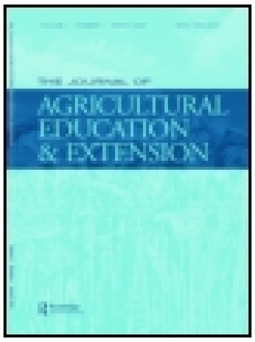

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Multi-stakeholder process strengthens agricultural innovations and sustainable livelihoods of farmers in Southern Nigeria

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Multi-stakeholder process strengthens agricultural innovations and sustainable livelihoods of farmers in Southern Nigeria

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ABSTRACT

Purpose: In this paper, we explore the strategic role of Multi-stakeholder processes (MSP) in agricultural innovations and how it has impacted livelihood assets' (LAs) capital dynamics of stakeholders in platforms in West Africa.
Design/Methodology/Approach: We demonstrate how LA capitals and socio-economic dynamics induced by MSP can enhance cassava production efficiency but also create opportunities and challenges that influence platform dynamics and impacts. We use a multistage sampling procedure and sustainable livelihood model (e.g. stochastic frontier functions and Tobit regression) to analyse LA capital dynamics of the stakeholders.
Findings: We showed that the LA of the MSP participants (0.72) was found to be significantly higher ($\chi^2 = 3.732$, $p < .10$) than that of the non-participants (0.45). The results further revealed a remarkable increase from 0 to 0.77 and from 0.33 to 0.82 for human capital and social capital, respectively, as stakeholders participate in MSPs' activities.
Practical implications: We recommend the institutionalization of MSP in the Agricultural Research for Development (AR4D) with more extension follow-up services so as to adequately and appropriately unleash the potentials in social capital networks that enable the development, effective dissemination and adoption of agricultural innovations.
Theoretical implications: This study suggests that soft-transfer of technologies seems to dominate at MSP inception. But at maturity, the results of the struggle between researchers and farmers would lead to co-reaction and community-based research. Consequently, the knowledge and power dynamics that take place within the MSP should be considered the centre of co-construction and platform dynamics.
Originality/Values: The study provided a practical experience on how MSP can be institutionalized in the AR4D programmes to support agricultural innovation systems and foster pro-poor growth and livelihoods.

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Introduction

Multi-stakeholder processes (MSP) are increasingly seen as a promising vehicle for agricultural innovation in developing countries (Hemmati 2002; Adekunle and Fatunbi 2012; Schut et al. 2015). In the field of agricultural research for development (AR4D), MSP forms an important element towards more structural and long-term collaboration and engagement between stakeholders in the agricultural sector, essential to achieve development impacts (Adekunle and Fatunbi 2012; Nederlof and Pyburn 2012; Schut et al. 2015). Researchers and the other developmental stakeholders need each other to achieve impact at scale. However, collaboration for AR4D has been insufficient so far. Different forms of multi-stakeholder approaches have been used in AR4D in different countries and regions. They include Farmer groups (both formal and informal) extensively used in Colombia (Ashby et al. 1995), and Mali and Senegal (Collion and Rondot 1997) to enable researchers and development stakeholders to interact efficiently with farmers; the farmer field school developed 25 years ago in Southeast Asia as an alternative to the prevailing top-down extension method of the green revolution. Others include participatory research, learning alliances, natural resource management platforms and local agricultural research committees (Röling 2009; Waters-Bayer et al. 2015).

In the previous AR4D, many of the recommendations were not compatible with farmer's socio-economic and heterogeneous environments. Thus a radical change in the AR4D approach took place, with greater emphasis on the importance of taking a whole-farm analytical approach, zooming out from plot-level to farm/household level, and seeking to better understand socio-technical interaction issues such as labour/land and input/output dynamics, management practices, goals and lifestyles of farmers, social constraints, economic opportunities, marketing strategies and externalities (energy supply and cost; impact of farm policies, etc.). This new thinking also required involving farmers, extension officers, policy-makers, researchers and other agricultural development stakeholders in the research design and implementation (Schut et al. 2015). This also needed an interdisciplinary strategy and involving all stakeholders throughout the innovation-design process and providing a space for experimentation, learning and negotiation (Klerkx, van Mierlo, and Leeuwis 2012). Consequently, the MSP approach emerged in response to the need to balance 'bottom-up' and 'top-down' approaches and 'demand-driven' paradigm for AR4D, focusing on all stakeholders and the heterogeneous environments. MSP requires new types of relationships between farmers, extension officers, policy-makers, researchers and other agricultural development stakeholders through changes in preferences, policies, or technological innovations, thereby generating new collaboration networks or new market opportunities for goods and services (Hemmati 2002; Adekunle and Fatunbi 2012; Schut et al. 2015).

Most of the studies on MSP focused on the best way to organize the process (Hemmati 2002; Adekunle and Fatunbi 2012) or the conditions that make the process successful (Klerkx, van Mierlo, and Leeuwis 2012; Schut et al. 2015). However, the implementation of MSP in innovation system thinking to improve livelihood is still not fully documented. MSP requires processes and instruments such as the Research for Development (R4D) Platforms and Innovation Platforms (IPs), used in programmes such as Humidtropics (Tenywa et al. 2010; Schut et al. 2015). These two mechanisms are inter-related. The R4D Platform at the strategic level, brings together stakeholders from the broader dimension covering the key components and sectors within the system, and helps in the confirmation of entry points, intervention domains, or work packages, upon which research can be undertaken, including removal of constraints for the scaling of technological and institutional innovation. IPs, on the other hand, at the operational or field level, are specific platforms developed to undertake analysis and action research on specific constraints, challenges or opportunities (entry points) identified through the R4D Platform. It can, therefore, be said that IPs are often spawned from R4D Platforms, and involve partners and stakeholders in specific innovation domains. Membership in R4D Platforms is generally much more diverse than for IPs, which usually tends to be focused on a particular issue such as a value chain for a particular commodity. However, in both cases, membership includes various combinations of researchers, farmers, development NGOs, extension departments, private sector, traders and policy-makers at different levels (Adekunle and Fatunbi 2012; Schut et al. 2015; Norman and Atta-Krah 2017). R4D and IPs provide insights about what type of innovations are technically feasible, economically viable and social-culturally and politically acceptable (Schut et al. 2014, 2015). In so doing they become aware of their fundamental interdependencies and define concerted action at a variety of scales to overcome their constraints and reach their objectives.

MSP emerges in AR4D because stakeholders find that they need to collaborate for change to happen through coherent agricultural research, development and policy strategies. However, the type of actors, the level of their participation in term of who takes decisions and the type of decision taken including facilitation and institutional arrangements determine whether MSP can lead to a change or innovation (Klerkx, van Mierlo, and Leeuwis 2012; Schut et al. 2015). Continuous engagement of stakeholders in planning, analysing, testing and implementing feasible combinations of socio-technical, governance, and policy options capable of improving livelihoods can work if how situations are analysed and articulated, are similar to the sense-making process described by Weick, Sutcliffe, and Obstfeld (2005). This means MSP to facilitate the capacity to analyse problems in a holistic way and the sharing of information. Identifying problems or constraints through a sense-making process is a central step to facilitate a collective decision. Secondly, in order to accommodate different mental models, MSP will have to access, produce and make available to all stakeholders all information that can help to identify best-fit solutions (Norman and Atta-Krah 2017). The decision then consists of identifying and testing a range of solutions available and choosing the most adapted solutions. Third, decisions should be taken collectively through institutional arrangements and the degree of collectiveness depends on the distribution of power within the platforms (Tenywa et al. 2010).

In recognition of these challenges, there is a strong need to revisit the role of MSP for enhancing systemic capacity to innovate in international AR4D aimed at enhancing the livelihoods of smallholder farmers and possible mainstreaming into other continental agricultural initiatives such as the Comprehensive African Agricultural Development Programme (CAADP) and political commitments such as the Maputo 2003 and Malabo 2013 declarations. This paper is building on two years constructive analysis of the influence of MSP on social capital assets of livelihood dynamics of stakeholders in platforms and how this impacted their efficiency in cassava production in West Africa under an integrated systems research programme called Humidtropics.[1] The Humidtropics R&D processes were influenced by the innovation systems perspective with an innovation lens in the design, implementation, and evaluation of the activities of the various actors involved in the innovation process (Schut et al. 2015; Wigboldus et al. 2016). A major benefit of Humidtropics was its inherent ability to distribute, and thereby minimize, farmer risks through the diversification of enterprises, allowing farmers to exploit a higher spectrum of marketing channels (Bisseleua and Degrande 2017) using MSP and its instruments that are the Research for Development (R4D) Platforms and Innovation Platforms (IPs). MSP were set up to enable various stakeholders engage and facilitate the process of integrated systems research capable of yielding development outcomes.

Studying and documenting this institutional experiment (Humidtropics' experience) in terms of process and outcomes is important to learn and draw lessons from the experience at the level of the process and to rethink our fundamental perspectives on what we actually mean by improvement in agriculture and rural development. We hypothesized that farmers participation to MSP will enhance their technical efficiency (TE) and productivity. We also opine that farmer's participation to MSP will increase their livelihood outcomes in term of social, natural, financial, human and physical capital.

Conceptual framework

MSP to support social capital asset of livelihood

Livelihood asset (LAs) capitals (Social, Natural, Financial, Human and Physical) have been a disregarded intangible aspect of MSP in integrated food production systems (Ologbon, Idowu, and Oyebanjo 2013). For example, social capital is rooted from the sociological background and it allows access to material and immaterial resources; information and knowledge to enhance the process of transformation of input to output (Gretzinger, Hinz, and Matiaske 2010). Social capital in the rural communities is available in rich stock but has remained untapped for efficient production of most food crops such as cassava. At a practical and operational level, social capital is broken into five dimensions which include: Groups diversity of membership; trust and solidarity; collective action and cooperation; social cohesion and inclusion; and information and communication. These dimensions can influence the dynamic of MSP, its efficiency and decision-making mechanisms (Wigboldus et al. 2016).

Social capital has been defined in many ways depending on the field of study of the authors. The definition of Bourdieu and Wacquant (1992) of social capital is more relevant for this study because we are dealing with platforms (R4D and IP) which are group of individuals that have established a strong network of more or less institutionalized relationships of mutual acquaintance and recognition. And also where at each of these phases of the innovation process, the role of the participants is likely to change from interest to active collaboration and finally ownership and leadership. The role of research and development organizations changes from initial leadership to facilitation of the process and finally to providing backstopping when and as required and the role of the private sector changes from interest to one of active collaboration and finally farmer support and commercial opportunity. This may lead to social learning and trust building. Social capital encompasses institutions, relationships and customs that shape the quality and quantity of society's social interactions. Social capital was found to be a critical factor for societies to prosper economically and for development to be sustainable

(Herrera, Rosas, and Lorcal 2014). Social capital, when enhanced in a positive manner, can improve project effectiveness and sustainability by building the community's capacity to innovate and to address their common needs such as increasing productivity and income or the management of common resources (Oxoby 2009). In the MSP social capital can be of a different magnitude and could include bonding social capital – referred to as the network that exists within a group and between people who are similar. Social capital could also include strengthening existing network between different groups or dealing with relationships between stakeholders from different societal levels about access to particular resources such as power and wealth (Roslan, Russayani, and Nor Azam 2010; Balogun and Yusuf 2011). The most relevant innovation system is the one that is constructed (i.e. takes into account the social network, individual preference and history, culture, power, policy and economic opportunity) to address a particular problem i.e. context specific (van Mierlo, Arkesteijn, and Leeuwis 2010). In MSP innovation goes beyond developing a technology to take into account the 'whole innovation systems' i.e. culture, power, institutions and policies as well as the actors themselves. The MSP and its instruments integrate various knowledge systems as well as the dynamic and evolving nature of situations, therefore putting strong emphasis on processes that can further 'social learning' i.e. the systematic learning process among multiple actors who together define a purpose related to the agreed necessity of concerted action at a variety of scales. This process of social learning includes cultural transformation, institutional development and social change. MSP can be a place where social capital is reinforced and farmers could get support from other stakeholders by learning from the group network on best-fit proven technologies and more lucrative markets or could meet, interact and negotiate systemic change.

MSP to support innovation systems

MSP is emerging as a promising mechanism of the innovation system on which stakeholders interact to jointly identify problems, device solutions, implement solutions and evaluate the cycle (Schut et al. 2015). However, such adaptive capacity is needed at all institutional levels – ranging from farmers and rural communities to national government and international organizations. The institutional setting needs to be enabled for the continuing processes of innovation and adaptation that define resilience (Hounkonnou et al. 2012). More recently, platforms (R4D and IPs) are providing alternative spaces for learning and change for individuals with different backgrounds and interests including farmers, traders, food processors, researchers, government officials active along the cassava value chain. The AR4D system is providing proven technologies for cassava production and sustainable natural resource management, but most of the interventions have focused on one dimension of the system, and produced to date relative evidence of scalable success. An integrated innovation system that facilitates interactions across scales and the different dimensions to address the complex problem posed by production efficiency and affordable ecological functions related to food production offers opportunities to respond more effectively to the resilient food systems' challenges. This requires taking into account the 'whole innovation systems' i.e. culture, power, institutions and policies as well as the actors themselves with strong emphasis on processes that further social learning. This means strengthening the systematic learning process among multiple actors who together define a purpose related to the agreed necessity of concerted action at a variety of scales. This also includes cultural transformation, institutional development and social change (Adekunle et al. 2013).

MSP is an arena that promotes knowledge exchange and learning among stakeholders. This may happen through soft-transfer (Paulre 2004), co-creation (Kilelu, Klerkx, and Leeuwis 2013; Schut et al. 2015) or community-based activities at the more operational level (Waters-Bayer et al. 2015). Soft-transfer happens when readily available technologies are pushed to end-user platform members or when research tries to use this strategic position (financial or social) to push his agenda. Soft-transfer processes align with the transfer of technology model and are more used at the inception stage of the MSP. Co-creation processes happen when research scientists and platform members jointly developed objectives and implementation protocols by blending scientific and local knowledge to create new knowledge (Nederlof, Wongtschowshi, and Van der lee 2011; Kilelu, Klerkx, and Leeuwis 2013; Schut et al. 2015). Co-creation requires some time to allow researchers to develop a good understanding of the context, the demand and to build trust with all stakeholders. Community-based research occurs when platform members are empowered to carry out their own research and experiments. They can call upon research scientists to endorse or improve their experiments. This process is well described in literatures using various concepts, such as positive deviant (Pant and Odame 2009), Lead farmer research (Waters-Bayer et al. 2015), endogenous innovation and social innovation (Bock and Fieldsend 2012). Community-based concepts emphasize the primary role of communities within the innovation processes. The three processes correspond respectively to knowledge transfer or internalization, knowledge hybridization and knowledge externalization and can occur simultaneously within MSP depending on the type of activities to be implemented.

The concept of efficiency

A production process involves the transformation of inputs into outputs. In crop production, technical inputs such as planting materials (seeds, stem cuttings, etc.), land, labour and fertilizer are combined to produce the crop. The transformation process depends on the levels of inputs used and the management practices that the farmers use to combine these inputs. Management practices used in production represent an amalgam of networks, knowledge and skills that the farmer has or acquires overtime including farm characteristics. The technical inputs and the management practices jointly determine the quantity and quality of output produced (Sokvibol, Li, and Pich 2016).

Efficiency is the comparison of what quantity is actually produced with what can be achieved with the same consumption of resources (input). Efficiency is a relationship between ends and means, a situation inefficient implies that more of the desired end could be achieved with less means, or that the means employed could produce more of the ends desired. ‘Less’ and ‘more’ in this context necessarily refer to less and more value. Thus, economic efficiency (EE) is measured not by the relationship between the physical quantities of ends and means, but by the relationship between the value of the ends and the value of the means. Farrell (1957) distinguished between three types of efficiencies which are technical efficiency (TE, allocative or price efficiency (AE) and product (TE × AE) that gives the third type known as economic efficiency (EE).

Research methods

Study area and context

Data for this study were collected after two years (2014 and 2015) of farmers' participation to Humidtropics platform-based research that used MSP to achieve agricultural development outcomes in Southwest Nigeria. The farming system in all the communities is dominated by cocoa in smallholdings where men, particularly senior men, occupy central positions. MSPs set up aim to facilitate partnerships and broad stakeholder participation in integrated systems research including both CGIAR and non-CGIAR entities, with particular involvement of local institutions and organizations. These research activities implemented through strategic platforms (R4D) and operational IP (Tenywa et al. 2010; Schut et al. 2015) go beyond individual research action and single component focus. They rather use a new mode of operation that brings groups of partners together to work on commonly identified challenges in a way that goes beyond individual partners' capacities. The implementation of this approach starts with the establishment of an R4D platform composed of representative from farmer organizations, private sector, government, research institutions and civil society. This is followed by the identification of the entry theme by the R4D for research for development interventions in Agriculture. This multi-stakeholder approach through platforms (MSP) used a Rapid Appraisal of Agricultural Innovation Systems (RAAIS) (Schut et al. 2015) to identify entry points, research topics and research questions in sustainable agriculture and natural resource management. IPs, on the other hand, are operational platforms developed to undertake analysis and action research on specific constraints, challenges or opportunities (entry points) identified through the R4D Platform. Researchers and all stakeholders involved in the different platforms (R4D and IP) agree on ways to work together while implementing integrated systems research.

Sampling procedure

A multistage sampling technique was used to select the respondents. The first stage was a purposive selection of two States (Osun and Oyo) out of the three States (Oyo, Osun, Ondo) in Southwestern Nigeria where the Humidtropics sites are located. The second stage was a purposive selection of two Local Government Areas (LGAs) where two Humidtropics IPs have been established in each of the two States, for a total of four LGAs. The third stage was a random selection of four villages in each of the LGAs. The fourth stage involved a random selection of 30 participants and 30 non-participants to the IP cassava farmers in each of the selected village making a sample size of 240 respondents. Participants and non-participants belong to the same LGAs. Only 200 responses comprising 93 participants and 107 non-participants who participated in the interviews were considered for the analysis.

Procedure for data collection

We collected quantitative data through structured and pretested questionnaires. Data collection was focused on socio – economic characteristics such as sex, age and years of formal education of the respondents and the forms of social capital network established. We also gathered data on the quantities and prices of input and output as related to production efficiency in Southwestern Nigeria.

Analytical tools

We used cassava production as a model to test the impact of MSP on livelihood outcomes based on the sustainable livelihood model. We used descriptive and inferential statistics. We mainly focused on social capital as a critical factor for farmers to prosper economically and sustain their development. In doing so, we used descriptive statistics (mean, mode and percentages) to describe the socio-economic characteristics and forms of social capital of cassava farmers. We also used inferential statistics (Stochastic frontier functions and Tobit regression) to determine the efficiency and effect of social capital on the efficiency of cassava production system in Southwestern Nigeria.

Stochastic frontier functions

We used stochastic frontier model (Battese and Coelli 1995) to determine the TEs, AEs and EEs of cassava production influenced by farmers' participation to MSP (Farrell 1957). We use Frontier 4.1. to obtain the maximum likelihood estimates for the Cobb–Douglas stochastic frontier model for cassava production efficiency. We simultaneously estimate the stochastic frontier model and the inefficiency model. Technical efficiency was modelled from Aigner, Lovell, and Schmidt (1977). Allocative efficiency (AE) (Girei et al. 2013) measure how efficient is the relationship between the total production cost and the individual factor cost. EE was computed as an overall performance of the product of Technical Efficiency (TE) and AE i.e. EE = TE * AE.

The empirical production frontier model was calculated based on cassava output (kg); farm size (ha); hired labour (Mandays); family labour (Mandays); fertilizer used (kg); herbicide applied (litre) and planting materials (kg). We also defined the inefficiency model, in term of technical inefficiency using variables such as Age (years), Household size (number), Farming experience (years), Sex (Male = 1, female = 0), Level of education (years) and Land ownership (own land = 1, otherwise = 0). We finally used the stochastic frontier cost function model to analyse the AE of the respondents based on the total cost of production per unit farm measured in Naira (1USD = 359 Naira); the cost of land; the cost of labour and the cost of inputs used such as fertilizer, insecticides, herbicides and stem cuttings.

Tobit regression analysis

We used the Tobit regression analysis to determine the effect of social capital on efficiency of cassava production. The efficiency was generated in the stochastic frontiers estimation computed based on the following equation:

$$E = \alpha_0 + \alpha_1 I_1 + \alpha_2 I_2 + \alpha_3 I_3 + \alpha_4 I_4 + \alpha_5 I_5 + \alpha_6 I_6 + \alpha_7 I_7 + \alpha_8 I_8 + \mu, \quad (1)$$

where E = efficiency, I_1 = Membership in innovation platform (0 = No, 1 = Yes), I_2 = Number of contact with research institutions (#), I_3 = Number of social organization of farmer (#), I_4 = Number of extension visit (#), I_5 = Decision-making in the family on farming (0 = No, 1 = Yes), I_6 = Year of Experience in Farming (years), I_7 = Educational level (years), I_8 = Age (years), $\alpha_{0,}\alpha_{1\,\ldots}\,\alpha_8$ are the parameters to be estimated.

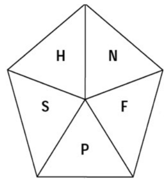
The Sustainable livelihood model was based on the following variables:

Human capital (Ch): the amount and quality of knowledge

Natural capital (Cn): the quality and quantity of natural resources
Financial capital (Cf): savings and regular inflow of money
Physical capital (Cp): infrastructure, tools and equipment
Social capital (Cs): social resources including networks for cooperation using MSP, mutual trust and support.

We estimated LA and pentagon using capitals (C):

$$C = \sum_{n=0}^{n} \frac{I_n}{T_n}$$



where C is the criteria score for each asset ($0 \leq C \leq 1$), n denotes nth indictor of criteria ($n = 1, 2, 3, \ldots n$); I denotes indicator; T denotes the total number of indicators; LA = (Cp + Cn + Ch + Cf + Cs)/5 where LA is LAs; Cp, Cn, Ch, Cf and Cs are the respective capital values of every type of LA; Cp denotes physical capital; Cn denotes natural capital; Ch denotes human capital; Cf denotes financial capital; Cs denotes social capital (Chen et al. 2013).

Limitation to this study

Data used in this study are mainly quantitative with strong focus on agricultural innovation systems (AIS). The study goes beyond context specific technology development to embrace behavioural change in agricultural innovation system thinking with strong emphasis on the importance of multi-stakeholder process (MSP) to help technical advisory services in applying existing knowledge to local situations. In this study, we use the MSP and its instruments that are the R4D and the IP to incentivize change at the grassroots by introducing innovative technologies. In such process, information and advice work in tandem with other institutional mechanisms to influence AIS. Here we argue that behaviour change leading to voluntary action will persist over time as it is more likely to become embedded in social norms. Attempts to incite voluntary action require an understanding of existing behaviours, and how advice can help influence behavioural change. We were not able to consistently document behavioural change following the introduction of new knowledge and technology. We focused our analyses on the role of MSP in social capital and the three processes of knowledge transfer, knowledge hybridization and knowledge externalization which is very innovative in the agricultural innovation system thinking literature.

Results

Socio-economic characteristics of the respondents

The distribution of respondents according to their sex, age, household size and year of experience in farming, level of education of both participants and non-participants to the MSP is shown in Table 1. The result showed that 74% of the respondents were male.

Table 1. Socio-economic characteristics of respondents.

	MSP	
Characteristic	Participants	Non-participants
Age (years)	48.2	44.2
Male (%)	81.8	76.6
Married (%)	92.5	84.1
Education (years)	6.6	7.8
Household Size (#)	8	7
Years of Experience in Farming	26.8	22

Technical efficiency of cassava production

The estimated parameters for production frontier model are summarized in Table 2. These parameters represent changes in the cassava output (kg) as a result of a unit change in the independent variables. They also show the relative importance of these variables to productivity of cassava for the MSP participants and non-participants. The positive and negative coefficients of the estimated parameters showed their relationship with the output. This means that a unit increase in the positive estimated parameters would lead to an increase in cassava output while negative coefficient would generate a reverse relationship with the cassava output.

Three variables have their coefficients significant: farms size of the respondents, labour investment in farm activities and the amount of improved cassava stem cuttings used as planting materials. The coefficient of the farm size for all respondents was −0.798 (significant at $p < .01$) meaning that an increase in farm size by one hectare resulted in a decrease of the output by 79.8% (Table 2). The coefficient of the farm size was negative for the non-participants (−1.814) and positive for the participants (0.623), suggesting that an increase in farm size will result in a decrease of the cassava output for non-participants as

Table 2. Maximum likelihood estimate of TE for cassava production.

	MSP	
Variables	Non-participant coefficient	Participant coefficient
Constant (β_0)	−0.898 (−0.47)	9.513 (4.96)***
Farm size (β_1)	−1.814 (−3.68)***	0.623 (1.18)
Labour (β_2)	0.548 (5.27)***	0.308 (3.37)***
Fertilizers (β_3)	−0.053 (−1.40)	−0.004 (−0.14)
Insecticides (β_4)	0.011 (0.23)	0.098 (1.38)
Herbicides (β_5)	0.029 (0.67)	−0.012 (−0.26)
Stem cuttings (β_6)	2.162 (4.45)***	−0.377 (−0.71)
Inefficiency Model		
Constant (δ_0)	−9.238 (−1.76)*	−0.632 (−0.72)
Age (δ_1)	0.040 (1.67)*	0.037 (1.41)
Household size (δ_2)	−0.184 (−1.59)	−0.085 (−1.01)
Years of experience (δ_3)	0.024 (0.98)	−0.028 (−1.45)
Years of education (δ_4)	−0.105 (−1.79)*	0.098 (1.48)
Sex (δ_5)	5.374 (1.71)*	−1.098 (−2.36)***
Land ownership (δ_6)	−0.311 (−0.48)	−0.309 (−0.97)
Diagnostics Statistics		
Sigma squared (δ^2)	1.622 (2.356)**	0.193 (3.714)***
Gamma (γ)	0.936 (24.970)***	0.366 (1.721)*
Log likelihood function	−59.502***	−39.025***
LR Test	19.235	16.847
Mean Technical Efficiency	0.78	0.87

***Significant level at 1%; **Significant level at 5% and *Significant level at 10%; the figures in the parenthesis are *t*-values.
Source: Data Analysis, 2015.

compared to participants. This result can be explained by the fact that participation to MSP contribute to gain more knowledge and to become more efficient in cassava production. We recorded a coefficient of 0.421 for hours spent on farm (significant at $p < .01$) and a coefficient of 1.103 (significant at $p < .01$) for improved cassava cuttings. All the parameter coefficients used in the inefficiency model was significant at 1% for participants and non-participants. Sex, household size and years of experience recorded a negative coefficient while age, years of education and land ownership have a positive coefficient. This implies that TE depends more on sex, household size and years of experience than on age, years of education and land ownership (Table 2).

AE of cassava production

Estimated parameters for the production frontier model as summarized in Table 3 represent percent change in the total cost as a result of unit change in the independent variables and the relative importance of these variables to resource used in cassava production by MSP participants and non-participants. The coefficient of cost of land renting, the cost of labour, the cost of herbicide and the cost of improved stem cuttings was significant. The cost of renting land with a coefficient of 0.188 (significant at $p < .01$) was positively related to the total cost. This shows that a unit increase in the cost incurred on land rent will result to increase the total cost by 18.8%. Similarly, the cost of improved stem cuttings, labour and herbicides were found to significantly influence the total cost of production by 12.3%, 26.9% and 1.7%, respectively. The years of experience and land ownership of the participant were the significant (at $p < .05$) variables in the inefficiency model. Their positive relationship implies that as the variables increase farmers become inefficient in the allocation of resources (Table 3).

Table 3. Maximum likelihood estimate of stochastic frontier for AE of cassava production.

	MSP	
Variables	Non-participant coefficient	Participant coefficient
Constant (β_0)	4.865 (5.51)***	7.409 (11.53)***
Land rent (β_1)	0.232 (3.43)***	0.136 (3.46)***
Labour cost (β_2)	0.368 (6.47)***	0.064 (1.13)
Fertilizers cost (β_3)	−0.020 (−1.01)	0.021 (1.88)*
Insecticides cost(β_4)	−0.003 (−0.37)	−0.010 (−1.07)
Herbicides cost (β_5)	0.015 (1.69)*	0.023 (2.25)**
Stem cuttings cost (β_6)	0.059 (0.52)	0.171 (2.66)***
Inefficiency Model		
Constant (δ_0)	0.001 (0.00)	0.007 (2.34)**
Age (δ_1)	−0.057 (−0.74)	−0.005 (−0.45)
Household size (δ_2)	0.040 (0.61)	0.002 (0.79)
Years of experience (δ_3)	0.043 (0.71)	0.139 (1.93)**
Years of education (δ_4)	(0.314) (0.59)	0.006 (0.87)
Sex (δ_5)	−0.035 (−0.71)	−0.048 (−0.54)
Land ownership (δ_6)	0.610 (0.61)	0.007 (2.34)**
Diagnostics Statistics		
Sigma squared (δ^2)	0.316 (0.896)	0.077 (8.947)***
Gamma (γ)	0.903 (7.488)***	1.000 (402.974)***
Log likelihood function	−9.749***	−11.608***
LR Test	14.030	17.056
Mean AE	1.316	2.248

***Significant at 1% level of probability; ** Significant at 5% level of probability and *Significant at 10% level of probability; the figures in the parenthesis are *t*-values.
Source: Data Analysis, 2015.

EE of cassava production

The economic efficiencies for all the respondents range from 0.11 for the least efficient farmer to 0.97 for the farmer that attained the highest efficiency, with a mean of 0.833 (Table 4). We noted that 68.2% of non-participants and 73.1% of participants had between 0.71 and 0.90 efficiency score while 29% of non-participants and 14% of participants had above 0.90 efficiency levels. However, the mean EE of non-participant was 0.852 as compared to 0.812 for participants. We observed a significant difference between EE of participants and non-participants to MSP. Non-participants are more efficient than participants in pure cassava farms production while participants to MSP are more economically efficient in cassava farm production in association with other food crops and leguminous species.

Effect of social capital on efficiency of cassava production

Analyses of the effects of social capital on the efficiency of cassava production revealed that the models were good fits with the log – likelihood estimates of −13.97, 368.22 and −10.44 for the TE, AE and EE (chi-square values of 29.06, 28.29 and 26.88, respectively, at $p < .01$) (Table 5). The TE, AE and EE used as dependent variables were censored at their mean values. Those above the mean efficiency were considered as efficient in production of cassava while those below were considered as inefficient. The coefficients of MSP membership were positive and significant at $p < .01$ for all the three types of efficiency (0.136 for TE, 0.0076 for AE and 0.124 for EE). As more farmers become member of the platforms, the TE, AE and EE of cassava production will increase by 13.6%, 0.76% and 12.4%, respectively (Table 5). However, the coefficients of contact with research institutions were negative and significant at acceptable levels. As contact with research institutions increases by one, farmer's TE will decrease by 3.05%, their AE by 0.23% and their EE by 2.86% as a result of poor rural advisory services network to backstop farmers.

Effect of participation to MSP on livelihood outcomes

Participation of farmers to MSP significantly increased their livelihood outcomes in term of social, natural, financial, human and physical capital (chi-square value of 3.732 at $p < .01$). Participants to MSP recorded a social capital asset value of 0.81 as compared to 0.38 for non-participants. Social capital indicators such as frequent interactions with research institutions, access to financial products and services such as personal saving,

Table 4. Maximum likelihood estimate of EE for cassava production.

	MSP		
Efficiency	Non-participant ($n = 107$)	Participant ($n = 93$)	T-test
≤30%	0.0	1.1	
31–50%	0.0	1.1	
51–70%	2.8	10.8	
71–90%	68.2	73.1	
≥91%	29.0	14.0	
Mean	0.852	0.812	2.896***

Source: Data Analysis, 2015.

Table 5. Effects of social capital on cassava production efficiency.

Variables	Technical efficiency Maximum likelihood estimate (β)	*t*-ratio	Allocative efficiency Maximum likelihood estimate (β)	*t*- ratio	Economic efficiency Maximum likelihood estimate (β)	*t*-ratio
MSP Membership	0.136*** (0.0402)	3.39	0.0076*** (0.002)	3.76	0.124*** (0.038)	3.29
No of research institution	−0.0305* (0.0167)	−1.83	−0.0023*** (0.00086)	−2.63	−0.0286* (0.0159)	−1.79
No of social organization	0.0155 (0.0121)	1.28	0.00071 (0.00068)	1.05	0.0157 (0.0119)	1.33
No of extension visit	0.00012 (0.0023)	0.05	0.00005 (0.00013)	0.41	0.0003 (0.0022)	0.14
Involvement decision-making on cassava farming	−0.016 (0.031)	−0.51	0.0012 (0.0017)	0.71	−0.00494 (0.0293)	−0.17
Year of experience in farming	0.0035** (0.0014)	2.49	0.00021*** (0.00008)	2.70	0.0035*** (0.0013)	2.61
Education level	−0.0066** (0.0027)	−2.46	0.00002 (0.00014)	−0.13	−0.0056** (0.0003)	−2.18
Age	−0.0022* (0.0002)	−1.92	0.00003 (0.0006)	−0.51	−0.0023** (0.0003)	−2.13
Constant	0.8969*** (0.0523)	17.14	1.0137*** (0.0291)	348.54	0.897*** (0.0503)	17.83
Sigma	13.6		0.86		13.39	
Chi^2	29.06		28.29		26.88	
Prob > chi^2	0.0003		0.0004		0.0007	
Pseudo R^2	0.5098		−0.0401		0.563	
Loglikelihood	−13.97		368.22		−10.44	

Note: *Significant at 10%; **Significant at 5%; ***Significant at 1%; figures in parentheses represent standard error.
Source: Data Analysis, 2015.

access to training and extension agents; and member of social network for knowledge exchange and collective action was higher for participants compared to non-participants (Table 6). Natural capital asset such as land ownership and land size was significantly ($p < .01$) higher among participants (0.84) than non-participants (0.74) which enhances their chances of applying innovations disseminated using MSP. However, the average value of natural capital did not show a remarkable increase or margin between

Table 6. Effects of MSP participation on LAs.

Capital	Indicators	Participant Weight	Participant Value	Non- participant Weight	Non- participant Value
Social	Social organization	0.80	0.81	0.66	0.38
	No of extension visit	0.85		0.89	
	Contact with research institution	0.91		0.46	
	Training received in cassava production	0.89		0.09	
	Involvement in decision-making on cassava farming activities	0.6		0.09	
Natural	Ownership of land	0.84	0.57	0.74	0.52
	Size of land	0.69		0.7	
	Legume Intercrop effect	0.18		0.11	
Financial	Annual Income	0.71	0.71	0.64	0.68
	Production expenditure	0.73		0.75	
	Living expenditure	0.68		0.66	
Human	Acquired skills in IP activity	0.82	0.77	0	0
	No of training attended	0.72		0	
Physical	Value of Motorcycle	0.68	0.75	0.63	0.71
	Value of radio	0.72		0.7	
	Access to a source of energy (e.g. Electricity, firewood, gas, etc.)	0.84		0.79	
LA			0.72		0.45
Kruskal–Wallis Test			$\chi^2 = 3.732$, $p < .10$		

participants and non-participants. The significant difference in natural capital asset value between participants and non-participants of MSP demonstrate a valuable and structural point for the stakeholders with changes in natural capital for the participants to provide a basis for sustainable livelihood development at the present and in the future. All financial capital indicators of participants to MSP were stronger than that of non-participants (Table 6). Participation to MSP increases the yield and income of participants and allows more investments in agriculture activities. Human capital asset value of non-participants (0.00) was significantly ($p < .010$) lower than that of participants (0.77). Physical capital asset of participants was 0.75 while that of non-participants was 0.71. These were mainly productivity enhancing assets (value of motorcycle, value of radio and access to energy resource) which are strongly correlated with sustainable income generation and livelihood improvements. Sustainable livelihood asset (SLA) comprising all the five capitals (social, natural, financial, human and physical) was found to be tremendously higher among the participants than the non-participants. This was supported by a completed and well-formed pentagon structure for participants than the non-participants (Figure 1).

Discussion

MSP and LA capitals improvement

We showed that sex, education, farming experience and household size are key socio-economic variables with positive impact on the productivity of farmers and livelihood interventions, which is in line with evidence from elsewhere (Bammeke 2003; Makinde et al. 2011; Kuye 2015). Despite the complexity encountered in separating 'difficulties' faced by farmers and 'preferences' made by these farmers, several interesting conclusions

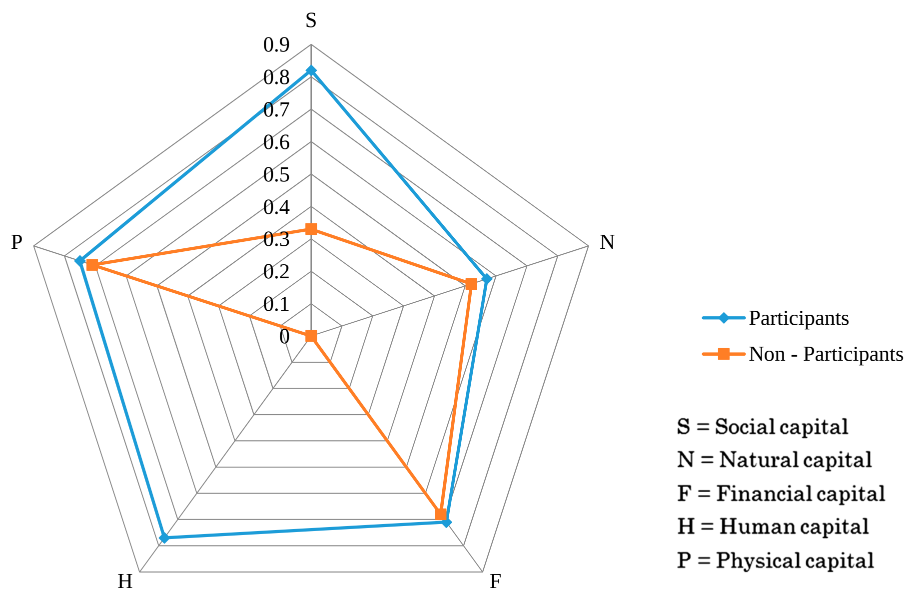


Figure 1. LA pentagon of MSP participants and non-participants.

come out of this study. Generally, agriculture and in particular cassava production was and still remains an underexploited opportunity to generate income and contribute to pro-poor growth in Nigeria. The low participation of women in cassava cultivation though they are equally as productive as men and the non-use of modern technology is some of the factors limiting the exploitation of the opportunities in cassava cultivation. According to farmers, this is due to the absence of adequate government support to cassava farmers as well as the poor AIS also cited by Hounkonnou et al. (2012). Innovation is not simply adopting new technologies. Instead, agricultural innovation is a co-evolutionary process that combines technological, social, economic and institutional changes resulting from multiple interactions between components of farming systems, supply chains and economic systems, policy environments and societal systems (Röling 2009; Klerkx, van Mierlo, and Leeuwis 2012).

We showed that social capital networks of farmers were consistently higher for participants than non-participants, indicating that social network and the value of social capital are more harnessed by virtue of participation in MSP or rural development programmes (Amit 2011; Herrera, Rosas, and Lorcal 2014).

A consistent result of this study is that farm size, expenditure on land preparation in terms of labour and the use of modern technology by participants to MSPs significantly and positively influence TE and productivity. The coefficient of contact with research institutions and extension officers makes the case for better access to researchers and extension services and rural advisory services programmes in new and modern methods of cultivation. In the absence of modern technology, the negative and significant correlation that exists between farm size and productivity is understandable. In addition, cost of improved technology, labour and inputs such as herbicides are the critical costs affecting the AE and productivity. This implies that resources are inefficiently allocated by farmers and call for adequate training programmes on optimum combination of modern input and institutional changes in agriculture. Moreover, the computed result of EE (Table 5) showed an advantage for MSP participants (t-value of 2.896).

MSPs and sustainable livelihood outcomes

Membership to MSPs increases significantly the social capital of the participants. MSP are arenas where farmers, researchers, civil society and NGOs representatives, government and private sector actors meet to discuss and agree on share vision and interventions of mutual benefits with the aim to achieve more co-creation and community-led action research (Mathé and Rey-Valette 2015). The interactions enable researchers to adapt technologies they are proposing to existing local conditions (Argyris and Schoen 2002). For this study, the interactions between researchers and other stakeholders help to build formal and informal relationships that facilitated the contact between different members and the development of mutual trust. This inter-personal trust helps MSP members to formulate their constraints more clearly and to build sense-making from these constraints in well-defined demands. Cassava farmers were able to meet researchers, extension agents and other private sectors' partners more easily than in normal circumstances to discuss and share problems and to acknowledge the benefit of information and knowledge exchange (Adekunle and Fatunbi 2012; Nederlof and Pyburn 2012; Schut et al. 2015). Farmers get support from researchers and extension agents on their problems and negotiate access to market and other credit facilities from the private sectors (Roslan, Russayani, and Nor Azam 2010; Balogun and Yusuf 2011). High financial capital indicators of participants to MSP is explained by the fact that MSP participants receive production incentives such as inputs, skill acquisition and training on less cost-intensive production techniques which have tremendously reduced their production expenditure. In addition to growing cassava, participants to MSP also grow cocoa, maize and vegetables. They also engage in other income-generating activities. MSP activities provided opportunities to participants to acquire livelihood improvement skills through training, participatory trials and demonstrations with positive impact on their attitude and personal development skills and significantly improve their production, economic and allocative efficiency. MSP goes beyond the 'transfer of technologies' (ToT) to support various functions including entrepreneurial activities, knowledge development and knowledge diffusion through networks. MSP also embraces guiding the search of knowledge and market formation, the creation of legitimacy, and counteract resistance to change. These functions all support sustainable livelihood outcomes in AIS (Kilelu, Klerkx, and Leeuwis 2014; Wigboldus et al. 2016).

The Tobit regression (Table 5) showed that social capital affects the TE, AE and EE of farmers in MSP. However, the significant social capital networks variable which include membership to MSP and contact with research institutions have respectively positive and negative relationship with efficiency. This could be explained by the fact that at the start of the MSP soft-transfer of technologies seems to dominate as research institutions try to find solutions to constraints expressed by farmers by going through their portfolio of technologies. This struggle could be constrained by donors to show evidence of dissemination and adoptions of technologies from research results. Along the way, the results of this struggle between researchers and farmers are translated into a joint formulation of demand-driven research questions, trust building and context-specific technologies application aiming at co-creation and then community-based research (Coe, Njoloma, and Sinclair 2016). The common trajectory in group dynamic will start from divergent thinking and eventually reach convergent thinking (Dror et al. 2016). The divergence may have a negative impact on farmer's TE than their AE as our results showed. The convergence may be due to the multiplication of institutional arrangements between researchers and other stakeholders in MSP. At inception, convergence could quickly happen when MSP stakeholders have shared previous experience in co-construction or when MSP is built on existing groups that were already dynamic and driven by their capacity to innovate (Leeuwis et al. 2014). Here, facilitation is key to create genuine interactions and learning processes based on trust, decision-making and the capacity of researchers and other MSP stakeholders to integrate various sources of knowledge to build new ones. This also requires a change in researcher practices through a simple and double loop learning processes guided by a new way of doing research and changes in terms of values (Argyris and Schoen 2002). Facilitators should have the capacity to break down scientific knowledge so that it can be understood, help to collectively analyse the major issues and problems and to clarify the various perspectives and perceptions of participants. This includes prioritization of major issues, identifying what they regard as barriers to success and possible solutions to overcome these problems. This should be followed by capacity building sessions during which participants (all stakeholders) learn how to integrate the various values, belief, perspectives, perceptions and assumptions into a system structure. This learning step is of particular importance in order for all involved to 'take' ownership, develop mutual understanding and co-construction (Leeuwis and Aarts 2011). Overall, this process provides all stakeholders with a better understanding of each other's mental model and to develop a shared understanding and trust (Nederlof, Wongtschowshi, and Van der lee 2011; Kilelu, Klerkx, and Leeuwis 2013). Therefore, the role of social capital on farmer efficiencies is critical in achieving sustainable livelihood outcomes.

Conclusion

The LA of MSP participants was found to be significantly higher than that of the non-participants as they participate in MSP for research and development. Participation of farmers in MSP should be institutionalized in AR4D and more extension follow-up services should be provided so as to adequately and appropriately unleash the potentials in social capital networks for improved productivity and livelihood. The TE, AE and EE of farmers indicate their low efficiency technically and economical while they are inefficient in allocating their limited resources. The stochastic frontier production function estimates showed that labour, farm size and use of improved planting materials were critical inputs for productivity while for the cost function estimates labour, farm size, use of herbicides and improved planting materials are the critical factor cost. The role of social capital on efficiency estimated using Tobit regression showed that membership in MSP increases the production efficiency while in contrast increase in the number of interactions with research institutions reduces the production efficiency, and this may be due to soft-transfer of technologies at inception. But at maturity, the results of this struggle between researchers and farmers would lead to co-reaction and community-based research. This requires more investments in multi-stakeholder approaches such as on the one evaluated in this study to enable the development and effective dissemination of agriculture innovations, thus fostering pro-poor growth and livelihoods.

Note

1. Integrated Systems Research in the Humid Tropics where research adopts a systems approach, encompassing the full range of intervention points from soil–plant–water-livestock relationships to markets and value chains as well as on cross-cutting issues such as gender and youth, policies and institutions and capacity development.

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References

Adekunle, A. A., and A. O. Fatunbi. 2012. "Approaches for Setting-up Platforms for Agricultural Research and Development." *World Applied Sciences Journal* 16 (7): 981–988.

Adekunle, A. A., A. O. Fatunbi, A. Agumya, F. Kwesiga, and M. P. Jones. 2013. "Maximizing Impact from Agricultural Research and Development: Potentials for Integrated Agricultural Research for Development (Forum for Agricultural Research in Africa [FARA])." http://www.faraafrica.org/media/uploads/docs/iar4d_proof_of_concep.pdf.

Aigner, D. J., C. A. K. Lovell, and P. Schmidt. 1977. "Formulation and Estimation of Stochastic Frontier Production Function Models." *Journal of Econometrics* 6: 21–37.

Amit, K. 2011. Enhancement of Social Capital Through Participation in Micro-Finance: An Empirical Investigation. MPRA Paper No. 39221.

Argyris, C., and S. Schoen. 2002. *Apprentissage organisationnel. Théorie, méthode, pratiques*, 380. Paris: DeBoeck University.

Ashby, J. A., T. Gracia, M. P. Guerrero, C. A. Quirós, J. I. Roa, and J. A. Beltran. 1995. "Institutionalizing Farmer Participation in Adaptive Technology Testing with the CIAL." Agricultural Research and Extension Network, Network Paper 57, Overseas Development Institute, London.

Balogun, O. L., and A. S. Yusuf. 2011. "Effect of Social Capital on Welfare of Rural Households in South – Western States Nigeria." *Journal of American Science* 7 (3): 48–59.

Bammeke, T. O. A. 2003. "Accessibility and Utilization of Agricultural Information in the Economic Empowerment of Women Farmers in South Western Nigeria." Ph.D. thesis, Department of Agricultural Extension and Rural Development, University of Ibadan, Nigeria, 120.

Battese, G. E., and T. J. Coelli. 1995. "A Model of Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data." *Empirical Economics* 20: 325–332.

Bisseleua, D. H. B., and A. Degrande. 2017. "Approaches to Operationalizing Integrated Systems Research." In *Sustainable Intensification in Smallholder Agriculture: An Integrated Systems Research Approach*, edited by I. Oborn, B. Vanlauwe, M. Phillips, R. Thomas, W. Brooijmans, and K. Atta-Krah, 99–105. London: Earthscan Food and Agriculture, Routledge.

Bock, B. B., and A. Fieldsend. 2012. "Social Innovation and Sustainability; How to Disentangle the Buzzword and Its Application in the Field of Agriculture and Rural Development." *Studies in Agricultural Economics (Budapest)* 114 (2): 57–63.

Bourdieu, P., and L. Wacquant. 1992. *An Invitation to Reflexive Sociology*. Chicago, IL: University of Chicago Press.

Chen, H., T. Zhu, M. Krott, J. F. Calvo, S. P. Ganesh, and I. Makoto. 2013. "Measurement and Evaluation of Livelihood Assets in Sustainable Forest Commons Governance." *Land use Policy* 30 (1): 908–914.

Coe, R., J. Njoloma, and F. Sinclair. 2016. "Loading the Dice in Favour of the Farmer: Reducing the Risk of Adopting Agronomic Innovations." *Experimental Agriculture* 1–17. doi:10.1017/S0014479716000181.

Collion, M. H., P. Rondot, F. Kiriro, and A. Roeleveld. 1997. "Partnership between Agricultural Services Institutions and Producer Organizations: Myth or Reality." In *Shaping Effective Collaboration among Stakeholders in Regional Agricultural Research and Development in Sub-Saharan Africa*, edited by H. Enserink, A. Cisse, F. Kiriro, and A. Roeleveld. Amsterdam: Royal Tropical Institute (KIT).

Dror, I., J. Cadilhon, M. Schut, M. Misiko, and S. Maheswari. 2016. *Innovation Platforms for Agricultural Development: Evaluating the Mature Innovation Platforms Landscape*, 220. London: EarthScan, Routledge.

Farrell, M. J. 1957. "The Measurement of Productive Efficiency." *Journal of the Royal Statistical Society. Series A (General)* 120 (3): 253–282.

Girei, A., B. Dire, M. M. Iliya, and M. Salihu. 2013. "Analysis of Impact of National Fadama II Facility in Alleviating Poverty on Food Crop Farmers in Adamawa State, Nigeria." *Global Journal of Agricultural Research* 1 (3): 8–15.

Gretzinger, S., H. Hinz, and W. Matiaske. 2010. "Cooperation in Innovation Networks: The Case of Danish and German SMEs." *Management Revue* 21 (2): 193–216.

Hemmati, M. 2002. *Multi-stakeholder Process for Governance and Sustainability: Beyond Deadlock and Conflict*. London: Earthscan.

Herrera, M. S. P., R. P. E. Rosas, and M. B. F. Lorcal. 2014. “Social Capital, Social Participation and Life Satisfaction among Chilean Older Adults.” *Revista de Saúde Pública* 48 (5): 739–749.

Hounkonnou, D., D. Kossou, T. Kuyper, C. Leeuwis, S. Nederlof, N. Röling, O. Sakyl-Dawson, M. Traore, and A. van Huis. 2012. “An Innovation Systems Approach to Institutional Change: Smallholder Development in West Africa.” *Agricultural Systems* 108: 74–83.

Kilelu, C. W., L. Klerkx, and C. Leeuwis. 2013. “Unravelling the Role of Innovation Platforms in Supporting co-Evolution of Innovation: Contributions and Tensions in a Smallholder Dairy Development Programme.” *Agricultural Systems* 118: 65–77.

Kilelu, C. W., L. Klerkx, and C. Leeuwis. 2014. “How Dynamics of Learning are Linked to Innovation Support Services: Insights From a Smallholder Commercialization Project in Kenya.” *The Journal of Agricultural Education and Extension* 20 (2): 213–232.

Klerkx, L., B. van Mierlo, and C. Leeuwis. 2012. “Evolution of Systems Approaches to Agricultural Innovation: Concepts, Analysis and Interventions.” In *Farming Systems Research Into the 21st Century: The New Dynamic*, edited by I. Darnhofer, D. Gibbon, B. Dedieu, and D. Dordrecht, 457–483. Berlin: Springer.

Kuye, O. O. 2015. “Comparative Analysis of Constraints to Cassava Production by Cassava Farmer Loan Beneficiaries and Loan non-Beneficiaries in South-South Nigeria.” *Global Journal of Agricultural Research* 3 (3): 38–52.

Leeuwis, C., and N. Aarts. 2011. “Rethinking Communication in Innovation Processes: Creating Space for Change in Complex Systems.” *The Journal of Agricultural Education and Extension* 17 (1): 21–36.

Leeuwis, C., M. Schut, A. Waters-Bayer, R. Mur, K. Atta-Krah, and B. Douthwaite. 2014. *Capacity to Innovate from a System CGIAR Research Program Perspective*. Program Brief: AAS-2014-29. Penang: CGIAR Research Program on Aquatic Agricultural Systems.

Makinde, A. A., N. J. Bello, F. O. Olasantan, M. A. Adebisi, and H. A. Adeniyi. 2011. “Seasonality and Crop Combination Effects on Growth and Yield of Two Sorghum (Sorghum bicolor) Cultivars in Sorghum/Maize/Okra Intercropin a Forest-Savanna Transition Zone of Nigeria.” *Agricultural Journal* 6 (3): 92–99.

Mathé, S., and H. Rey-Valette. 2015. “Local Knowledge of Pond Fish-Farming Ecosystem Services: Management Implications of Stakeholders’ Perceptions in Three Different Contexts (Brazil, France and Indonesia).” *Sustainability* 7 (6): 7644–7666.

Nederlof, S., and R. Pyburn. 2012. “Introduction: Enhancing Innovation.” In *One Finger Cannot Lift a Rock: Facilitation Innovation Platforms to Trigger Institutional Change in West Africa*, edited by N. Nederlof and R. Pyburn, 3–14. Amsterdam: KIT.

Nederlof, S., M. Wongtschowshi, and F. Van der lee. 2011. *Putting Heads Together: Agricultural Innovation Platforms in Practice*. The Netherlands: KIT.

Norman, D., and K. Atta-Krah. 2017. “Systems Research for Agricultural Development: Past, Present and Future.” In *Sustainable Intensification in Smallholder Agriculture: An Integrated Systems Research Approach*, edited by I. Oborn, B. Vanlauwe, M. Phillips, R. Thomas, W. Brooijmans, and K. Atta-Krah, 19–22. London: Earthscan Food and Agriculture, Routledge.

Ologbon, O. A. C., S. D. Idowu, and O. Oyebanjo. 2013. “Effect of Social Capital on the Technical Efficiency of Arable Crop Farmers in Ibarapa Area of Oyo State, Nigeria.” *Ibadan Journal of Agricultural Research* 9: 234–243.

Oxoby, R. 2009. “Understanding Social Inclusion, Social Cohesion, and Social Capital.” *International Journal of Social Economics* 36 (12): 1133–1152.

Pant, L. P., and H. H. Odame. 2009. “The Promise of Positive Deviants: Bridging Divides between Scientific Research and Local Practices in Smallholder Agriculture.” *Knowledge Management for Development Journal* 5 (2): 160–172.

Paulre, B. 2004. “L’analyse évolutionniste contemporaine du changement technique et de l’innovation. CLES.” *Cahiers Lillois d’économie et de sociologie*: 43–44.

Roslan, A., I. Russayani, and A. Nor Azam. 2010. “The Impact of Social Capital on Quality of Life: Evidence from Malaysia.” *European Journal of Economics, Finance and Administrative Sciences* 22: 113–123.

Röling, N. 2009. “Conceptual and Methodological Developments in Innovation.” In *Innovation Africa, Enriching Farmers’ Livelihoods*, edited by P. C. Sanginha, A. Waters-Bayer, S. Kaaria, J. Njuki, and C. Wettasinha, 9–34. London: Earthscan.

Schut, M., L. Klerkx, M. Sartas, D. Lamers, M. Mc Campbell, I. Ogbonna, P. Kaushik, K. Atta-Krah, and C. Leeuwis. 2015. “Innovation Platforms: Experiences with Their Institutional Embedding in Agricultural Research for Development.” *Experimental Agriculture* 52 (4): 1–25.

Schut, M., A. van Paassen, C. Leeuwis, and L. Klerkx. 2014. “Towards Dynamic Research Configurations: A Framework for Reflection on the Contribution of Research to Policy and Innovation Processes.” *Science and Public Policy* 41: 207–218.

Sokvibol, K., H. Li, and L. Pich. 2016. “Technical Efficiency and Its Determinants of Rice Production in Cambodia.” *Economies* 4 (22): 1–17.

Tenywa, M. M., K. P. C. Rao, J. B. Tukahirwa, R. Buruchara, A. A. Adekunle, J. Mugabe, C. Wanjiku, et al. 2010. “Agricultural Innovation Platform As a Tool for Development Oriented Research: Lessons and Challenges in the Formation and Operationalization.” *Learning Publics Journal of Agriculture and Environmental Studies* 2 (1): 117–146.

van Mierlo, B., M. Arkesteijn, and C. Leeuwis. 2010. “Enhancing the Reflexivity of System Innovation Projects with System Analyses.” *American Journal of Evaluation* 31 (2): 143–161.

Waters-Bayer, A., P. Kristianson, C. Weitasinha, L. Veldhuizen, G. Quiroga, K. Swaans, and B. Douthwaite. 2015. “Exploring the Impact of Farmer-led Research Supported by Civil Society Organizations.” *Agriculture & Food Security* 4 (4): 2–7.

Weick, K. E., K. M. Sutcliffe, and D. Obstfeld. 2005. “Organizing and the Process of Sensemaking.” *Organization Science* 16 (4): 409–421.

Wigboldus, S., L. Klerkx, C. Leeuwis, M. Schut, S. Muilerman, and H. Jochemsen. 2016. “Systemic Perspectives on Scaling Agricultural Innovations.” *A Review of Agronomy & Sustainable Development* 36 (46): 2–20.