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Impact Assessment Report of YIIFSWA Project

Raising Household Income, Improving Food Security and Reducing Poverty in Nigeria

B.D. Mignouna, N. Maroya, B. Aighewi, L. Kumar, B. Akinribido, J. Ikeorgu, T. Abdoulaye, A.A. Akinola, A.D. Alene, V.M. Manyong, and R. Asiedu

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Acronyms and Abbreviations

ADP	Agricultural Development Project
AEZ	Agroecological zone
AFD	Arimathea Foundation for Development
ATE	Average treatment effect
ATT	Average treatment on treated
ATU	Average treatment on untreated
AYMT	Adaptive Yam Minisett technology
BMGF	Bill & Melinda Gates Foundation
DD	Difference-in-Differences
DS	Derived savanna
FAOSTAT	FAO Statistical Databases
FCT	Federal Capital Territory
FFS	Farmer field school
FGT	Foster, Greer, and Thorbecke
FMARD	Federal Ministry of Agriculture & Rural Development
GPS	Global Positioning System
HF	Humid forest
ICT	Information and Communication Technologies
IE	Impact evaluation
IITA	International Institute of Tropical Agriculture
JDPM	Justice for Peace and Development
LGA	Local Government Area
MSHR	Missionary Sisters of the Holy Rosary
NGO	Non-governmental organization
OECD-DAC	Organisation for Economic Cooperation and Development- Development Assistance Committee
PSM	Propensity score matching
RAND	Random
R&D	Research and Development
SAVE	Sustenance Ago Ventures
SGS	Southern Guinea savanna
SHOP	Umuasua-Isuikwuato Small Holder Oil Palm Farmers' Cooperative Society Ltd
YIIFSWA	Yam Improvement for Income and Food Security in West Africa
YMT	Yam minisett technology

Executive Summary

This document reports the changes that occurred as result of the intervention of the Yam Improvement for Income and Food Security in West Africa (YIIFSWA) project. The project was initiated to assess and understand the yam-based systems in Nigeria in order to identify the interventions that could potentially help to increase productivity in the region. The Bill & Melinda Gates Foundation (BMGF) provided grants to the International Institute of Tropical Agriculture (IITA) to work with other stakeholders in West Africa over the period of five years (2011-2016). The vision for the project was to increase by 40% the productivity (yield and net output) of 200,000 smallholder farmers in Ghana and Nigeria, and deliver key global good research products.

This study followed the quasi-experimental impact evaluation process and employed community, household, and field survey tools taking account of intervention logic. The quasi-experimental methods included differencing and matching techniques.

The objectives of the evaluation were to:

(i) Assess the results and the status of the project to promote accountability, and
(ii) Extract lessons learnt and prepare recommendations to enhance the design, implementation, operation, and management of other similar future projects.

To achieve the above objectives, the study methodology included a review of existing project documents, field observations, focus group discussions, and interviews. The main survey design used during the baseline study based on a multistage, random sampling procedure, drawing on the universe of households was also used for this endline survey. The same total of 800 sample households was retained for the study, this consisting of participating and non-participating households from the same yam growing areas of Nigeria targeted during the baseline. Therefore, trained enumerators administered the same survey questionnaires prepared for the baseline through personal interviews and field measurement. Both primary and secondary data were used for quantitative and qualitative analysis. Primary information were collected by means of structured questionnaires and a set of qualitative interview questions for focus group discussions was used to capture field, household, and community-specific information. Secondary information were collected from government policy documents, reports, publications, and other relevant published and unpublished past related works.

This study focused on providing an answer to the question of how much impact the AYMT interventions of YIIFSWA project had had on rural farm households' income and food security and how this has contributed to the reduction of poverty in Nigeria. We started by documenting the rate of AYMT awareness and adoption among the sampled farmers. The result showed that the AYMT adoption rate was about 18%; the awareness rate was 23%. Furthermore, the proportion of adopters among the exposed farmers was 75%, confirming that awareness / exposure is very important in achieving a high rate of AYMT adoption. Therefore, policy and programs that would further increase the farmers' awareness were recommended. In addition, the existing extension program was encouraged to be well rehabilitated and supported to improve the performance of extension agents and increase the number of contacts with farmers to improve their awareness.

The summary statistics of households' asset ownership shows that the project had significantly contributed to the possession of more assets at the endline compared to the pre-project. The yield

differential shows that there was higher yam output, implying that adoption of AYMT and benefits from other interventions can lead to an increase in food security and generate a reduction in poverty. Additionally, the result of the FGT poverty measures confirmed the potential of the project to curb poverty in rural areas of Nigeria and among the farming households, as it revealed that poverty indices were higher among the non-beneficiaries than with the project's beneficiaries. Results showed that adoption of AYMT resulted in a poverty reduction among the rural population by 10% points translating into 119,177 individuals being lifted out of poverty in Nigeria. This is consistent with the findings in several studies that demonstrated that adoption of agricultural technologies helped to reduce poverty levels. This serves to set the roadmap for the second phase that aims at developing and proving that a functional, commercial seed yam system in Nigeria stands a high chance of reducing further the present endemic and prevalent poverty situation among the households in rural areas.

With the current level of AYMT adoption and appreciation of the value of availability and dissemination of quality planting materials, the project is generating positive impacts that call for concerted efforts towards implementation and scaling out of the key breakthroughs of the first phase. These include the implementation of seed quality standards approved by the regulatory bodies of Nigeria using the quality management protocol for certification of breeder, foundation and commercial seeds and the novel high ratio propagation technologies for production of high quality planting materials. There will be a need for establishing appropriate business models and strengthening the business skills of the registered commercial seed yam entrepreneurs. The specialization of actors along the value chain for seed yam tubers will promote the competitiveness and sustainability of the commercial seed system.

Introduction

Yam plays important roles in the food security, income generation, and socio-cultural life of at least 90 million people in West Africa. Many of these are smallholders producing the crop on small plots of land. Several constraints limit realization of the full potential of the crop and thereby its contribution to the livelihoods of smallholder producers.

Consultations with stakeholders and value chain actors carried out in the preparation of this project proposal had identified the key constraints to yam productivity as scarcity of high quality seed yam of local and improved varieties, high levels of post-harvest losses, high production costs, and low and declining soil fertility. These constraints have therefore formed the basis for interventions by the Yam Improvement for Income and Food Security in West Africa (YIIFSWA) project.

The YIIFSWA project was initiated to assess and understand the yam-based systems, with the aim of identifying the opportunities for interventions that could potentially help to increase productivity in the region. The project was funded by the BMGF for the IITA to work in collaboration with other stakeholders in West Africa for the period of 2011-2016.

The aims of the project in the following five years were as follows: (a) increase yam productivity (yield and net output) by 40% for at least 200,000 smallholder yam farms (90% with less than 2 acres) in Ghana and Nigeria; (b) deliver key global good research products that would contribute to the 10-year vision of doubling incomes from yam for 3 million smallholder farming families who depend on yam in West Africa; it would also contribute to food security for producers and consumers. Specific key innovations that helped to contribute to the required increase in productivity in Ghana and Nigeria included (a) ensuring the sustainable availability of high quality seed yam on a commercially viable, price competitive basis capable of increasing yield by at least 50%; (b) developing post-harvest storage and handling technologies capable of reducing post-harvest losses by 30%; and production technology packages capable of increasing productivity by 50%. Supplemental funds were received for the aeroponic culture of yam, developed within YIIFSWA, to be tested with agencies in the public and private sectors in Ghana and Nigeria.

To achieve this goal, the project had started with the following objectives:

- Strengthen small-scale farmer and trader market linkages, particularly in less accessible production areas, to realize benefits from increased ware yam productivity and market demand.
- Strengthen capacities and empower smallholder farmers in the yam value chain.
- Establish sustainable availability of high quality seed yam on a commercially viable (price competitive) basis in targeted areas.
- Reduce post-harvest losses and improve product quality.
- Develop technologies for high ratio propagation of high quality pre-basic and basic seed yam.
- Evaluate and scale-out yam production technologies with improved and local popular varieties.
- Develop strategies and Identify more effective tools for the management and prevention pests and diseases.

These objectives were supported by cross-cutting components: project leadership, partnership and management, impact monitoring, and communication and information dissemination.

For more details on YIIFSWA project, we refer the reader to YIIFSWA Working Paper Series No.1 ISBN 978-978-8444-36-7 (Maroya et al. 2014).

After an External Mid-term Review at around three years of implementation, the initial seven objectives of the project were repackaged into two major components as follows: the seed component that deals with the development of the formal and informal seed yam systems. It focused on the reduction of postharvest losses, development of technologies for high ratio propagation of high quality breeder and foundation seed yam, and identification of more effective tools and strategies for the management and prevention of pests and diseases. The second component (leadership, governance, and partnerships) included project monitoring, evaluation, and learning; communication and information dissemination; project coordination and management, as well as the evaluation and scale-out of production technologies using new and local popular varieties.

Participants in the YIIFSWA project were expected to significantly increase yam productivity and income by improving yields through improved technologies. Based on these hypotheses, the focus of this evaluation is on the following expected outcomes and associated impact indicators (Table 1).

The project has ended the initial 5 years and its impact evaluation (IE) is rooted within broader monitoring and evaluation system providing a core set of tools that stakeholders and partners can use to focus on results. Borrowing from the OECD-DAC Glossary (2002), the most widely shared definition of impact is “change, positive and negative, primary and secondary, produced by a development intervention, directly or indirectly, intended or unintended.” Impact occurs at multiple levels and at different timeframes (short-term, medium-term and long-term) resulting from an intervention. Impact occurs in different ways depending on the type of intervention and the context. An IE is a systematic and pragmatic study that measures the changes attributable to a defined intervention, attempting to establish whether the intervention has made a difference in the lives of people.

Impact evaluations are mostly conducted for two main purposes, (i) accountability comparing and reflecting costs and effects on final outcomes such as income and poverty, an, (ii) learning: exploring how well or poorly an intervention works. This second aspect relates to a better understanding with the causal chains expected to link project investments to achieve specified changes in the lives of people especially in yam growing areas. Impact evaluations are thus an essential tool for learning and accountability, although they are not the right tool for every project. They should be used selectively, with a special focus on where the potential for learning is the greatest. During evaluations, the feedback of lessons learnt can help improve future project design, plan and implementation. The accountability of the project can provide information to the public.

Table 1. Project expected outcomes.

Expected Outcomes	Indicators
Increased yam yield	Percentage yield increase
Increased household income	Percentage household income and consumption
Increased food security	Percentage food expenditure

The objectives of the evaluation with respect to YIIFSWA project were to:

- document adoption at the farm level technologies promoted by the project and assess factors affecting their adoption;
- estimate the early impacts, positive and negative, primary and secondary, that resulted from the project;
- assess the direct and indirect contributions of the project on the life of smallholder yam farmers, whether intended or unintended, and
- draw lessons from the project that may be useful in the design of proposal of a second phase of the project and its implementation or future projects of a similar nature.

To assess impact, it was necessary to identify a counterfactual and then to take measures to ensure the estimate of impact is free from bias. Quasi-experimental methods include differencing, and the matching techniques used.

This report consists of seven sections. Section One introduces the study. Section Two presents the approach and methodology used for the study, while Section Three describes the changes in socioeconomic characteristics of households. Section Four reports the changes in livelihood assets in the surveyed area and Section Five discusses the changes in livelihood context and strategies. The changes in livelihood shocks and poverty are presented in Section Six. Lastly, Section Seven gives a summary of findings with implications for the study.

Approach and Methodology

This section provides the details of the evaluation in terms of tools for data collection and analysis. The approach and methodology used for this project evaluation is well detailed in the YIIFSWA Working Paper Series No.7 ISBN 978-978-8444-67-1 (Mignouna et al. 2016).

Prospective evaluations were developed at the same time as the project design and built into project implementation. Baseline data were collected for both treatment and control groups prior to implementation (Mignouna et al. 2014a). Prospective impact evaluations (IEs) were adopted to produce strong and credible evaluation results, with the generation of baseline data to establish pre-project measures of outcomes of interest. This provided advance information on beneficiaries and comparison groups. The baseline survey served as a foundation for before and after comparison of pre- and post-treatment states. It therefore allows for the application of a quasi-experimental design, which is discussed in the sub-sections, together with the qualitative means to be used to collect data. This section provides details of the endline survey undertaken to complete impact evaluation.

Survey area and sampling procedure

This section provides the details of the endline survey design in terms of collection methods, questionnaire design, and applied statistical analysis. This study is designed following the format set for the baseline study. The survey was necessary to calculate the impact estimators and was designed to be comparable to the baseline survey as much as possible, thereby encompassing the same survey design and instruments.

Study area

Following the baseline survey, the endline survey was done within the same major yam-producing zones using the same multistage, random sampling design, drawing on the 800 households based on the same sampling frame as detailed in “Impact Evaluation Protocols for Agricultural projects by Mignouna et al. 2016.

The total number of households including beneficiaries and non-beneficiaries is shown in the Table 2. The village and communities’ non-beneficiaries were chosen to ensure that they were comparable in terms of biophysical and socio-economic characteristics (ethnicity, farming systems, etc.). Table 2 provides information about the States and communities, and numbers of beneficiary and non-beneficiary households surveyed; Figure 1 shows a spread of the surveyed sites.

Estimation of benefit/participation in the YIIFSWA Project

The household’s participation leading to a certain benefit in the project was dichotomous, involving mutually exclusive alternatives. The household either benefited or it did not. The concept of benefit/participation relates to who took part in the variety of agricultural products and services such as input development, distribution, trainings, and demonstrations as stated below.

The endline survey involved a sampling of the same respondents from the original baseline survey, conducted in 2012 (Mignouna et al. 2014a; 2014b). A list of all households existing in the surveyed communities made up the sampling frame. The treatment variable t took a value of 1 if a household benefited from the project (treatment group), otherwise the value of t was zero (control group). The survey covered 800 households; 214 of these were classified as treated households (general treatment), 586 were in the control/comparison group (Table 2).

The survey instrument was the same questionnaire used during the baseline. It was field-tested during a three-day training exercise with the new set of enumerators and local researchers.

Data were checked using data-cleaning syntax that controlled for errors. Data cleaning was later done at the IITA headquarters by an experienced professional consultant.

Table 2. Household sampling by treatment.

States	#LGAs selected and adjusted	#Communities selected	#Households selected		
			Treatment	Control	Total Hhs
FCT	4	20	74	6	80
Niger	7	35	16	124	140
Nasarawa	3	15	23	37	60
Benue	6	30	19	101	120
Ebonyi	3	15	11	49	60
Enugu	7	35	32	108	140
Kogi	4	20	5	75	80
Edo	3	15	29	31	60
Oyo	3	15	5	55	60
Total	40	200	214	586	800

NB. LGAs = Local Government Areas; Hhs = households

The surveyed areas in Nigeria are therefore depicted in Figure 1.

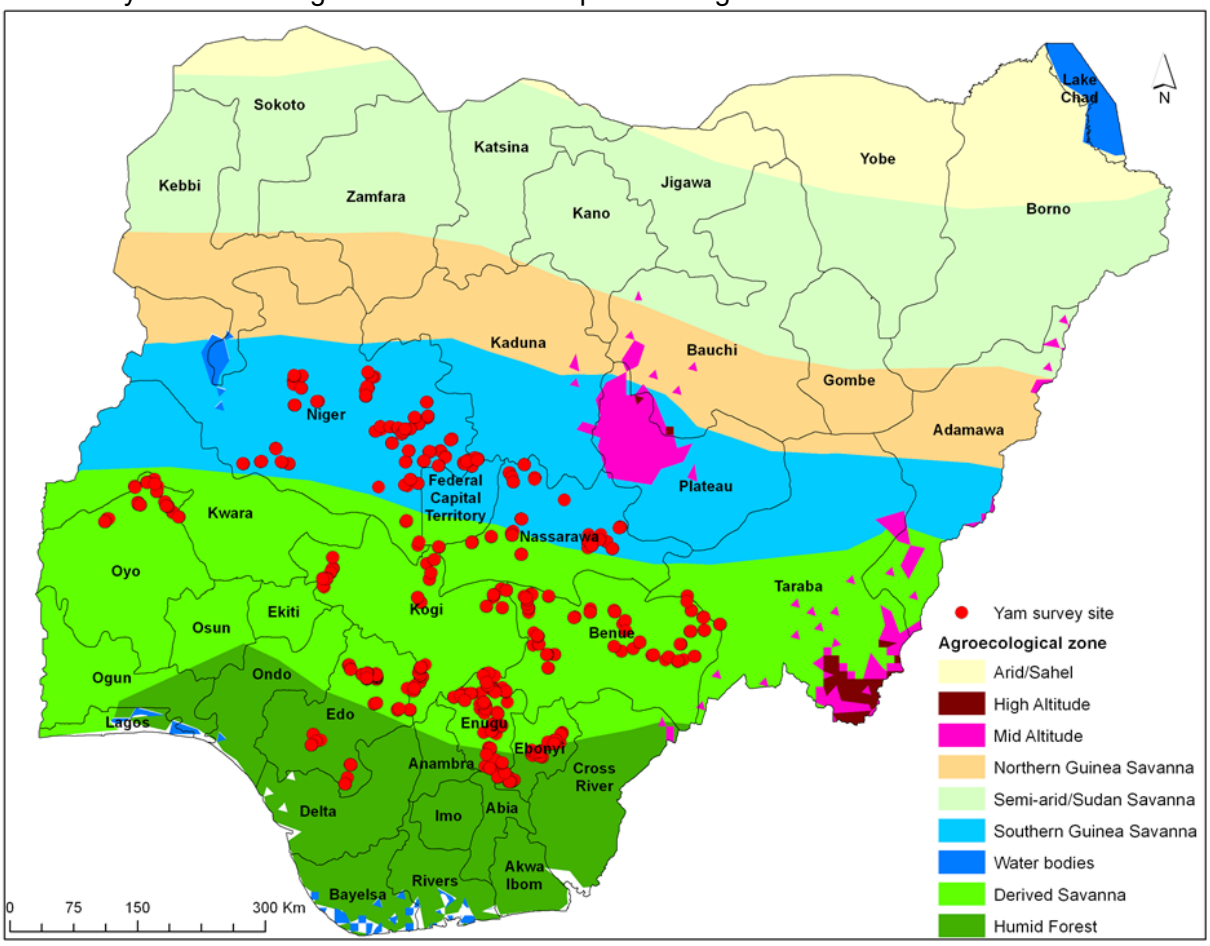

Figure 1. Map of surveyed areas in Nigeria, 2016.

Sample size determination

The need for quantitative and qualitative information about households requires a statistically plausible sample of the target population. Accurate sampling is important to minimize the risk of sampling bias and to allow inferences about the population to be drawn with a level of confidence that can be statistically estimated. The Confidence Interval Approach used previously for the baseline survey was used to estimate the sample size (Mignouna et al. 2014).

Therefore, the endline survey targeted the same total of 800 sample households consisting of participating and non-participating households and was conducted at the end of the second semester 2015 and the beginning of 2016 in Nigeria.

The same questionnaires prepared for the baseline survey (Mignouna et al. 2014a; 2014b) were administered by trained enumerators through personal interviews and field measurement. The surveys were conducted in the same project areas as for the baseline.

For field measurement, one out of the retained households was randomly selected from each selected community.

More details on the sampling procedure could be found in the YIIFSWA working paper No. 4 (Mignouna et al. 2014a).

Data collection instruments

Data were collected using structured questionnaires on the community, household and field (Mignouna et al. 2014a), and a set of qualitative approaches was used including focus groups and interviews with selected beneficiaries and other key informants.

Indicators for assessing project impact

Agricultural projects such as YIIFSWA are designed to improve production or the returns to agriculture. Therefore, the IEs of such projects focus on important production-based indicators: yields, productivity, technology adoption, changes in food for home consumption. Collecting information of this type can be challenging, beginning with the definition of the sample unit. In fact, although production is often linked to multiple plots and crops the decision-making process takes place at the household level. The full logic of an agricultural project should be considered but certain indicators can be more readily attributed to a given project, hence an IE focuses on these results. Projects may also contribute to achieve some results with a wider scope, such as a reduction in poverty rates, which may be very difficult to attribute to the project. Additionally, different indicators require measurement and estimation at distinct time intervals. For instance, the adoption of new practices is often a short-run measure but a change in productivity is a medium to long-run measure. In considering indicators, the timing of measurement and the possibility of being able to attribute the effects to the project should be considered.

The evaluation aims to synthesize quantitative estimates of the effectiveness of demonstration plots for the Adaptive Yam Minisett Technology (AYMT) relating to intermediate outcomes such as knowledge acquisition, adoption and diffusion of technology, and final outcomes such as output (tonnes), agricultural yields (output/hectare), household income, food security, and poverty status.

The structured questionnaires were administered by enumerators under supervisors, all trained in different methodology workshops which were organized by IITA M&E team. The trainings were followed by pre-testing questionnaires; subsequently these were modified based on feedback received.

Field data collection, data entry, and database management

A schedule for field data collection was then developed with the assistance of the extension agents from the Federal Ministry of Agriculture and Rural Development (FMARD) to organize teams and assign villages/communities according to geographic position. After a preliminary tour of a week organized in surveyed areas to set up the recruitment process for potential enumerators, data collection was undertaken from the end of 2015.

For more details on field measurements and field data management, an interested reader is referred to YIIFSWA working Paper No. 7 (Mignouna et al. 2016).

Evaluation design: quasi-experimental design

Since data collection tends to be representative samples of treated and control households, statistical methods, particularly coming from the econometrics' literature were used to identify impact. For YIIFSWA, the quasi-experimental design is chosen.

Difference-in-Differences approach

The Difference-in-Differences (DD) approach is one of the most popular non-experimental techniques in IE since it allows the control for some types of selection in a straightforward and intuitive way, if baseline data are available. In a DD model, the relevant comparison is changes in the indicator over time. Here, the difference of outcome indicator levels is measured for both the treatment group and a control group, before and after the treatment. The difference between these two mean differences is subsequently calculated. This two-step approach gives the method its name1. The impact of the project is thus defined as:

$$\left(Y_{t'} - Y_t \mid D = 1\right) - \left(Y_{t'} - Y_t \mid D = 0\right)$$

With:
t being the time of the baseline and;
t' the time of the post-treatment survey.

The result equals the project's impact if the underlying assumption holds true that the difference between before and after the intervention in the control group served as a proper counterfactual for the treatment group (Wooldridge 2001). The difference between these two differences, shown in the shaded cell in Table 3, is the DD estimator.

Table 3. The Difference-in-Differences Estimator.

	Baseline (2011)	Post (2015)	1st difference
Treatment (T)	T_{2011}	T_{2015}	$\Delta T = (T_{2015} - T_{2011})$
Comparison (C)	C_{2011}	C_{2015}	$\Delta C = (C_{2015} - C_{2011})$
			Difference-in-differences
			$DD = (\Delta T - \Delta C)$

1The approach is named non-uniformly in the literature, the most common terms being double-difference-method, or otherwise difference-in-difference estimator.

The endline surveys, necessary for calculating the impact estimators, should be comparable to the baseline survey as closely as possible, ideally encompassing the same survey design, same questionnaire, same interviewers, etc., and targeting the same respondents.

Beside the DD estimation, another technique was used to gauge the impact as follows.

Propensity Score Matching approach

This approach is based on the selection of a group most similar to the treatment group in terms of the probability of being selected, which is derived from accumulated contributions from observed characteristics.

Economic impacts are assessed using propensity Score Matching (PSM) to control for the self-selection into adoption that normally arises when technology adoption is not randomly assigned. The main parameter of interest in a non-experimental framework is the Average Treatment effect for the Treated population (ATT), expressed as:

$$\tau ATT = E(Y_1 - Y_0 | D = 1) = E(Y_1 | D = 1) - E(Y_0 | D = 1)$$

Where:

Y_1 denotes the value of the outcome when the household adopts the technology (1), and Y_0 is the value of the same variable when the household does not adopt (0).

The problem that arises with unobservability is by virtue of the fact that $E(Y_1 | D = 1)$ can be estimated but not $E(Y_0 | D = 1)$. Although $\tau = E(Y_1 | D = 1) - E(Y_0 | D = 0)$ can normally be estimated, it is potentially a biased estimator of τATT .

YIIFSWA: Contributory cause and causal packages

Simple sufficient causation could be more promising in that an intervention on its own may be sufficient to produce the impact but in YIIFSWA, many interventions are a 'contributory' cause and are demanding conditions for impact to occur. There are a variety of ways that such impacts might be realized, for example, in quality training outcomes and empowerment. It is difficult for statistical and econometric models to deal with multiple causalities and to capture the influence of combinations of causal factors rather than of each factor as a free-standing agent.

As mentioned Mignouna et al. (2016), the causal package consists of the delivery mechanism for a variety of agricultural products and services such as input development, distribution, trainings, and demonstrations. Most of the interventions in the work plan that reach farmers do not introduce novel technologies but rather build upon the existing practices of clients through initiating simple improved management to increase yields. These technologies are also largely appropriate within the context of social and cultural norms regarding gender roles. Also for any yield-increasing technology, it allows for higher gross output and is recommended to producers as a package including AYMT and the associated best management practices. We focus, however, here on the "seeds" component of the technology, for two reasons. First, much of IITA-funded research consists of the development of better planting materials. Secondly, the choice of how much of complementary inputs to use is itself an endogenous response to the adoption of the new variety, and hence it is an integral part of what determines the impact of adopting a new variety. In this context, attention would be on the role of the AYMT in that package. Was it a necessary ground-preparing cause, a necessary triggering cause,

or something that did not make any difference? Would a similar effect have occurred without the intervention? If the intervention was indeed a trigger, then a stronger claim becomes possible. If the intervention starts the causal chain and possibly supports change along the way it is possible to claim that it was the intervention that made the difference because it was an initiating contributory cause.

Adoption of Adaptive Yam Minisett technology

To overcome the shortcomings of the traditional methods of producing seed yam in West Africa, the NRCRI and IITA through research efforts developed in 1982 an effective and affordable technique, the yam minisett technique (YMT), for farmers to produce their own seed yam (IITA 1985). Using this technique, the multiplication ratio could increase from the traditional 1:5 to 1:30 (Orkwor et al. 2000). The development and introduction of YMT are key strategies for transforming the sector and for enhancing the well-being of the rural population in West Africa. The technology has been promoted for three decades. However, these efforts have not been rigorously evaluated and there is a lack of panel data that could be utilized to empirically trace adoption since the 1980s. Moreover, several studies which have attempted to address the areas (Ironkwe et al. 2005; Bolarinwa and Oladeji 2009; Wiredu et al. 2012; Abubakar et al. 2015) revealed that few households have adopted the new technology and many “disadopt”; recently not much is heard regarding YMT because it is not being actively promoted and is evidently unconvincing (Aighewi et al. 2002). Both adoption and disadoption have been going on simultaneously. Such a challenge has been investigated and this provided an opportunity for YIIFSWA to address the gap on disadoption rates and an Adaptive Yam Minisett technology (AYMT) was introduced to strengthen the yam seed system for quantity and quality assurance. On this note, YIIFSWA has been vigorously promoting the adoption of AYMT since its inception in 2011. However, the current level of adoption and its associated impact on farming households are yet to be empirically investigated. Among others, this study would provide this empirical evidence.

The project’s working paper No. 7 contains more details on the YIIFSWA project scheme set up using participatory approaches with an integrated training and visit model to encourage smallholder farmers to produce good quality seeds as well as providing links to retailers of farm inputs.

Empirical investigation into adoption of AYMT

The adoption of AYMT helps to increase productivity, farm incomes, and food security, and so reduce poverty levels, thus improving household welfare. The decision of whether to adopt AYMT hinges upon a careful evaluation of many factors. The observed choice to adopt AYMT is hypothesized to be the result of a complex set of inter-technology preference comparisons made by farmers.

Determinants of adoption of AYMT

The study uses a logistic model to estimate the probability that a given household adopts AYMT. Logit regression is a linear probability model for binary response where the response probability is evaluated as a linear function of the explanatory variables (Maddala 1983; Wooldridge 2003).

Specification of the logit regression model

The decision is defined as a binary outcome of the use of AYMT by households in the sample, with 1 assigned to households that were adopters and zero otherwise. Then, the response probability by household i (Pi) can be expressed as follows.

$$P_i = F(z_i) = F(\beta x_i) = \{1 / [1 + \exp(-z_i)]\} = [\exp(z_i)] / [1 + \exp(z_i)]$$

Where;
F(zi) is the value of the logistic cumulative density function associated with each possible value of the underlying index, and
zi and xi are the independent variables that will influence this decision;
βxi is a linear combination of the independent variables such that

$$z_i = \beta_0 + \beta_1 x_{i1} + \ldots + \beta_k x_{ik} + \varepsilon_i$$

Where;
zi is the unobserved index level or the logarithm of the odds ratio of the ith observation;
β is the parameter to be estimated; and
εi is a random error or disturbance term.

The coefficients in the logit analysis are estimated using maximum likelihood and serve the purpose of indicating a direction of influence on probability.
The adoption of AYMT is not a simple process and may be influenced by several working hypotheses, similarly to any other new agricultural technologies adoption research (Adesina et al. 2000; Herath and Takeya 2003; Mendola 2005). A farmer's decision to adopt or reject a technology at any time is hypothesized as influenced by the combined effects of many factors. In this study, we hypothesize that the factors influencing AYMT adoption include each of the following.

Household-specific factors

The experience (EXP) of the farmer is likely to have a range of influences on adoption measured in terms of the number of years since a respondent started farming on his own experience would improve the farmer's skills in the production operations. Farmers' experience increases the likelihood of understanding the benefits of AYMT, therefore older farmers are expected to use their farming experience to make informed decisions on the adoption of the new technology.

The gender of the household head is hypothesized to relate positively to the adoption of AYMT. The assumption is that the head of the household is the primary decision-maker and men have more access and control than women over vital production resources due to many socio-cultural values and norms.

Education level of the household head increases a farmer's ability to obtain, process, and use information relevant to the adoption of AYMT. Hence, education would increase the probability of a farmer adopting AYMT. Educated farmers have been found to be more likely to adopt innovations (Asfaw and Admassie 2004; Mignouna et al. 2011). It was hypothesized that education is positively related to AYMT adoption. Education can contribute to a reduction of the productivity differential by increasing the speed of technology transfer and by increasing farmers' knowledge and assisting them in improving not only AYMT adoption but also farm management practices. Additionally, it also plays an important role in improving the information flow from farmers to scientists (Anderson 2007).

Household size—a proxy to labor availability—is the major source of labor for farm activities. Large households have the capacity to relax the labor constraints required during AYMT introduction. Therefore, a larger household size is expected to affect positively the decision of adopting AYMT. Large households also have higher demands that motivate the adoption of new farm technologies to increase the farmers' income as a means for meeting those demands (Akinola 1987).

Farm-specific factor

Farm size (FSIZE): the influence of farm size holding the adoption decision may be both ways. Farm size was therefore hypothesized to have a positive relation as having a large amount of land contributes to perceived security and increased willingness to invest in AYMT (Caveness and Kurtz 1993). Furthermore, as land availability becomes more inelastic, farmers facing land scarcity may be unwilling to sacrifice croplands for this not well-known technique. Thus, a positive relationship was hypothesized between land and AYMT adoption on the one hand; and on the other hand, households endowed with more land may diversify into crops that are not yam and hence reduce the urgency for adopting the new technology. Therefore, a negative relationship was hypothesized between land and AYMT adoption.

Institutional Factors

Access to extension agents (NEXT) received by a farm was hypothesized to increase farmers' likelihood of adopting AYMT after increasing their exposure to awareness. Therefore, a positive influence on farmers' adoption of AYMT was hypothesized.

Membership in a social group (MBER) enhances social capital allowing trust, ideas, and information exchange. Better social relations and communication among farmers are crucial for technology diffusion and adoption. Thus, membership to a group could increase the technology adoption.

Findings from a study on the adoption of high yielding maize technology in major maize growing regions of Ethiopia (Tesfaye et al. 2001) reveal that the distance to the nearest market center significantly and positively influence the adoption decision about improved maize.

Data analysis

The same scale of analysis or level of aggregation as in the baseline study is used here (Mignouna et al. 2014a).

Data analysis at the first level made use of computations that generated secondary variables such as indices and yields. More on a number of aggregate measures of poverty could be found in the Project Working Paper No. 7 for any interested reader (Mignouna et al. 2016).

Estimation of number of poor lifted out of poverty

The actual number of individuals lifted out of poverty (N ind) as a result of adopting AYMT is estimated following Dontsop-Nguezet et al. *forthcoming* and Feleke et al. 2016.

$$N_{ind} = \left[\frac{P_{rr} * N_h * P_{ss}}{P_{sf}} \right] * H_s$$

Where;

P_{rr} denotes poverty reduction rate;

N_h is the number of farm households who adopted AYMT;

P_{ss} is the population size of sample area;

P_{sf} is population of sampled households or individuals; and

H_s is the average household size.

Changes in Socio-Economic Household Characteristics

In this section, the major socio-economic characteristics of households in the endline survey are covered and presented in reference to the baseline.

Selected characteristics of sampled households

The main characteristics of sampled households are related to the distribution of heads of households by gender, age, years of formal education, as well as household size. At the end of the project, given the length of time from the baseline survey, we did not expect to see major changes in the underlying demographic characteristics of the farm families across the surveyed areas. However, some differences in the families' headship could be expected.

Figure 2 summarizes the results of baseline and endline surveys by general household characteristics. Due to the brief time lapse between the two surveys and the fact that the same households were visited in both surveys, demographic characteristics were expected to remain relatively constant over time, and were not necessarily dependent on project intervention.

At the end of the project, the family heads had a younger average age compared with the baseline. More than half of the household heads attended school; the average number of years of schooling was low in both rounds, although a comparative advantage was noticed at the endline. The average number of years of schooling for household heads was slightly higher at the endline, from 6.2 to 7.3 years. There was no change in the sex of the household heads as the majority continued to be male (Fig. 2).

The positive changes at the endline were most probably linked to the variation that occurred within the household headship translated into a reduction in the average age of household heads, as well as the decrease of 1.5 years from the baseline to endline of experience in yam production. These changes were due to reasons such as illness and death which caused heads to be replaced by younger and more literate family members of the same sex. This was confirmed by the slight reduction in the average family size considered as proxy indicating the availability of household labor supply. All these changes were connected with the replacement of prime age adults that altered household composition.

In general, the data confirmed the expectations as in general socio-economic household characteristics did not change substantially between both assessment periods, although there were slight changes in demographics after the project's interventions.

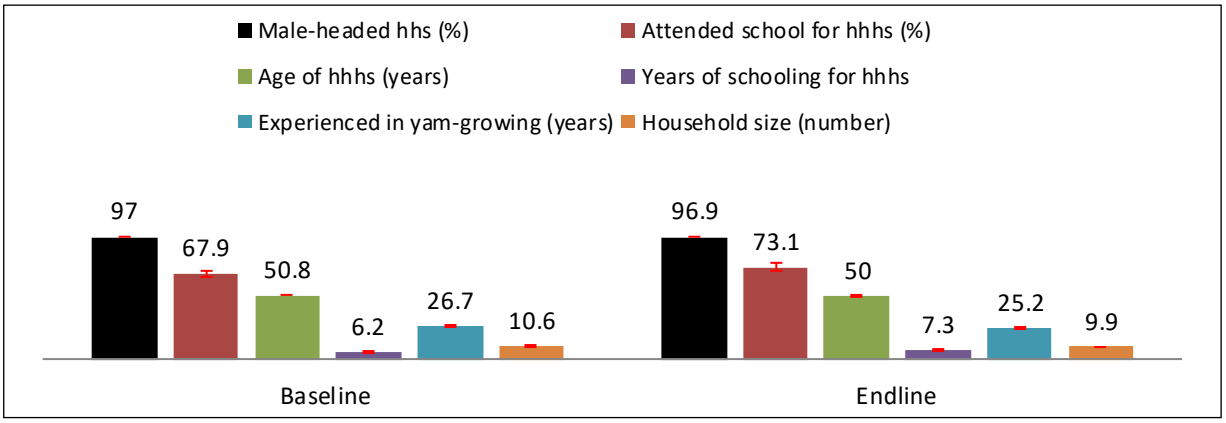

Figure 2. Selected household characteristics, baseline and endline survey rounds.

Changes in Livelihood Assets/Capital

This section indicates the changes that occurred with households endowed with livelihood assets. These assets could determine the kind of livelihood strategies households engaged in to sustain a reasonable standard of living.

Changes in land allocation

Land is an important factor of production influencing the livelihoods of farmers. This mostly refers to the land area that was used for crop production during the survey year. Land use plays an important role in Nigeria as a substantial majority of the land area used in the country is under agriculture, employing a larger proportion of the population. Any change in farming systems, such as change in land use, can affect the farmer's livelihood and strategies.

The average farm sizes in the study area are presented in Figure 3. Many farm households in the project area operate small and fragmented plots. A striking finding is the disparity between minimum and maximum farm sizes. In sum, Figure 3 reveals that the average farmer operated small fragmented plots that added up to an average of about 2.4 ha/household at the beginning and end of the project. The land allocated to yam increased by 3% points between the two periods, from 64 to 67 percent (Fig. 3).

In general, the average farm sizes in the project area showed large disparities among farming households but no change was observed between the total own land allocated to crops in the surveyed areas at the beginning and end of the project. Only land under yam increased and this change was required for yam cultivation as a rational decision following the yield gains experienced as a result of interventions introduced by YIIFSWA project.

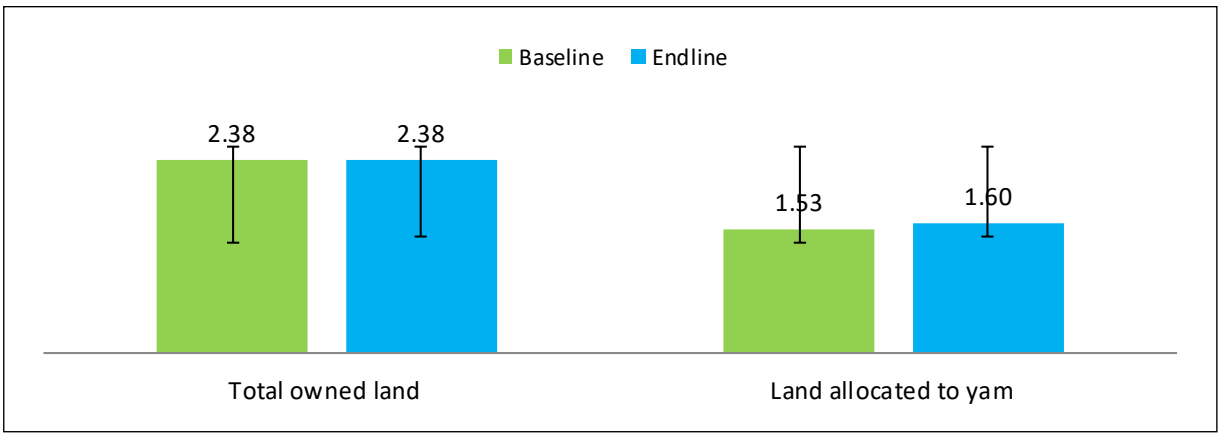

Figure 3. Changes (ha) in land holding.

Changes in housing conditions

The housing conditions in which families live reflect the level of endowment with assets. Assets can provide leverage for catalyzing the transformation of agricultural resources into livelihood outcomes.

Important positive changes were observed regarding the main walling material of the main residential houses in the surveyed areas. From the pre-project to the end, households built with concrete blocks increased by 8% points from 42 to 50%. About 42% used mud bricks before the project against 37% afterwards; 5% used pole & mud before the project against 1% afterwards. The number of households using sticks and grass also went down during the same period. The proportion of households with iron sheets doubled (Fig. 4) and the use of unburned bricks increased slightly.

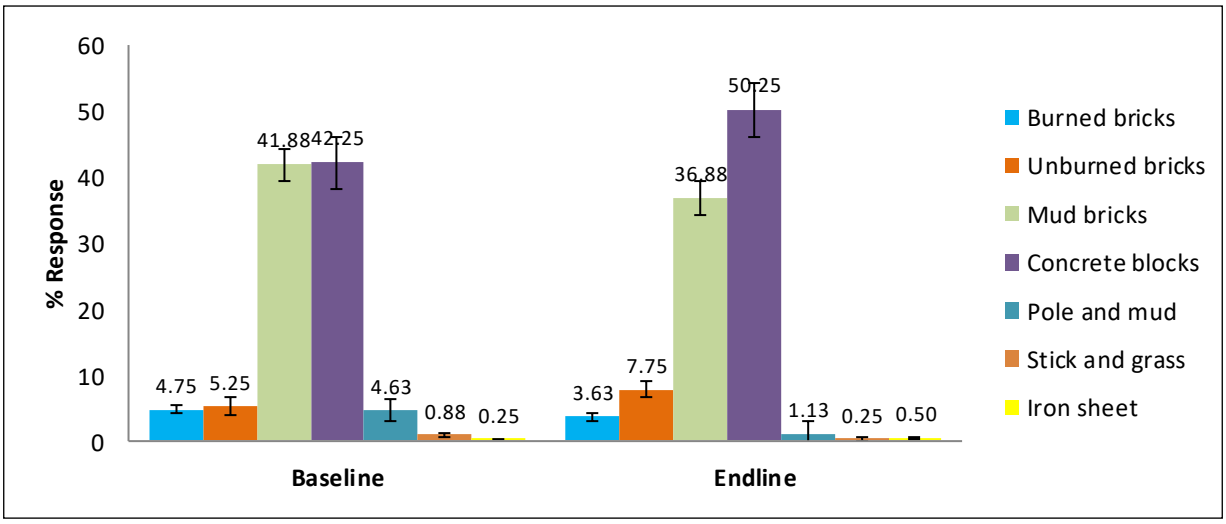

Figure 4. Changes in the distribution of households according to main walling material.

During the project lifetime, a noticeable reduction in households living in houses built with poor walling material was reported against an increasing number of households using better materials such as concrete blocks.

The type of roofing is a good indicator of improvement in housing conditions. Fewer households were found using grass thatch during the endline as compared to the baseline; those that roofed with better materials, iron sheets, tiles, and asbestos, increased after the project's interventions (Fig. 5).

About sanitation, proper disposal of excreta and minimum levels of personal and domestic hygiene are essential for protecting public health. Safe handling and disposal are being achieved through different types of sanitary facilities existing in the surveyed areas. More households used private and shared flush toilets during the endline survey compared with the baseline. At the same period, few households abandoned the ordinary pit latrines and the use of open air option in favour of better sanitary facilities after project intervention (Fig. 6).

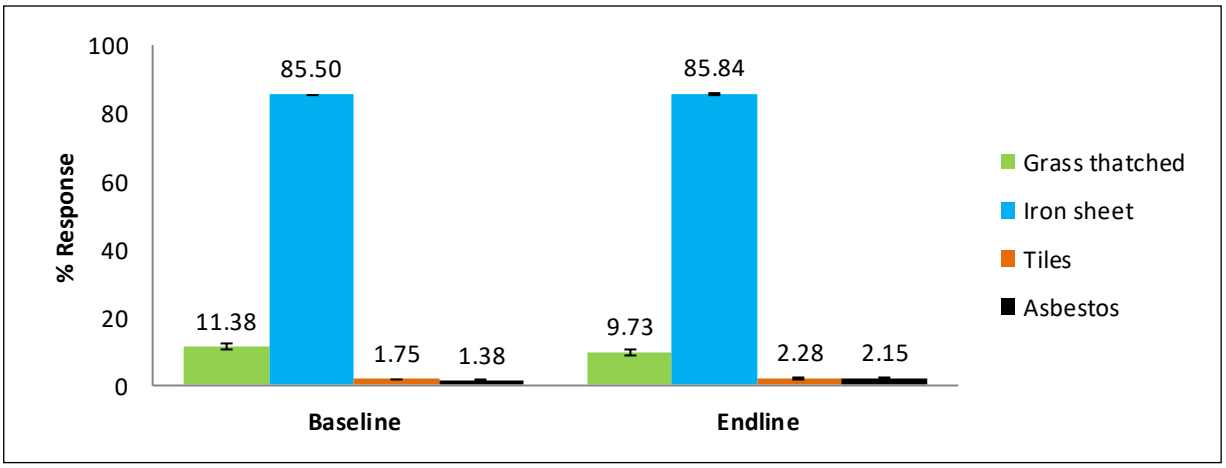

Figure 5. Changes in main roofing material of the main residential house.

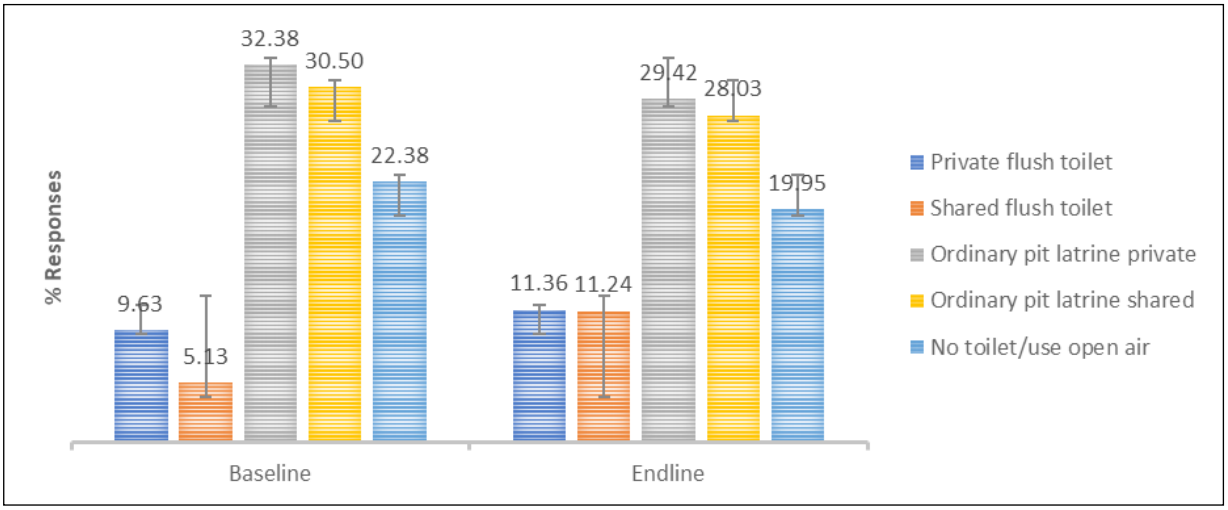

Figure 6. Changes in the distribution of households according to types of sanitation.

Positive changes are perceived regarding the type of toilets used in the surveyed areas. The project might have contributed to the improvement of sanitation and the hygienic practices of the target population.

Generally, the project could be said to have contributed to the positive changes observed in the housing conditions in the project target areas.

Changes in household assets

The level of asset ownership in a household is an indication of its endowment and provides a good measure of household resilience in times of food crisis resulting from crop failures, famine, or natural disasters. This is because a household can easily fall back on its assets in times of need by selling or leasing them.

Figure 7 presents the agricultural and non-agricultural assets owned by the farming households. The most common productive assets possessed were hoes and cutlasses. This is understandable, as these are required for productive activities. Possession by the households of beds, chairs, and tables seemed higher than for any other household assets. Assets of certain types including radios, CD players, television sets, stoves, and motorbikes are identified as wealth indicators followed by others such as axes, sprayers, and cellphones. Better-off households are expected to accumulate such items. Households' possession of cars was low. The presence of all other household assets such as tractors, water pumps, and fish ponds was negligible.

In conclusion, households in the study still relied on hand implements for their farming activities. The next section covers significant changes in the possession of different assets or household items.

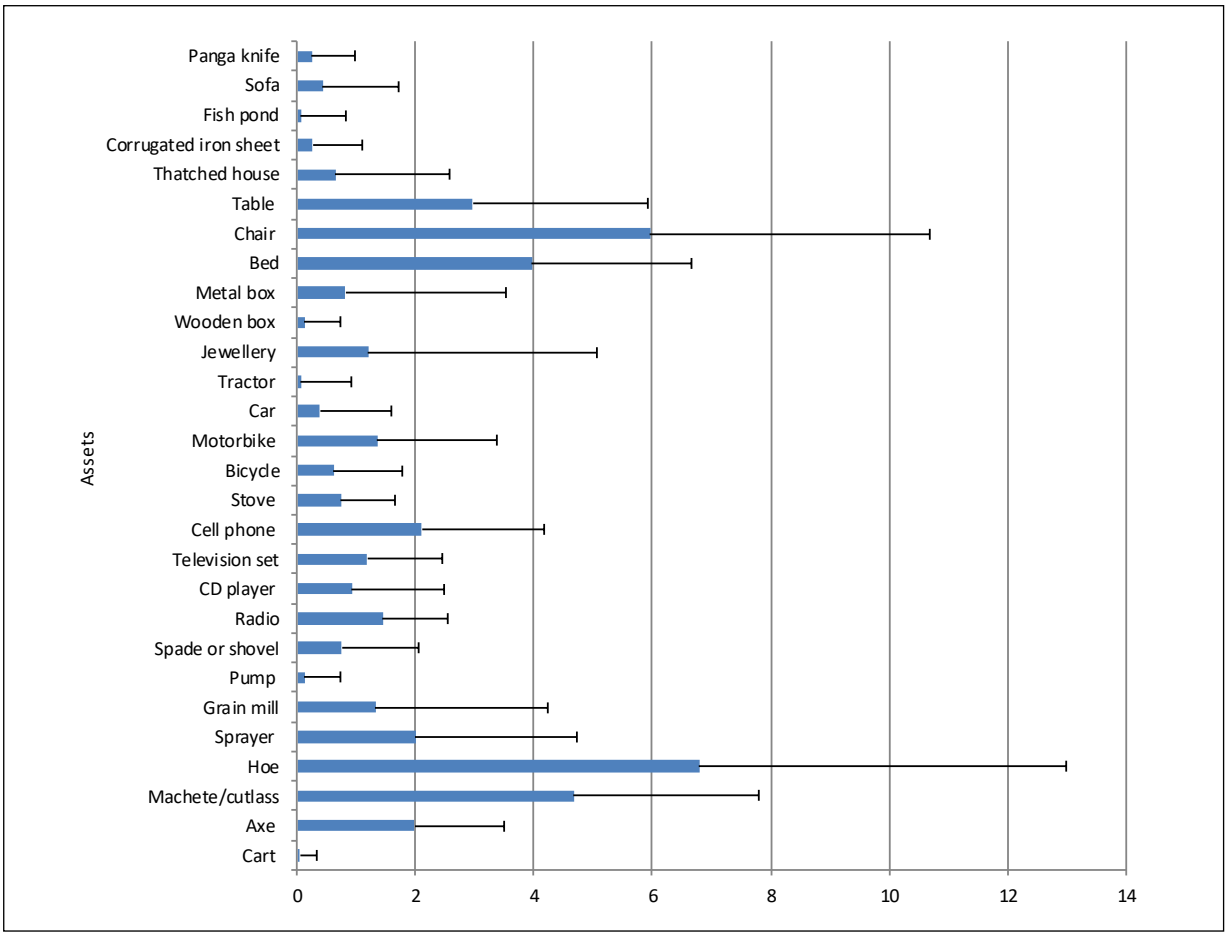

Figure 7. Ownership of household assets.

Difference-in-differences estimation results of productive and household assets

The analysis here uses a DD approach, comparing the changes at the household level in general and between households in various AEZs. This approach is based on the idea that treated and control households may have experienced improvements due to changes in the economy or other factors; thus, to see the differential impact of YIIFSWA project, it is necessary to evaluate how the changes experienced by project households differed from those of other households.

Tables 4 to 7 compare agricultural assets of interest of the treated households with the control. Some agricultural assets were found to be significantly different between the two groups. The items of farm equipment that increased with the YIIFSWA intervention between 2011 and 2015 for participants in YIIFSWA project compared to non-participants included axes, machetes, hoes, sprayers, and fishponds (Table 4). On average, only fish ponds had no statistically significant increases; carts and spades decreased between the two periods although not significantly (Table 4). Significant difference in agricultural asset ownership was particularly more evident in the derived savanna (DS) than in any other AEZ (Table 4). This might be due to increased cultivation of yam in the DS as a result of YIIFSWA's greater activities there than in any other zone.

Table 4. Farm equipment.

AEZ	Outcome variable	Cart	Axe	Matchete	Hoe	Spade	Sprayer	Fish pond
All (N=800)	Baseline							
	Control	0.04	1.97	4.63	6.86	0.74	1.83	0.03
	Treated	0.12	1.76	4.47	5.00	1.02	1.37	0.02
	Diff (T-C)	0.08*	-0.22	-0.16	-1.86**	0.28	-0.46	-0.01
	Follow-up							
	Control	0.00	1.52	3.74	3.57	0.65	1.61	-0.00
	Treated	0.01	2.20	4.98	7.56	0.78	2.82	0.17
	Diff (T-C)	0.01	0.68**	1.24*	4.00***	0.12	1.21**	0.17
	Diff-in-Diff	-0.07	0.90**	1.40*	5.86***	-0.16	1.67**	0.18
SGS (N=232)	Baseline							
	Control	0.01	2.34	4.99	7.61	0.58	2.23	0.07
	Treated	0.43	2.71	4.43	3.57	0.71	0.57	-0.00
	Diff (T-C)	0.42***	0.38	-0.57	-4.04	0.14	-1.66	-0.07
	Follow-up							
	Control	0.00	1.50	4.75	2.50	0.50	3.25	-0.00
	Treated	-0.00	2.39	5.36	8.26	0.54	2.62	0.03
	Diff (T-C)	-0.00	0.89	0.61	5.76*	0.04	-0.63	0.03
	Diff-in-Diff	-0.42***	0.51	1.18	9.80**	-0.10	1.03	0.10
DS (N=476)	Baseline							
	Control	0.05	1.83	4.40	6.85	0.79	1.75	0.02
	Treated	0.08	1.64	4.64	5.44	1.03	1.62	0.03
	Diff (T-C)	0.02	-0.19	0.24	-1.41	0.24	-0.13	0.01
	Follow-up							
	Control	-0.00	1.25	3.13	3.69	0.38	1.19	-0.00
	Treated	0.01	2.10	4.81	6.96	0.85	2.95	0.32
	Diff (T-C)	0.01	0.85**	1.68**	3.28*	0.48	1.76**	0.32
	Diff-in-Diff	-0.01	1.04**	1.44	4.69**	0.24	1.90**	0.31
HF (N=92)	Baseline							
	Control	0.04	1.86	4.96	5.36	0.85	1.38	0.00
	Treated	-0.00	1.00	2.33	2.67	1.67	-0.00	0.00
	Diff (T-C)	-0.04	-0.86	-2.63	-2.69	0.82	-1.38	0.00
	Follow-up							
	Control	-0.00	3.00	5.67	4.33	2.33	1.67	0.00
	Treated	0.00	1.86	4.14	7.64	1.50	3.00	0.00
	Diff (T-C)	0.00	-1.14	-1.52	3.31	-0.83	1.33	0.00
	Diff-in-Diff	0.04	-0.28	1.10	6.00	-1.65	2.71	0.00

Note: *** p<0.01; ** p<0.05; * p<0.1

Many more assets owned by the households substantially increased in number among the participants than with the non-participants after the intervention. Possession of other items of farm equipment and housing appliances also increased with the YIIFSWA intervention in the pooled sample, except for TV sets (Table 5). The only significant increase was found with cell phones.

Table 5. Other farm equipment and housing appliances.

AEZ	Outcome variable	Pump	Grain mill	Radio	CD Player	TV set	Cell phone
All	Baseline						
	Control	0.16	1.05	1.43	0.92	1.15	2.02
	Treated	0.04	1.06	1.35	0.96	1.22	1.20
	Diff (T-C)	-0.12	0.01	-0.08	0.04	0.08	-0.82***
	Follow-up						
	Control	0.00	1.39	1.52	0.78	1.22	1.78
	Treated	0.11	2.29	1.48	0.93	1.26	2.71
	Diff (T-C)	0.11	0.89	-0.04	0.15	0.04	0.93**
	Diff-in-Diff	0.23	0.88	0.04	0.11	-0.03	1.75***
SGS	Baseline						
	Control	0.15	1.16	1.66	1.14	1.38	2.49
	Treated	-0.00	1.14	1.14	0.57	1.14	1.00
	Diff (T-C)	-0.15	-0.02	-0.52	-0.57*	-0.23	-1.49*
	Follow-up						
	Control	-0.00	2.00	0.75	0.75	1.00	2.25
	Treated	0.12	2.48	1.41	0.83	1.13	2.61
	Diff (T-C)	0.12	0.48	0.66	0.08	0.13	0.36
	Diff-in-Diff	0.26	0.50	1.18	0.64	0.36	1.85
DS	Baseline						
	Control	0.17	1.09	1.37	0.86	1.09	1.91
	Treated	0.03	1.13	1.41	1.08	1.26	1.26
	Diff (T-C)	-0.15	0.04	0.04	0.22	0.16	-0.66**
	Follow-up						
	Control	-0.00	1.50	1.63	0.63	1.13	1.56
	Treated	0.09	1.92	1.56	1.05	1.31	2.81
	Diff (T-C)	0.09	0.42	-0.06	0.42	0.18	1.24**
	Diff-in-Diff	0.24	0.38	-0.11	0.20	0.02	1.90***
HF	Baseline						
	Control	0.10	0.64	1.19	0.79	0.92	1.54
	Treated	0.33	-0.00	1.00	0.33	1.00	1.00
	Diff (T-C)	0.23	-0.64	-0.19	-0.46	0.08	-0.54
	Follow-up						
	Control	0.00	-0.00	2.00	1.67	2.00	2.33
	Treated	0.21	3.50	1.36	0.71	1.64	2.64
	Diff (T-C)	0.21	3.50**	-0.64	-0.95*	-0.36	0.31
	Diff-in-Diff	-0.02	4.14*	-0.45	-0.49	-0.44	0.85

Note: *** p<0.01; ** p<0.05; * p<0.1

Other consumer durables increased with the project interventions in the pooled sample except for stoves (Table 6). On average, there were statistically significant increases for possession of motorbike and jewellery.

Table 6. Other consumer durables.

AEZ	Outcome variable	Stove	Bicycle	Motorbike	Car	Tractor	Jewellery
All	Baseline						
	Control	0.74	0.69	1.42	0.40	0.08	1.28
	Treated	0.86	0.57	0.96	0.31	0.02	0.57
	Diff (T-C)	-0.12	-0.12	-0.46	-0.09	-0.06	-0.71
	Follow-up						
	Control	0.96	0.26	0.87	0.44	-0.00	-0.00
	Treated	0.67	0.47	1.37	0.35	0.01	1.29
	Diff (T-C)	-0.28	0.21	0.50	-0.09	0.01	1.29
	Diff-in-Diff	-0.40	0.32	0.96*	0.002	0.06	2.00*
SGS	Baseline						
	Control	0.70	0.84	1.45	0.36	0.10	2.01
	Treated	1.00	0.86	0.57	0.29	-0.00	0.57
	Diff (T-C)	0.30	0.02	-0.88	-0.08	-0.10	-1.44
	Follow-up						
	Control	1.00	0.75	1.25	0.50	-0.00	-0.00
	Treated	0.54	0.59	1.22	0.25	0.01	1.51
	Diff (T-C)	-0.46	-0.16	-0.03	-0.25	0.01	1.51
	Diff-in-Diff	-0.77	-0.18	0.84	-0.18	0.11	2.95
DS	Baseline						
	Control	0.75		1.45	0.41	0.08	0.99
	Treated	0.82		1.05	0.26	0.03	0.62
	Diff (T-C)	0.07		-0.41	-0.15	-0.06	-0.38
	Follow-up						
	Control	0.69		0.75	0.19	-0.00	-0.00
	Treated	0.76		1.32	0.44	0.00	1.09
	Diff (T-C)	0.07		0.57	0.25	0.00	1.09
	Diff-in-Diff	-0.01		0.97	0.40	0.06	1.46
HF	Baseline						
	Control	0.81	0.583	1.15	0.43	0.01	1.07
	Treated	1.00	0.67	0.67	1.00	0.00	-0.00
	Diff (T-C)	0.19	0.08	-0.49	0.57	-0.01	-1.07
	Follow-up						
	Control	2.33	0.00	1.00	1.67	0.00	-0.00
	Treated	0.86	0.57	2.43	0.29	0.00	1.43
	Diff (T-C)	-1.48**	0.57	1.43	-1.38	0.00	1.43
	Diff-in-Diff	-1.67**	0.49	1.92	-1.95	0.01	2.50

Note: *** p<0.01; ** p<0.05; * p<0.1

The results indicating the type of house and furniture owned have shown that the household assets increased among the treated and the control before and after YIIFSWA's interventions (Table 7) with exception on chairs, tables, and sofas. On average, there were statistically significant increases for metal boxes and thatched houses (Table 7). Similarly, the effect was still higher in the DS than in the other agricultural zones.

Table 7. Type of house and furniture.

AEZ	Outcome variable	Wooden box	Metal box	Bed	Chair	Table	Sofa	Thatched house	Corrugated roofed house
All	Baseline								
	Control	0.13	0.93	3.94	5.86	2.98	0.40	0.73	0.22
	Treated	0.04	0.08	3.55	6.49	2.86	0.94	0.14	0.02
	Diff (T-C)	-0.09	-0.85**	-0.39	0.63	-0.12	0.54***	-0.59**	-0.20
	Follow-up								
	Control	-0.00	0.22	4.00	7.00	3.57	0.00	0.13	0.35
	Treated	0.11	0.73	4.13	6.02	2.88	0.44	0.52	0.46
	Diff (T-C)	0.11	0.52	0.13	-0.98	-0.69	0.44	0.39	0.11
	Diff-in-Diff	0.20	1.36*	0.52	-1.61	-0.56	-0.10	0.98*	0.31
SGS	Baseline								
	Control	0.20	1.49	4.32	6.32	3.24	0.59	0.31	0.22
	Treated	-0.00	-0.00	3.14	6.14	3.29	1.71	0.29	-0.00
	Diff (T-C)	-0.20	-1.49	-1.18	-0.17	0.04	1.12**	-0.02	-0.22
	Follow-up								
	Control	-0.00	-0.00	4.00	6.00	3.75	0.00	-0.00	-0.00
	Treated	0.17	0.81	3.49	6.22	3.00	0.49	0.49	0.42
	Diff (T-C)	0.17	0.81	-0.51	0.22	-0.75	0.49	0.49	0.42
	Diff-in-Diff	0.37	2.30	0.67	0.39	-0.79	-0.63	0.52	0.64
DS	Baseline								
	Control	0.12	0.79	3.87	5.68	2.83	0.32	1.00	0.21
	Treated	0.05	0.10	3.72	6.74	2.92	0.74	0.13	0.03
	Diff (T-C)	-0.07	-0.68	-0.15	1.07	0.10	0.42**	-0.88**	-0.19
	Follow-up								
	Control	-0.00	-0.00	3.69	5.69	2.63	-0.00	0.13	0.19
	Treated	0.07	0.74	4.48	5.52	2.66	0.37	0.60	0.51
	Diff (T-C)	0.07	0.74	0.79	-0.16	0.03	0.37	0.47	0.33
	Diff-in-Diff	0.14	1.43*	0.94	-1.23	-0.06	-0.06	1.35*	0.51**
HF	Baseline								
	Control	0.04	0.43	3.47	5.76	3.15	0.38	0.35	0.24
	Treated	0.00	0.00	2.33	4.00	1.00	1.67	0.00	0.00
	Diff (T-C)	-0.04	-0.43	-1.14	-1.76	-2.15	1.29*	-0.35	-0.24
	Follow-up								
	Control	0.00	1.67	5.67	15.33	8.33	0.00	0.33	1.67
	Treated	0.00	0.29	5.29	7.93	3.57	0.64	0.21	0.36
	Diff (T-C)	0.00	-1.38	-0.38	-7.4**	-4.8**	0.64	-0.12	-1.31**
	Diff-in-Diff	0.04	-0.95	0.76	-5.64	-2.61	-0.65	0.23	-1.07

Note: *** p<0.01; ** p<0.05; * p<0.1

As shown in Tables 4 to 7 above, ownership of more assets increased because of project interventions implying that the project has started contributing to improve the livelihoods of the farming households.

In summary, the impact on livelihood shown by positive changes in most of the household assets between the beginning of the project and the time of the follow-up survey resulted from the project interventions in the study areas.

Changes in Livelihood Contexts and Strategies

This section assesses changes in livelihood contexts and strategies among yam-growing households in Nigeria following YIIFSWA project interventions.

Awareness and adoption of Adaptive Yam Minisett technology

Awareness of AYMT is one of the significant predictors of the decision to adopt the technology.

Technology adoption means different things to different people. As a consistent process, it is basic to enabling hesitant users to successfully adopt and use a technology. There is no perfect definition of technology adoption, largely due to the remarkable variability existing in types of technology and the conditions under which people adopt them. Adoption can have several definitions but it is important to agree on one so that the criteria for measurement are acceptable to all. A simplistic definition of adoption is the use of a technology (Langyintuo 2008).

The rate of adoption is the percentage of farmers who have adopted a given technology (Nkonya et al. 1998). According to Van den Ban and Hawkins (1988) the rate and pattern of adoption of agricultural innovations vary according to the type of crop, the location, and the specific innovation. There are also several definitions of an adopter, which also vary widely across studies depending on the complexity of the technology. According to Doss (2003), an adopter is found to be growing any of the introduced improved crop varieties. The adoption could be measured as a discrete state with binary variables (adopt or not adopt) or as a continuous measure at a specific time depending on the given technology (Doss 2003). A knowledge of the technology adoption levels can help to assess where farmers are in the adoption process. Moreover, it could assist in giving needed support as they move from acceptance of a technology through to use of it.

Farmers' knowledge and practices before and after the intervention by the project were assessed to estimate the influence of technology awareness, knowledge, and understanding. Few (less than 6%) had heard of the technology developed more than three decades ago but did not adopt it (Fig. 8). This hard-pressed for refining the technology as to suit better its clients. An important proportion of households was aware of the adaptive technology introduced and vigorously promoted by the project and about 18% of households surveyed planted the technology; the awareness rate was 23.3%. Furthermore, the proportion of adopters among those who were exposed to / aware of the technology was 75%, confirming that awareness / exposure was very important in achieving a high rate of AYMT adoption.

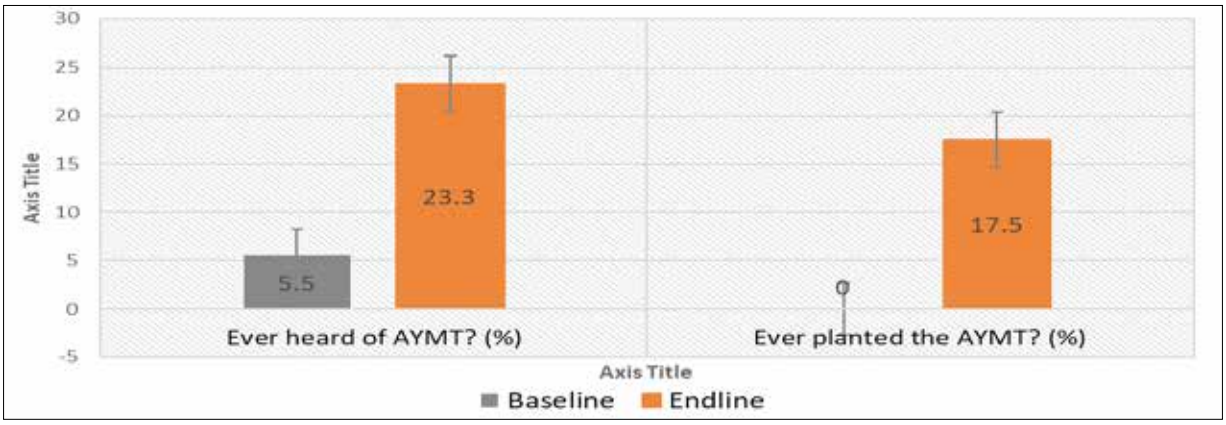

Figure 8: Distribution of households by awareness and adoption of AYMT.

When the endline data on a gender perspective basis are disaggregated, female-headed households were better off in terms of technology awareness and adoption (Fig. 9). This becomes noteworthy when taking into consideration how few are represented in the sampled households.

More investigation may be needed on the reasons why male-headed and female-headed households adopt AYMT at different rates.

Could gender-linked differences in the adoption of AYMT be attributed to the inherent characteristics of the technology or result from gender-linked differences in access to key inputs?

We will further investigate these differences in another study.

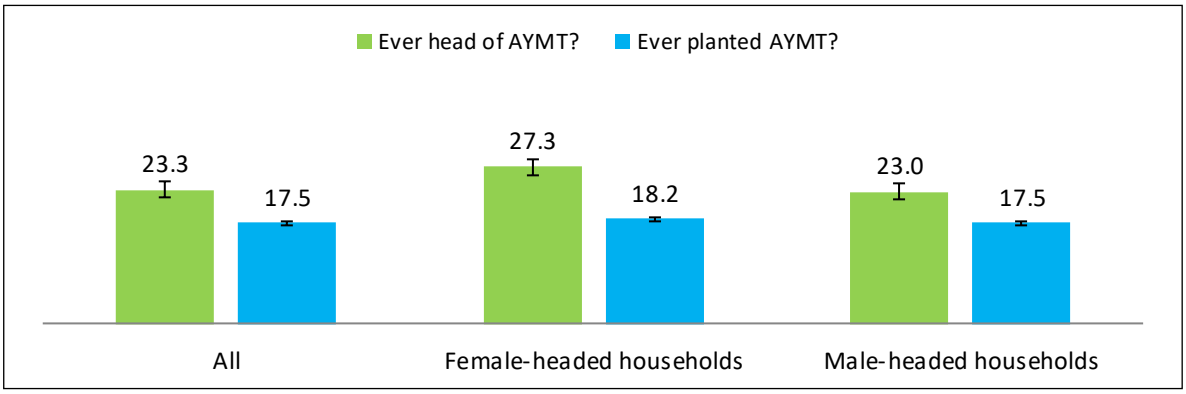

Figure 9. Distribution of households by awareness and adoption of AYMT by gender.

Adoption of AYMT from project target areas

No adoption was reported at the baseline study and great variation in the rate of AYMT adoption is noticed with the endline data within the project target areas. The adoption rate in the whole sample as shown (Table 8) was about 18% meaning that adoption of technology is making appreciable headway although conventional techniques of seed yam production are still dominating the system. Lower adoption rates were reported from Enugu, Kogi, Oyo, Benue, and Niger States.

Table 8: AYMT adoption rate by State.

STATE/COUNTRY	Estimated population (2010)	AYMT Adoption rate (%)	# AYMT Beneficiaries (Individuals)	# AYMT Beneficiaries (Households)
0	1	2	3=(1*2)/100	4=3/Hh size
Nigeria	31,111,132	17.5	5,444,448	513,627
Benue	4,565,302	5.8	264,788	24,980
Ebonyi	2,202,766	10.0	220,277	20,781
Edo	3,561,803	41.7	1,485,272	140,120
Enugu	3,474,487	3.6	125,082	11,800
Federal Capital Territory	1,360,639	78.8	1,072,184	101,149
Kogi	3,584,365	5.0	179,218	16,907
Nasarawa	2,035,656	30.0	610,697	57,613
Niger	4,181,028	6.4	267,586	25,244
Oyo	6,145,086	5.0	307,254	28,986

Nearly one-fifth of the sample households adopted the technology. This is a good starting point in formalizing the seed supply system to reverse the traditional production system that is dominant in the region. This will help farmers to improve the quality of their seed stocks, hence their productivity and production.

Sources of information on AYMT

Households that were aware of the AYMT were further requested to indicate the source of their knowledge about the technique. Table 9 captures the responses, and the most important source of information. About 51% of the respondents were informed through IITA and its contracted NGOs which trained farmers via AYMT demonstrations. This could be because of the ability of these households to have face-to-face contact with these sources. It is also that they participated in and observed the field demonstrations conducted. Moreover, these sources allowed a two-way process of communication. On the other hand, the low percentage of use of local input providers could be attributed to non-availability of such sources. Other sources like local leaders, friends from other communities and ADPs officials who were directly in touch with farmers were important in having farmers exposed to the technology.

Institutions played a significant role in farmers' exposure to AYMT in the project area and are therefore needed for promotion and dissemination of the technology. This will also improve the adoption rate and strengthen impact.

Table 9. Distribution of households by main source of information.

Source of information	All	SGS	DS	HF
N	800 (188)	232 (87)	476 (81)	92 (20)
Government extension	13.3	10.3	16.1	15.0
Farmers' coop/group	6.9	2.3	12.4	5.0
IITA, NGOs	50.5	50.6	45.7	70.0
NRCRI	2.1	4.6	0.0	0.0
Relative/neighbor	6.4	4.6	8.6	5.0
Radio/newspaper/TV	2.1	1.2	3.7	0.0
Local input provider	0.5	0.0	1.2	0.0
Others	18.1	26.4	12.4	5.0

N = Number of respondents; number of valid cases are in parentheses.
SGS = Southern Guinea Savanna; DS = Derived Savanna; HF = Humid Forest.

Reasons for non-adoption of AYMT

The perception of farmers gave an insight into the factors likely to be limiting adoption. The households that were aware of the technique and responded to this question gave a number of reasons why adoption was low in some places. Unavailability of technical knowledge about the technology was the most important reason for non-adoption (Fig. 10) followed by technology availability. Some felt a lack of cash/credit to acquire it was a reason as it involves the use of other inputs such as fungicide and insecticide (chemicals) for treatment. Other reasons were the availability of chemicals, fear of technology failure, and a belief that the conventional practice is better. Findings revealed that many households lack adequate information about the technology vital to help develop the necessary confidence in it and trust.

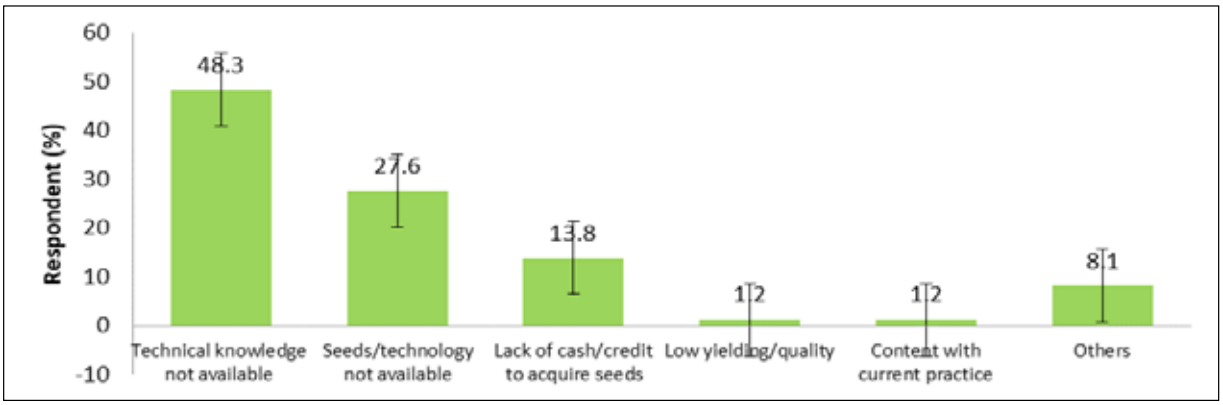

Figure 10. Reasons for non-adoption of AYMT.

There is a need to address the potential/perceived constraints to the uptake of the technology using effective mass communication strategies, which are significant predictors of the decision to adopt AYMT.

Determinants of adoption of AYMT

Understanding the factors influencing technology adoption helps us predict and manage those who adopt and when, and under what conditions adoption takes place. A complex set of determinants such as farm-specific, institutional, and technology-related factors affect the adoption of new technologies, particularly in subsistence farming.

This study used a logistic model to estimate the probability that a given household adopts AYMT. The p-value and the associated chi-square indicated that the model as a whole is statistically significant and has a good fit. Three out of nine explanatory variables tested were significant in explaining the adoption of AYMT (Table 10). The significant variables are age of household head, membership in social groups, and number of contacts with extension services. The negative association of age and adoption indicates that the younger the household head, the greater the chances of AYMT adoption. There is a different relation between membership of social groups and number of contacts with extension services, institutional factors, which have a significant influence on AYMT adoption. Adoption increases with farmers' membership of social groups and number of contacts with extension services.

Table 10. AYMT adoption determinants.

Variable	Coef.	Std. Err.	z	P>|z|
Household-specific factors				
AGE	-0.0197	0.0093	-2.13	0.033**
EDUC	0.0314	0.0233	1.35	0.177
FEM	0.0347	0.0469	0.74	0.460
HSIZE	0.0044	0.0326	0.13	0.894
Farm-specific factors				
FSIZE	-0.0160	0.0470	-0.34	0.733
Institutional factors				
CREDIT	0.3294	0.7505	0.44	0.661
MBER	0.9353	0.2433	3.84	0.000***
NCONT_EXT	0.2739	0.0835	3.28	0.001***
DIST_LMRKET	0.0008	0.0035	0.22	0.827
constant	-1.9367	0.5996	-3.23	0.001***
Model summary				
Model	Logit			
Dependent variable	AYMT Adoption			
Number of observations	688			
Software used	STATA			
LR chi2 (df)	50.74 (9)			
Prob > chi2	0.0000			
Pseudo R2	0.0951			
Log likelihood function	-241.5262			

Significance levels: *, ** and *** are P<0.1, P<0.05 and P<0.01, respectively

Age, membership of a social group, and number of contacts with extension services are responsible for increasing the probability of AYMT adoption in the study area. Membership of associations enhances farmers' access to technological information. It improves social interactions and catalyzes information flow among farmers which in turn enhance technology adoption. The number of contacts by extension services with farmers is an important determinant of adoption because newly developed technologies such as AYMT are usually introduced to farmers through extension agents. This shows that great effort is required to institute adequate awareness raising programs.

Changes in yield

The impact of YIIFSWA interventions including AYMT on total yam productivity was assessed by comparing productivity differentials between the baseline and the endline along with AYMT adopters and non-adopters. Since the same 800 households were surveyed at both periods under the same conditions, the likely source of productivity variation is the project interventions.

Incremental yield estimates from recall-based information

Yam harvests were estimated using farmers' memory recall of the quantity/number of tubers harvested. The average weight of a randomly sampled series was captured in the respective surveyed area (Mignouna et al. 2014b). The mean productivity at the endline was higher than that of the baseline (Table 11) amounting to productivity advantage of about 18%.

Table 11. Incremental yield from recall-based information between baseline and endline.

Country	AEZ	Yield (t ha-1)		Difference	
		Baseline	Endline	t ha-1	Percentage
Nigeria	All	9.4 (8.7)	11.1 (5.5)	1.7	18.1
	SGS	9.2 (8.3)	11.3(5.4)	2.1	22.8
	DS	9.3 (8.7)	11.0 (5.6)	1.7	18.3
	HF	10.4 (9.9)	10.9 (5.7)	0.5	04.8

N = Number of respondents; Figures in parentheses represent standard deviation.
SGS = Southern Guinea Savanna; DS = Derived Savanna; HF = Humid Forest.

In terms of productivity differentials between AYMT adopters and non-adopters, the mean productivity of adopters was higher than that of non-adopters amounting to productivity advantage of about 13% (Table 12).

Table 12. Incremental yield from recall-based information between AYMT adopters and non-adopters.

Country	Yield (t ha-1)		Difference	
	Adopters	Nonadopters	t ha-1	Percentage
Nigeria	12.4	10.8	1.6	13.0

This confirmed that there is a positive contribution in yam output from adopting AYMT as well as other YIIFSWA interventions.

Incremental yield estimates from field measurement

Yam yield and field area were measured with the help of the owner of the field. The method follows the exact procedure followed during the baseline (Mignouna et al. 2014a; 2014b). Yields from field measurements at the endline were higher than at the baseline (Table 13). The difference reflects the positive contribution of the YIIFSWA project. The yield could have been higher if some of the fields used for measurement were not destroyed by cattle as complained the field owners. This explains the negative difference in SGS.

In summary, yam yields were higher when measured than those reported through recall-based information, and for the endline than during pre-project. The difference in yam measured through recall-based information and measurement can be linked either to the crop cut method used likely in overestimating the yield or in underestimating the crop production through farmers' interviews.

Table 13. Incremental yield from field measurement between baseline and endline.

Country	AEZ	Yield (t ha-1)		Difference	
		Baseline	Endline	t ha-1	Percentage
Nigeria	All	19.5 (11.0)	21.9 (7.1)	2.4	12.3
	SGS	27.1 (7.0)	22.3 (6.9)	-4.8	-17.7
	DS	19.5 (11.6)	22.2 (6.7)	2.7	13.8
	HF	15.0 (9.6)	20.7 (8.3)	5.7	38.0

N = Number of respondents; Figures in parentheses represent standard deviation.
SGS = Southern Guinea Savanna; DS = Derived Savanna; HF = Humid Forest.

Changes in Livelihood Shocks and Poverty

This section depicts the changes in shocks faced by a household from the baseline to the endline in pursuit of its livelihood strategy. It also exposes the values of poverty indices by comparing the household data collected on food and non-food consumption and expenditure. The use of income as a poverty indicator is often criticized as being more difficult to measure accurately. Hence the use of expenditure as a poverty indicator is preferred. Household expenditure, which is the cost of goods and services acquired for private use during both surveys, is considered a suitable substitute. This is because it requires relatively fewer variables than household income since consumers may not make long-term adjustments to spending if they believe that changes in their income are only temporary.

Changes in shocks experienced by households

In pursuit of its livelihood strategy, a household always faces shocks, which could be common or specific in nature. Food deficit was the main periodic shock experienced by most households across the surveyed areas. This type of vulnerability results from qualitative analysis considering the respondents' perception about the number of households affected by food shortages and the frequency of food shortages during the season.

Households' own perception of food security status

To assess the farm family's food consumption, memory recall on different food shortage scenarios in the past 12 months was employed. The respondents were asked whether their households had sufficient food during the previous year. Figure 11 shows how households perceived their food security status. This perception was observed to be different between the two rounds of surveys. From baseline to the endline, households reported a decrease to 1% throughout the year of food shortages from about 5% and of occasional food shortages from about 32% to 26% (Fig. 11). Households reporting no food shortage but no surplus increased from about 44% to 54% during the two periods. Households reported food surplus were almost unchanged during the same periods. Improvement reported as contribution to food sufficiency is likely due to the increase in productivity attributed to the interventions of the YIIFSWA project. They are good indications of improved food security in the region.

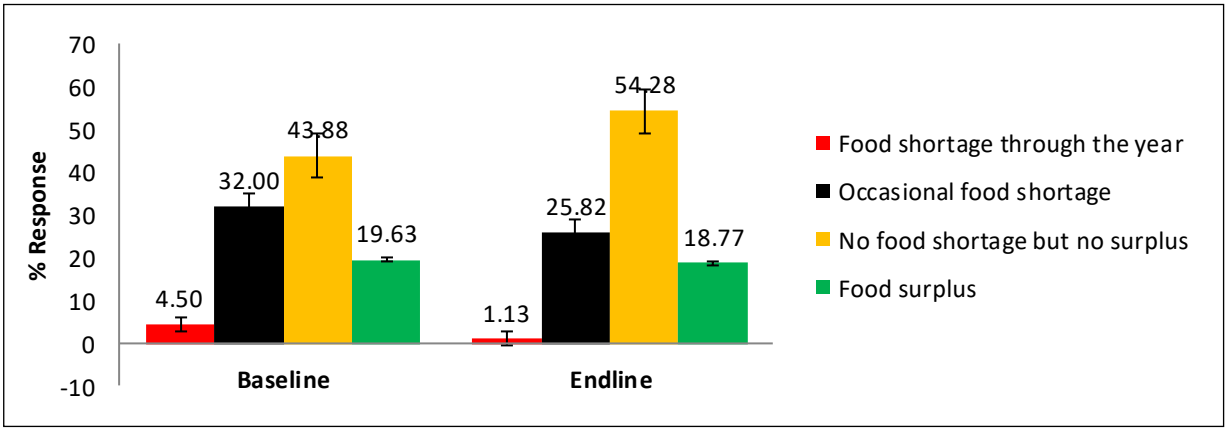

Figure 11. Changes in family food consumption status in the last 12 months.

Household expenditure and poverty

Total expenditure included household expenditure on consumables and non-food items. Under food expenditure, all the food items consumed by the household during a year, were collected. Food consumption included food that the household purchased, produced, and received from other sources. Total expenditure on food, was obtained by aggregating expenditure on all food items. Total expenditure on each food group, was calculated by aggregating expenditure on all food and non-food items falling within a group.

Poverty measurements

Individual consumption, was used to generate poverty measurements belonging to the family of indices derived from the Foster, Greer and Thorbecke equation to estimate the changes that occurred as result of YIIFSWA's interventions starting from the baseline to the endline. The basic measure of poverty is the size of the population that falls below the poverty line and the same, is reported by the poverty headcount index as a percentage of the total population. The depth of poverty or the poverty gap provides information regarding how far the population is from the poverty line. Poverty severity considers not only the distance separating the poor from the poverty line but also inequality among the poor.

Two poverty lines, are used for poverty measures: the relative poverty line set as two-thirds of the mean annual per capita expenditure and the absolute poverty line based on the standard international poverty line of $1.25/day/capita to allow the cross-country comparisons of poverty rates that are notoriously difficult. The number of poor in the surveyed area generally reduced using both methods although the two measures, cannot be compared directly.

Half of the households surveyed during the pre-project period lived below the relative poverty line but by the endline, the proportion had reduced to 38% (Table 14). Similarly, the relative poverty gap was 8% points less for the baseline as compared to the endline despite the increase in population, while the severity of the relative poverty reduced by 5% points from the baseline. These same trends of relative poverty indices were found across the AEZs.

Regarding the absolute poverty line, 44% of households at the baseline were poor although this proportion reduced to 38% at the endline. The absolute poverty depth was found to be 20% for the group at the baseline and 16% at the endline. Similarly, the absolute poverty severity at the endline went down by 2% points from the baseline value.

When the data were disaggregated to reflect gender (Table 14) the incidence of relative poverty was found to reduce from the baseline as compared to the endline by 13% points with male-headed households and by 9% points with female-headed households.

Table 14. Poverty indices by AEZ and gender.

Category		Headcount		Poverty gap index		Poverty severity index	
		Baseline	Endline	Baseline	Endline	Baseline	Endline
Relative Poverty line							
AEZ	All	0.50	0.38	0.24	0.16	0.15	0.10
	SGS	0.59	0.39	0.29	0.17	0.18	0.11
	DS	0.46	0.38	0.22	0.16	0.14	0.10
	HF	0.51	0.33	0.23	0.16	0.13	0.10
Gender	MHH	0.50	0.37	0.24	0.16	0.15	0.10
	FHH	0.54	0.45	0.29	0.25	0.18	0.15
AEZ	All	0.44	0.38	0.20	0.16	0.12	0.10
	SGS	0.52	0.40	0.24	0.18	0.15	0.11
	DS	0.40	0.38	0.19	0.16	0.11	0.10
	HF	0.41	0.29	0.20	0.14	0.11	0.09
Gender	MHH	0.44	0.37	0.20	0.16	0.12	0.10
	FHH	0.54	0.45	0.25	0.24	0.14	0.13

SGS = Southern Guinea Savanna; DS = Derived Savanna; HF = Humid Forest.
MHH = Male-headed households; FHH = Female-headed households.

With relative poverty, disaggregating households by treatment presents interesting findings. The incidence of poverty was 10% points lower for the treated group as compared to their counterparts (Table 15). Likewise, the poverty depth for the control group was estimated to be 18%; the corresponding figure for the treatment group was 10%. In a similar fashion, the severity of poverty for the control group was found to be almost twice that of the treatment group.

These findings are due to the higher and relatively stable income generated from the beginning to the end of the project interventions and by the treated group.

Table 15. Relative poverty indices by treatment.

Category	Headcount		Poverty gap index		Poverty severity index	
	Non-treated	Treated	Non-treated	Treated	Non-treated	Treated
All	0.41	0.31	0.18	0.10	0.10	0.05
MHH	0.41	0.30	0.18	0.09	0.10	0.05
FHH	0.48	0.46	0.26	0.20	0.15	0.11

SGS = Southern Guinea Savanna; DS = Derived Savanna; HF = Humid Forest.
MHH = Male-headed households; FHH = Female-headed households

Changes in per capita expenditure using propensity score matching

Using Radius Matching as a matching strategy, Table 16 shows that the Average Treatment on Treated (ATT) of YIIFSWA project on per capita expenditure of beneficiaries was N13,128.44. This implies that yam farmers, beneficiaries that earned directly or indirectly from YIIFSWA project had greater per capita expenditure compared with the non-beneficiaries. Furthermore, the results showed that YIIFSWA project increased the per capita expenditure and had the potential to bring yam farmers out of poverty.

Table 16. Changes of YIIFSWA on per capita expenditure.

Parameter	YIIFSWA Beneficiaries	YIIFSWA Non-beneficiaries	Difference	S.E.
Radius Matching				
Unmatched	69084.44	53393.37	15691.07	3074.60
ATT	69146.94	56018.50	13128.44	3103.10
ATU	53459.95	65073.25	11613.30	.
ATE			11884.37	.

Source: YIIFSWA Field Survey, 2015
ATU: Average Treatment on Untreated, ATE: Average Treatment Effect

Changes in food security using propensity score matching

The common definition of food security is access by all people at all times to sufficient food for an active and healthy life (World Bank 1986). Implicit in this definition are three important dimensions: (i) availability of sufficient quantity and appropriate quality of food supplied through own production or otherwise; (ii) access by all households and individuals to enough and adequate resources to acquire such food; and (iii) utilization of this food through an adequate diet, water, sanitation, and health care (Timmer 2012). In subsistence economies, households' food security is largely linked to the availability of food from households' home grown or own production. Gifts and transfers from friends and relatives also play important roles. Food purchased are also common but limited due to lack of liquidity.

The results of the propensity score matching (PSM) presented in Table 17 show that the ATT of YIIFSWA project on food security (per capita expenditure on food) of beneficiaries was N8,632.64 for the Radius Matching technique. This implies that the project beneficiaries that profited directly or indirectly from YIIFSWA project are more food secured than the non-beneficiary farmers.

Table 17. Impact of YIIFSWA on food security.

Parameter	YIIFSWA Beneficiaries	YIIFSWA Non-beneficiaries	Difference	S.E.
Nearest Neighbor Matching				
Unmatched	54777.50	45702.31	9075.19	2758.97
ATT	55031.99	46399.35	8632.64	3054.58
ATU	45609.05	51025.52	5416.47	.
ATE			5991.86	.

Source: YIIFSWA Field Survey Data, 2015
ATU: Average Treatment on Untreated, ATE: Average Treatment Effect

In summary, we are interested in this study by the Average Treatment Effect on the Treated, which gives the average effect of the project on per capita expenditure and food security. The results show a positive effect on income and food security. This implies that the increase in productivity generated by the project interventions leads to an increase in household income and food security, which adds up to poverty reduction in the region.

Estimation of the total number of poor households lifted out of poverty

Beyond establishing causality between adoption and poverty, we have also estimated the number of households who have managed to overcome poverty as a result of the adoption of improved yam technology by estimating the population of adopting households and applying the FGT headcount indices of poverty computed from the DD technique.

Table 18 provides estimates of the total number of people lifted out of poverty due to adoption of AYMT in Nigeria. It revealed that adoption of AYMT resulted in poverty reduction among rural population by about 10% points, translating into 119,177 individuals or 12,038 households that were moved out of poverty in the study region.

This is consistent with the findings of several studies, which demonstrated that adoption of agricultural technologies helped to reduce poverty levels (Mendola 2007; Moyo et al. 2007; Minten and Barrett 2008; Becerril and Abdulai 2010).

Table 18. Poverty-reduction impact of AYMT adoption.

No	Variable	All
1	Sample for each zone [1]	800
2	Adoption rate (%) [2]	17.5
3	Poverty rate in the treated group [3]	31.3
4	Poverty rate in the non-treated group [4]	41.1
5	Poverty reduction rate (% point) [5=4-3]	0.098
6	Adopting households (number) [6=1*2/100]	140
7	Average household size [7]	9.9
8	Population in sampled households [8=1*7]	7,920
9	People out of poverty from sample (number) [9=5*6*7]	135.8
10	Population size of sampled area [10]	6,950,552**
11	Poor lifted out of poverty (number) [11=9/8*10]	119,177

Notes:
(3) & (4) = The poverty reduction rate was estimated from FCT using the absolute poverty line with difference-in-differences approach
(7) = This is the total number of individuals in the entire household sampled.
(10) = Total population by LGA from Census data 2006 obtained from National population commission.
http://www.nigerianelitesforum.com/ng/people-of-nigeria/42212-nigeria-population-by-local-government.html#ixzz4jKsROgfF
** See Annex 4
Source: YIIFSWA Field Survey Data, 2015.

Conclusions and Implications

The survey for this study was done using the same design as the baseline survey. Data collection used structured questionnaires including community, household and field, and a set of qualitative approaches. Data were collected in 9 states, 40 LGAs, 200 communities, and 800 households selected from yam growing areas of Nigeria. Trained enumerators administered the structured questionnaires under skilled supervisors after the pre-testing of questionnaires and guidelines. Descriptive statistics, Difference-in-Differences approach, and propensity score matching were mainly employed to assess the impacts of YIIFSWA project. The analysis of the baseline and endline survey results demonstrates various aspects of positive impact of YIIFSWA project. This study attempts to document adoption at the farm level of a technological package promoted by YIIFSWA and assesses factors affecting their adoption. It also estimates the early impacts that result from the project. The study evaluates the direct and indirect contributions of the project on smallholder yam farmers and thereby draws lessons that may be useful in the design and implementation of any other future project of a similar nature including a second phase of YIIFSWA.

These results indicated that more than half of the household heads had attended school; the average number of years of schooling was low in the two rounds, but by the endline, the average years of schooling for household heads are higher. The main characteristics of sampled households were related to the distribution of heads of households by gender, age, and years of formal education as well as to the household size. At the end of the project, there were no major changes in the underlying demographic characteristics of the farm families' due to the brief lapse of time between the two surveys.

Results indicated in general that socioeconomic household characteristics did not change significantly between both assessment periods though the positive changes that were reported could certainly be associated with the project interventions. The average farm sizes in the project area showed large disparities among farming households but no change was observed between the total land allocated to crops in the surveyed areas at the beginning and end of the project. Only the area of land under yam increased and changes in land utilization would have been required for yam cultivation as a rational decision following the potential yield gains experienced as result of the YIIFSWA project.

This study focused mainly on providing answers to the question of how much impact the project has had on rural households' income and food security and how it has contributed to the reduction of poverty in Nigeria. We started by documenting the rate of AYMT adoption and awareness among the sampled farmers. The result showed that the adoption rate was about 18% while the awareness rate was 23%. Furthermore, the proportion of adopters among the exposed farmers was 75%, confirming that awareness / exposure is very important in achieving a high rate of adoption. Policies and programs that would further increase farmers' awareness of the technology should be implemented and thoroughly monitored. In addition, the existing extension program should be properly rehabilitated and supported to improve the performance of the extension agents and increase the number of contacts with farmers.

The summary statistics of households' asset ownership showed that the project significantly contributed to the ownership of more assets at the endline compared to the pre-project, for the treated

as well as the non-treated. The higher yam output implies that adoption of AYMT and benefits from other interventions can lead to an increase in food security, and generate a reduction in poverty. Additionally, the result of the FGT poverty measures further confirms the potential of the project to curb poverty in rural areas and among the farming households. The adoption of AYMT resulted in poverty reduction among rural population by 10% points translating into 119,177 individuals being lifted out of poverty in the states of intervention. This further proposes the continuation of the AYMT for commercial seed yam production in the second phase of the YIIFSWA project as a guarantee of escape from the morass of the present endemic and prevalent poverty situation in rural areas of Nigeria and among the households.

Apart from training farmers through demonstration on AYMT, the YIIFSWA project carried out many other technologies/practices' development and dissemination activities with the aim of increasing yam productivity in Nigeria, some of which resulted in breakthroughs. The implication of this impact study, which revealed the level of positive impacts of AYMT adoption, calls for concerted efforts towards implementation and the scaling out of the YIIFSWA project key breakthroughs namely:

- Implementation of quality control standards approved by the regulatory bodies of Nigeria using the quality management protocol for certification of yam planting materials.
- Improvement in seed health management methods incorporating virus elimination techniques and indexing for certification.
- Use of novel high ratio propagation technologies (Temporary Bioreactor System and Aeroponics System) for production of high quality planting materials, especially breeder and foundation seeds yam.

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Annexes

Annex 1. Percentage distribution of households by awareness and adoption of AYMT by States.

Characteristics	All	1	2	3	4	5	6	7	8	9
N	800	120	60	60	140	80	80	60	140	60
Ever heard of AYMT? (%)	23.3	7.5	15.0	50.0	12.1	92.5	8.8	35.0	10.7	6.7
Ever planted AYMT? (%)	17.5	5.8	10.0	41.7	3.6	78.8	5.0	30.0	6.4	5.0

N = Number of respondents;
1 = Benue; 2 = Ebonyi; 3 = Edo; 4 = Enugu; 5 = FCT; 6 = Kogi; 7 =Nasarawa; 8 = Niger; 9 = Oyo.

Annex 2. YIIFSWA Project Communities in Nigeria.

States	LGAs	Communities
BENUE	Agatu	Enumgba
BENUE		Igoje
BENUE		Obagaji
BENUE		Okokolo
BENUE		Oshigbudu
BENUE	Gboko	Adzer-Nor
BENUE		Akpager
BENUE		Luga
BENUE		Tchowanye
BENUE		Yandev
BENUE	Katsina-Ala	Abaji
BENUE		Gbor
BENUE		Ikowe
BENUE		Sai
BENUE		Tor-Donga
BENUE	Otukpo	Adoka
BENUE		Ogali
BENUE		Otobi
BENUE		Otukpo Nobi
BENUE		Uwaba-Aokwu
BENUE	Tarka	Agudu
BENUE		Gwarche
BENUE		Nyambee
BENUE		Tyiotyu
BENUE		Wannune
BENUE	Ukum	Ayati
BENUE		Chito
BENUE		Kyado
BENUE		Vaase
BENUE		Zaki-Biam
EBONYI	Ezza North	Ekka
EBONYI		Inyere
EBONYI		Nkomoro
EBONYI		Ogboji
EBONYI		Umuoghara
EBONYI	Ivo	Akaeze-Ukwu
EBONYI		Ihenta
EBONYI		Iyuoji
EBONYI		Mgbede
EBONYI		Umobor
EBONYI	Izzi	Agbaja
EBONYI		Agbanyim
EBONYI		Igbeagu
EBONYI		Ndieze
EBONYI		Yimaegu

States	LGAs	Communities
EDO	Esan	Illushi
EDO		Ivue
EDO		Obeidu
EDO		Onogholo
EDO		Oria
EDO	Orthioromwon	Iguemokhua
EDO		Owuo
EDO		Ugoniyekonhonma
EDO		Umoghun-Nokhwa
EDO		Uromehe
EDO	Owan East	Arokho
EDO		Ihiebe
EDO		Irbiaro
EDO		Ohanmi
EDO		Warake
ENUGU	Aninri	Mpu
ENUGU		Ndiaboh
ENUGU		Nenwe
ENUGU		Oduma
ENUGU		Opanku
ENUGU	Awgu	Agbogugu
ENUGU		Agwu
ENUGU		Amoli
ENUGU		Ifite
ENUGU		Maku
ENUGU	Enugu East	Alulu
ENUGU		Amorji
ENUGU		Ibagwa
ENUGU		Nkwugbo
ENUGU		Ugwogo
ENUGU	Igbo-Eze	Aguibeje
ENUGU		Amube
ENUGU		Okpo
ENUGU		Onicha
ENUGU		Umuopu
ENUGU	Igbo Etiti	Ekwegbe
ENUGU		Ohodo
ENUGU		Ozalla
ENUGU		Ukehe
ENUGU		Umunko
ENUGU	Udenu	Imilike
ENUGU		Obollo Eke
ENUGU		Obollo Etiti
ENUGU		Ozalla-Ezimo
ENUGU		Umundu
ENUGU	Uzo-Uwani	Abbi
ENUGU		Nimbo
ENUGU		Nrobo
ENUGU		Opanda
ENUGU		Uvuru
FCT	Abaji	Agyana
FCT		Makana
FCT		Nuku
FCT		Pandagi
FCT		Yewuni
FCT	Gwagwalada	Ibura II
FCT		Luda
FCT		Pagadan
FCT		Raphin Zuti
FCT		Wura

States	LGAs	Communities
FCT	Kuje	Chibiri
FCT		Kiyi
FCT		Shadarbi
FCT		Shazi
FCT		Tarkarba
FCT	Kwali	Ashara
FCT		Kilankwa I
FCT		Ubo Saidu
FCT		Ubosharu
FCT		Yambabu
KOGI	Ibaji	Odogwu
KOGI		Ogaine
KOGI		Ojuba
KOGI		Onyedega
KOGI		Ujeh
KOGI	Idah	Ajibaja
KOGI		Ekwokata
KOGI		Ichala
KOGI		Ijobe
KOGI		Ojigagala
KOGI	Omala	Abejukolo
KOGI		Ajiyolo
KOGI		Bagaji
KOGI		Icheke ?
KOGI		Odoh
KOGI	Yagba East	Ejuku
KOGI		Imela
KOGI		Jege
KOGI		Ponyan
KOGI		Takete-Isao
NASARAWA	Lafia	Adogi
NASARAWA		Agudu
NASARAWA		Assakio
NASARAWA		Bukan Buzu
NASARAWA		Bukan Koto
NASARAWA	Nasarawa	Gadabuke
NASARAWA		Karmu
NASARAWA		Kwoho
NASARAWA		Laminga
NASARAWA		Mararaba Udege
NASARAWA	Obi	Agyaragu
NASARAWA		Daddere
NASARAWA		Kpangwa
NASARAWA		Obi
NASARAWA		Zherugba
NIGER	Bosso	Beji
NIGER		Garatu
NIGER		Garusu
NIGER		Gbaiko
NIGER		Kampala
NIGER	Gurara	Bonu
NIGER		Diko
NIGER		Lambata
NIGER		Lefu
NIGER		Tufa
NIGER	Lapai	Birnin Maza
NIGER		Gabi
NIGER		Gulu
NIGER		Gupa
NIGER		Lapai

States	LGAs	Communities
NIGER	Mashegu	Babban Ramin
NIGER		Makari
NIGER		Mashegu
NIGER		Masuchi
NIGER		Sahorami
NIGER	Rafi	Karaya
NIGER		Katako
NIGER		Madaka
NIGER		Sambuga
NIGER		Tegina
NIGER	Shiroro	Gwada
NIGER		Kadna
NIGER		Pina
NIGER		She
NIGER		Zumba
NIGER	Tafa	Azhi
NIGER		Garam
NIGER		Gyedna
NIGER		Ijagwari
NIGER		Sabon Wuse
OYO	Irepo	Adagbangba
OYO		Gudu
OYO		Nufe
OYO		Sooro
OYO		Welewele
OYO	Olorunsogo	Alawa
OYO		Bi-Alaso
OYO		Dogo
OYO		Igbeti
OYO		Tesi Garubar
OYO	Orelope	Bonni
OYO		Igbope
OYO		Kajola
OYO		Oloko
OYO		Sooro

Annex 3. Characteristics of AEZs.

Parameters	SGS	DS	HF
LGP (days)	181–210	211–270	> 270
Soil types	Luvisol, Acrisol, Vertisol	Lixisol, Leptosol, Plinthosol, Nitisol, Luvisol	Nitosol, Ferrasols, Vertisol, Fluvisol
Annual rainfall (mm)	1200–1500	1300–2000	> 2000
Altitude (masl)	< 800	< 800	< 800
Rainy season	June–October	May–October	March–November
Solar radiation (MJ/m2/day)	15	15	12
Rainfall pattern	Bimodal	Bimodal	Bimodal
Main rainfed crop	Yam, Cowpea, Sorghum, Maize, Sweetpotato, Cassava, Cocoyam	Yam, Maize, Sweetpotato, Cassava, Cocoyam	Yam, Rice, Maize, Sweetpotato, Cassava, Cocoyam

SGS = Southern Guinea Savanna; DS = Derived Savanna; HF = Humid Forest; LGP = Length of growing period.
Sources: IITA (1992); Jagtap (1995); FAO/IIASA/ISRIC/ISSCAS/JRC (2009).

Annex 4. Estimated population by YIIFSWA Project LGAs in Nigeria.

States	LGAs	Population
BENUE	Agatu	115,523
BENUE	Gboko	358,936
BENUE	Katsina-Ala	224,718
BENUE	Otukpo	261,666
BENUE	Tarka	79,494
BENUE	Ukum	216,930
EBONYI	Ezza North	145,619
EBONYI	Ivo	120,919
EBONYI	Izzi	234,072
EDO	Esan	167,721
EDO	Orthioromwon	182,717
EDO	Owan East	154,385
ENUGU	Aninri	133,723
ENUGU	Awgu	198,134
ENUGU	Enugu East	279,089
ENUGU	Igbo-Eze	259,431
ENUGU	Igbo Etiti	209,248
ENUGU	Udenu	178,466
ENUGU	Uzo-Uwani	124,480
FCT	Abaji	58,444
FCT	Gwagwalada	157,770
FCT	Kuje	97,367
FCT	Kwali	85,837
KOGI	Ibaji	128,129
KOGI	Idah	79,815
KOGI	Omala	108,402
KOGI	Yagba East	140,150
NASARAWA	Lafia	330,712
NASARAWA	Nasarawa	596,669
NASARAWA	Obi	148,874
NIGER	Bosso	147,359
NIGER	Gurara	90,974
NIGER	Lapai	110,127
NIGER	Mashegu	215,022
NIGER	Rafi	181,929
NIGER	Shiroro	235,404
NIGER	Tafa	83,544
OYO	Irepo	122,553
OYO	Olorunsogo	81,759
OYO	Orelope	104,441
Total		6,950,552