Vanlauwe, B. (2016). Sustainable intensification of agricultural systems in the Central African Highlands: The need for institutional innovation. *Agricultural Systems*, 145, 165–176. <https://doi.org/10.1016/j.agry.2016.03.005>

This study identifies entry points for innovation for sustainable intensification of agricultural systems. An agricultural innovation systems approach is used to provide a holistic image of (relations between) constraints faced by different stakeholder groups, the dimensions and causes of these constraints, and intervention levels, timeframes and types of innovations needed. Our data shows that constraints for sustainable intensification of agricultural systems are mainly of economic and institutional nature. Constraints are caused by the absence, or poor functioning of institutions such as policies and markets, limited capabilities and financial resources, and ineffective interaction and collaboration between stakeholders. Addressing these constraints would mainly require short- and middle-term productivity and institutional innovations, combined with middle- to long-term NRM innovations across farm and national levels. Institutional innovation (e.g. better access to credit, services, inputs and markets) is required to address 69% of the constraints for sustainable intensification in the Central Africa Highlands. This needs to go hand in hand with productivity innovation (e.g. improved knowhow of agricultural production techniques, and effective use of inputs) and NRM innovation (e.g. targeted nutrient applications, climate smart agriculture). Constraint network analysis shows that institutional innovation to address government constraints at national level related to poor interaction and collaboration will have a positive impact on constraints faced by other stakeholder groups. We conclude that much of the R4D investments and innovation in the Central Africa Highlands remain targeting household productivity at farm level. Reasons for

that include (1) a narrow focus on sustainable intensification, (2) institutional mandates and pre-analytical choices based project objectives and disciplinary bias, (3) short project cycles that impede work on middle- and long-term NRM and institutional innovation, (4) the likelihood that institutional experimentation can become political, and (5) complexity in terms of expanded systems boundaries and measuring impact.

Keywords: Rapid Appraisal of Agricultural Innovation Systems (RAAIS), farming systems research, CGIAR research program on integrated systems for the humid tropics (humid tropics), participatory action research, sub-Saharan Africa

48. Systemic perspectives on scaling agricultural innovations. A review

Wigboldus, S., Klerkx, L., Leeuwis, C., Schut, M., Muilerman, S., & Jochemsen, H. (2016). Systemic perspectives on scaling agricultural innovations. A review. *Agronomy for Sustainable Development*, 36(3), 46. <https://doi.org/10.1007/s13593-016-0380-z>

Agricultural production involves the scaling of agricultural innovations such as disease-resistant and drought-tolerant maize varieties, zero-tillage techniques, permaculture cultivation practices based on perennial crops and automated milking systems. Scaling agricultural innovations should take into account complex interactions between biophysical, social, economic and institutional factors. Actual methods of scaling are rather empirical and based on the premise of 'find out what works in one place and do more of the same, in another place'. These methods thus do not sufficiently take into account complex realities beyond the concepts of innovation transfer, dissemination, diffusion and adoption. As a consequence, scaling initiatives often do not produce the desired effect. They may produce undesirable effects in the form of negative spill-overs or unanticipated side effects such as environmental degradation, bad labor conditions of farm workers and loss of control of farming communities over access to genetic resources. Therefore, here, we conceptualise scaling processes as an integral part of a systemic approach to innovation, to anticipate on the possible consequences of scaling efforts. We propose a method that connects the heuristic framework of the multi-level perspective on socio-technical transitions (MLP) to a philosophical 'modal aspects' framework, with the objective of elucidating the connectedness between technologies, processes and practices. The resultant framework, the PRactice-Oriented Multi-level perspective on Innovation and Scaling (PROMIS), can inform research and policymakers on the complex dynamics involved in scaling. This is illustrated in relation to three cases in which the framework was applied: scaling agro-ecological practices in Nicaragua, farmer field schools on cocoa cultivation in Cameroon and 'green rubber' cultivation in Southwest China.

Keywords: systemic analysis, innovation systems, diffusion of innovations. adoption of innovations, technology transfer, responsible innovation, sustainability transitions, upscaling, outscaling

49. Systems approaches to innovation in pest management: reflections and lessons learned from an integrated research program on parasitic weeds in rice

Rodenburg, J., Schut, M., Demont, M., Klerkx, L., Gbèhounou, G., Oude Lansink, A., Mourits, M., Rotteveel, T., Kayeke, J., van Ast, A., Akanvou, L., Cissoko, M., Kamanda, J., & Bastiaans, L. (2015). Systems approaches to innovation in pest management: reflections and lessons learned from an integrated research program on parasitic weeds in rice. *International Journal of Pest Management*, 61(4), 329–339. <https://doi.org/10.1080/09670874.2015.1066042>

This paper provides a retrospective look at a systems-oriented research program, on the increasing occurrence of parasitic weeds in rainfed rice in sub-Saharan Africa, to qualitatively assess merits and identify challenges of such approach. We gained a broad contextual overview of the problem and different stakeholders' roles, which enabled identification of entry points for innovations in parasitic weed management. At the crop level parasitic weed infestation is associated with poor soil fertility and water management. Farmers' infrequent use of inputs to control them was caused by various factors, ranging from fears of undesired side effects (agronomic) to a lack of quality control of products (institutional). Furthermore, there may be enough extension agents, but they lack the required training on (parasitic) weed management to provide farmers with advice, while their organizations do not provide them with the necessary means for farm visits. At even higher organizational levels we observed a lack of coherent policies on parasitic weed control and implementation of them. Merits and challenges of an integrated multi-stakeholder and multi-level research project are discussed.

Keywords: multi-disciplinary, trans-disciplinary, agricultural innovation systems (AIS), farmer participation, multi-stakeholder, crop protection

50. Technological innovations for improving cassava production in sub-Saharan Africa

Mbanjo, E. G. N., Rabbi, I. Y., Ferguson, M. E., Kayondo, S. I., Eng, N. H., Tripathi, L., Kulakow, P., & Egesi, C. (2021). Technological innovations for improving cassava production in sub-Saharan Africa. *Frontiers in Genetics*, 11, 623736. <https://doi.org/10.3389/fgene.2020.623736>

Cassava is crucial for food security of millions of people in sub-Saharan Africa. The crop has great potential to contribute to African development and is increasing its income-earning potential for small-scale farmers and related value chains on the continent. Therefore, it is critical to increase cassava production, as well as its quality attributes. Technological innovations offer great potential to drive this envisioned change. This paper highlights genomic tools and resources available in cassava. The paper also provides a glimpse of how these resources have been used to screen and understand the pattern of cassava genetic diversity on the continent. Here, we reviewed the approaches currently used for phenotyping cassava traits, highlighting the methodologies used to link genotypic and phenotypic information, dissect the genetics architecture of key cassava traits, and identify quantitative trait loci/markers significantly associated with those traits. Additionally, we examined how knowledge acquired is utilized to contribute to crop improvement. We explored major approaches applied in the field of molecular breeding for cassava, their promises, and limitations. We also examined

the role of national agricultural research systems as key partners for sustainable cassava production.

51. Yam improvement for income and food security in West Africa: effectiveness of a multi-disciplinary and multi-institutional team-work

Maroya, N., Asiedu, R., Kumar, P. L., Mignouna, D., Lopez-Montes, A., Kleih, U. K., Phillips, D., Ndiame, F, Ikeorgu, J, & Otoo, E (2014). Yam improvement for income and food security in West Africa: Effectiveness of a multi-disciplinary and multi-institutional team-work. *Journal of Root Crops*, 40(1), 85–92. https://www.researchgate.net/publication/266078856_Yam_Improvement_for_Income_and_Food_Security_in_West_Africa_Effectiveness_of_a_Multi-Disciplinary_and_Multi-Institutional_Team-Work

The overall goal of the five year project “Yam Improvement for Income and Food Security in West Africa” (YIIFSWA) funded by the Bill and Melinda Gates Foundation and led by the International Institute of Tropical Agriculture, Ibadan, Nigeria is to: (a) increase yam productivity by 40% for 2,00,000 smallholder yam farmers in Ghana and Nigeria and (b) deliver key global good research products that will contribute to the 10-year overall vision to sustainably double incomes from yams for 3 million smallholder yam farming families and contribute to ensuring food security for producers and consumers. Implemented by scientists of twenty specialized partner organizations, comprising research institutes, Universities, governmental and non-governmental organizations, YIIFSWA has impacted yam value chain stakeholders through research and development interventions. The significant contributions made in the project during the past 18 months are discussed in this paper. These include: a baseline survey conducted in key yam growing areas in Ghana and Nigeria, training of yam producers on adapted yam miniset technique and production of seed yam, undertaking in depth value chain assessments, developing the capacity of Farmers Organizations (FOs) by linking them to service providers (SPs), participatory evaluation of new yam genotypes and available improved technologies, successful development of yam virus diseases diagnostics and development of novel techniques for high ratio yam propagation such as aeroponics and bioreactors.

Keywords: yam, value chain, capacity development, seed yam, propagation, Ghana, Nigeria

Gender and effectiveness of projects/programs (35)

1. Agricultural extension in Eastern Democratic Republic of Congo: does gender matter?

Lambrecht, I., Vanlauwe, B., & Maertens, M. (2016). Agricultural extension in Eastern Democratic Republic of Congo: does gender matter? *European Review of Agricultural Economics*, 43(5), 841–874. <https://doi.org/10.1093/erae/jbv039>

Agricultural extension programs often evaluate their gender strategy by the proportion of female participants. However, female participation is not necessarily conducive for reaching program objectives. We analyze whether participation of female farmers in an agricultural

extension program in South Kivu increases adoption of three technologies: improved legume varieties, row planting and mineral fertilizer. Joint male and female program participation leads to the highest adoption rates. Female participation is not conducive for the adoption of capital-intensive technologies while it is for (female) labor-intensive technologies. Participation of female-headed households is more effective for technology adoption than participation of female farmers in male-headed households.

Keywords: gender, agricultural technology adoption, agricultural extension, eastern DR Congo, integrated soil fertility management

2. A gendered ecosystem services approach to identify novel and locally-relevant strategies for jointly improving food security, nutrition, and conservation in the Barotse Floodplain

Estrada-Carmona, N., Attwood, S., Cole, S. M., Remans, R., & DeClerck, F. (2020). A gendered ecosystem services approach to identify novel and locally-relevant strategies for jointly improving food security, nutrition, and conservation in the Barotse Floodplain. *International Journal of Agricultural Sustainability*, 18(4), 351–375. <https://doi.org/10.1080/14735903.2020.1787618>

Multiple lines of evidence call for the use of locally-relevant strategies to guide and support sustainable agricultural intensification while improving development and conservation outcomes. The goal of this study was to identify the ecosystem services from natural and agricultural systems to achieve this aim in the Barotse Floodplain of Zambia. Our methodology utilized a gender-sensitive ecosystem services approach, whereby local knowledge from women and men was harnessed to understand which services and their sources are important. In addition, we identified the various constraints and options people encounter for developing sustainable and nutritious agriculture while achieving conservation outcomes. The results of our study indicate that the floodplain provides a broad range of ecosystem services, which are important for securing local livelihoods and wellbeing. The forests in the uplands and the grasslands in the plains are the primary sources of the 17 provisioning and regulating ecosystem services assessed. Nonetheless, both are often converted to agriculture due to their high soil fertility. We identified opportunities and challenges for sustainable agricultural intensification and development in areas with lower conservation concerns. We discussed the constraints and limitations for promoting sustainable and inclusive agriculture in those areas.

Keywords: agrobiodiversity, wetlands, Zambia, aquatic agricultural systems, neglected and underutilized species, agro-ecosystems

3. Cassava trait preferences of men and women farmers in Nigeria: implications for breeding

Teeken, B., Olaosebikan, O., Haleegoah, I., Oladejo, E., Madu, T., Bello, A., Parkes, E., Egesi, C., Kulakow, P., Kirscht, H., & Tufan, H. A. (2018). Cassava trait preferences of men and women farmers in Nigeria: implications for breeding. *Economic Botany*, 72(3), 263–277. <https://doi.org/10.1007/s12231-018-9421-7>

Nigeria is the world's largest cassava producer, hosting a diverse array of cassava farmers and processors. Cassava breeding programs prioritize "common denominator" traits in setting breeding agendas, to impact the largest possible number of people through improved varieties. This approach has been successful, but cassava adoption rates are less than expected, with room for improvement by integrating traits in demand by farmers and processors. This paper aims to inform breeding priority setting, by examining trait and varietal preferences of men and women cassava farmer/processors. Men and women in eight communities in Southwest and Southeast Nigeria were consulted using mixed methods. Women and men had significantly different patterns of cassava use in the Southwest. Fifty-five variety names were recorded from the communities demonstrating high genetic diversity maintained by growers, especially in the Southeast. High yield, early maturity, and root size were most important traits across both regions, while traits women and men preferred followed gender roles: women prioritized product quality/cooking traits, while men placed higher priority on agronomic traits. Trait preference patterns differed significantly between the Southeast and Southwest, and showed differentiation based on gender. Patterns of access to stem sources were determined more by region and religion than gender.

Keywords: plant breeding, cassava, gender, trait preferences, Nigeria

4. Correlates and consequences of women's participation in the cowpea value chain in eastern Zambia

Gondwe, T., Tegbaru, A., Oladeji, A. E., Khonje, M., Manda, J., & Gaya, H. (2017). Correlates and consequences of women's participation in the cowpea value chain in eastern Zambia. *Agrekon*, 56(3), 263–273. <https://doi.org/10.1080/03031853.2017.1317643>

This paper analyzes the link between gender differences and different activities along the cowpea value chain as well as food security and asset-based poverty using a recent cross-sectional data set of over 120 farm households in Eastern Zambia. We used the endogenous switching probit regression model to account for both observed and unobserved heterogeneity. Results show that women's participation in the cowpea value chain significantly increases cowpea production, marketing, and adoption of improved cowpea varieties. It also reduces both food insecurity and poverty. However, women's participation in the value chain is limited by low levels of education, access to extension, credit, village markets, and improved agricultural technologies. Policies to address these constraints that limit women's participation in the cowpea value chain have the potential to reduce gender disparities, food insecurity, and poverty.

Keywords: gender, cowpea, food security, impact, endogenous switching, probit, Zambia

5. Gender and mechanization: Exploring the sustainability of mechanized forage chopping in Tanzania

Fischer, G., Wittich, S., Malima, G., Sikumba, G., Lukuyu, B., Ngunga, D., & Rugalabam, J. (2018). Gender and mechanization: Exploring the sustainability of mechanized forage

chopping in Tanzania. *Journal of Rural Studies*, 64, 112–122. <https://doi.org/10.1016/j.jrurstud.2018.09.012>

Mechanization is currently experiencing a revival in agricultural research and development, with a new emphasis on equity and sustainability. This study evaluates the introduction of forage chopper machines in seven villages in northern Tanzania from a farmer's perspective. Data collected through focus group discussions and a survey are used for a gender analysis of this technology within a broader sustainable intensification indicator framework. The results not only draw attention to unabated challenges to smallholder mechanization (such as high operational costs or weak supporting infrastructures), but also show how the technology's sustainability is contingent upon equity dynamics on the household and community levels. The evaluation framework proved suitable for a holistic assessment. A broader approach to gender issues would strengthen its interdisciplinary claim. Suggestions for promoting the chopper's sustainability include gender-sensitive training and the establishment of group models for machine operation based on agreed and fair regulations.

Keywords: agricultural mechanization, gender, sustainability, livestock, Tanzania

6. Gender differentials and adoption of drought tolerant maize varieties among farmers in northern Nigeria

Gaya, H. I., Tegbaru, A., Bamire, A. S., Abdoulaye T., & Kehinde, A. D. (2017). Gender differentials and adoption of drought tolerant maize varieties among farmers in northern Nigeria. *European Journal of Business and Management*, 9(5), 81–87. www.iiste.org/Journals/index.php/EJBM/article/viewFile/35330/36352

This study examined gender differences in farmer's adoption of drought tolerant maize (DTM) varieties in Northern Nigeria. Specifically, it described the socio-economic characteristics of the farmers by gender; determined their rate of adoption of the DTM varieties; and analyzed the factors affecting the rate of adoption of the varieties. The study was conducted in seven: Borno, Bauchi, Kano, Kaduna, Niger, Zamfara, and Kwara states of Nigeria. A multistage sampling procedure was used to select 946 respondents, comprising 626 males and 320 females. Data were collected with the use of a survey questionnaire that contained questions on respondent's socio- economic characteristics such as age, years of schooling, household size, farm size, access to credit, level of awareness and adoption of DTM varieties and extension contact, among others. Data were analyzed using descriptive statistics and probit regression model. The results for the entire respondents showed average values of 46 years for age, seven years for year of schooling, 11 for household size, 6.93 for farm size and 5.7 ha for land area allocated to maize, with a significant difference ($p < 0.05$) between male and female farmers for each of the variables. The adoption rate of DTM was 56.3% on the average in the entire sample with a significant difference ($p < 0.05$) between male (61.8%) and female farmers (53.5%). The determinants of adoption of DTM varieties for both male and female farmers were access to credit, participation in field days, household size, fertilizer application, source of seeds and level of awareness of the variety, specific to male farmers was land area

allocated to maize and number of livestock while source of information about the DTM variety was specific to female farmers. It was concluded that policy strategies aimed at improving the uptake of DTM varieties must consider equality in male and female farmers' access to basic resources, such as credit, land, labor, and participation in different meetings.

Keywords: gender, drought tolerant, maize varieties, adoption, Nigeria.

7. Gender participation and decision making in crop management in Great Lakes Region of Central Africa

Ochieng, J., Ouma, E., & Birachi, E. (2014). Gender participation and decision making in crop management in Great Lakes Region of Central Africa. *Gender, Technology and Development*, 18(3), 341–362. www.tandfonline.com/doi/abs/10.1177/0971852414544007

In Rwanda, Burundi, and the Democratic Republic of Congo (DRC), increased crop productivity is fundamental to accelerating economic growth and improving the well-being of rural households, especially women and children, who are normally resource constrained. This article examines the degree to which women participate in farm management and decision making for crop production activities, and the socioeconomic factors that influence their participation. Our study found out that farms managed by women are cultivated much less intensively than male-managed farms, because of the limited ability of women to acquire technological inputs such as fertilizers and improved seeds. While legumes are grown by both men and women, cassava seems to be “a women’s crop,” both in terms of cultivation and harvesting. We found that accessibility to rural credit, extension services, social capital in the form of groups, and engagement in off-farm activities are critical for stimulating women’s participation in crop production activities. Therefore, women must be empowered through programs designed to promote crops that interest them. They should also be provided agricultural services such as credit to encourage the acquisition of production-enhancing inputs to increase crop yields.

Keywords: production, decision making, gender, intensive, well-being, women

8. Gender, education and poverty in DR Congo: A microeconomic analysis based on Oaxaca-Blinder decomposition

Nyamuhirwa, D.-M. A. (2019). Gender, education and poverty in DR Congo: A microeconomic analysis based on Oaxaca-Blinder decomposition. *Economics*, 8(2), 44–48. <http://www.sciencepublishinggroup.com/journal/paperinfo?journalid=177&doi=10.11648/j.eco.20190802.11>

This paper analyzes gender, education and poverty in DRC through a Blinder-Oaxaca decomposition approach. The latter was needed in this study to judge the difference in level of consumption expenditure per adult equivalent per day depending on whether the household is headed by a man or a woman. Preliminary results based on the regression of the variable of interest (consumption expenditure per adult equivalent per day) on the endogenous variables considered (the age of the head of the household and his level of education) showed that

age of household head is negatively influences the dependent variable when the head of household is a man and positively when it is a woman. It has also been found that educational attainment significantly influences the dependent variable at all levels of the education system considered in the female-headed household group. The decomposition showed that if female heads of household had the same endowments as men then the consumption expenditure per adult equivalent per day would decrease by approximately \$ 0.0334. In short, differences in staffing between male and female head of household are more beneficial to the household when the woman participates in the management of the household.

Keywords: gender, education, poverty, Oaxaca-Blinder

9. Gender, vegetable value chains, income distribution and access to resources: Insights from surveys in Tanzania

Fischer, G., Gramzow, A., & Laizer, A. (2017). Gender, vegetable value chains, income distribution and access to resources: Insights from surveys in Tanzania. *European Journal of Horticultural Science*, 82(6), 319–327. <https://doi.org/10.17660/eJHS.2017/82.6.7>

In sub-Saharan countries, male farmers are frequently seen as producers of cash crops and marketable vegetables, while female farmers are perceived as producers of food crops for home consumption. Few authors have tried to validate this perception of gender in the production of traditional vegetables, and gender differences in access to resources and markets remain under explored. The same holds true for traders of traditional vegetables who share the same value chain. The few studies available have tended to focus either on the household (as the unit of production) or on the market (for trade), neglecting interrelationships between the two. This knowledge gap must be addressed if men and women are to benefit equally from interventions to counteract poverty. A survey of 360 smallholder farmers and 82 vegetable traders in Tanzania was conducted under the “Africa Research in Sustainable Intensification for the Next Generation” program funded by the United States Agency for International Development (USAID) and led by the International Institute of Tropical Agriculture (IITA). Its objective was to examine gender relationships within production and within trade, as well as between the actors in both groups. Research foci were on production activities and income, market performance and access to resources as important areas of gendered value chain analysis. Results show no pronounced gender division in the production process, with the exception of pest and disease management, input purchase and seed selection (all predominantly carried out by men). Clear differences between male and female farmers emerged in the allocation of income from various crops. An exploration of why leafy vegetables are grown revealed that the juxtaposition of food crops and cash crops in relation to gender needs to be rethought. Market performance of female producers of leafy vegetables was weaker than that of their male counterparts and that of female traders. Both male and female traders rated their decision-making power as high in relation to the income generated through vegetable sales. For female smallholders, access to land constituted a major constraint. Women in male-headed households had the least contact with extension officers and training.

Without careful consideration of these and other results of gender analysis in value chains, interventions are at risk of failing to improve the livelihoods of producers and traders.

Keywords: gender relations, value chain analysis, horticulture, traditional vegetables, vegetable production, vegetable trade, smallholder agriculture

10. Gender-based constraints affecting biofortified cassava production, processing and marketing among men and women adopters in Oyo and Benue States, Nigeria

Olaosebikan, O., Bello, A., Owoade, D., Ogunade, A., Aina, O., Ilona, P., Muheebwa, A., Teeken, B., Iluebbey, P., Kulakow, P., Bakare, M., & Parkes, E. (2018). Gender-based constraints affecting biofortified cassava production, processing and marketing among men and women adopters in Oyo and Benue States, Nigeria. *Physiological and Molecular Plant Pathology*, 105, 17–27. <https://doi.org/10.1016/j.pmpp.2018.11.007>

This study identified gender-based constraints affecting the production, processing and marketing of biofortified cassava in two states in Nigeria, using a mixed methods approach. The study identified major differences between the two study sites (Benue and Oyo). The scale of production of biofortified cassava is higher in Oyo state among adult men because of their active involvement and collaboration with research institutes within the state and the ease of transporting products to Lagos State for designated diverse markets. However, in Benue state more adult and young women are engaged in cultivation, processing and marketing business to meet up with the increased demand due to higher consumer acceptance in this region. Gender analysis revealed that lack of access to hired labor restricted the scale of production among women in especially Oyo state. Low product price and high price of processing equipment, poor market infrastructure and middlemen exploitation were constraints significantly more mentioned by women in general. Majorly, the men identified limited processing facilities/equipment as the most important constraint affecting the demand of biofortified cassava roots, while generally women were more constrained by the shortage of basic amenities and trainings that hindered their processing efficiency. The study proposes integration of gender-responsive strategies to further enhance the delivery of biofortified cassava products in Nigeria.

Keywords: biofortified-cassava, constraints, gender, Nigeria

11. Gendered mobilities and immobilities: Women's and men's capacities for agricultural innovation in Kenya and Nigeria

Lodin, J. B., Tegbaru, A., Bullock, R., Degrande, A., Nkengla, L. W., & Gaya, H. I. (2019). Gendered mobilities and immobilities: Women's and men's capacities for agricultural innovation in Kenya and Nigeria. *Gender, Place & Culture*, 26(12), 1759–1783. www.tandfonline.com/doi/full/10.1080/0966369X.2019.1618794

Social norms surrounding women's and men's mobility in public spaces often differ. Here we discuss how gendered mobilities and immobilities influence women's and men's capacities to innovate in agriculture. We analyze four case studies from Western Kenya and Southwestern

Nigeria that draw on 28 focus group discussions and 32 individual interviews with a total of 225 rural and peri-urban women, men and youth. Findings show that women in both sites are less mobile than men due to norms that delimit the spaces where they can go, the purpose, length of time and time of day of their travels. Overall, Kenyan women and Nigerian men have better access to agricultural services and farmer groups than their gendered counterparts. In Southwestern Nigeria this is linked to masculine roles of heading and providing for the household and in Western Kenya to the construction of women as the 'developers' of their households. Access and group participation may reflect norms and expectations to fulfill gender roles rather than an individual's agency. This may (re)produce mobility pressures on time constrained gendered subjects. Frameworks to analyze factors that support women's and men's agency should be used to understand how gendered mobilities and immobilities are embedded in community contexts and affect engagement in agricultural innovation. This can inform the design of interventions to consider the ways in which norms and agency intersect and influence women's and men's mobilities, hence capacity to innovate in agriculture, thus supporting more gender transformative approaches.

Keywords: gender, mobility, agriculture, innovation, Kenya; Nigeria

12. Is taking gender into account for development and diffusion of agricultural innovations justified? The case of drought tolerant maize in Northern Benin

Baco, M. N., Affoukouk T., Moumouni I., & Abdoulaye, T. (2015). Is taking gender into account for development and diffusion of agricultural innovations justified? The case of drought tolerant maize in Northern Benin. *Journal of Agricultural Extension and Rural Development*.7 (10), 290-297. <http://dx.doi.org/10.5897/JAERD2015.0720>

This study was initiated to contribute to the debate on the relationship between gender and adoption of innovations. It aims, under a participatory varietal selection, to identify the preferences of men and women farmers on maize varieties tolerant to drought in northern Benin. The methodology used is a comparison of two approaches to identify the best varieties according to gender. The first combines criteria weighting and a comparison of varieties. The second is based on the principle of democratic vote. Sixty farmers have participated in this study. The results of this work show two key points. At the stage of criteria selection, women identified the organoleptic quality as a preferred seed characteristic. By comparing the results of the two methods of choice, it appears that both methods lead to the same results in the case of women's preferences, while in men groups, the results vary according to the methods. It contributes to the literature by showing how distinctly women can prioritize criteria that are not the top concern of the men and by the way, can contribute to increase the adoption of varieties that contains both preferences of men and women.

Keywords: Benin, gender, innovation, participatory varieties selection maize

13. Mapping cassava food value chains in Tanzania's smallholder farming sector: The implications of intra-household gender dynamics

Masamha, B., Thebe, V., & Uzokwe, V. N. E. (2018). Mapping cassava food value chains in Tanzania's smallholder farming sector: The implications of intra-household gender dynamics. *Journal of Rural Studies*, 58, 82–92. <https://doi.org/10.1016/j.jrurstud.2017.12.011>

A gendered mapping of the structure and coordination (functioning) of traditional cassava value chains is important for marginalized groups such as women in rural development. In contrast to global high value chains, traditional food value chains and associated gender relations as well as power dynamics within households have received little attention. We conducted a cross sectional study in Kigoma, Mwanza, the coastal region, and Zanzibar Island in Tanzania. Data were collected through structured interviews conducted with 228 farmers, combined with key informant interviews, direct observations, repeated household visits, and literature review. The results of the study revealed that there are weak linkages within the cassava value chain, which is highly gendered. While production and processing nodes of the chain, which commenced from villages, were dominated by women and children, women were not well-integrated within high value nodes such as marketing in urban areas and cross-border trading, which were dominated by men. Transportation of cassava to highly lucrative markets was also dominated by men. Cassava processing was conducted at the household level as well as within small-scale cooperatives, with the major portion of this work being done by women. Supporting institutions were found to be involved in the supply of planting material, training, and the provision of processing equipment. In general, men played a prominent role in the control of resources, marketing, and income. In conclusion, the mapping of cassava value chains could help to identify avenues for understanding of poverty, enhancing food security, upgrading capacities, reducing gender inequality, and enhancing women's participation in marketing and income control in the cassava value chains.

Keywords: cassava value chain, gender, smallholder farmers, household

14. Patterns and structure of household income inequality in rural Ethiopia

Gebeyehu, B., Feleke, S., Tufa, A., Lemma, T., Tefera, T., & Manyong, V. (2018). Patterns and structure of household income inequality in rural Ethiopia. *World Development Perspectives*, 10, 80–82. <https://ideas.repec.org/a/eee/wodepe/v10-12y2018ip80-82.html>

The report examines patterns of gender income inequality in rural Ethiopia and draws insights and implications on whether income growth policy should be gender-neutral or gender-responsive. The report also examines the structure of the income distribution and draws insights and implications on whether income distribution policy should primarily address the disparity in income across the households within the same group or the gap between the different groups.

Keywords: rural livelihoods, income diversification, Ethiopia

15. Resolving the gender empowerment equation in agricultural research: A systems approach

Tegbaru, A., FitzSimons, J., Kirscht, H., & Hillbur, P. (2015). Resolving the gender empowerment equation in agricultural research: A systems approach. *Journal of Food, Agriculture and Environment*, 13(3/4), 131–139. www.wfpublisher.com/Abstract/4094

The aim of this paper was to bridge the socio-technical divide in agricultural systems research by providing an approach that addresses marginalized groups, particularly rural women, and their access to and ownership of agricultural intensification processes. By revisiting social systems theory and the evolution of gender approaches in the CGIAR, the paper provides socio-spatial perspectives on gender supported by a landscape approach to innovation, agency and empowerment. A systems approach to empowerment is critical to make agricultural research-for-development gender transformative. The paper explores a more inclusive CGIAR systems research in the light of the ambitions to alleviate poverty, improve nutrition and income without compromising the long-term productivity of the natural environment. The empowering dimension of systems research is distinct from that of commodity focused value chain approaches and other traditional gender approaches within agriculture which have separated gender and development from systems thinking.

Keywords: gender, systems research, innovation, agency, empowerment

16. The role of women in production and management of RTB crops in Rwanda and Burundi: Do men decide, and women work?

Okonya, J. S., Mudege, N. N., Rietveld, A. M., Nduwayezu, A., Kantungeko, D., Hakizimana, B. M., Nyaga, J. N., Blomme, G., Legg, J. P., & Kroschel, J. (2019). The role of women in production and management of RTB crops in Rwanda and Burundi: Do men decide, and women work? *Sustainability*, 11, 4304. <https://doi.org/10.3390/su11164304>

This paper evaluates the determinants of decision-making in relation to the production of four crops (banana, cassava, potato, and sweet potato). Understanding the division of labor and decision-making in crop management may lead to designing better interventions targeted at improving efficiency in smallholder agriculture. In 2014, the research team conducted a quantitative household survey with heads of households involving 261 women and 144 men in Burundi and 184 women and 222 men in Rwanda. Most of the decisions and labor provision during the production of both cash crops (potato and banana) and food crops (sweet potato and cassava) were done jointly by men and women in male-headed households. Higher values for 'credit access', 'land size', and 'farming as the main occupation of the household head' increased the frequency of joint decision-making in male-headed households. A decline in the amount of farm income reduced the participation of men as decision-makers. A reduction in total household income and proximity to the market was correlated with joint decision-making. Gender norms also contributed to the lower participation of women in both decision-making and labor provision in banana and potato cultivation. Although a large proportion of decisions

were made jointly, women perceived that men participate more in decision-making processes within the household during the production of cash crops. Increased participation by women in decision-making will require an active and practical strategy which can encourage adjustments to existing traditional gender norms that recognize men as the main decision-makers at both the household and community levels.

Keywords: banana, cassava, potato, sweet potato, gender division of labor, decision-making

17. Unlocking the household ‘black box’: A gendered analysis of smallholder farmers’ participation in the cassava (*Manihot esculenta* Crantz) value chain in Tanzania

Masamha, B., Thebe, V., & Uzokwe, V. N. (2018). Unlocking the household ‘black box’: A gendered analysis of smallholder farmers’ participation in the cassava (*Manihot esculenta* Crantz) value chain in Tanzania. *Journal of International Development*, 30(1), 20–41. <https://doi.org/10.1002/jid.3317>

Women in developing countries are often omitted from key parts of the agricultural value chains. We used household survey data in bi-probit and ordinary least squares regression models to estimate the determinants of women’s participation in cassava cultivation and marketing in Tanzania. Land size and region, among other factors, were significant determinants of household decisions to grow cassava. Policies for improving women’s land rights and infrastructure would help to promote their participation in cassava production, processing and marketing. Improved methods of delivering extension information would also improve women’s participation in the cassava value chain markets.

18. Women’s empowerment in traditional food value chains at the micro level: Evidence from cassava smallholder farming in Tanzania

Masamha, B., Uzokwe, V. N. E., & Thebe, V. (2018). Women’s empowerment in traditional food value chains at the micro level: Evidence from cassava smallholder farming in Tanzania. *Agroecology and Sustainable Food Systems*, 42(1), 28–47. <http://dx.doi.org/10.1080/21683565.2017.1325433>

Empowering women improves household food productivity and security. We examined women’s empowerment within the cassava value chain according to the five domains of empowerment of the Women’s Empowerment in Agriculture Index, using data from 228 respondents in Tanzania. Disempowerment indices for women and men were 0.95 and 0.14, respectively. Women were disempowered in the production, leadership, and time domains. Women were empowered in the resource’s domain, which entailed joint ownership and decision making. Marital status and educational levels were significantly associated with women’s empowerment. Policies to improve women’s empowerment should focus on securing ownership of resources and access to credit.

Keywords: Africa, cassava, five domains of empowerment (5DE), Tanzania, traditional food value chain, women’s empowerment

19. Addressing gendered varietal and trait preferences in West African maize

Tegbaru, A., Menkir, A., Nasser Baco, M., Idrisou, L., Sissoko, D., Eyitayo, A. O., Abate, T., & Tahirou, A. (2020). Addressing gendered varietal and trait preferences in West African maize. *World Development Perspectives*, 20, 100268. <https://doi.org/10.1016/j.wdp.2020.100268>

Maize is the most important cereal in Sub Saharan Africa; however, yields are significantly lower than those possible with improvements in cultivars and management. Maize breeding programs need to produce material with improved resistance to increasing environmental stresses and incorporate the man and women farmer preferred traits that relate to yield, post-harvest, nutritional, and processing qualities. This research uses gender-disaggregated data recorded during participatory on-farm maize trials by the Stress Tolerant Maize Program conducted in agroecological zones of Benin, Nigeria and Mali) to identify men and women farmer's expressed varietal and trait preferences in order to evaluate plant breeding strategy. A multi-stage varietal and trait identification process was used to identify gender shared and distinctive varietal trait preferences for product development and dissemination. The data indicates that progress has been made by the Project in considering the range of traits valued by both men and women farmers and indicates those that should be considered for gender-focused product pipeline development in the future. The study concludes by underlining the need for adjustment in breeding to improve partnerships with food scientists, post-harvest specialists and private seed sector on the packaging and delivery of technologies to farmers and other value chain actors.

Keywords: maize, breeding, gender, varieties, traits, partnerships

20. Contracting and gender equity in Tanzania: using a value chain approach to understand the role of gender in organic spice certification

Bullock, R., Gyau, A., Mithoefer, D., & Swisher, M. (2018). Contracting and gender equity in Tanzania: using a value chain approach to understand the role of gender in organic spice certification. *Renewable Agriculture and Food Systems*, 33(1), 60–72. <https://doi.org/10.1017/S1742170517000151>

Value chain development (VCD) initiatives within the horticultural and organic sectors in Africa are promising strategies to improve smallholder welfare. Contracting institutional arrangements are a common feature of VCD initiatives and are increasing in number in sub-Saharan Africa as a way to source organic products from smallholder producers. The objective of this study is to better understand men and women's participation in spice producing households that sell under contract and in conventional market chains in the East Usambaras, Tanzania. We draw on New Institutional Economics, political economy and the value chain analysis framework to assess the potential role of contracting to promote gender equity among smallholder organic horticultural producers. We describe intra-household decision making over resources and marketing, access to benefits of contracting, and labor distribution between men and women in contracting and non-contracting households. We then extend the gender analysis to

evaluate the role of gender in contracting and conventional value chains operating within the community and district. Using a cross-sectional research design and data collected through 13 focus group discussions, 54 personal interviews and 156 household questionnaires, we show that contracting reduces transaction costs in the chain compared with the conventional trade. However, norms in the wider political economic context give rise to gendered patterns of participation in both household and chain activities in contracting and non-contracting households. Our findings suggest that contracting does not provide significant opportunities for women in married households to participate and benefit based on limited participation in decision-making and access to trainings. Divorced women and widows gain access to contract employment opportunities to earn income. This study highlights the importance of understanding gender relations in the household and community to guide the development of gender equitable VCD initiatives and contracting approaches.

21. Contribution of men and women to food crop production labour in Africa: Information from COSCA

Enete, A., Nweke, F., & Tollens, E. F. (2002). Contribution of men and women to food crop production labour in Africa: Information from COSCA. *Outlook on Agriculture*, 31(4), 259–265. <https://doi.org/10.5367/000000002101294155>

It is widely reported that women provide the bulk of food production labor in Africa. Since efficient targeting of improved technologies demands an understanding of who is likely to use them, and new farm technologies have often been inappropriate for women's needs, this paper presents the relative contributions of men and women to food production labor in six major cassava-producing countries of Africa. The paper is based on farm-level information collected within the framework of the Collaborative Study of Cassava in Africa (COSCA). While the number of fields in which women provided more labor for each farm task increased consistently from the initial farm operations, such as land clearing and seedbed preparation, through sowing (planting) and weeding to the final farm operations such as harvesting and transportation, for which women provided more labor for the largest number of fields, the reverse was the case for men. The relative number of households where females provided more field labor than males was higher among female-headed households than among male-headed ones. Such households were characterized by a lower working age male/female ratio, and/or were engaged in tree crop production, which often absorbed male labor. Villages where females provided more field labor than males were more common in remote areas where access to markets was poor and population density sparse, or in countries where men had fled the villages because of political repression. Such villages were also more common among non-Muslim communities than among predominantly Muslim societies. On the whole, however, men contributed more labor in significantly more fields than women in most places. These observations suggest that it could be misleading to generalize that women are providing the bulk of food production labor across Africa. They provide clear evidence of gender division of labor on the farm, and help to explain gender bias in agricultural extension efforts in Africa. Recommendations that pre-harvest extension activities should be mainly directed at women

have hardly been heeded. It is recommended that these activities should be targeted at both men and women, but more toward women where men have fled the villages for political reasons or for commercial ones such as poor market access opportunities.

22. Economic efficiency and supply response of women as farm managers: Comparative evidence from Western Kenya

Alene, A., Manyong, V., Omany, G.*, Mignouna, H., Bokanga, M., & Odhiambo, G. D.* (2008). Economic efficiency and supply response of women as farm managers: Comparative evidence from Western Kenya. *World Development*, 36(7), 1247–1260. <https://doi.org/10.1016/j.worlddev.2007.06.015>

This paper assessed the relative economic efficiency and output supply and input demand responses of women farmers in western Kenya. The results showed that women are as technically and allocatively efficient as men. However, neither men nor women have absolute allocative efficiency. Women farmers are equally responsive to price incentives in terms of output supply and input demand. While education and extension contact have significant effects on overall maize supply and input demand, only extension contact has significant effects among women farmers. The paper discusses a number of significant results and concludes with implications for policy.

Keywords: efficiency, supply response, input demand, women, Africa, Kenya

23. Engaging with cultural practices in ways that benefit women in northern Nigeria

Tipilda, A., Alene, A., & Manyong, V. (2008). Engaging with cultural practices in ways that benefit women in northern Nigeria. *Development in Practice*, 18(4/5), 551–563. www.jstor.org/stable/27751958

This study explores the intra-household impact of improved dual-purpose cowpea (IDPC) from a gender perspective, in terms of productivity and food, fodder, and income availability, the impact of which is linked to the income thus placed in the women's hands. Surplus income is important in providing food and nutritional benefits to the home, particularly during periods of risk. More importantly, income generated through the adoption of improved cowpea varieties has entered a largely female domain, where transfers of income reserves were passed on between women of different ages, with significant impact in terms of social and economic development. However, the technology has strengthened the separation of working spheres between men and women. Future technologies should, from the outset, explore provisions existing within the local rubric, to focus on women with the aim of expanding their participation in agriculture with the associated benefits to their families.

Keywords: gender and social diversity, labor and livelihoods, technology, methods, sub-Saharan Africa

24. Gender analysis in grain maize value chain in northern and central Benin

Adetonah, S., Coulibaly, O., Satoguina, H.*, Sangare, A.*, & Dossavi-yovo, N. H. (2016). Gender analysis in grain maize value chain in northern and central Benin. *International Journal of Research in Social Sciences*, 6(7), 51–64. <https://cgspace.cgiar.org/handle/10568/79758>

Maize is one of the most important food crops in the world and, together with rice and wheat, provides at least 30% of the food calories to more than 4.5 billion people in 94 developing countries. It is produced across Benin and mainly women and young people are involved in the maize grain value chain. This study aimed to carry out a gender analysis in the maize grain value chain in northern and central Benin. Specifically to analyze the division of labor according to gender in the grain maize value chain, identify the factors that influence access to and control of resources and measure the distribution of profits from the commercialization activities. Data have been collected at random in a stratified method including 90 producers, 33 processors and 33 corn traders. The Harvard analytic framework, descriptive statistics and binominal logit patterns have been used for the analysis. In terms of resource accessibility, the results showed that men have more access and control the resources in both areas than women with limited access to credit, training, land and information in the chain. Moreover, the logistic regression results noted that socio-economic factors such as level of education, accessibility to credits and equipment positively affect the control of resources by women.

Keywords: gender, value chain, maize, northern and central Benin, division of labor

25. Gender and generation: an intra-household analysis on access to resources in southern Mali

De Groote, H., & Coulibaly, N. (1998). Gender and generation: an intra-household analysis on access to resources in southern Mali. *African Crop Science Journal*, 6(1), 79–95. <https://cgspace.cgiar.org/handle/10568/101004>

This paper analyzes the difference of access to productive resources within the household of Southern Mali. Information was collected through separate group discussions with older men, and women from six villages. This information was complemented with a formal survey of 96 households in 12 villages. It was found that the essential difference between individuals related to access are gender, age, marriage and being the head of the household. The head of the household, always a man, manages the common fields, but otherwise men have less access than women to private plots and to the gathering of forest products. They have, however, more access to animals, and own all equipment. Differences between ethnic groups are very important. Methodologically, an effort has been made to reduce the age into categories of generation and relation to the head of the household, but generally, these variables did not perform very well. For future intra-household surveys following strata need to be distinguished for sampling: heads of household, dependent men and women. Other influential variables to be included in the survey are age, ethnic groups, marriage and participation in field work.

Keywords: access, gender, intra-household resource allocation, Mali, resources

26. Gender and impact of climate change adaptation on soybean farmers' revenue in rural Togo, West Africa

Ali, E., Awade, N. E., & Abdoulaye, T. (2020). Gender and impact of climate change adaptation on soybean farmers' revenue in rural Togo, West Africa. *Cogent Food & Agriculture*, 6(1), 1743625. <https://doi.org/10.1080/23311932.2020.1743625>

This study assesses the impact of climate change (CC) adaptation on farm-level revenue among 500 soybean farmers randomly selected in three districts in Togo using endogenous switching regression method. The survey results indicate that only 40.37% of the women have adapted to CC against 59.62% of the men. Moreover, being member of farmer-based organization (FBO), access to credit and extension services, agricultural training of women are the main factors that increase the likelihood of adaptation. The gender-differentiated impact shows that women would earn more than men from adaptation, while losing compared to men if they do not take any adaptation actions. The loss from non-adapting to CC will increase by 0.268% of the soybean revenue. However, the heterogeneity effects suggest further assessment on the adopted technology in soybean farming in the study areas. Adaptation policy that seeks to ensure food security and enhance farmers' welfare in subsistence agriculture should consider the gender dimension, while reviewing the financial policy in terms of affordability, access of extension services and supporting FBO will increase technologies adoption and farming revenue.

Keywords: adaptation, climate change, gender, soybean, endogenous switching regression

27. Gender and innovation in agriculture: a case study of farmers' varietal preference of drought tolerant maize in southern Guinea Savannah region of Nigeria

Ayinde, O. E.*, Abdoulaye, T., Olaoye, G.*, & Akangbe, J.* (2013). Gender and innovation in agriculture: a case study of farmers' varietal preference of drought tolerant maize in southern Guinea Savannah region of Nigeria. *Albanian Journal of Agricultural Sciences*, 12(4), 617–625. <https://cgspace.cgiar.org/handle/10568/76667?show=full>

Maize is one of the world's three primary cereal crops, sustainable increasing production of this crop is important to farmers to be able to meet the ever increasing consumption of maize which is one of the major reasons for the development of Drought tolerant maize variety (DTMA). The study analyzes farmers' varietal preference of drought tolerant maize in Southern Guinea Savannah region of Nigeria. It specifically determined the socioeconomic characteristics of farmers, identified their gender based preference for Drought Tolerant maize variety and elucidated the reasons for preference. Three-stage stratified sampling technique was used. Well-structured questionnaire was used to collect information from a total of 48 farmers. Descriptive, Ranking and LSD were used to analyze the data collected. The result of the analysis showed that majority of the male and female farmers have primary education and are youths. The result of varietal preference differs between genders in some locations Male farmers identified big cobs with full grains, big seed, and multiple cobs as the main reasons for

their preference while female farmers identified yellow color of seed, nutrient fortified seed and big cobs with full grains as the main reasons for their preference. It is therefore recommended that effort should be made to involve male and female farmers in the varietal selection procedure as to facilitate easy adoption of hybrid maize. The women are more concerned with the food security of their family and hence are important segment in maize innovation that improve the food security of farming households. It is therefore imperative that programs and policies should not exclude female farmers.

Keywords: innovation, gender, drought-tolerant maize variety, Nigeria

28. Gender and variety selection: Farmers assessment of local corn varieties in southern Mali

Defoer, T., Kamara, A., & De Groote, H. (1997). Gender and variety selection: Farmers assessment of local corn varieties in southern Mali. *African Crop Science Journal*, 5(1), 65–76. <https://cgspace.cgiar.org/handle/10568/103844>

In order to respond to the variability of local conditions and production objectives, farmers in southern Mali generally grow several varieties of maize, representing different characteristics. Their selection criteria have been reported to be quite different from those of breeders. Moreover, women's criteria for processing and consumption have often been neglected. The complexity and variability of farmers' production strategies and objectives make it difficult to grasp farmers' selection criteria, for both gender. In southern Mali, thematic research on the improvement of cereal varieties consists of testing new varieties on-station, followed by multi-location on-farm trials managed by researchers. Researchers' principal selection criteria are yield maximisation and agro-climatic stability. As such, several high yielding varieties have been selected for extension, but have, however, failed to be widely adopted. A participatory research methodology has been developed to quantify farmers' criteria for growing and prioritising local varieties. Through open evaluations, the relative importance of the different local varieties and their major characteristics, important to farmers, can be depicted. Pair-wise comparisons result in gender specific prioritising of varieties and quantification of decision-making criteria. Linking decision making criteria with farmer and farm characteristics assists in explaining underlying objectives and strategies. This new methodology was used to assess local maize varieties in two zones in southern Mali. The results show that there was a wide range of selection criteria other than yield and ecological adaptability. The importance of these criteria differed substantially between zones and among male and female farmers, reflecting their production objectives and strategies. Incorporation of these criteria early in the selection program could help breeders to produce varieties with a better chance of adoption. Through quantification of these criteria, it is possible to help prioritise breeders' selection criteria and to predict future adoption.

Keywords: gender, maize, southern Mali, on-farm

29. Gender differences in technology adoption and agricultural productivity: Evidence from Malawi

Hirpa Tufa, A., Alene, A. D., Cole, S. M., Manda, J., Feleke, S., Abdoulaye, T., Chikoye, D., & Manyong, V. (2022). Gender differences in technology adoption and agricultural productivity: Evidence from Malawi. *World Development*, 159, 106027. <https://doi.org/10.1016/j.worlddev.2022.106027>

It is widely recognized that female farmers have considerably less access to productive assets and support services than male farmers. There is limited evidence of gender gaps in technology adoption and agricultural productivity after accounting for the differential access to factors of production between males and females. This study investigates the gender differences in the adoption of improved technologies and agricultural productivity in Malawi using nationally representative data collected from 1600 households and 5238 plots. We used a multivariate probit model to analyze the gender differences in the adoption of improved technologies, including intercropping, use of improved varieties, crop rotation and residue retention, manure use, and minimum tillage. To analyze gender differences in agricultural productivity, we used an exogenous switching regression (ESR) model and recentered influence function decomposition. We found that female plot managers were more likely to adopt intercropping and minimum tillage but less likely to adopt crop rotation and use improved varieties than male plot managers. The ESR model estimation results showed that female-managed plots were 14.6–23.1% less productive than male-managed plots. The gender productivity gaps also indicated that female plot managers had an 8.2% endowment advantage but a 23.1% structural disadvantage than male plot managers. The importance of structural effects in accounting for the gender productivity gap highlights the need for policies and agricultural development programs that consider the underlying factors shaping gender productivity gaps rather than focusing solely on agricultural production factors.

Keywords: gender, productivity, technology adoption, plot managers, Malawi

30. Gender in climate change, agriculture, and natural resource policies: insights from East Africa

Ampaire, E. L., Acosta, M., Huyer, S., Kigonya, R., Muchunguzi, P., Muna, R., & Jassogne, L. (2020). Gender in climate change, agriculture, and natural resource policies: insights from East Africa. *Climatic Change*, 158(1), 43–60. <https://doi.org/10.1007/s10584-019-02447-0>

Gender mainstreaming was acknowledged as an indispensable strategy for achieving gender equality at the 1995 Beijing Platform for Action. Since then, governments have made substantial efforts in developing gender-responsive policies and implementation strategies. The advent of climate change and its effects, which have continued to impact rural livelihoods and especially food security, demands that gender mainstreaming efforts are accelerated. Effective gender mainstreaming requires that gender is sufficiently integrated in policies, development plans, and implementation strategies, supported by budgetary allocations. This study analyzes

the extent of gender integration in agricultural and natural resource policies in Uganda and Tanzania, and how gender is budgeted for in implementation plans at district and lower governance levels. A total of 155 policy documents, development plans, and annual action plans from national, district, and sub-county/ward levels were reviewed. In addition, district and subcounty budgets for four consecutive financial years from 2012/2013 to 2015/2016 were analyzed for gender allocations. Results show that whereas there is increasing gender responsiveness in both countries, (i) gender issues are still interpreted as “women issues,” (ii) there is disharmony in gender mainstreaming across governance levels, (iii) budgeting for gender is not yet fully embraced by governments, (iii) allocations to gender at sub-national level remain inconsistently low with sharp differences between estimated and actual budgets, and (iv) gender activities do not address any structural inequalities. We propose approaches that increase capacity to develop and execute gender-responsive policies, implementation plans, and budgets.

31. Gender influence on participation in cassava value chains in smallholder farming sectors: Evidence from Kigoma region, Tanzania

Masamha, B., Uzokwe, V. N., Ntagwabira, F. E., Gabagambi, D., & Mamiro, P. (2019). Gender influence on participation in cassava value chains in smallholder farming sectors: evidence from Kigoma Region, Tanzania. *Experimental Agriculture*, 55(1), 57–72. <https://doi.org/10.1017/S0014479717000552>

When the agricultural value chain involves profit making, it results in changes in the production and distribution relationships among men and women in terms of access to and control of markets, resources and benefits emanating from product value chain participation. This affects not only individual incomes but also gender equality. This study examined gender relationships in the cassava value chain in the Kigoma region of Tanzania. The aim was to assess gender participation in the cassava value chain. Multi-stage sampling was used to select the respondents in four districts. A structured questionnaire was administered to 384 randomly selected household heads. A chi-square test was used to test for significant relationships among the variables. Results indicated that gender was significantly related to socio-economic characteristics. About 34% of the women participating in the cassava value chain were young, some below 17 years. There were significant relationships between gender and access to resources (land, extension services and markets), control over resources (land, house and household assets) and benefits (revenue) generated from cassava value chains. Overall, there was gender disparity in participation along the cassava value chain. These results suggest that any intervention in the cassava value chain should consider gender relations to benefit men and women and alleviate household poverty.

32. Gender participation and decision making in crop management in great lakes region of Central Africa

Ochieng, J., Ouma, E., & Birachi, E. (2014). Gender participation and decision making in crop management in great lakes region of Central Africa. *Gender, Technology and Development*,

In Rwanda, Burundi, and the Democratic Republic of Congo (DRC), increased crop productivity is fundamental to accelerating economic growth and improving the well-being of rural households, especially women and children, who are normally resource constrained. This article examines the degree to which women participate in farm management and decision making for crop production activities, and the socioeconomic factors that influence their participation. Our study found out that farms managed by women are cultivated much less intensively than male-managed farms, because of the limited ability of women to acquire technological inputs such as fertilizers and improved seeds. While legumes are grown by both men and women, cassava seems to be “a women’s crop,” both in terms of cultivation and harvesting. We found that accessibility to rural credit, extension services, social capital in the form of groups, and engagement in off-farm activities are critical for stimulating women’s participation in crop production activities. Therefore, women must be empowered through programs designed to promote crops that interest them. They should also be provided agricultural services such as credit to encourage the acquisition of production-enhancing inputs to increase crop yields.

Keywords: production, decision making, gender, intensive, well-being, women

33. Sustainable agricultural intensification and gender-biased land tenure systems: an exploration and conceptualization of interactions

Fischer, G., Darkwah, A., Kamoto, J., Kampanje-Phiri, J., Grabowski, P., & Djenontin, I. (2021). Sustainable agricultural intensification and gender-biased land tenure systems: an exploration and conceptualization of interactions. *International Journal of Agricultural Sustainability*, 19(5/6), 403–422. <https://doi.org/10.1080/14735903.2020.1791425>

How does sustainable agricultural intensification’s (SAI) tenet of increased productivity on the same area of land relate to prevailing gender-biased land tenure systems? How can one conceptualize the interactions between intensified land use and control over land, labor, crops and benefits – and how can equitable outcomes be facilitated? These questions (which have not yet received sufficient attention in SAI research) are explored in this study using a qualitative methodology and a gender-transformative approach. Semi-structured interviews and focus group discussions with a total of 248 respondents were conducted in matrilineal and patrilineal intensification contexts in Ghana and Malawi. We develop a conceptual framework that extends Kabeer’s institutional analysis to include gender implications of SAI. Selected cases reveal how farmers and key actors link land use intensification to existing land-related institutions with diverse outcomes. We conclude that SAI interventions should adopt gender-transformative approaches. These facilitate equitable outcomes by supporting consensus-based institutional changes and creating positive synergies between multiple scales.

Keywords: gender, land, sustainable agricultural intensification, Ghana, Malawi

34. Sustainable and equitable agricultural mechanization? A gendered perspective on maize shelling

Fischer, G., Kotu, B., & Mutungi, C. (2021). Sustainable and equitable agricultural mechanization? A gendered perspective on maize shelling. *Renewable Agriculture and Food Systems*, 36(4), 396–404. <https://doi.org/10.1017/S1742170521000016>

How can agricultural mechanization be accomplished in a sustainable and equitable way? This question has gained increased prominence in mechanization research over the past few years. In this study, we apply the question to mechanized maize shelling in Tanzania as a case in point. Data from a survey with 400 farmers and from semi-structured interviews with 21 key informants are combined for a gender analysis that relies on Kabeer's concept of four institutional sites (household, community, market and government). The findings reveal that although mechanization reduces men's and women's perceived drudgery of shelling, relief depends on gendered patterns of labor allocation and decision-making at the household level. As a result, the transformation of inequitable norms emerges as paramount. Key informants identified additional aspects that would make mechanized shelling more equitable and sustainable, such as mainstreaming gender and mechanization in comprehensive agricultural training, or the sensitization of mechanized input suppliers and manufacturers to farmers' preferences (including gender-sensitive machine design). Concerted efforts in multiple institutional sites are needed to achieve lasting change in respect of equity in mechanization.

Keywords: gender, labor, maize, mechanization, post-harvest processes, sustainability, Tanzania

35. Women eat more rice and banana: The influence of gender and migration on staple food choice in East Africa

Bechoff, A., Forsythe, L., Njau, M., Martin, A., Audifas, G., Abass, A., & Tomlins, K. (2020). Women eat more rice and banana: The influence of gender and migration on staple food choice in East Africa. *Ecology of Food and Nutrition*, 59(5), 506–524. <https://doi.org/10.1080/03670244.2020.1755278>

An original approach was used to examine how staple food choice differs by gender and migration: this consisted of a quantitative survey (6 locations with urban consumers from various economic classes (n = 123)), a qualitative in-depth interview with a subset of those consumers (n=18), and focus group discussions (n = 13). Men and women had similar results in terms of their preferred staple food choice attributes; yet women indicated consuming more rice and banana, and men, more maize and cassava (Chi-squared test; $p < 0.05$). Migration status and life stage (formative or adult years) also influenced the type and diversity of staple crops reported.

Keywords: food choice, staple, gender, urban migration, mixed methods

Research priority setting (29)

1. A framework for priority setting in climate smart agriculture research

Thornton, P. K., Whitbread, A. M., Baedeker, T., Cairns, J. E., Claessens, L., Baethgen, W. E., Bunn, C., Friedmann, M., Giller, K. E., Herrero, M. T., Howden, M., Kilcline, K., Nangia, V., Ramírez Villegas, J., Kumar, S., West, P. C., & Keating, B. (2018). A framework for priority setting in climate smart agriculture research. *Agricultural Systems*, 167, 161–175. <https://doi.org/10.1016/j.agsy.2018.09.009>

Climate-smart agriculture (CSA) is widely promoted as an approach for reorienting agricultural development under the realities of climate change. Prioritising research-for-development activities is crucial, given the need to utilize scarce resources as effectively as possible. However, no framework exists for assessing and comparing different CSA research investments. Several aspects make it challenging to prioritise CSA research, including its multi-dimensional nature (productivity, adaptation and mitigation), the uncertainty surrounding many climate impacts, and the scale and temporal dependencies that may affect the benefits and costs of CSA adoption. Here we propose a framework for prioritising agricultural research investments across scales and review different approaches to setting priorities among agricultural research projects. Many priority setting case studies address the short- to medium-term and at relatively local scales. We suggest that a mix of actions that span spatial and temporal time scales is needed to be adaptive to a changing climate, address immediate problems and create enabling conditions for enduring change.

Keywords: adaptation, mitigation, climate change, agriculture, research

2. A spatial framework for *ex-ante* impact assessment of agricultural technologies

Andrade, J. F., Edreira, J. I. R., Farrow, A., Loon, M. P. van, Craufurd, P. Q., Rurinda, J., Zingore, S., Chamberlin, J., Claessens, L., Adewopo, J., Ittersum, M. K. van, Cassman, K. G., & Grassini, P. (2019). A spatial framework for *ex-ante* impact assessment of agricultural technologies. *Global Food Security*, 20, 72–81. <https://doi.org/10.1016/j.gfs.2018.12.006>

Traditional agricultural research and extension relies on replicated field experiments, on-farm trials, and demonstration plots to evaluate and adapt agronomic technologies that aim to increase productivity, reduce risk, and protect the environment for a given biophysical and socio-economic context. To date, these efforts lack a generic and robust spatial framework for *ex-ante* assessment that: (i) provides strategic insight to guide decisions about the number and location of testing sites, (ii) define the target domain for scaling out a given technology or technology package, and (iii) estimate potential impact from widespread adoption of the technology(ies) being evaluated. In this study, we developed a data-rich spatial framework to guide agricultural research and development (AR&D) prioritization and to perform *ex-ante* impact assessment. The framework uses “technology extrapolation domains”, which delineate regions with similar climate and soil type combined with other biophysical and socio-

economic factors that influence technology adoption. We provide proof of concept for the framework using a maize agronomy project in three sub-Saharan Africa countries (Ethiopia, Nigeria, and Tanzania) as a case study. We used maize area and rural population coverage as indicators to estimate potential project impact in each country. The project conducted 496 nutrient omission trials located at both on-farm and research station sites across these three countries. Reallocation of test sites toward domains with a larger proportion of national maize area could increase coverage of maize area by 79–134% and of rural population by 14–33% in Nigeria and Ethiopia. This study represents a first step in developing a generic, transparent, and scientifically robust framework to estimate *ex-ante* impact of AR&D programs that aim to increase food production and reduce poverty and hunger.

Keywords: agricultural R&D, spatial framework, impact assessment, scaling out

3. Accounting for correlation among environmental covariates improves delineation of extrapolation suitability index for agronomic technological packages

Muthoni, F. K., Baijukya, F., Bekunda, M., Sseguya, H., Kimaro, A., Alabi, T., Mruma, S., & Hoeschle-Zeledon, I. (2019). Accounting for correlation among environmental covariates improves delineation of extrapolation suitability index for agronomic technological packages. *Geocarto International*, 34(4), 368–390. <https://doi.org/10.1080/10106049.2017.1404144>

This paper generates an extrapolation suitability index (ESI) to guide scaling out of improved maize varieties and inorganic fertilizers. The best-bet technology packages were selected based on yield gap data from trial sites in Tanzania. A modified extrapolation detection algorithm was used to generate maps on two types of dissimilarities between environmental conditions at the reference sites and the outlying projection domain. The two dissimilarity maps were intersected to generate ESI. Accounting for correlation structure among covariates improved estimate of risk of extrapolating technologies. The covariate that highly limited the suitability of specific technology package in each pixel was identified. The impact based spatial targeting index (IBSTI) identified zones that should be prioritized to maximize the potential impacts of scaling out technology packages. The proposed indices will guide extension agencies in targeting technology packages to suitable environments with high potential impact to increase probability of adoption and reduce risk of failure.

Keywords: big data, novel correlation, priority setting, risk of failure, spatial targeting

4. Agricultural intensification and efficiency in the West African savannas: evidence from northern Nigeria

Okike, I. O., Jabbar, M. A., Manyong, V. M., Smith, J. W., Akinwumi, J. A., & Ehui, S. K. (2001). *Agricultural Intensification and Efficiency in the West African Savannas: Evidence from Northern Nigeria*. Research Report 182891. Nairobi: International Livestock Research Institute. <https://ideas.repec.org/p/ags/ilirrr/182891.html>

Agricultural intensification in West Africa is in its early stages and several hypotheses have been postulated about its evolution and possible pathways. In addition, farm efficiency may vary across farms and other socio-economic domains, opening opportunities to improve efficiency and productivity through reallocation of current resources and introducing new technologies that target farmers. A survey was conducted among 559 households in 8 villages, 4 each in the northern Guinea savannah (NGS) and Sudan savannah (SS) zones of northern Nigeria, each representing a combination of high or low population density and high or low market access, to test these hypotheses.

5. Analysing optimum and alternative farm plans for risk averse grain crop farmers in Kaduna state, northern Nigeria

Olarinde, L, Manyong, V., & Okoruwa, V (2008). Analysing optimum and alternative farm plans for risk averse grain crop farmers in Kaduna state, northern Nigeria. *World Journal of Agricultural Sciences*, 4(1), 28–35. <https://biblio.iita.org/documents/olarinde-analysing-2008.pdf-56727e528e463a4f3f7df3cb48682c5e.pdf>

It has been argued that the limited success of Nigeria in rural development programs could be due to absence of a prior analysis of attitudes toward, risk inherent in traditional agriculture. This paper was therefore conceived to explain farmers' cropping patterns vis-à-vis their attitudes toward risk. The paper applied an analytical procedure that made use of the conventional linear programming, and the Target Minimization of total absolute deviations (Target MOTAD) as the major tools. Results indicate that farmers' existing and profit maximizing crop plans are risk inefficient. They also show that there are increasing levels of risks of the farm plans as the farm size decreases. Sustainable farm plans that minimize risk and can ensure desirable returns (gross margins) are suggested for the three identified categories of farmers that were surveyed for the analysis. The study provides a critical methodological framework that can help understand the alternative ways in which these farmers actually manage risk, particularly in a complex and unstable economic environment such as Nigeria.

Keywords: risk aversion, economic optimum, northern Nigeria

6. Assessing the representativeness and repeatability of testing sites for drought-tolerant maize in West Africa

Badu-Apraku, B., Akinwale, R, Obeng-Antwi, K, Haruna, A, Kanton, R, Ado, S. G, Coulibaly, N, Yallou, C, & Oyekunle, M. (2013). Assessing the representativeness and repeatability of testing sites for drought-tolerant maize in West Africa. *Canadian Journal of Plant Science*, 93(4), 699–714. <https://doi.org/10.4141/cjps2012-136>

The selection of suitable breeding and testing sites is crucial to the success of a maize (*Zea mays* L.) improvement program. Twelve early-maturing maize cultivars were evaluated for 3 yr at 16 locations in West Africa to determine the representativeness, discriminating ability, and repeatability of the testing sites and to identify core testing sites. Genotype main effect plus genotype by environment interaction (GGE) biplot analysis revealed that Zaria (Nigeria),

Nyankpala (Ghana), and Ejura (Ghana) displayed the highest discriminating ability. Two mega-environments were identified. Bagou, Nyankpala, Bagauda, Ikenne, and Mokwa constituted the first mega-environment (ME1); Ejura, Ina and Sotuba represented the second (ME2). The ME1 would be more useful for evaluating early maize genotypes for tolerance to drought than ME2 because locations in ME1 were more strongly correlated to Ikenne (managed drought stress site). Among the test locations, Bagou and Mokwa were found to be closely related to Ikenne in their ranking of the cultivars for drought tolerance; Zaria was the exact opposite, indicating that this was the least suitable location for evaluating genotypes for drought tolerance. Nyankpala and Ikenne were identified as the core testing sites for ME1 and Ejura for ME2. TZE Comp 3 C2F2 was identified as the highest yielding cultivar for ME1 and Syn DTE STR-Y for ME2, indicating that they could be used as check cultivars. Ikenne, Nyankpala, and Ejura had moderately high repeatability. They were closer to the average environment axis of each mega-environment and will be useful for culling unstable genotypes during multi-locational testing. Other sites were less representative and not repeatable and will not be useful for evaluating early maize cultivars for drought tolerance.

7. Economic analysis of crop-livestock integration in the northern Guinea savannah of Nigeria

Ndubuisi, A., Zeddies, J., Manyong, V., & Smith, J. (2000). Economic analysis of crop-livestock integration in the northern Guinea savannah of Nigeria. *Der Tropenland, Beiträge zur Tropischen Landwirtschaft und Veterinärmedizin*, 101, 69–83. <https://hdl.handle.net/10568/99863>

Research was undertaken on the economics of crop-livestock integration in the Northern Guinea Savannah of Nigeria. The aim of the study was to quantify the reciprocal contributions of crops and livestock and also the factors affecting the integration of crops and livestock production in the area. Field data were collected during the 1996/97 farming season from 150 respondents randomly selected at two locations (Zaria and Bauchi) and classified into crop farmers (CF) and crop-livestock farmers (C-LF). The two locations represent different levels of market opportunities. The Zaria area is hypothesized to follow a market-driven path of agricultural intensification while the Bauchi area follows a population-driven path of agricultural intensification. Results of the study showed that the CF in the Zaria area recorded a gross margin (GM) of NGN62,035. This was about three and a half times the GM in Bauchi (NGN17,262). Similarly, the C-LF in the Zaria area recorded a much higher GM (NGN145,334) over that recorded by the C-LF in the Bauchi area (34,367). Among the general factors affecting crop-livestock integration are land, labor, availability of feed, availability of organic and inorganic fertilizer, age and level of education of the farmers. The study concluded that by integrating and using crop-livestock farm linkages, farmers can improve their economic gains more substantially especially in areas with better market opportunities (Zaria). Therefore efforts should be made to substantially improve the market infrastructure and solve some of the problems affecting crop-livestock integration in the NGS of Nigeria.

Keywords: crops, livestock, economics, farmers, markets

8. Economic analysis of cut-and-carry, and alley cropping systems of mulch production for plantains in south-eastern Nigeria

Ruhigwa, B. A., Gichuru, M., Spencer, D., & Swennen, R. (1994). Economic analysis of cut-and-carry, and alley cropping systems of mulch production for plantains in south-eastern Nigeria. *Agroforestry Systems*, 26, 131–138. <https://link.springer.com/article/10.1007/BF00707011>

Organic mulch is beneficial to plantain because it maintains soil fertility, prevents erosion and suppresses weeds. Mulch availability is however a major constraint. Mulching in a cut-and-carry system with *Pennisetum purpureum* Schum. (elephant grass) was compared with mulching with the prunings of *Alchornea cordifolia* (Schum., & Thonn.), *Dactyladenia barteri* (Hook. f. ex Oliv.) Engel. (Syn. *Acioa barteri*), *Gmelina arborea* (Roxb.) and *Senna siamea* (Lam.) Irwin & Barneby (Syn. *Cassia siamea*) in alley cropping systems. Plantain in *Pennisetum* mulch treatment gave the highest bunch yield, but similar net revenues per hectare as the *Dactyladenia* treatment, while *Gmelina*, *Alchornea* and *Senna* treatments produced the lowest incomes. But when the land required to produce *Pennisetum* mulch was included in the economic analysis, the net revenue per hectare was negative over three years of cropping. The returns to labor were also much lower for the *Pennisetum* compared to the alley cropping systems. Among the in-situ mulch sources, *Gmelina* had the highest labor requirement because of the high pruning frequency. In addition, weeding in *Gmelina*, *Alchornea* and *Senna* treatments resulted in high labor demand due to the rapid decomposition of the mulch materials leaving the soil bare for weeds to invade. *Dactyladenia* alley cropping was the most profitable of the five plantain production systems studied.

9. Evaluating and scaling-up integrated *Striga hermonthica* control technologies among farmers in northern Nigeria

Franke, A., Ellis-Jones, J., Tarawali, G., Schulz, S., Hussaini, M. A, Kureh, I, White, R., Douthwaite, B., Oyewole, B., & Olanrewaju, A. (2006). Evaluating and scaling-up integrated *Striga hermonthica* control technologies among farmers in northern Nigeria. *Crop Protection*, 25(8), 868–878. <https://doi.org/10.1016/j.cropro.2005.11.014>

The results are presented of a project to promote integrated *Striga* control (ISC) technologies to farmers in the Guinea savanna of northern Nigeria. Extension agents used a participatory research and extension approach (PREA) to encourage farmers to test and adopt ISC technologies. Over a 2-year period, the performance of the technologies was compared with the common farmers' practice with respect to crop yields, *Striga* seedbank, *Striga* damage and economics, as well as the adoption and adaptation of ISC technologies among lead farmers and others. ISC improved crop productivity on average by 88%. In the farmers' practice, *Striga* seedbank increased by 46% in 2 years, while in plots under ISC it was reduced by a similar percentage. ISC resulted in higher margins than the farmers' practice, but increased labor requirements were found to be a limitation for the expansion of the recommended technologies. Improved seed varieties, however, were rapidly adopted by farmers, but often used at lower plant populations than recommended and in mixed cropping systems. It was estimated that the participation of each extension agent resulted in the transfer of knowledge and seed to an

average of 240 farmers. In addition, the PREA had improved community, group, and farmer–extension agent relationships. Ongoing demand by Government and NGOs for training in PREA, extension material and improved seed suggested that scaling-up has continued beyond the lifespan of the project.

10. *Ex ante* appraisal of agricultural research and extension: A choice experiment on climbing beans in Burundi

Lambrecht, I., Vranken, L., Merckx, R., Vanlauwe, B., & Maertens, M. (2015). *Ex ante* appraisal of agricultural research and extension: A choice experiment on climbing beans in Burundi. *Outlook on Agriculture*, 44(1), 61–67. <https://doi.org/10.5367/oa.2015.0199>

Research on agricultural technology adoption generally occurs *ex post*, after the introduction of a technology. In this paper, the authors use a choice experiment to reveal farmers' preferences for new agricultural technologies *ex ante*, before new technologies are developed and introduced. The authors implement a choice experiment among 200 farmers in Burundi and use mixed logit models to analyze preferences for specific traits of improved climbing bean varieties. It was found that farmers had a strong preference for climbing bean varieties that resulted in higher yields and improved soil fertility, while the maturation period and the responsiveness to fertilizer were less important. Seed price was found to matter only for the most food-insecure farmers. These choice experimental results can inform agricultural research and extension programs *ex ante* to take into account farmers' preferences and accelerate the adoption of new technologies.

Keywords: agricultural research and extension, technology adoption, choice experiment, climbing beans, sub-Saharan Africa

11. Ex-ante economic impact assessment of genetically modified banana resistant to *Xanthomonas* wilt in the Great Lakes Region of Africa

Ainembabazi, J. H., Tripathi, L., Rusike, J., Abdoulaye, T., & Manyong, V. (2015). Ex-ante economic impact assessment of genetically modified banana resistant to *Xanthomonas* wilt in the Great Lakes Region of Africa. *PLOS ONE*, 10(9), e0138998. <https://doi.org/10.1371/journal.pone.0138998>

Background: Credible empirical evidence is scanty on the social implications of genetically modified (GM) crops in Africa, especially on vegetatively propagated crops. Little is known about the future success of introducing GM technologies into staple crops such as bananas, which are widely produced and consumed in the Great Lakes Region of Africa (GLA). GM banana has a potential to control the destructive banana *Xanthomonas* wilt disease.

Objective: To gain a better understanding of future adoption and consumption of GM banana in the GLA countries which are yet to permit the production of GM crops; specifically, to evaluate the potential economic impacts of GM cultivars resistant to banana *Xanthomonas* wilt disease.

Data Sources: The paper uses data collected from farmers, traders, agricultural extension agents and key informants in the GLA.

Analysis: We analyze the perceptions of the respondents about the adoption and consumption of GM crop. Economic surplus model is used to determine future economic benefits and costs of producing GM banana.

Results: On the release of GM banana for commercialization, the expected initial adoption rate ranges from 21 to 70%, while the ceiling adoption rate is up to 100%. Investment in the development of GM banana is economically viable. However, aggregate benefits vary substantially across the target countries ranging from US\$ 20 million to 953 million, highest in countries where disease incidence and production losses are high, ranging from 51 to 83% of production.

Conclusion: The findings support investment in the development of GM banana resistant to *Xanthomonas* wilt disease. The main beneficiaries of this technology development are farmers and consumers, although the latter benefit more than the former from reduced prices. Designing a participatory breeding program involving farmers and consumers signifies the successful adoption and consumption of GM banana in the target countries.

Keywords: ex-ante economic impact, genetically modified banana, *Xanthomonas* wilt, Great Lakes Region of Africa

12. Ex-ante evaluation of cassava research for development in Malawi: A farm household and random utility modeling approach

Rusike, J., Jumbo, S., Ntawuruhunga, P., Kawonga, J. M., James, B., Okechukwu, R., & Manyong, V. M. (eds) (2010). Ex-ante evaluation of cassava research for development in Malawi: A farm household and random utility modeling approach. Presented at African Association of Agricultural Economists (AAAE) Third Conference/AEASA 48th Conference, September 19–23, 2010, Cape Town, South Africa. <https://doi.org/10.22004/ag.econ.96182>

Ex ante evaluation of agricultural research for development projects has become important in recent years for priority setting, ex post impact assessment and learning about generalizability to other populations and contexts. We apply farm household and random utility modeling to baseline survey data and evaluate the impact of a cassava research for development project in Malawi prior to its implementation. The project is being implemented to unlock the potential of cassava in response to the global food crisis. We find that a high proportion of farm households are not self-sufficient in food production and can be assisted by increasing the productivity of land and labor in production, processing and marketing of cassava to reduce deficits and increase marketed surplus. The research for development embeds research in an innovation systems network and speeds up exposure, awareness, adoption and diffusion. This increases the likelihood that incremental benefits will be generated and accrue earlier compared to the counterfactual without the project

13. Ex-ante welfare impacts of adopting maize-soybean rotation in eastern Zambia

Manda, J., Alene, A., Mukuma, C., & Chikoye, D. (2017). Ex-ante welfare impacts of adopting maize-soybean rotation in eastern Zambia. *Agriculture, Ecosystems and Environment*, 249, 22–30. <https://doi.org/10.1016/j.agee.2017.07.030>

This paper estimates the welfare impacts of adoption of maize-soybean rotation in eastern Zambia using data from on-farm trials and household survey data collected from over 800 households. The on-farm trials were conducted from 2012 to 2015 while the household survey was conducted in 2012. The study evaluated maize-soybean rotation where soybean was grown with and without inoculants and inorganic fertilizer, whereas continuous maize cropping was used as a control. The paper estimated household level income changes and poverty reduction due to adoption of maize-soybean rotation using market level economic surplus as well as household level analyses to allocate economic surplus changes to individual households. The results showed that several factors influence the adoption of maize-soybean rotation, including land ownership, education, and age of the household head. Results also showed that adoption of maize-soybean rotation reduced per-unit production costs by between 26 and 32% compared to continuous maize. Ex-ante welfare impact analysis showed significant potential income gains and poverty reduction following adoption of maize-legume rotation in eastern Zambia. The paper concludes with implications for policy to promote wider adoption of soil fertility management practices such as maize-soybean rotation for increased maize productivity in Zambia.

Keywords: economic surplus, maize-legume rotation, poverty, Zambia

14. Ex-ante evaluation of promising soybean innovations for sub-Saharan Africa

Gbegbelegbe, S., Alene, A., Kamara, A., Wiebe, K., Manyong, V., Abdoulaye, T., & Mkandawire, P. (2019). Ex-ante evaluation of promising soybean innovations for sub-Saharan Africa. *Food and Energy Security*, 8(4), e00172. <https://doi.org/10.1002/fes3.172>

This study undertakes an ex-ante evaluation of the effects of alternative technology and policy options on soybean supply and demand in sub-Saharan Africa (SSA) to 2050. Current soybean consumption in SSA is dominated by cooking oil followed by soybean cake used as animal feed. Due to weak processing sectors and low soybean yields, the region is currently importing about 70% of its consumption requirements. Based on the results from a geospatial bio-economic modeling framework, soybean consumption in SSA is projected to more than double by 2050 compared to 2010 due in part to a rising population and rising incomes. On the other hand, supply from domestic production is projected to increase by 80% over the same period. Hence, by 2050, net imports into SSA would be nearly 4 times higher than supply from domestic production. Under a future drier climate, some of the production gains achieved through soybean research and extension would be lost and this would further worsen the soybean demand gap in SSA relative to the baseline. This study shows that relying on conventional breeding alone to increase soybean yields in SSA would not be enough to substantially reduce the future demand gap. A combination of promising innovations affecting

the soybean value chain across SSA would be needed to close the soybean demand gap in SSA by 2050 under a drier future climate.

Keywords: climate change, geospatial bio-economic modeling, IMPACT, import dependency, soybean, sub-Saharan Africa.

15. Future prospects for cassava root yield in sub-Saharan Africa

Nweke, F., & Spencer, D. (1995). Future prospects for cassava root yield in sub-Saharan Africa. *Outlook on Agriculture*, 24(1), 35–42. <https://doi.org/10.1177/003072709502400108>

Primary data collected over a wide area in Africa show that average cassava root yield is not declining as the population increases because the land is being cultivated more intensively in response to demographic pressures. Although fallow periods are becoming shorter, organic manuring, improved market infrastructures and the use of purchased inputs such as labor compensate for this. The yields of improved cassava varieties in Nigeria show that technology can be relied upon to raise production in future, provided that the conditions necessary for the widespread adoption of improved varieties prevail in most African countries.

Keywords: cassava, Nigeria, future prospects

16. Geospatial approach for delineating extrapolation domains for sustainable agricultural intensification technologies.

Muthoni, F. K., Baijukya, F., Sseguya, H., Bekunda, M., Hoeschle-Zeledon, I., Ouko, E., & Mubea, K. (2017). Geospatial approach for delineating extrapolation domains for sustainable agricultural intensification technologies. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLII-3/W2, 145–149. <https://doi.org/10.5194/isprs-archives-XLII-3-W2-145-2017>

Sustainable intensification (SI) is a viable pathway to increase agricultural production and improve ecosystem health. Scaling SI technologies in locations with similar biophysical conditions enhance adoption. This paper employs novel extrapolation detection (ExeDet) algorithm and gridded bioclimatic layers to delineate extrapolation domains for improved maize variety (SC719) and inorganic fertilizers (YaraMila-CEREAL® and YaraBela-Sulfan®) in Tanzania. Suitability was based on grain yields recorded in on-farm trials. The ExeDet algorithm generated three maps: (1) the dissimilarity between bioclimatic conditions in the reference trial sites and the target extrapolation domain (Novelty type-1), (2) the magnitude of novel correlations between covariates in extrapolation domain (Novelty type-2) and (3) the most limiting covariate. The novelty type1 and 2 maps were intersected and reclassified into five suitability classes. These classes were cross-tabulated to generate extrapolation suitability index (ESI) for the candidate technology package. An impact based spatial targeting index (IBSTI) was used to identify areas within the zones earmarked as suitable using ESI where the potential impacts for out scaling interventions can be maximized. Application of ESI and IBSTI is expected to guide extension and development agencies to prioritize scaling intervention based on both biophysical suitability and potential impact of particular technology

package. Annual precipitation was most limiting factor in largest area of the extrapolation domain. Identification of the spatial distribution of the limiting factor is useful for recommending remedial measures to address the limiting factor that hinder a technology to achieve its full potential. The method outlined in this paper is replicable to other technologies that require extrapolation provided that representative reference trial data and appropriate biophysical grids are available.

Keywords: extrapolation suitability index, correlation structure, inorganic fertilizers, GIS, improved maize varieties, scaling out, spatial targeting, Tanzania

17. Identifying crop research priorities based on potential economic and poverty reduction impacts: The case of cassava in Africa, Asia, and Latin America

Alene, A. D., Abdoulaye, T., Rusike, J., Labarta, R., Creamer, B., Río, M. del, Ceballos, H., & Becerra, L. A. (2018). Identifying crop research priorities based on potential economic and poverty reduction impacts: The case of cassava in Africa, Asia, and Latin America. *PLOS ONE*, 13(8), e0201803. <https://doi.org/10.1371/journal.pone.0201803>

It is widely recognized that increasing agricultural production to the levels needed to feed an expanding world population requires sharply increased public investment in research and development and widespread adoption of new technologies, but funding for national and international agricultural research has rather declined in recent years. In this situation, priority setting has become increasingly important for allocating scarce research resources among competing needs to achieve greater impacts. Using partial equilibrium economic surplus models and poverty impact simulations, this paper assesses cassava research priorities in Africa, Latin America and Caribbean, and Asia based on the potential economic and poverty reduction impacts of alternative research and technology options. The results showed that efficient planting material production and distribution systems and sustainable crop and soil fertility management practices have the greatest expected economic and poverty reduction impacts in the three regions. Lack of clean planting materials is a major constraint to adoption and it is envisaged that efficient production and distribution systems for planting material can accelerate technology adoption by farmers. Similarly, sustainable crop and soil fertility management practices play a key role in closing the observed yield gaps, especially in Africa. The paper discusses the results of the priority assessment for key cassava research options and concludes with the implications for cassava research priorities.

18. Long-term spatial-temporal trends and variability of rainfall over eastern and southern Africa

Muthoni, F. K., Odongo, V., Ochieng, J., Mugalavai, E. M.*, Mourice, S. K.*, Hoeschle-Zeledon, I., Mwila, M.*, & Bekunda, M. (2019). Long-term spatial-temporal trends and variability of rainfall over eastern and southern Africa. *Theoretical and Applied Climatology*, 137, 1869–1882. <https://doi.org/10.1007/s00704-018-2712-1>

This study investigates the spatial-temporal trends and variability of rainfall within East and South Africa (ESA) region. The newly available Climate Hazards group Infrared Precipitation with Stations (CHIRPS-v2) gridded data spanning 37 years (1981 to 2017) was validated

against gauge observations ($N=4243$) and utilized to map zones experiencing significant monotonic rainfall trends. Standardised annual rainfall anomalies revealed the spatial-temporal distribution of below and above normal rains that are associated with droughts and floods respectively. Results showed that CHIRPS-v2 data had a satisfactory skill to estimate monthly rainfall with Kling-Gupta efficiency ($KGE=0.68$ and a high temporal agreement ($r=0.73$) while also preserving total amount ($\beta=0.99$) and variability ($\gamma=0.8$). Two contiguous zones with significant increase in annual rainfall ($3\text{--}15\text{ mm year}^{-1}$) occurred in Southwest Zambia and in Northern Lake Victoria Basin between Kenya and Uganda. The most significant decrease in annual rainfall (-20 mm year^{-1}) was recorded at Mount Kilimanjaro in Tanzania. Other significant decreases in annual rainfall ranging between -4 and -10 mm year^{-1} were observed in Southwest Tanzania, Central-South Kenya, Central Uganda and Western Rwanda. CHIRPS-v2 rainfall product provides reliable high spatial resolution information on amount of rainfall that can complement sparse rain gauge network in rain-fed agricultural systems in ESA region. The observed spatial-temporal trends and variability in rainfall are important basis for guiding targeting of appropriate adaptive measures across multiple sectors.

19. Long-term trend in rainfall identify priority zones for targeting climate smart agricultural technologies in East and Southern Africa

Muthoni, F. K., Odongo, V., Ochieng, J., & Hoeschle-Zeledon, I. (2018). Long-term trend in rainfall identify priority zones for targeting climate smart agricultural technologies in East and Southern Africa. *Geophysical Research Abstracts*, 20. <https://meetingorganizer.copernicus.org/EGU2018/EGU2018-4628.pdf?pdf>

Climate change and variability has increased frequency and intensity of agricultural drought with consequent impacts on global agricultural production. These impacts are significantly higher in rain-fed agriculture in Africa. Adoption of climate smart agricultural (CSA) practices is one of viable option to mitigate impacts of climate change and variability. Specific CSA technologies are suited for particular biophysical context. Spatial targeting is required to guide their dissemination in suitable context and support site specific agro-advisory. Information on spatial-temporal trends of rainfall that could support spatial targeting of CSA technologies in Africa is limited by sparsely distributed and poorly monitored meteorological stations. Satellite derived products offer a logical alternative for discerning long-term spatio-temporal trends in rainfall. Remote sensing derived monthly and annually aggregated time series rainfall data spanning 34 years was obtained for Tanzania, Malawi and Zambia. Mann-Kendall test was used to identify zones with significant monotonic changes. The magnitude of change was determined using Theil-Sen's slope estimator. Zones with significant long-term trends were identified for targeting appropriate CSA technologies depending on direction and magnitude of observed trend. Maps revealing zones experiencing significant increasing and decreasing trends in rainfall over space and time were generated. The corresponding rate of change (Theil-Sen's slope) was mapped and matched with changes. For monthly time series, May to September recorded the highest area with significant decreasing trend but of low magnitude. Rainfall in Zambia revealed a significant decreasing trend in October but increase in November and December. Results in this paper identify spatial and temporal trends in rain-fed

agricultural potential. Maps on long-term spatial-temporal trends in rainfall have great potential to guide development partners and extension agents on spatial targeting CSA technologies to appropriate zones to reduce their risk of failure. Results further demonstrate the potential of time series satellite derived rainfall data in guiding spatial targeting of CSA technologies and agro-advisory services.

Keywords: climate change, drought, monotonic trends, spatial-temporal analysis, spatial targeting, satellite rainfall estimates

20. Scaling-up agricultural technologies: who should be targeted?

Mellon Bedi, S., Azzarri, C., Hundie Kotu, B., Kornher, L., & von Braun, J. (2021). Scaling-up agricultural technologies: Who should be targeted? *European Review of Agricultural Economics*, jbab054. <https://doi.org/10.1093/erae/jbab054>

The effects of agricultural technology adoption on farm performance have been studied extensively but with limited information on who should be targeted during scaling-up. We adopt the newly defined marginal treatment effect approach in examining how farmers' resource endowment and unobserved factors influence the marginal benefits of adopting sustainable intensification (SI) practices. We estimate both the marginal and average benefits of adopting SI practices and predict which marginal farm household entrants will benefit the most at scale. Findings indicate that farmers' resource endowment and unobserved factors affect the marginal benefits of adopting SI practices, which also influence maize yield and net returns among adopters. Finally, results imply that scaling up SI practices will favor farm household entrants associated with the lowest probability of adoption based on observed socioeconomic characteristics.

Keywords: cross-sectional models, spatial models, treatment effect models, quantile regressions, technological change: choices and consequences, diffusion processes

21. Setting priorities: case study of IITA's root and tuber crops systems program Introduction to priority setting

Manyong, V., Okechukwu, R., Ojiambo, P., & Robert, A. (2008). Setting priorities: case study of IITA's root and tuber crops systems program Introduction to priority setting. *African Journal of Root and Tuber Crops*, 8, 6–12. www.researchgate.net/publication/265125156_Setting_priorities_case_study_of_IITA's_root_and_tuber_crops_systems_program_Introduction_to_priority_setting

This report presents results from a priority setting exercise conducted on the strategic objectives and activities of the Root and Tuber Systems Program as a part of a process to develop strategic plans to guide the activities of IITA for the following 10 years. The scoring method was applied to rank activities and statistical tests were used to validate the ranking from the scoring method. Thirty-five Project members participated in data generation. The results indicate the proportion of each strategic objective between 18 and 22%. Within each strategic

objective, the score of each activity relative to the maximum achievable score resulted in the ranking of activities. Statistical tests showed some activities to be significantly not different in ranking from others. There is a clear importance attached to activities of strategic objective 1, compared to those of the others. Activity 4 of strategic objective 1 emerged as a top activity among all the activities. The disciplines of scientists did not affect the scores significantly or the perceived importance of activities. It is advocated that priority setting is an iterative process that needs to be implemented continuously in various steps to improve the efficiency of the project operations.

Keywords: priority setting, Root and Tuber Systems Project, IITA

22. Sustainable recommendation domains for scaling agricultural technologies in Tanzania

Muthoni, F. K., Guo, Z., Bekunda, M., Sseguya, H., Kizito, F., Baijukya, F., & Hoeschle-Zeledon, I. (2017). Sustainable recommendation domains for scaling agricultural technologies in Tanzania. *Land Use Policy*, 66, 34–48. <https://doi.org/10.1016/j.landusepol.2017.04.028>

Low adoption of sustainable intensification technologies hinders achievement of their potential impacts on increasing agricultural productivity. Proper targeting of locations to scale-out particular technologies is a key determinant of the rate of adoption. Targeting locations with similar biophysical and socio-economic characteristics significantly increases the probability of adoption. Areas with similar biophysical and socio-economic characteristics are referred to as recommendation domains (RDs). This study used geospatial analysis to delineate sustainable recommendation domains (SRDs) for scaling improved crop varieties and good agronomic practices in Tanzania. The study uses K-means clustering to identify relatively similar clusters from grid raster's representing biophysical and socio-economic environments. Critical ecosystems are masked-out from the clusters to generate the SRDs. The potential impacts of scaling technologies in the generated SRDs were assessed and a spatial targeting index developed. Results identify 20 SRDs and the bio-socio-economic gradients that delineate them. This study proposes an Impact Based Spatial Targeting Index (IBSTI) as an objective tool for priority setting when scaling agricultural technologies. IBSTI identified priority areas within each SRD that should be targeted to maximize potential impacts of a scaling intervention. The data-driven clustering method is recommended for regions with limited technology trials. Results demonstrate the potential of geospatial tools in generating evidence-based policies on scaling of sustainable intensification technologies.

Keywords: critical ecosystems, impact based spatial targeting index (IBSTI), K-means clustering, GIS, priority setting, sustainable intensification

23. Targeting agricultural research based on potential impacts on poverty reduction: Strategic program priorities by agro-ecological zone in Nigeria

Alene, A., Manyong, V., Tollens, E. F., & Abele, S. (2007). Targeting agricultural research based on potential impacts on poverty reduction: Strategic program priorities by agro-ecological zone in Nigeria. *Food Policy*, 32(3), 394–412. <https://doi.org/10.1016/j.foodpol.2006.07.004>

Growing concern for poverty in the face of declining agricultural research budgets has increasingly required formal priority setting of public agricultural research in developing countries to ensure that scarce research resources are allocated in ways that will have the greatest impact on the poor. This paper assessed the potential impacts of alternative commodity research programs on poverty reduction in three agro-ecological zones of Nigeria and identified strategic agricultural research priorities in the three zones. The paper discusses the poverty reduction-based priorities and their role in facilitating dialogue between research managers and policymakers aimed at sharpening the focus of agricultural research to achieve poverty reduction objectives in Nigeria.

Keywords: agricultural research, poverty reduction, priority setting, Nigeria

24. Targeting drought-tolerant maize varieties in Southern Africa: a geospatial crop modeling approach using big data

Tesfaye, K., Sonder, K., Cairns, J., Magorokosho, C., Tarekegn, A., Kassie, G. T., Getaneh, F., Abdoulaye, T., Abate, T., & Erenstein, O. (2016). Targeting drought-tolerant maize varieties in Southern Africa: A geospatial crop modeling approach using big data. *International Food and Agribusiness Management Review*, 19(A), 1–18. <https://hdl.handle.net/10568/76332>

Maize is a major staple food crop in Southern Africa and stress tolerant improved varieties have the potential to increase productivity, enhance livelihoods and reduce food insecurity. This study uses big data in refining the geospatial targeting of new drought-tolerant (DT) maize varieties in Malawi, Mozambique, Zambia, and Zimbabwe. Results indicate that more than 1.0 million hectares (Mha) of maize in the study countries is exposed to a seasonal drought frequency exceeding 20% while an additional 1.6 Mha experience a drought occurrence of 10–20%. Spatial modeling indicates that new DT varieties could give a yield advantage of 5–40% over the commercial check variety across drought environments while crop management and input costs are kept equal. Results indicate a huge potential for DT maize seed production and marketing in the study countries. The study demonstrates how big data and analytical tools enhance the targeting and uptake of new agricultural technologies for boosting rural livelihoods, agribusiness development and food security in developing countries.

Keywords: big data, drought tolerance, geospatial analysis, maize, spatial crop modeling, targeting

25. The potential benefits of GIS techniques in disease and pest control: An example based on a regional project in Central Africa

Bouwmeester, H., Abele, S., Manyong, V., Legg, C., Mwangi, M., Nakato, V., Coyne, D., & Sonder, K. (2010). The potential benefits of GIS techniques in disease and pest control: An example based on a regional project in Central Africa. *Acta Horticulturae*, 1(879), 333–340. <http://dx.doi.org/10.17660/ActaHortic.2010.879.34>

Pests and diseases of bananas (*Musa* spp.) threaten the livelihoods of over 20 million people in the Great Lakes region. Geographic information systems (GIS) provide valuable

tools in monitoring, predicting, managing and fighting the spread of pests and diseases. The tools offer opportunities for cost-effective and efficient targeting of control interventions. In monitoring, GIS can be used to determine the spatial extent of a disease, to identify spatial patterns of the disease and to link the disease to auxiliary spatial data. GIS can also be used to predict the projected spread of diseases, to provide input for risk assessment models in pest control and in quantifying changing thresholds of pests and diseases due to climate change. In order to use GIS techniques at a larger scale, a protocol for data collection and management is essential. This paper illustrates the use of GIS tools on data collected to identify critical intervention areas to combat the spread of Banana *Xanthomonas* wilt (BXW). In a survey covering the Great Lakes region, on-farm incidence of the disease was monitored and precise GPS coordinates of each sampled field were recorded. This enabled accurate mapping of the disease and performing the various spatial analyses, permitting an understanding of the geographical distribution of BXW infection. Data on food security and dependency on banana to rural populations was linked to the BXW severity to target priority areas of interventions and maximize impact.

Keywords: GIS, agriculture, disease, pest, BXW, mapping, bananas, interpolation

26. To diversify or not to diversify, that is the question. Pursuing agricultural development for smallholder farmers in marginal areas of Ghana

Bellon, M. R., Kotu, B. H., Azzarri, C., & Caracciolo, F. (2020). To diversify or not to diversify, that is the question. Pursuing agricultural development for smallholder farmers in marginal areas of Ghana. *World Development*, 125, 104682. <https://doi.org/10.1016/j.worlddev.2019.104682>

Many smallholder farmers in developing countries grow multiple crop species on their farms, maintaining *de facto* crop diversity. Rarely do agricultural development strategies consider this crop diversity as an entry point for fostering agricultural innovation. This paper presents a case study, from an agricultural research-for-development project in northern Ghana, which examines the relationship between crop diversity and self-consumption of food crops, and cash income from crops sold by smallholder farmers in the target areas. By testing the presence and direction of these relationships, it is possible to assess whether smallholder farmers may benefit more from a diversification or a specialization agricultural development strategy for improving their livelihoods. Based on a household survey of 637 randomly selected households, we calculated crop diversity as well as its contribution to self-consumption (measured as imputed monetary value) and to cash income for each household. With these data we estimated a system of three simultaneous equations. Results show that households maintained high levels of crop diversity: up to eight crops grown, with an average of 3.2 per household, and with less than 5% having a null or very low level of crop diversity. The value of crop species used for self-consumption was on average 55% higher than that of crop sales. Regression results show that crop diversity is positively associated with self-consumption of food crops, and cash income from crops sold. This finding suggests that increasing crop diversity opens market opportunities for households, while still contributing to self-consumption. Given these findings, crop diversification seems to be more beneficial to these farmers than specialization. For

these diversified farmers, or others in similar contexts, interventions that assess and build on their de facto crop diversity are probably more likely to be successful.

Keywords: crop diversity, production diversification, agricultural development, Ghana

27. Training transfer for sustainable agricultural intensification in Tanzania: Critical considerations for scaling-up

Sseguya, H., Bekunda, M., Muthoni, F. K., Flavian, F.*, & Masigo, J. (2018). Training transfer for sustainable agricultural intensification in Tanzania: Critical considerations for scaling-up. *Journal of Agricultural Science and Technology*, 20, 661–671. www.researchgate.net/publication/329220893

Sustainable Intensification (SI) in agriculture is fronted as a promising approach to increase agricultural production in Sub-Saharan Africa countries. Technologies that can lead to realization of the SI goal are available but one of the key challenges is the low reach among smallholder farmers due to, among others, ineffective training and co-learning. In this study, a survey methodology was used to obtain data from 145 trainees in a sustainable intensification intervention in Kongwa and Mvomero districts, Tanzania, to analyze the drivers of training transfer. Hierarchical linear regression revealed that motivation of trainees, training design and delivery, and work environment (peer, extension and local institutional support) had positive effects on transfer of the training. For successful transfer of training, recommendations given were a deliberate focus on selection of suitable trainees and ensuring their motivation to learn; use of appropriate documentation, extension and training methods; strengthening farmers' networks for peer learning; and strengthening collaborations with local institutions.

Keywords: agricultural development, co-learning, peer learning, sub-Saharan Africa

28. Trends of rainfall onset, cessation, and length of growing season in Northern Ghana: Comparing the rain gauge, satellite, and farmer's perceptions

Atiah, W. A., Muthoni, F. K., Kotu, B., Kizito, F., & Amekudzi, L. K. (2021). Trends of rainfall onset, cessation, and length of growing season in Northern Ghana: Comparing the rain gauge, satellite, and farmer's perceptions. *Atmosphere*, 12(12), 1674. <https://doi.org/10.3390/atmos12121674>

Rainfall onset and cessation date greatly influence cropping calendar decisions in rain-fed agricultural systems. This paper examined trends of onsets, cessation, and the length of growing season over Northern Ghana using CHIRPS-v2, gauge, and farmers' perceptions data between 1981 and 2019. Results from CHIRPS-v2 revealed that the three seasonal rainfall indices have substantial latitudinal variability. Significant late and early onsets were observed at the West and East of 1.5° W longitude, respectively. Significant late cessations and longer growing periods occurred across Northern Ghana. The ability of farmers' perceptions and CHIRPS-v2 to capture rainfall onsets are time and location-dependent. A total of 71% of farmers rely on traditional knowledge to forecast rainfall onsets. Adaptation measures applied were not always consistent with the rainfall seasonality. More investment in modern climate

information services is required to complement the existing local knowledge of forecasting rainfall seasonality.

Keywords: CHIRPS-v2, climate change adaptation, farmer perceptions, rainfall cessation, rainfall onset

29. Typology of households adopting improved soybean technology: an application of the discriminant analysis model in northern Nigeria

Ojiako, I. A., Manyong, V., & Ikpi, A (2008). Typology of households adopting improved soybean technology: an application of the discriminant analysis model in northern Nigeria. *Journal of Agricultural and Food Economics*, 3(1–2), 31–42. <https://cgspace.cgiar.org/handle/10568/92155>

A two-stage typology of adopters and non-adopters of improved soybean varieties introduced to farmers in northern Nigeria was investigated using the discriminant analysis model. Labor expenses, active membership of associations and exposure to extension services significantly discriminated the two groups, out of thirteen factors used in the linear discriminating Junction. Involved alone in a second-stage of model discrimination, the three variables achieved a 94.1 percent correct classification performance. The linear discriminating Junctions' coefficients were positive for the three variables, implying that the chances of belonging to the high adoption group would increase if these characteristics increased in magnitude. In scaling out crop-improvement technologies to households attention should be focused on these institutional and financial factors that best facilitated adoption of new crop germplasm.

Keywords: improved soybean varieties, typology of adopters, discriminant analysis, soybean research, households, malnutrition

Youth initiatives (26)

1. African rural youth engagement in agribusiness: Achievements, limitations, and lessons

Yami, M., Feleke, S., Abdoulaye, T., Alene, A., Bamba, Z., & Manyong, V. (2019). *Sustainability*, 11(1), 185. <https://doi.org/10.3390/su11010185>

Engaging rural youth in agribusiness has become an important strategy to create employment opportunities in Africa. To this end, governments and development partners have implemented various interventions that facilitate youth engagement in agribusiness for several years. However, there is a dearth of evidence on what worked and what did not work well, making it difficult to inform evidence-based policy making. In an effort to fill this knowledge gap, a comprehensive literature review of the outcomes of interventions related to youth engagement in agribusiness was conducted using a deductive coding approach. Results showed that the interventions implemented by governments and development partners across Africa have succeeded in producing favorable outcomes despite some limitations. Interventions that

integrate capacity development, financial support for startups, and continuous mentorship on the technical and financial aspects of youth-run agribusiness projects proved successful in enhancing youth engagement in agribusiness. This suggests that the design and implementation of future interventions should be based on an integrated approach that considers diversity of youths' aspirations and shared capabilities, interests, expectations, as well as challenges associated with access to resources and participation in collective action. The design of future interventions should also be built on strong partnerships among rural communities, academia, research, and private sector for increased impact on livelihood improvements.

Keywords: aspirations of youth, access to resource, collective action, achievements, limitations, rural youth, skills development, youth engagement in agribusiness

2. Youth participation in agriculture and poverty reduction in Nigeria

Osabohien, R., Wiredu, A. N., Nguetzet, P. M. D., Mignouna, D. B., Abdoulaye, T., Manyong, V., Bamba, Z., & Awotide, B. A. (2021). Youth participation in agriculture and poverty reduction in Nigeria. *Sustainability*, 13, 7795. <https://doi.org/10.3390/su13147795>

With data from 683 systematically selected households, the study employed the Heckman two-stage model and the propensity score matching method (PSM) to examine the impact of youth participation in agriculture as a primary occupation on income and poverty in Nigeria. The results indicate that the gender of the youth and their determination to stay in agriculture significantly increases the probability that youth will participate in agriculture as a primary occupation. In addition, youth participation in agriculture as a main occupation contributes significantly to per capita household income and has the likelihood to reduce poverty by 17%. The daily wage rate of hired labor and the total farmland owned are the variables that positively explained the per capita income. Poverty was reduced by market access, having agriculture as a primary occupation, income from agricultural production, the total monetary value of all the household assets, determination to remain in agriculture, and the square of the respondents' age. These results imply that creating employment for youth by engaging them in agriculture as a full-time occupation can increase their income and reduce poverty. However, the promotion of other secondary occupations, land, and market access is also vital.

Keywords: agribusiness; per capita income; poverty reduction; sustainable development; youth unemployment

3. Impact of youth-in-agribusiness program on employment creation in Nigeria

Bello, L. O., Baiyegunhi, L. J. S., Mignouna, D. B., Adeoti, R., Dontsop-Nguetzet, P. M., Abdoulaye, T., Manyong, V., Bamba, Z., & Awotide, B. A. (2021). Impact of youth-in-agribusiness program on employment creation in Nigeria. *Sustainability*, 13, 7801. <https://doi.org/10.3390/su13147801>.

The increasing rate of youth unemployment in Africa, particularly in Nigeria, remains among the challenges to social and economic stability. Accordingly, the Nigerian government implemented several interventions, including the Youth-in-Agribusiness (YIA) program to

reduce youth unemployment. However, the effect of these programs on gainful employment creation is yet to be documented. Therefore, this study examined the impact of the YIA program on creating gainful employment among the youth. Multistage random sampling was used to obtain cross-sectional data from 668 youth in Southwestern Nigeria. Propensity score matching and endogenous switching probit techniques were used for the estimations. Results indicated that variables such as educational attainment, access to training, non-agricultural activity, membership in a youth organization, access to credit, productive resources, and youth location were significant and positively influenced youth decision to participate in the YIA program. Furthermore, participation in the YIA program has a significant positive impact on gainful employment among the youth. Therefore, the study recommends that strengthening social capital such as youth organization, credit scheme (financed by private and government), vocational training, and educational system is vital in enhancing participation in the YIA program and eventually gainful employment of youth.

Keywords: impact, youth, agribusiness, employment, propensity score matching, endogenous switching probit, Nigeria.

4. Analyse de l'efficience technique des exploitations avicoles productrices d'œufs de table: cas des jeunes entrepreneurs au Bénin

Houedjofonon, E. M., Ahoyo Adjovi, N. R., Adeoti, R., Abdoulaye, T., Mignouna, D. B., Chogou, S. K., & Honfoga, B. (2019). Analyse de l'efficience technique des exploitations avicoles productrices d'œufs de table: cas des jeunes entrepreneurs au Bénin. *Bulletin de la Recherche Agronomique du Bénin*, 24, 194–204.

http://www.slire.net/download/2594/article_24_pg_brab_n_sp_cial_itra_oct_2019_houedjofonon_et_al_analyse_efficience_technique.pdf

(French): La filière œuf de table est un secteur d'activité pour de nombreux jeunes entrepreneurs au Bénin. L'objectif de l'étude était d'analyser l'efficience technique et les sources d'inefficience des exploitations des jeunes entrepreneurs produisant des œufs de table au Bénin. La statistique descriptive et l'approche de frontière stochastique utilisant une spécification de la fonction Cobb Douglas ont été les méthodes utilisées sur des données de panel non cylindrées couvrant la période de 2010 à 2017. Les résultats ont indiqué que le score moyen de l'efficience technique a été de 0,91, traduisant une performance technique élevée des exploitations avicoles dirigées par des jeunes entrepreneurs. Mais le score moyen le plus faible a été de 0,48 tandis que le meilleur score était de 0,97. De plus, un peu moins du tiers des exploitations ont obtenu un score d'efficience technique inférieur à la moyenne. Ce qui montre que des efforts restent à fournir pour améliorer les niveaux actuels d'efficience techniques de ces exploitations. Les meilleurs scores d'efficience technique étaient obtenus par les exploitations avicoles de grandes tailles ayant reçu une formation professionnelle et faisant recours aux services vétérinaires pour gérer les maladies. En conséquence, l'Etat peut bien s'appuyer sur les jeunes entrepreneurs avicoles pour réaliser son objectif d'accroître la production des œufs de table. Parmi les actions envisageables, l'appui à l'accroissement de la taille des exploitations avicoles et le renforcement des capacités techniques et managériales

des entrepreneurs sont à souligner, avec un accent particulier sur les chefs d'entreprises femmes.

Mots clés: Entrepreneur, œufs de table, efficience technique, frontière stochastique, Bénin.

()The table egg sector is a domain of activity for many young entrepreneurs in Benin. The objective of the study was to analyze the technical efficiency and the sources of inefficiencies of the farms of young entrepreneurs producing table eggs in Benin. The descriptive statistics and the stochastic frontier approach using a specification of the Cobb Douglas function were the methods used on non-displacement panel data covering the period from 2010 to 2017. The results indicated that the average technical efficiency score was 0.91 reflecting a high technical performance of the poultry farms of young entrepreneurs. But the lowest average score was 0.48 while the best score was 0.97. Almost a third of the farms obtained a technical efficiency score below the average. This shows that efforts remain to be made to improve the current levels of technical efficiency of these farms. The highest technical efficiency scores were obtained by large, large poultry farms that had received professional training and used veterinary services to manage diseases. As a result, the Benin Government may well rely on young poultry entrepreneurs to achieve its goal of increasing the production of table eggs. The actions should contribute to increasing the size of poultry farms and strengthening the technical and managerial capacities of entrepreneurs with a particular focus on women entrepreneurs.

Keywords: entrepreneur, table eggs, technical efficiency, stochastic frontier, Benin

5. Assessment of factors influencing youth involvement in horticulture agribusiness in Tanzania: A case study of Njombe Region

Ng'atigwa, A. A., Hepelwa, A., Yami, M., & Manyong, V. (2020). Assessment of factors influencing youth involvement in horticulture agribusiness in Tanzania: A case study of Njombe Region. *Agriculture*, 10(7), 287. <https://doi.org/10.3390/agriculture10070287>

Involvement of youth in horticulture agribusiness has become a vital approach to create employment opportunities among the youth in Tanzania. This study aimed at examining the extent of youth participation and factors influencing youth involvement in horticulture agribusiness with a focus on innovations in post-harvest management (PHM). Data were collected from a sample of 576 male and female youth in Njombe region using a multi-stage random sampling technique. Data were analyzed using an ordered logit model and descriptive statistics. Results of the ordered logit analysis showed that primary school education, Form IV and above, management innovation, access to credit, good perception of horticulture for agribusiness and improved packaging materials positively and significantly influence youth involvement in horticulture agribusiness. Gender and land size had a negative and significant influence on youth involvement in horticulture agribusiness, as indicated by higher percentages of male youth (59%) participation in the horticulture agribusiness. Therefore, this study suggests increased investment in capacity development of the youth on PHM innovations and the development of rural infrastructure such as agro-processing and storage facilities by the

government and private sector. Increasing the availability of improved packaging materials and provision of youth-friendly credit schemes could encourage youth in horticulture agribusiness.

Keywords: youth, agribusiness, gender equity, horticulture, post-harvest losses, Tanzania, youth unemployment

6. Determinants of youth participation in agricultural training programs: the case of Fadama program in Nigeria

Adeyanju, D., Mburu, J., Mignouna, D., & Akomolafe, K. (2021). Determinants of youth participation in agricultural training programs: the case of Fadama program in Nigeria. *International Journal of Training Research*, 19(2), 142–166. <https://doi.org/10.1080/14480220.2021.1905685>

This paper investigated the determinant of youth participation in agricultural training programs using the case of Fadama program. A multi-stage sampling technique was used to select a total of 977 respondents comprising of 455 participants and 522 non-participants. Data collected were analyzed using descriptive and inferential statistics. The study showed that high asset index reduces youths' likelihood of participation. Also, participation in the program was negatively but significantly influenced by gender and household size but positively by age, years of education, perception of agribusiness, agribusiness ownership and youth's intentions to start farming. The result of the descriptive showed that majority of the respondents (56%) indicated lack of access to finance as their major barrier to participating in agribusiness and in agribusiness training. Other barriers include lack of mentorship and information. The study therefore recommends the need for strategies to facilitate youth access to credit, mentorship and timely information.

Keywords: youth unemployment, agricultural training, training programs, agribusiness

7. Effect of ICT tools attributes in accessing technical, market and financial information among youth dairy agripreneurs in Tanzania

Okello, D., Feleke, S., Gathungu, E., Owuor, G., & Ingasia, O. (2020). Effect of ICT tools attributes in accessing technical, market and financial information among youth dairy agripreneurs in Tanzania. *Cogent Food & Agriculture*, 6(1). <https://doi.org/10.1080/23311932.2020.1817287>

The purpose of this article is to determine the effect of Information and communications technology (ICT) tools' attributes in accessing technical, market and financial information among youthful dairy agripreneurs in Arumeru District, Tanzania. Data were collected through a standardized questionnaire from 347 farming households. Descriptive statistics and multivariate probit regression were used to analyze the data. The results of the study show that utilization of the various ICT tools (mobile phone, television (TV) and radio) is interrelated, whereas several factors, including extension contacts, installation of electricity, level of buyer trust, availability of market information and receiving of remittances, are found to affect the

probability of ICT use. Findings also reveal that complementarity, accessibility, relevance and timeliness had a positive effect on ICT use, while the feedback attribute had a negative influence on ICT use. This finding underscores the need to consider ICT tools' attributes when designing a sustainable ICT-based information delivery model for dairy youth agripreneurs. An understanding of actual users' preference for ICT attributes can provide a blueprint for the ongoing ICT-based public- and private-sector initiatives that target youth-users more effectively.

Keywords: attributes, youth, dairy agripreneurs, information communication technology, Arumeru

8. Ethiopia's agricultural transformation: Agribusiness contribution to reducing youth unemployment

Wossen, T., & Ayele, S. (2018). Ethiopia's agricultural transformation: Agribusiness contribution to reducing youth unemployment. *IDS Bulletin*, 49(5). <https://doi.org/10.19088/1968-2018.171>

This article explores empirical evidence on the relationship between agricultural transformation, ownership structure of agribusinesses, and employment creation in Ethiopia. It draws on secondary data to present evidence of Ethiopia's agricultural transformation, employment trends, and the agribusiness sector's contribution to employment generation. The country's agricultural sector has shown signs of transformation in the form of both labor movements to the more productive manufacturing and services sectors, and productivity growth through the commercialization and creation of agribusinesses. The findings suggest that the growing numbers of agribusinesses are generating more jobs for youth but also reveal a number of challenges to overcome, such as skills gaps, low pay in the private sector, and inflexible land ownership and transfer processes. The study suggests targeted policy reforms to incentivize efficient and competitive private agribusinesses, and to address agribusiness-related constraints, skills and wage gaps, as well as land ownership and rental market constraints.

Keywords: agriculture, youth, unemployment

9. Hard work and hazard: Young people and agricultural commercialization in Africa

Yeboah, T., Chigumira, E., John, I., Anyidoho, N. A., Manyong, V., Flynn, J., & Sumberg, J. (2020). Hard work and hazard: Young people and agricultural commercialization in Africa. *Journal of Rural Studies*, 76, 142–151. <https://doi.org/10.1016/j.jrurstud.2020.04.027>

An emerging orthodoxy supports the proposition that the rural economy – built around agriculture but encompassing much more – will serve as sweet spot of employment opportunities for many millions of young people into the foreseeable future. However, our understanding of how rural young people in Africa take advantage of processes of rural transformation or engage with the rural economy is limited. Drawing on qualitative research conducted with 117 rural young people in three country contexts (Ghana, Zimbabwe and Tanzania), this paper reports the findings on the steps and pathways through which young people construct livelihoods

in hotspots of agricultural commercialization. Overall what emerges from a diversity of backgrounds, experiences and pathways is that the commercialized rural economies within which they operate offer them a variety of income earning opportunities. Family and broader social relations are key in enabling young people to access the needed resources in the form of land, capital, and inputs to begin their ventures. Between family and rental markets, there is little evidence that young people's engagement with crop production is limited by their inability to access land. We also find evidence of asset accumulation by young people in the form of housing, furniture and savings among others, which reflects the combination of relatively dynamic rural economies, enabling social relations, and hard work. However, for many it is a struggle to stay afloat, requiring effort, persistence, and an ability to navigate setbacks and hazards. Our findings challenge a number of assumptions underlying policy and public discourse around rural young people and employment in Africa. We highlight some key implications for policy seeking to promote youth employment in rural Africa.

Keywords: transformation, intensification, young people, Africa, Zimbabwe, Ghana, Tanzania

10. Unlocking the potential of agribusiness in Africa through youth participation: An impact evaluation of N-Power Agro Empowerment Program in Nigeria

Ogunmodede, A., Ogunsanwo, M., & Manyong, V. (2020). Unlocking the potential of agribusiness in Africa through youth participation: An impact evaluation of N-Power Agro Empowerment Program in Nigeria. *Sustainability*, 12(14), 5737. <https://doi.org/10.3390/su12145737>

In a country of about 200 million people, the government has over the years constituted various initiatives to address the issue of unemployment, food security, and youth involvement in agriculture. However, the impact of these initiatives has been minimal due to the inconsistency in government policies, changes in government, inadequate implementation mechanism amongst others. This study, therefore, evaluated the impact of the N-power Agro Program on youth employment and income generation through agribusiness in Nigeria. Six hundred and forty-five respondents were randomly selected from the database of N-Power. Structured questionnaires were used in obtaining the data. The statistical analysis of collected data applied descriptive methods, logistic regression model, and regression discontinuity design. The value of ATE of the regression discontinuity design of the income of the participants of N-Power Agro is greater by N30,191.46 than for the nonparticipants. The result of the logistic regression model shows that age, level of education, years of agribusiness experience, and employment status significantly influenced the choice of creating employment through agribusiness and of participating in the N-Power Agro program. The impact of the N-Power Agro program for Nigeria's young men and women on employment and income generation for participants was shown to be effective and positive with the RDD recording an increase in the beneficiaries' income and a discontinuity in the design. Upscaling this program and wider implementation in other countries in collaborations with youth, rural communities and private sectors will ensure that the government can bridge the skills deficit in Africa's youth, develop their capacities for entrepreneurship, and hence, increase jobs creation.

Keywords: youth unemployment, entrepreneurship, aspirations of youth, access to resources, higher education, rural development, training and skills development, sustainability and food security

11. Youth agricultural entrepreneurship: Assessing the impact of agricultural training programmes on performance

Adeyanju, D., Mburu, J., & Mignouna, D. (2021). Youth agricultural entrepreneurship: Assessing the impact of agricultural training programmes on performance. *Sustainability*, 13(4), 1697. <https://doi.org/10.3390/su13041697>

Using the case of the Fadama Graduate Unemployed Youth and Women Support (GUYS) program, this study investigated the impact of agricultural training programs on youth agripreneurship performance in Nigeria. A total of 977 respondents comprising of 455 participants of the program and 522 non-participants were sampled across three states in Nigeria. Data were collected using a well-structured questionnaire programmed on Open Data Kit (ODK). Data were analyzed using the Endogenous Treatment Effect Regression (ETER) model. The probit model results revealed that participation in the program was significantly influenced by age, years of formal education, marital status, current residence, employment type, and perception of training. The empirical analysis showed that after controlling for endogeneity, participation in the program led to better performance which was measure in terms of average income from agripreneurship activities. These findings highlight the significance of training in improving the performance of young agripreneurs and suggest the need to encourage and out-scale programs such as the Fadama GUYS, both in Nigeria and elsewhere in Africa as they can contribute to better performance of youth-owned agribusiness firms.

Keywords: youth, agripreneurship performance, agricultural programs, agricultural training

12. Access to finance and rural youth entrepreneurship in Benin: Is there a gender gap?

Senou, M. M., & Manda, J. (2022). Access to finance and rural youth entrepreneurship in Benin: Is there a gender gap? *African Development Review*, 34(1), 29–41. <https://doi.org/10.1111/1467-8268.12623>

Rural entrepreneurship is an important employment generation intervention for the fast-growing young labor force in developing countries. Many bottlenecks including access to finance impede rural youths to perform in their new ventures. This paper examines the impact of access to finance on rural youths' entrepreneurship in Benin using data from the second wave of the School-To-Work Transition (SWTS) survey involving over 900 youths. The paper employs the endogenous switching regression technique (ESR), combined with propensity score matching, to investigate the drivers of rural youths' access to finance and its impact on entrepreneurship intention and performance. The results indicate that age, education, poverty status, experience, working in the agricultural sector and the existence of a bank branch are important determinants of rural youths' access to finance. The results also show that access to finance increases the probability of youth's entrepreneurship by 15.2% on average. Similarly, the turnover increased by 15.86% for the youths who accessed finance. Moreover, the study shows a significant gender gap in rural entrepreneurship of 5.24% among youths that had access to finance in Benin. These results suggest that policymakers should encourage formal

financial institutions to reduce their credit eligibility conditions for youths who do not have collateral.

Keywords: access to finance, rural entrepreneurship, SWTS, ESR, Benin

13. Analysis of technical efficiency among youth involved in crop production in Njombe Region, Tanzania

Ng'Atigwa, A. A., Hepelwa, A., Manyong, V., & Feleke, S. (2022). Analysis of technical efficiency among youth involved in crop production in Njombe Region, Tanzania. *Cogent Economics & Finance*, 10(1), 2103923. <https://doi.org/10.1080/23322039.2022.2103923>

This study aimed to estimate the Technical Efficiency (TE) of youth crop farmers in Njombe Region of Tanzania, and analyze the determinants of technical inefficiency for crops produced. Data were collected from 572 youths in 16 villages of Njombe Region by using a random sampling technique. The Stochastic Production Function (SPF) model analyzed technical efficiency among the youth crop farmers. Results show that youth crop farmers in the study region exhibited decreasing returns to scale, as confirmed by the Returns to Scale of 0.275. The mean TE of crops produced was 19.32%, implying that youth farmers still have room to improve their farming efficiency by 80.68% using the same land resources. Most youth farmers had technical efficiency scores from 18.5% to 20.5%. In addition, the estimated SPF model and inefficiency parameters showed that age, land ownership, and extension contact are factors which reduced technical inefficiency in the study region. Thus, more emphasis might focus on enhancing the accessibility of youth farmers to extension services, land ownership, and efficient use of farm inputs might improve the TE of youth crop farmers in Tanzania and the world as a whole.

Keywords: crops, technical efficiency, youth, stochastic frontier, Tanzania

14. Assessing the impact of Youth-in-Agribusiness Program on poverty and vulnerability to poverty in Nigeria

Bello, L. O., Baiyegunhi, L. J. S., Danso-Abbeam, G., Ogunniyi, A. I., Olagunju, K., Abdoulaye, T., Manyong, V., Bamba, Z., & Awotide, B. A. (2022). Assessing the impact of Youth-in-Agribusiness Program on poverty and vulnerability to poverty in Nigeria. *Agriculture*, 12(5), 735. <https://doi.org/10.3390/agriculture12050735>

Poverty persists in many developing countries, including Nigeria, owing to inadequate infrastructure, unemployment, or poor working conditions, among other factors. Youth poverty and vulnerability to poverty have been identified to prevalent among the young population. Using an endogenous switching probit regression approach, in this study, we evaluated the impacts of youth participation in agribusiness programs (YIAPs) on poverty and vulnerability to poverty in Nigeria. Our findings revealed that some demographic and institutional factors significantly influence poverty and vulnerability to poverty among youth. The impact estimates indicate that participation in an agribusiness program has a significant positive effect on

poverty reduction among youth. Moreover, there would have been about a 28% reduction in exposure to future poverty for non-participants had they participated in a YIAP. Our results suggest that intervention programs, such as YIAPs, that focus on skill acquisition and youth empowerment should be strengthened and scaled-up in order to improve youth welfare and subsequently reduce/eradicate poverty and vulnerability to poverty among youth.

Keywords: poverty, youth, agribusiness program, endogenous switching probit regression, Nigeria

15. Do youth farmers benefit from participating in contract farming? Evidence from French beans youth farmers in Arusha, Tanzania

Marwa, M. E., & Manda, J. (2022). Do youth farmers benefit from participating in contract farming? Evidence from French beans youth farmers in Arusha, Tanzania. *Agrekon*, 61(4), 379–398. <https://doi.org/10.1080/03031853.2022.2099917>

Contract farming (CF) is often seen as a system that enhances production efficiency leading to increased agricultural productivity and improved farmer livelihoods. However, there is a conflict in the literature on its impact on young farmers who are involved in farming in Sub-Saharan Africa. This paper evaluates the impacts of CF on crop yield, crop and household income among the youth farmers involved in French bean farming in Tanzania using cross-sectional data of 273 households. The study employs an endogenous switching regression (ESR) model that accounts for observed and unobserved factors to estimate the impact of CF. Further, the propensity score matching (PSM) model is used to check the robustness of ESR results. The results indicate that 162 farmers had contracts and French bean yields and incomes significantly increased with CF. Specifically, the empirical results reveal that CF leads to a gain of 17%, 34% and 37.5% in the yield, crop income and household income. Participation and impact of contract farming differed according to different socio-economic/institutional variables, such as access to extension services.

Keywords: contract farming, French bean, youth participation, endogenous switching regression, impact, Tanzania

16. Economic analysis of youth participation in agripreneurship in Benin

Akrong, R., & Kotu, B. H. (2022). Economic analysis of youth participation in agripreneurship in Benin. *Heliyon*, 8(1), e08738. <https://doi.org/10.1016/j.heliyon.2022.e08738>

The study assessed the factors affecting youth participation in rural entrepreneurship in Benin using data from the School-to-Work Transition Survey (SWTS) and applying the binary logit and the multinomial logit models. The results showed youth who have a larger number of children are more likely to choose agricultural businesses (agripreneurship) while those who have formal education, who have received training on entrepreneurship, who have registered business, and those who have located in urban areas are more likely to engage in non-agricultural businesses. Within agripreneurship, youth who belong to a larger household are

more likely to engage in farming while those who are educated, who have access to credit, and who are located in urban areas are more likely to be engaged in non-farming agri-businesses. The study also revealed that cash crop production among Beninese youth was positively influenced by access to credit. The findings suggest that it would be necessary to promote development programs that are geared toward enhancing the capacities of the youth with regards to concepts and skills of entrepreneurship in agriculture and measures to overcome challenges associated with different agribusiness activities.

Keywords: agribusiness, agripreneurship, cash crop, entrepreneurship, youth

17. Entrepreneurial intention among undergraduate agricultural students in the Republic of Benin

Kaki, R. S., Mignouna, D. B., Aoudji, A. K. N., & Adéoti, R. (2023). Entrepreneurial intention among undergraduate agricultural students in the Republic of Benin. *Journal of African Business*, 24(1), 111–128. <https://doi.org/10.1080/15228916.2022.2031584>

This study aims at investigating the determinants of entrepreneurial intentions of undergraduate students in agriculture to start self-employed agribusiness after graduation in the Republic of Benin. A sample of 351 final year agricultural students was selected from four universities both public and private in the Republic of Benin using a cluster sampling method. The data were collected through a structured questionnaire and analyzed using descriptive statistics and a binary logistic regression. The results reveal that an important of respondents (44.16%) were willing to start their own agribusiness venture as self-employment after graduation with a preference for agro-processing enterprises (35.48%) and crop production enterprises (26.45%). Significant factors that influence agricultural students' willingness to take up self-employment in agribusiness were age, students major, type of university attended, experience in agribusiness, friend role model, and overall perception toward agribusiness environment. The study recommends incorporation of entrepreneurial education in the curriculum for all majors, involvement of agribusiness professionals/entrepreneurs in the training programs, establishment of entrepreneurship clubs, visibility of successful youth entrepreneurs in agribusiness, and creation of conducive agribusiness environment for youth graduates.

Keywords: entrepreneurial intentions, agribusiness, youth, self-employment, Republic of Benin

18. Farmers' credit access in the Democratic Republic of Congo: Empirical evidence from youth tomato farmers in Ruzizi plain in south Kivu

Bonnke, S. M., Dontsop-Nguezet, P., Biringanine, A. N., Jean-Jacques, M. S., Manyong, V., & Bamba, Z. (2022). Farmers' credit access in the Democratic Republic of Congo: Empirical evidence from youth tomato farmers in Ruzizi plain in south Kivu. *Cogent Economics & Finance*, 10(1), 2071386. <https://doi.org/10.1080/23322039.2022.2071386>

This article assesses the opinions of youth tomato growers on the accessibility of agricultural credit and factors that influence the accessibility in the Democratic Republic of the Congo

(DRC). Data originated from a household survey for the 2019/2020 farming season. We interviewed 218 youth tomato growers from 6 horticulture production zones in the South Kivu, eastern DRC. The result reveals a low rate of 20.6% on accessing agricultural credit among tomato growers. The topmost nature of agricultural credit received was cash-based, mostly from informal sources of finance (92.7%). The findings reveal that the lack of information on agricultural credit, the fear of credit default, and the absence of Microfinance Institutions in the study areas were the highest-ranking factors hindering tomato growers from accessing agricultural credit services. Our probit model shows that total household income, gender, and tomato growers' membership in a cooperative were essential factors that explain the probability of accessing agricultural credit. We recommend formalising the agricultural credit system by improving agri-finance extension service delivery to associations of tomato growers among the young to access and use agricultural microcredit services effectively to enhance agricultural production, which is a proxy for rural employment creation and poverty reduction.

Keywords: agricultural credit accessibility, horticulture, microfinance, probit model, South Kivu, DRC

19. Impact of agricultural programs on youth engagement in agribusiness in Nigeria: A case study

Adeyanju, D. F., Mburu, J., & Mignouna, D. (2020). Impact of agricultural programs on youth engagement in agribusiness in Nigeria: A case study. *Journal of Agricultural Science*, 12(5), 145. <https://doi.org/10.5539/jas.v12n5p145>

Using the case of Fadama Graduate Unemployed Youth and Women Support (FGUYS) program, this study assessed the impact of agricultural programs on youth engagement in agribusiness in Nigeria. A total of 977 respondents comprising of 455 participants of the program and 522 non-participants were sampled across three states in Nigeria. Data were analyzed using Descriptive and Endogenous Switching Probit Regression (ESPR) Model. The result showed that participation in the program was influenced by age, years of formal education, perception of agricultural programs and type of employment. Furthermore, the results showed a positive impact of the program on youths' likelihood to engage in agribusiness. The study recommends the need to invest more in agricultural programs such as the case study since it has desirable economic outcome for young people. Also, there is a need to improve the general outlook of agriculture such that it becomes more attractive to young people.

Keywords: youth, youth unemployment, agribusiness, agricultural programs

20. Impact of intensive youth participation in agriculture on rural households' revenue: Evidence from rice farming households in Nigeria

Fasakin, I. J., Ogunniyi, A. I., Bello, L. O., Mignouna, D., Adeoti, R., Bamba, Z., Abdoulaye, T., & Awotide, B. A. (2022). Impact of intensive youth participation in agriculture on rural households' revenue: evidence from rice farming households in Nigeria. *Agriculture*, 12(5), 584. <https://doi.org/10.3390/agriculture12050584>

The youth unemployment situation is an essential component of the current agricultural policy agenda of the Federal Government of Nigeria. Deep-rooted debates on finding a lasting solution to this problem using agriculture have been targeted as one of the panaceas. Using data from 207 systematically selected rice-producing households, this study employed the Propensity Score Matching method (PSM) and the Inverse Probability Weighted Regression Adjustment method (IPWRA) to examine the effect of intensive youth participation in agriculture on productivity and household revenue in Nigeria. We found that the key factors influencing the decisions of youth to participate in agriculture intensively include the number of years of farming experience, access to credit, membership in social groups, income, and land access. The PSM results indicate that rice productivity could increase by 1088.78 kg/ha if youth decide to intensively participate in agriculture. The IPWRA results show a positive and significant impact of intensive youth participation in agriculture on productivity and revenue. Therefore, our results suggest that efforts by the government and stakeholders toward encouraging flexible accessibility to credit (low-interest and easy repayment) and land without collateral to young people could enhance their participation in intensive agriculture and could subsequently boost productivity and household revenue.

Keywords: youth employment, primary occupation, rural households, southern Nigeria

21. Influence of agricultural degree programme environment on career in agribusiness among college students in Nigeria

Ikuemonisan, E. S., Abass, A. B., Feleke, S., & Ajibefun, I. (2022). Influence of agricultural degree programme environment on career in agribusiness among college students in Nigeria. *Journal of Agriculture and Food Research*, 7, 100256. <https://doi.org/10.1016/j.jafr.2021.100256>

The Dundee Ready Educational Environment Measure was used as a universal diagnostic inventory to assess the educational environment of Agricultural Degree Programme of the selected institutions. A logistic regression model, which assumes the probability of respondents' preference for the choice of Agribusiness as a career, was deployed to achieve some objectives of the study. Multiple Analysis of Variance (MANOVA) and T-Test were also used. The study revealed that majority of the students were trapped below the poverty threshold, with only 27% willing to pursue agribusiness as a career. Although there was evidence of more positive than negative perceptions about their educational environment (50%–87.4%), there were indications that all the indicators captured in the subscales need a lot of improvement (<88%). Similarly, the study found that students' perceptions of their learning environment, learning atmosphere, quality of teaching, and ease of the course of study have a significant influence on their choice of agribusiness as a career. The study recommends that there must be deliberate efforts to improve the quality of learning by developing tailor-made agribusiness education, quality of teachers, quality of the academic atmosphere, and scholarship for highflyers among the students to increase their participation in agribusiness.

Keywords: Dundee ready educational environment measure, logistic regression, MANOVA, undergraduate agricultural students, rational theory of choice

22. “Stop calling me a youth!”: Understanding and analysing heterogeneity among Ugandan youth agripreneurs

Turolla, M., Swedlund, H. J., Schut, M., & Muchunguzi, P. (2022). “Stop calling me a youth!”: Understanding and analysing heterogeneity among Ugandan youth agripreneurs. *Africa Spectrum*, 57(2), 178–203. <https://doi.org/10.1177/00020397221105292>

The African “youth” population is growing at a fast and steady pace, attracting attention from scholars, policymakers, and politicians. Yet, we know relatively little about this large and heterogeneous segment of the population. This paper presents data from 110 interviews and ten focus groups with youth engaged in commercial agriculture across all four regions of Uganda. Capitalising on this ethnographic data, we provide an analytical framework for studying complexity among the heterogeneous social category of youth agripreneurs. The aim of the paper is twofold: First, to reconcile anthropological studies that highlight the heterogeneity of African youth with demographic understandings of youth as a statistical category defined by an age bracket. Second, to advance an operational definition of youth that allows for more context-sensitive and tailored programs. Our results suggest that while “youth” is an important category demographically, the opportunities and challenges faced by youths are often not related to age.

23. The effect of ICT use on the profitability of young agripreneurs in Malawi

Jolex, A., & Tufa, A. (2022). The effect of ICT Use on the profitability of young agripreneurs in Malawi. *Sustainability*, 14(5), 2536. <https://doi.org/10.3390/su14052536>

The agricultural sector’s significant position in an economy and high potential benefits of agricultural transformation give developing countries major opportunities, especially for youth, to commercially start an agricultural enterprise. Increasing youth engagement in agriculture is fundamental for sustainably transforming agriculture and reducing youth unemployment. In achieving this, information and communication technologies hold great potential. Harnessing youth agribusiness opportunities through the use of ICT and its innovations are key to increasing profitability and providing employment. The study assesses the effect of the intensity of ICT use on profit using data collected from 317 young agripreneurs and an ordered logit model. The results show that profitability increases with the number of ICT tools used to receive and disseminate information relevant to agribusinesses. Therefore, relevant stakeholders should strive toward the implementation of programs that increase the number of ICT tools that can be used in agribusinesses.

Keywords: agribusiness, ICT, profit, Malawi, youth

24. The effect of land inheritance on youth migration and employment decisions in Rwanda

Byishimo, P., Tufa, A., Yami, M., Alene, A. D., Feleke, S., Abdoulaye, T., & Manyong, V. (2022). The effect of land inheritance on youth migration and employment decisions in Rwanda. *Sustainability*, 14(9), 5404. <https://doi.org/10.3390/su14095404>

There is growing mobility of rural youth mainly caused by limited access to land resources and inadequacy of job opportunities. Increased population density coupled with low education rates has increased pressure on natural resources, especially land. This paper assessed the effect of land inheritance on youth migration and employment in Rwanda using the 2010/11 and 2013/14 Integrated Household Living Conditions Surveys (EICVs) data collected from 8160 households by the National Institute of Statistics of Rwanda (NISR). In-depth key informant interviews and focus group discussions, at institutional and cooperative levels, were conducted to supplement and support survey results. We used the Hausman test to choose between the fixed-effects and random-effects models. Results show that land inheritance has a negative and statistically significant effect on youth migration and non-agriculture-based employment. This implies that greater access to land through inheritance reduces the likelihood of youth migration and their participation in nonagricultural employment. The paper concludes with implications for policy aimed at creating increased access to land, expanding youth employment opportunities in rural areas, and reducing rural–urban youth migration.

Keywords: access to land; rural youth; youth migration; youth employment; Rwanda

25. Entrepreneurial potential and agribusiness desirability among youths in South Kivu, Democratic Republic of the Congo

Simbeko, G., Nguezet, P.-M. D., Sekabira, H., Yami, M., Masirika, S.A., Bheenick, K., Bugandwa, D., Nyamuhirwa, D.-M. A., Mignouna, J., Bamba, Z., & Manyong, V. Entrepreneurial potential and agribusiness desirability among youths in South Kivu, Democratic Republic of the Congo. *Sustainability*, 15(1), 873. <https://doi.org/10.3390/su15010873>

In the Democratic Republic of Congo (DRC), entrepreneurship in the agriculture sector remains for youth a key pillar for income creation. However, few are attracted by agribusiness despite stakeholders' efforts toward engaging youth in agriculture. Therefore, this study examines the relationship between entrepreneurial potential characteristics and youth desirability to start an enterprise in agriculture among 514 young people in Eastern DRC. This study revealed that youth in South Kivu have different entrepreneurship potential features and agribusiness desirability levels according to their gender and living area. Hence, the youth's agribusiness desirability is motivated by an awareness of emerging agripreneurial activities, land ownership, parent involvement in farming activities as a role model, perceived agribusiness as an employment source, management-organizing and opportunistic competencies, market analysis, negotiating, and planning skills. Therefore, efforts to attract youth into agribusiness should focus on the use of media, the creation of awareness of available agribusiness initiatives in their area, and the setup of land policy. This is in addition to putting in place capacity-building programs on entrepreneurial and business skills through incubators, and the formalization of youth agribusiness groups that foster capitalizing experiences between new and accelerated agripreneurial enterprises, with the support of parents and financial institutions, focusing on gender sensitivity, in both rural and urban areas.

Keywords: entrepreneurial potential, agribusiness desirability, agribusiness, youths, DRC

26. The effects of foreign direct investment on youth unemployment in the Southern African Development Community

Mkombe, D., Tufa, A. H., Alene, A. D., Manda, J., Feleke, S., Abdoulaye, T., & Manyong, V. (2021). The effects of foreign direct investment on youth unemployment in the Southern African Development Community. *Development Southern Africa*, 38(6), 863–878. <https://doi.org/10.1080/0376835X.2020.1796598>

This paper examines the effect of foreign direct investment (FDI) on youth unemployment in the Southern African Development Community (SADC) region using panel data from the World Bank World Development Indicators for the period 1994–2017. Results from the Feasible Generalized Least Squares (FGLS-Parks) technique show that FDI has an insignificant effect on reducing youth unemployment in the SADC region. This could be because the type of FDI in the region is partly mergers and acquisitions, which has fewer jobs creating capacity compared to Greenfield investment. This suggests the need for governments in the region to pursue labor-absorbing FDI policies and also ensure that foreign investment inflows are channelled toward labor-intensive sectors that have high labor absorptive capacity such as horticulture and floriculture.

Keywords: foreign direct investment, youth unemployment, SADC, Feasible Generalized Least Squares Parks

Consumers' acceptance (19)

1. End-user preferences for plantain food products in Nigeria and implications for genetic improvement

Amah, D., Stuart, E., Mignouna, D., Swennen, R., & Teeken, B. (2020). End-user preferences for plantain food products in Nigeria and implications for genetic improvement. *International Journal of Food Science and Technology*, 56, 1148–1159. <https://doi.org/10.1111/ijfs.14780>

Plantain is an important food security crop for farming households in Nigeria. This study investigates the relative importance of plantain food products and their quality descriptors from the perspective of farmers in Southern Nigeria, to inform end-user oriented and socially inclusive breeding strategies that drive hybrid adoption. Surveys were conducted in twelve rural communities in three states in the plantain belt of Nigeria, consisting of key informant interviews, sex-disaggregated focused group discussions and individual interviews. Dodo (fried plantains), boli (roasted plantains), boiled plantain, plantain with beans and porridge were the most common food products identified in the study areas. Fruit size, pulp texture (firmness/softness), color, maturity stage and taste were identified as the most critical characteristics, with impact on quality of processed food products. There were significant differences between states regarding the importance of plantain food products, but little interstate and gender differences for fresh fruit and food product quality characteristics.

Keywords: breeding, consumer preference, food quality characteristics, *Musa* spp., plantain hybrid

2. An assessment of willingness to pay by maize and groundnut farmers for aflatoxin biocontrol product in northern Nigeria

Ayedun, B., Okpachu, G., Manyong, V., Atehnkeng, J., Akinola, A., Abu, G. A., Bandyopadhyay, R., & Abdoulaye, T. (2017). An assessment of willingness to pay by maize and groundnut farmers for aflatoxin biocontrol product in northern Nigeria. *Journal of Food Protection*, 80(9), 1451–1460. <https://doi.org/10.4315/0362-028X.JFP-16-281>

In Nigeria, Aflasafe is a registered biological product for reducing aflatoxin infestation of crops from the field to storage, making the crops safer for consumption. The important questions are whether farmers will purchase and apply this product to reduce aflatoxin contamination of crops, and if so under what conditions. A study was carried out to address these questions and assess determinants of willingness to pay (WTP) for the product among maize and groundnut farmers in Kano and Kaduna states in Nigeria. A multistage sampling technique was used to collect primary data from 492 farmers. The majority of farmers who had direct experience with Aflasafe (experienced farmers) in Kano (80.7%) and Kaduna (84.3%) had a WTP bid value equal to or greater than the threshold price (\$10) at which Aflasafe was to be sold. The mean WTP estimates for Aflasafe for experienced farmers in Kano and Kaduna were statistically the same. However, values of \$3.56 and \$7.46 were offered in Kano and Kaduna states, respectively, by farmers who had never applied Aflasafe (inexperienced farmers), and the difference here was significant ($P < 0.01$). Regression results indicate that contact with extension agents ($P < 0.01$) and access to credit ($P < 0.05$) positively and significantly influenced the probability that a farmer would be willing to pay more for Aflasafe than the threshold price. Lack of awareness of the importance of Aflasafe was the major reason cited by inexperienced farmers (64% in Kano state and 21% in Kaduna state) for not using the product. A market strategy promoting a premium price for aflatoxin-safe produce and creating awareness and explaining the availability of Aflasafe to potential users should increase Aflasafe usage.

Keywords: Aflasafe, aflatoxin, biocontrol, logit model, willingness to pay

3. Assessment of willingness-to-pay for Aflasafe KE01, a native biological control product for aflatoxin management in Kenya

Migwi, B., Mutegi, C., Mburu, J., Wagacha, J., Cotty, P., Bandyopadhyay, R., & Manyong, V. M. (2020). Assessment of willingness-to-pay for Aflasafe KE01, a native biological control product for aflatoxin management in Kenya. *Food Additives & Contaminants A*, 37(11), 1951–1962. [10.1080/19440049.2020.1817571](https://doi.org/10.1080/19440049.2020.1817571)

Contamination of key staples with aflatoxins compromises the quality of food and feed, impedes trade, and negatively affects the health of consumers whereas acute exposure can be fatal. This study used the Contingent Valuation Method (CVM) on a sample of 480 farmers in counties prone to aflatoxin contamination to assess the willingness to pay (WTP) by farmers for Aflasafe KE01, a promising biological control product for the management of aflatoxin contamination of key staples in Kenya, compare its cost with that of a similar product in use in Nigeria, and determine factors likely to affect its adoption. Four hundred and eighty

households from four counties identified as aflatoxin hotspots in Kenya were purposively selected and interviewed using a semi-structured questionnaire. The mean WTP per kilogram of Aflasafe KE01, using Contingent Valuation Method in the four counties ranged from Kenya Shillings (Ksh) 113 to 152/kg compared to a cost of Ksh 130/kg, the price of a similar product, Aflasafe™, in Nigeria. Factors that positively influenced farmers' WTP included information from crop extension services and access to credit. To facilitate the adoption of Aflasafe KE01 or any other biocontrol product in Kenya and elsewhere, there is a need for increased education efforts through extension services to farmers about aflatoxins. Strategies to ensure that the biocontrol product is integrated into the credit scheme of the technological packages to farmers need to be considered.

Keywords: aflatoxins, biological control, Aflasafe KE01, Kenya, contingent valuation method, CVM, willingness to pay, WTP

4. Breeding cassava to meet consumer preferences for product quality

Abass, A., Awoyale, W., Sanni L., & Shittu, T. (2017). Breeding cassava to meet consumer preferences for product quality. In Hershey, C. (ed.) *Achieving Sustainable Cultivation of Cassava*. Volume 2: Genetics, Breeding, Pests and Diseases, pp. 1–14. Cambridge: Burleigh Dodds Science Publishing. <https://cgspace.cgiar.org/handle/10568/83518>.

Cassava (*Manihot esculenta* Crantz) is ranked as the sixth most important source of calories in the human diet worldwide. An estimated 800 million people depend on the starchy roots and their products as sources of dietary energy. Cassava leaves provide high protein content and many micronutrients, such as the carotenoid precursors of vitamin A. Cassava's combined abilities to produce high yields under poor conditions and suitability for underground storage make it a classic 'food security crop'. Africa dominates the global production of cassava with 53.7% of global output being produced in the continent. New high-yielding Tropical Manioc Selection (TMS) varieties from IITA have transformed cassava from a low-yielding, famine-reserve crop to a high-yielding cash crop for both rural and urban consumers in Africa. Although mean yields of cassava at the national level are in the range of 7–11 metric tonnes per hectare on farmers' fields in Africa, recent breeding work by both national and international research centers has made yields up to 30–45 metric tons per hectare obtainable when improved agronomic practices are combined with improved varieties. The opportunity provided by this high yield in terms of lower production cost per hectare has made cassava a potential crop for large-scale or commercial-scale production. This chapter looks at the range of uses of cassava and what this means for target properties in breeding new varieties. It reviews the range of breeding preferences amongst farmers, and a range of nutritional, sensory, processing and product properties that could be used in setting future breeding priorities for cassava.

Keywords: food security, value chain, cassava breeding, uses of cassava, consumer preferences, nutritional properties, sensory properties

5. Consumer preferences and socioeconomic factors decided on plantain and plantain-based products in the Central Region of Cameroon and Oyo State, Nigeria

Udomkun, P., Masso, C., Swennen, R., Innawong, B., Fotso Kuate, A., Alakonya, A., Lienou, J., Ibitoye, D. O., & Vanlauwe, B. (2021). Consumer preferences and socioeconomic factors decided on plantain and plantain-based products in the Central Region of Cameroon and Oyo State, Nigeria. *Foods*, 10(8), 1955. <https://doi.org/10.3390/foods10081955>

Plantain is a key staple food in Central and West Africa, but there is limited understanding of its market in Africa. In addition, the cooking methods for enhancing the nutritional value, consumer preference, and willingness to pay for plantain and plantain-based products are not well understood. The knowledge gaps in the market and consumer dimension of the food chain need to be known to increase plantain utilization and guide breeding efforts. This research contributes by examining the cooking methods, consumer preference, and willingness to pay for plantain and plantain-based products in Cameroon and Nigeria. A household survey sample of 454 Cameroonian consumers in four divisions of Central Region and 418 Nigerian consumers in seven government areas of Oyo State in southwest Nigeria was the basis for the analysis. The results showed some levels of similarity and difference in the consumption and cooking of boiled, roasted, and fried plantain in both countries. The trend in consumption of all plantain-based products was constant in Cameroon but increased in Nigeria. The most important factor influencing Cameroonian consumers' choice of plantain and its products was taste, while the nutrition trait influenced Nigerian consumers. Both Cameroonian and Nigerian consumers considered packaging, location of produce, and size and quantity as the least important factors. In addition, socioeconomic characteristics were significant determinants of consumers' choices to consume plantain and its products. Gender significantly influenced ($p < 0.05$) taste, while nutrition was significantly driven ($p < 0.05$) by education and annual income. Household size played a significant role ($p < 0.05$) in consumers' choices when the price was considered. These findings serve as a guideline to improve existing products to match the needs of consumers in each country and develop products for different consumer segments and potentially increase production.

Keywords: banana and plantain, consumer behavior, consumer choice, processed products, quality attributes, willingness to purchase

6. Smallholder agro-processors' willingness to pay for value-added solid-waste management solutions

Omilani, O., Abass, A. B., & Okoruwa, V. O. (2019). Smallholder agro-processors' willingness to pay for value-added solid-waste management solutions. *Sustainability*, 11(6), 1759. <https://doi.org/10.3390/su11061759>

The paper examined the willingness of smallholder cassava processors to pay for value-added solid wastes management solutions in Nigeria. We employed a multistage sampling procedure to obtain primary data from 403 cassava processors from the forest and Guinea savannah zones of Nigeria. Contingent valuation and logistic regression were used to determine the

willingness of the processors to pay for improved waste management options and the factors influencing their decision on the type of waste management system adopted and willingness to pay for a value-added solid-waste management system option. Women constituted the largest population of smallholder cassava processors, and the processors generated a lot of solid waste (605–878 kg/ processor/ season). Waste was usually dumped (59.6%), given to others (58.1%), or sold in wet (27.8%) or dry (35.5%) forms. The factors influencing the processors' decision on the type of waste management system to adopt included sex of processors, membership of an association, quantity of cassava processed and ownership structure. Whereas the processors were willing to pay for new training on improved waste management technologies, they were not willing to pay more than US\$3. However, US\$3 may be paid for training in mushroom production. It is expected that public expenditure on training to empower processors to use solid-waste conversion technologies for generating value-added products will lead to such social benefits as lower exposure to environmental toxins from the air, rivers and underground water, among others, and additional income for the smallholder processors. The output of the study can serve as the basis for developing usable and affordable solid-waste management systems for community cassava processing units in African countries involved in cassava production.

Keywords: cassava processors, smallholders, solid waste, pollution, value-added, willingness to pay

7. What are the key factors influencing consumers' preference and willingness to pay for meat products in Eastern DRC?

Udomkun, P., Ilukor, J., Mockshell, J., Mujawamariya, G., Okafor, C., Bullock, R., Nabahungu, N. L., & Vanlauwe, B., (2018). What are the key factors influencing consumers' preference and willingness to pay for meat products in Eastern DRC? *Food Science and Nutrition*, 6(8), 2321–2336. <https://hdl.handle.net/10568/97758>

Dietary patterns for consumers among the elite and middle-income classes in developing countries are shifting rapidly toward the consumption of more animal-based products. Although this shift presents opportunities, there are significant market failures affecting their preferences and willingness to pay (WTP). This study used a multi-stage sample survey of 309 consumers from three different communities of Bukavu, Eastern DRC, to examine the effect of socioeconomic/demographic characteristics and quality attributes on consumers' purchasing decisions and WTP for meat products. The results suggested that about 53% of the respondents were dissatisfied with meat products in the market due to their high price, low quantity, unhealthiness, and harmful effects. Older female respondents living in urban areas were more likely to purchase meat products. Their WTP was significantly determined by attributes such as color, in-mouth texture, and availability. Nutrition, harmful effects, and availability of meat products are the important factors that influence purchasing decisions among higher income groups. Addressing these market failures could have an impact on the meat market, improving the nutrition of low income consumers and ensuring food safety standards in DRC and other developing countries with similar challenges.

Keywords: meat products, willingness to pay, meat production

8. Will farmers intend to cultivate Provitamin A genetically modified (GM) cassava in Nigeria? Evidence from a k-means segmentation analysis of beliefs and attitudes

Oparinde, A., Abdoulaye, T., Mignouna, D. B., & Bamire, A. S. (2017). Will farmers intend to cultivate Provitamin A genetically modified (GM) cassava in Nigeria? Evidence from a k-means segmentation analysis of beliefs and attitudes. *PLOS ONE*, 12(7), e0179427. <https://doi.org/10.1371/journal.pone.0179427>

Analysis of market segments within a population remains critical to agricultural systems and policy processes for targeting new innovations. Patterns in attitudes and intentions toward cultivating Provitamin A GM cassava are examined through the use of a combination of behavioral theory and *k*-means cluster analysis method, investigating the interrelationship among various behavioral antecedents. Using a state-level sample of smallholder cassava farmers in Nigeria, this paper identifies three distinct classes of attitude and intention denoted as low opposition, medium opposition and high opposition farmers. It was estimated that only 25% of the surveyed population of farmers was highly opposed to cultivating Provitamin A GM cassava.

Keywords: market segments, Provitamin A GM cassava, Nigeria

9. Willingness to pay for biofertilizers among grain legume farmers in northern Ghana

Banka, M., Aidoo, R., Abaidoo, R. C., Fialor, S. C., & Masso, C. (2018). Willingness to pay for biofertilizers among grain legume farmers in northern Ghana. *Journal of Scientific Research & Reports*, 9(1), 1–13. <https://dx.doi.org/10.9734/jsrr/2018/40457>

Background: The call for use of improved Soil Fertility Management (SFM) technologies is a prerequisite to increase agricultural productivity among farmers. This study assessed farmers' willingness to pay (WTP) for selected financially rewarding biofertilizer technologies/packages for legume production in northern Ghana. Primary data was elicited from 400 grain legume farmers selected from Northern and Upper West Regions of Ghana through a simple random sampling technique. The double bounded dichotomous choice (DBDC) format of contingent valuation approach was employed to elicit willingness to pay values and determinants of farmers WTP was evaluated using the maximum likelihood estimation procedure.

Results: The results showed that about 60%, 25% and 46% of soya, cowpea, and groundnuts farmers were willing to pay for the selected biofertilizers (Biofix, BR3267 and Legumefix respectively) at prices not exceeding GHC 14.00, GHC 28.00 and GHC 20.00 per 0.2kg of the respective biofertilizers. Legume farmers in Northern Region were however willing to pay higher for the three biofertilizer technologies as compared to their counterparts in Upper West Region. For 0.2 kg each of Biofix, BR3267 and Legumefix, farmers in Northern Region were willing to pay approximately GHC 17.00, GHC 12.00 and GHC 23.00 respectively whereas those in Upper West Region were willing to pay GHC 14.00, GHC 9.00 and GHC 11.00 for the same quantity of each biofertilizer. The study identified farming experience, FBO membership, awareness and previous use of biofertilizers as significant determinants of farmers' willingness to pay for Biofertilizers.

Conclusion: Comparatively, mean prices farmers are willing to pay for these three technologies are below ex-factory prices, hence subsidizing the cost of production of these biofertilizers in the initial stages would be relevant for improving farmers' uptake of these fertilizers. Sustained awareness creation through periodic education and sensitization by using FBOs as leverage points is also highly recommended to improve farmers' understanding of the concept of biofertilizer use.

Keywords: willingness to pay, WTP, biofertilizers, grain legume, soil fertility management

10. Willingness to pay of Nigerian poultry producers and feed millers for aflatoxin-safe maize

Johnson, A. M., Abdoulaye, T., Ayedun, B., Fulton, J. R., Widmar, N. J. O., Adebowale, A., Bandyopadhyay, R., & Manyong, V. (2020). *Agribusiness*, 36(2), 299–317. <https://doi.org/10.1002/agr.21621>

Dietary aflatoxin exposure is a widespread problem in the developing world and causes severe negative health consequences to humans and livestock animals. A new biological control product, called Aflasafe, has been introduced in Nigeria to mitigate aflatoxin contamination of maize in the field and in storage. No known prior work has estimated how much African agribusinesses using maize for animal feed will pay for aflatoxin-safe maize. This study measured the levels of Aflasafe awareness, surveyed current aflatoxin management practices, and estimated, using choice experiments, willingness to pay (WTP) for aflatoxin-safe maize by Nigerian poultry producers and feed millers. Data was gathered from 272 orally administered surveys, which included discrete choice experiments examining maize purchasing decisions. Results suggest that the proportion of enterprises that were aware of aflatoxin was found to vary across states. Two latent classes of Nigerian poultry producers and feed millers were identified that were willing to pay average premiums of 4.9% and 30.9%, respectively for maize with 10 parts per billion (ppb) aflatoxin concentration relative to maize with 20 ppb aflatoxin concentration. Both latent classes were, on average, willing to pay larger premiums for maize with 4 ppb aflatoxin concentration. There was evidence that latent class membership, and hence WTP, varied based on awareness of aflatoxin and across geographies.

11. Consumers' perceptions and willingness to pay for organically grown vegetables

Coulibaly, O., Nouhoheflin, T., Aitchedji, C. C., Cherry, A. J., & Adegbola, P. (2011). Consumers' perceptions and willingness to pay for organically grown vegetables. *International Journal of Vegetable Science*, 17(4), 349–362. <https://doi.org/10.1080/19315260.2011.563276>

Vegetable production plays an important role in food security and provides food and raw materials for industries, income from sales, and employment for small households in urban and peri-urban areas in West Africa. However, some significant health hazards may occur due to misuse of chemicals pesticides applied during vegetable production. Reducing health risks by developing alternatives to synthetic pesticides may be beneficial for consumers and producers. This study assesses the potential market for organically grown vegetables and

analyzes consumer awareness and perceptions of synthetic pesticide residues in vegetables. Price levels that consumers are willing to pay for chemical-free vegetable products were evaluated. A hedonic-pricing model (preferences choice) was used to identify determinants of consumer willingness to pay for organically grown vegetables. Data were collected with a questionnaire on consumer perceptions of produce quality problems, awareness of pesticide use on vegetables, and willingness to pay for synthetic pesticide free vegetables. Consumers were aware of heavy use of synthetic pesticides on vegetables. Consumer preferences for quality vegetables included damage free, freshness, size, color, and firmness. Consumers were willing to pay a premium of more than 50% for synthetic pesticide-free vegetables. The most likely factors affecting consumer willingness to pay for organically grown vegetables were awareness of chemical residues and health risks, damage free, reliable availability of products, taste, and income level. There is a potential demand for synthetic pesticide-free vegetables.

Keywords: *Brassica oleracea*, *Solanum lycopersicum*, organically based pesticides, synthetic pesticides, residue, West Africa

12. Diversifying the utilization of maize at household level in Zambia: quality and consumer preferences of maize-based snacks

Alamu, E. O., Olaniyan, B., & Maziya-Dixon, B. (2021). Diversifying the utilization of maize at household level in Zambia: Quality and consumer preferences of maize-based snacks. *Foods*, 10(4), 750. <https://doi.org/10.3390/foods10040750>

This study evaluated the nutritional, antinutritional properties, and consumer preferences of five maize-based snacks at the household level. The physical, nutritional, and antinutritional properties were analyzed with standard laboratory methods, while a structured questionnaire was used for the data collection on consumer preferences of the maize products. There were significant ($p < 0.05$) differences in the proximate parameters of the maize snack samples. Antinutritional properties among maize snacks all fell within the permissible range. Respondents from all districts showed no significant ($p > 0.05$) differences in maize chin-chin variants and maize finger variants except for Serenje and Mkushi districts where maize chin-chin and maize finger showed significant ($p < 0.05$) differences in their sensory ratings. However, across districts, the most rated maize finger variant was the spiced 100% maize finger. In conclusion, maize-based snacks enriched with soybean flour have proven nutritious with a reasonable acceptability level.

Keywords: maize snacks; nutritional characterization; consumer preferences

13. End-user preferences for pounded yam and implications for food product profile development

Otegbayo, B, Madu, T, Oroniran, O, Chijioke, U, Fawehinmi, O, Okoye, B, Tanimola, A, Adebola, P. O., & Obidiegwu, J.* (2021). End-user preferences for pounded yam and implications for food product profile development. *International Journal of Food Science and Technology*, 56(3), 1458–1472. <https://doi.org/10.1111/ijfs.14770>

Pounded yam is a popular food in Nigeria. This study reports end-user preferences for pounded yam and implications for trait evaluation by breeding program. The study was carried out in two pounded yam-consuming regions in Nigeria: south-east and south-west. Multistage sampling technique was used to collect information from users along food chain. This involved market, individual, key informant interviews and focus group discussions. Responses of participants were used to develop product profile of pounded yam from raw material (yam) to final product. Key user-preferred quality traits for pounded yam in both regions were color and textural quality followed by taste and aroma which are lesser attributes. There were regional differences in ranking of these quality attributes but no gender difference. This information will be useful in determining food quality indicators that can be used to select breeding lines for preferred quality traits in pounded yam.

14. Estimating market demand for fresh yam characteristics using contingent valuation: implications for crop breeding and production choices

Amegbeto, N. K., Manyong, V., Coulibaly, O., & Asiedu, R. (2008). Estimating market demand for fresh yam characteristics using contingent valuation: implications for crop breeding and production choices. *Agricultural Economics*, 39(3), 349–363. <https://cgspace.cgiar.org/handle/10568/92239>

This study uses the Box–Cox (BC) transformations to examine nonlinearity in price modeling and compare results from several functional specifications in hedonic price analysis of yam in Togo. Based on a sample of 6,402 observations on price and produce characteristics generated through a market experiment, it is found that the BC quadratic asymmetric specification is the most suitable function. Several characteristics are valued more than others, and prices vary across species, time, and market sites. Some residual symptoms of pest and disease damages on yam tubers reduce their market values. Tuber weight exhibits a diminishing marginal value and price per kilogram decreases above an optimum size; therefore, producers do not derive additional reward from extra-large tubers. We conclude that, to effectively access and benefit from urban markets, producers should focus on small size, low weight, and conical shaped-tubers, which are easy to process and meet the esthetic qualities preferred by urban consumers. The implications for research on improved variety development to reduce poverty and for crop and resource management practices are drawn.

Keywords: hedonic price, Box-Cox transformation, heteroskedacity, yam characteristics

15. Evaluation of nutritional and antinutritional properties of African yam bean (*Sphenostylis stenocarpa* (Hochst ex. A. Rich.) Harms) seeds

Adegboyega, T. T., Abberton, M., Abdelgadir, A. H., Dianda, M., Maziya-Dixon, B., Oyatomi, O., Ofodile, S., & Babalola, O. O.* (2020). Evaluation of nutritional and antinutritional properties of African yam bean (*Sphenostylis stenocarpa* (Hochst ex. A. Rich.) Harms) seeds. *Journal of Food Quality*, 2020, 6569420. <https://doi.org/10.1155/2020/6569420>

African yam bean (*Sphenostylis stenocarpa* (Hochst ex. A. Rich.) Harms) is an annual legume with the capacity to produce bean seeds in a pod and produce tubers with varying seed

patterns and colors. It is suggested to have the potential to significantly boost food security in sub-Saharan Africa due to its considerable nutritional qualities but still yet underutilized. Many farmers show limited interest in its production owing to limited knowledge of its nutritional profile, income generation capacity for small-holder farmers', processing, and other related utilization concerns. This study evaluated the proximate and antinutrient composition of processed and unprocessed seeds of African yam bean (*Sphenostylis stenocarpa* (Hochst ex. A. Rich.) Harms). Seeds were harvested from the experimental research field consisting of 50 accessions at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. They were divided into two portions; the first was processed by oven drying at 60°C for 24 hours and the second was left raw. There were significant differences ($P < 0.05$) in the levels of proximate and antinutrient in the forms in which the samples were analyzed. TSs104 had the highest protein content of 25.08%, while the lowest was TSs68 (20.50%). However, in the unprocessed seed, protein content ranged between 24.93% (TSs38) and 19.13% (TSs11). Both processed and unprocessed seeds had high carbohydrate contents. In processed seeds, TSs9 (62.93%) had the highest percentage and TSs1 (29.64%) recorded the lowest. In unprocessed seed, the percentage ranged between 67.36% (TSs4) and 54.23% (TSs38). The observed variation may suggest possible suitability of seed for various end-use products and targeted breeding programs for crop improvements. In sub-Saharan Africa, this lesser-known legume could be adapted as a promising food crop in combating protein-energy malnutrition.

Keywords: African yam bean; nutritional properties, anti-nutritional properties, IITA, Nigeria

16. Farmers perception and criteria for cassava variety preference in Cameroon

Njukwe, E., Hanna, R., Kirscht, H., & Araki, S. (2013). Farmers perception and criteria for cassava variety preference in Cameroon. *African Study Monographs*, 34(4), 221–234. <https://cgspace.cgiar.org/handle/10568/76676>

To assess farmers' perception and criteria for cassava variety preference prior to the dissemination of improved varieties in Cameroon, field visits were organized at the Mbalmayo research farm of International Institute of Tropical Agriculture (IITA) during the vegetative and harvest periods, and a sensory quality test was conducted in a participatory manner. Parameters recorded were statistically analyzed using analysis of variance procedure (ANOVA), resulting in the selection of five varieties for multilocal testing and demonstration. To complement this effort, thirty cassava farmers in Ebolowa, Bertoua, Bamenda, Ngaoundere making a total of one hundred and twenty were interviewed following structured questionnaires, and their fields assessed. Results show that farmers cultivate many varieties of cassava for different uses but prefer early maturing variety (96.7%), high yield (89.2%), and resistant to pests and diseases (88.3%). In addition, there was regional preference. Farmers in Ebolowa and Bertoua preferred leafy, sweet roots and early branching varieties (TMS-92/0326, TMS96/0023) while those in Bamenda and Ngaoundere preferred tall, drought tolerant (TMS92/0057), fibrous (TMS-96/1414) for gari (roasted cassava granules) and in some cases flowering varieties (M94/0121) for apiculture. Results served as feedback information to research, extension, policy makers and other stakeholders. This constitutes an attractive scheme for deployment of

the improved varieties and complements programs of the Cameroonian government for roots and tuber (PNDRT), with the main objective to increase the productivity of cassava.

Keywords: cassava, improved variety, farmers perception, farmers preference, Cameroon

17. Farmers' preferences for high-input agriculture supported by site-specific extension services: Evidence from a choice experiment in Nigeria

Oyinbo, O., Chamberlin, J., Vanlauwe, B., Vranken, L., Kamara, Y. A., Craufurd, P., & Maertens, M. (2019). Farmers' preferences for high-input agriculture supported by site-specific extension services: Evidence from a choice experiment in Nigeria. *Agricultural Systems*, 173, 12–26. <https://doi.org/10.1016/j.agsy.2019.02.003>

Agricultural extension to improve yields of staple food crops and close the yield gap in Sub-Saharan Africa often entails general recommendations on soil fertility management that are distributed to farmers in a large growing area. Site-specific extension recommendations that are better tailored to the needs of individual farmers and fields, and enabled by digital technologies, could potentially bring about yield and productivity improvements. In this paper, we analyze farmers' preferences for high-input maize production supported by site-specific nutrient management recommendations provided by an ICT-based extension tool that is being developed for extension services in the maize belt of Nigeria. We use a choice experiment to provide ex-ante insights on the adoption potentials of site-specific extension services from the perspective of farmers. We control for attribute non-attendance and account for class as well as scale heterogeneity in preferences using different models, and find robust results. We find that farmers have strong preferences to switch from general to ICT-enabled site-specific soil fertility management recommendations which lend credence to the inclusion of digital technologies in agricultural extension. We find heterogeneity in preferences that is correlated with farmers' resource endowments and access to services. A first group of farmers are strong potential adopters; they are better-off, less sensitive to risk, and are more willing to invest in a high-input maize production system. A second group of farmers are weak potential adopters; they have lower incomes and fewer productive assets, are more sensitive to yield variability, and prefer less capital and labor intensive production techniques. Our empirical findings imply that improving the design of extension tools to enable provision of information on the riskiness of expected outcomes and flexibility in switching between low-risk and high-risk recommendations will help farmers to make better informed decisions, and thereby improve the uptake of extension advice and the efficiency of extension programs.

Keywords: agricultural technology adoption, agricultural extension, ICT-based extension, site-specific extension, soil fertility management, maize yield

18. Farmers' knowledge, use and preferences of parasitic weed management strategies in rain-fed rice production systems

Tippe, D. E., Rodenburg, J., Schut, M., van Ast, A., Kayeke, J., & Bastiaans, L. (2017). Farmers' knowledge, use and preferences of parasitic weed management strategies in rain-fed rice

production systems. *Crop Protection*, 99, 93–107. <https://doi.org/10.1016/j.cropro.2017.05.007>

Rain-fed rice production in sub-Saharan Africa is often hampered by parasitic weeds. This study assessed farmers' awareness, use, preference and adoption criteria of parasitic weed management practices in rain-fed rice production environments in Tanzania. Surveys and workshops were organized in three affected rice growing areas in Morogoro-rural, Songea and Kyela district, supplemented with on-farm experiments in Kyela. In all districts, farmers were aware of the locally occurring parasitic weed species, *Rhamphicarpa fistulosa* (lowland) and *Striga asiatica* (upland), and they considered these weeds more problematic than non-parasitic weeds. Though they mostly practise hand weeding, farmers were aware of a wide range of control options. Local access, affordability, ease of implementation and control efficacy were considered important criteria for adoption, whereas trade-offs, like lack of preferred grain quality traits in resistant varieties, were mentioned as an important break on adoption. Based on informal discussions with farmers, altered sowing times, resistant rice varieties and soil amendments were marked as feasible control options and tested in a farmer-participatory manner in four years of experimentation in upland and lowland fields. In both types of fields, the contribution of soil amendment to parasitic weed suppression was not evident, but rice husk was marked as a suitable and cheap alternative to inorganic fertilizers. Control of *R. fistulosa* in lowlands was perceived to be best realized by early crop establishment, escaping major parasite damage due to the relatively slow early development of this weed species. The local variety Supa India, appreciated for its grain qualities and marketability, remained the preferred variety. For the control of *S. asiatica*, late planting was preferred, requiring a short-duration variety to minimize risk of drought stress during grain filling. The short-duration NERICA-10 was most preferred, as it combined a favorable short cycle length with resistance to *S. asiatica* and good grain appearance. Farmer participation in technology testing showed to be crucial in defining locally adapted and acceptable parasitic weed control strategies. Yet, it is argued that without lifting important constraints related to credit and input supply, it will be impossible to sustainably solve the parasitic weed problem in rain-fed rice.

Keywords: *Oryza sativa*, witchweed, *Striga asiatica*, rice vampireweed, *Rhamphicarpa fistulosa*, participatory research

19. Using a discrete choice experiment to elicit the demand for a nutritious food: Willingness-to-pay for orange maize in rural Zambia

Meenakshi, J. V., Banerji, A., Manyong, V., Tomlins, K., Mittal, N., & Hamukwala, P. (2012). Using a discrete choice experiment to elicit the demand for a nutritious food: Willingness-to-pay for orange maize in rural Zambia. *Journal of Health Economics*, 31(1), 62–71. <https://doi.org/10.1016/j.jhealeco.2012.01.002>

Using a discrete choice experiment, this paper estimates the willingness to pay for biofortified orange maize in rural Zambia. The study design has five treatment arms, which enable an analysis of the impact of nutrition information, comparing the use of simulated radio versus community leaders in transmitting the nutrition message, on willingness to pay, and to account for possible novelty effects in the magnitude of premiums or discounts. The estimation strategy

also takes into account lexicographic preferences of a subset of our respondents. The results suggest that (a) orange maize is not confused with yellow maize, and has the potential to compete with white maize in the absence of a nutrition campaign, (b) there is a premium for orange maize with nutrition information, and (c) different modes of nutritional message dissemination have the same impact on consumer acceptance.

Keywords: discrete choice experiments, vitamin A deficiency, biofortification.



● **social science**
● **research for development**



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