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Impact Assessment Report of YIIFSWA Project

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

B.D. Mignouna, N. Maroya, B. Aighewi, L. Kumar, T. Abdoulaye, A.A. Akinola, P. Otabil, H. Braimah, A.D. Alene, V.M. Manyong and R. Asiedu

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Acronyms and abbreviations

AEZ	Agroecological zone
ATE	Average treatment effect
ATT	Average treatment on treated
ATU	Average treatment on untreated
AYMT	Adapted Yam Minisett technique
BMGF	Bill & Melinda Gates Foundation
CRS	Catholic Relief Services
DD	Difference-in-Differences
DS	Derived Savanna
ECASARD	Ecumenical Association for Sustainable Agricultural and Rural Development
FAOSTAT	FAO Statistical Databases
FFS	Farmer field school
FGT	Foster, Greer, and Thorbecke
GPS	Global Positioning System
HF	Humid forest
ICT	Information and Communications Technologies
IE	Impact evaluation
IITA	International Institute of Tropical Agriculture
MoFA	Ministry of Food and Agriculture
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 Agro Ventures
SGS	Southern Guinea Savanna
YIIFSWA	Yam Improvement for Income and Food Security in West Africa
YMT	Yam minisett technique

Executive Summary

This document reports the changes which occurred as result of the intervention of 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 order to identify the opportunities of 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 2011-2016. The vision for the project's first five years is to increase by 40% the yam productivity (yield and net output) for 200,000 smallholder yam farmers in Ghana and Nigeria, and deliver key global good research products that will contribute to the longer-term vision of improving yam productivity and livelihoods of yam dependent farmers.

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

The objectives of the evaluation were to:

(i) Assess the results and the current status of the project in order to promote accountability, and;

(ii) Extract lessons learnt and prepare recommendation to enhance the design, implementation, operation and management of a possible project's second phase or other similar future projects.

To achieve the above objectives, the study methodology included a review of existing documents, field observations, focused 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 used for this endline survey with the same total of 600 sample households consisting of participating and non-participating households from the same yam growing areas of Ghana targeted at the baseline. Therefore, same survey questionnaires used for the baseline were administered by trained enumerators 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 YIIFSWA project had on rural farm households' income and food security and how this has contributed to the reduction of poverty in Ghana. We started by documenting the rate of AYMT adoption and awareness among the sampled farmers. The result showed that the AYMT adoption rate was about 43%, while the awareness rate was 87%. Furthermore, the proportion of adopters among the exposed / aware farmers was half confirming that awareness / exposure is important in achieving a high rate of adoption. Therefore, policy and programmes that would further increase the farmers' awareness were recommended.

The summary statistics of households' asset ownership shows that the project has significantly contributed to the possession of more assets, at the endline compared to the pre-project, as well as for the treated compared to the non-treated. The yield differential shows higher yam output.

This implies that adoption of AYMT and benefits from other interventions lead to increase in food security, and generate a reduction in poverty. Additionally, the result of the FGT poverty measures confirms the potential of the project to curb poverty in rural areas of Ghana and among the farming households as it reveals that poverty indices are higher among the non-beneficiaries than the project beneficiaries. Results show that adoption of AYMT resulted in poverty reduction among rural population by 10% points, translating into 25,040 individuals being lifted out of poverty in the country. This is consistent with the findings in several studies which demonstrated that adoption of agricultural technologies helped to reduce poverty levels. This serves to set the roadmap for a second phase aims at developing and proving a functional, commercial seed yam seed system in Ghana as a guarantee to lower more the prevalent poverty situation in rural areas of Ghana and among the households.

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 less than two acres. Several constraints limit realization of the full potential of the crop and thereby its contribution to the livelihoods of small-holder producers.

Consultations with stakeholders and value chain actors carried out in the preparation of this project proposal 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.

This project aims in the next five years to: (a) increase yam productivity (yield and net output) by 40% for 200,000 small-holder yam farms (90% with less than 2 acres) in Ghana and Nigeria; and (b) deliver key global good research products that will contribute to the 10-year vision of doubling incomes from yams for 3 million small-holder farming families who depend on yams in West Africa, and contribute to food security for producers and consumers. Specific key innovations that contribute to the required increase in productivity in Ghana and Nigeria include: (a) ensuring the sustainable availability of high quality seed yams on a commercially viable, price competitive basis capable of increasing yield by at least 50%; (b) 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 testing of the system for aeroponic culture of yam, developed within YIIFSWA, with agencies in the public and private sectors in Ghana and Nigeria.

To accomplish this goal, the Project aimed to achieve 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 postharvest losses and improve product quality.
- Develop technologies for high ratio propagation of high quality breeder and foundation seed yam.
- Evaluate and scale-out yam production technologies with improved and local popular varieties.
- Identify more effective prevention and management tools and strategies for pests and diseases.

These objectives are being supported by cross-cutting components: Project leadership, partnership and management, monitoring, evaluation, and learning, and communication and information dissemination.

For more details on YIIFSWA project, an interested reader is referred to YIIFSWA working Paper No 1 by Maroya et al. (2014a).

After an external mid-term review, the initial seven objectives of the project were repackaged into two major components. One is the seed component, which deals with the development of the formal and informal seed yam systems. It focuses on establishment of sustainable seed system through the reduction of postharvest losses, development of technologies for high ratio propagation of high quality pre-basic and basic seed yam, and identification of more effective tools and strategies for the prevention and management of pests and diseases. The second component (leadership, governance, and partnerships) includes project monitoring, evaluation, and learning; communication and information dissemination; project coordination, partnerships and management, as well as the evaluation and scale-out of production technologies using new and local popular varieties.

YIIFSWA project participants were expected to significantly increase their agricultural productivity and income by improving yield using improved technology and especially with focus here on Adaptive Yam Minisett Technique (AYMT). Based on these hypotheses, we focused our evaluation on the following expected outcomes and associated impact indicators (Table 1).

The project has just ended and its impact evaluation (IE) is rooted within broader monitoring and evaluation systems which provide a core set of tools that stakeholders can use to focus on results. Borrowing from the OECD-DAC Glossary (2002), the most widely shared definition, of "impact is considered as change, positive and negative, primary and secondary, produced by a development intervention, directly or indirectly, intended or unintended". Impact occurs at multiple levels and different time frames (short-term, medium term, and long-term) resulting from an intervention and the context. 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 that are attributable to a defined intervention, attempting to establish whether the intervention has made a difference in the lives of people.

Mostly, impact evaluations are conducted for two main purposes, (i) accountability comparing and reflecting costs and effects on final outcomes such as income and poverty. (In YIIFSWA case that are attributed to investments) and, (ii) learning: exploring how well or poorly a particular intervention works and relates to 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 essential tools for learning and for accountability. However, they are not the right tools for every project. They should be used selectively, with a special focus on where the potential for learning is greatest.

Table 1. Project expected outcomes.

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

The purpose of the evaluation is to assess a project in order to: (i) improve its future design and plans through feedback of lessons learned; and (ii) promote a basis for accountability, including the provision of information to the public.

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

- document adoption of the project promoted technologies and assess factors affecting their adoption;
- estimate the early impacts, positive and negative, primary and secondary that result from the project;
- assess the direct and indirect contribution of the project on smallholder yam farmers, whether intended or unintended, and;
- Draw lessons from the project that may be useful in the design and implementation of a second phase or other 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 gives an introduction to the study. Section Two presents the approach and methodology used for the study, while Section Three describes the changes in socio-economic 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 of the study.

Approach and Methodology

This section provides the details of the evaluation in terms of collection methods and instruments, and applied statistical analysis. The approach and methodology used for the 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 of the project design, and were built into project implementation. Baseline data were collected prior to implementation for both treatment and control groups (Mignouna et al. 2014). Prospective 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 a before and after comparisons 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 as to complete the 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 after the baseline study. The survey is necessary for calculating the impact estimators and is 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 total of 600 households based on the same sampling frame. Anyone interested in more details can read Mignouna et al. (2016).

As Table 2 shows, the total number of households included beneficiaries and non-beneficiaries. The village and communities' non-beneficiaries were chosen such that they were comparable in terms of biophysical and socioeconomic characteristics (ethnicity, farming systems, etc.). The Table 2 gives information about the districts and communities, and numbers of farmers' beneficiaries and non-beneficiaries' households surveyed, while Figure 1 shows a spread of the surveyed sites.

Estimation of Benefit/Participation in YIIFSWA Project

The concept of benefit/participation relates to who takes part in the variety of agricultural products and services such as input development, distribution, trainings, and demonstrations as stated in the paragraph below. The households' participation leading to a certain benefit in the project is dichotomous, involving two mutually exclusive alternatives. The household either benefited or not.

This survey was a sampling of the same respondents from the original baseline survey, conducted in 2012 (see Mignouna et al. 2014). A list of all households existing in the surveyed communities as of 2012 made up the sampling frame. The treatment variable T takes a value of 1 if a household benefited from the project (treatment group) and 0 otherwise (control group). As presented in Table 2, the survey covered 600 households, of which 500 treated households (general treatment) and 100 in the control/comparison group, while Figure 1 shows a spread of the surveyed sites.

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

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

Table 2. Household sampling by treatment.

Districts	#Communities selected	#Households selected		Total Hhs
		Treatment	Control	
Ejura	16	76	20	96
Atebubu	21	116	10	126
Kintampo	30	134	46	180
East Gonja	23	116	22	138
Mion	10	58	02	60
Total	100	500	100	600

NB. Hhs = households

The surveyed areas in Ghana are therefore depicted in Fig. 1.

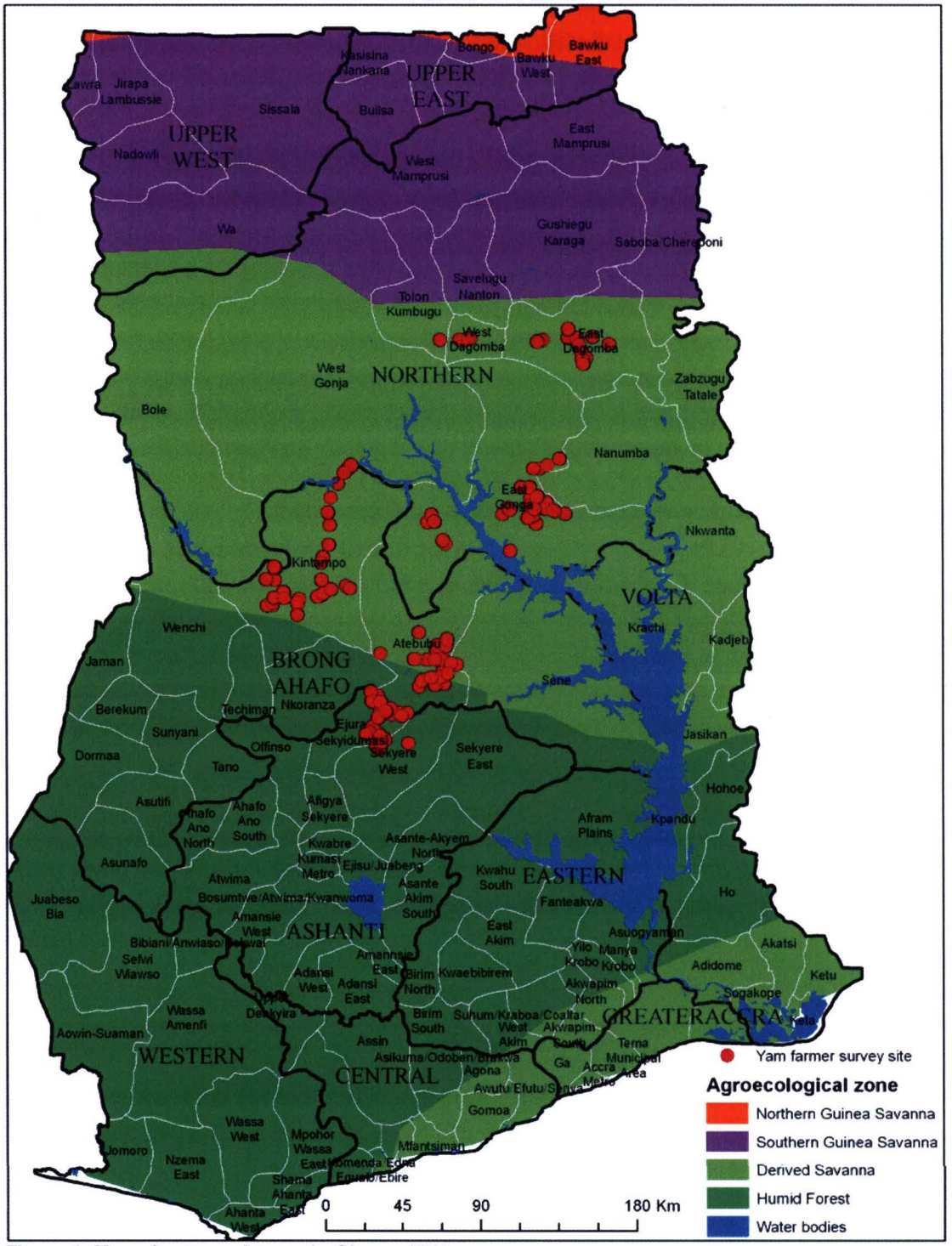

Figure 1. Map of surveyed areas in Ghana, 2016.

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 before for the baseline survey was used to estimate the sample size (Mignouna et al. 2014).

Therefore, the endline survey targeted the same total of 600 sample households consisting of participating and non-participating households and was conducted at the end of the second semester 2015 and beginning 2016 in Ghana.

Same prepared survey questionnaires as for the baseline (Mignouna et al. 2014) were administered by trained enumerators through personal interviews and field measurement. The surveys were conducted in the same project areas as they were 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 7 by Mignouna et al. 2016.

Data collection instruments

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

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 production-based indicators: yields, productivity, technology adoption, income, changes in food for home consumption. Collecting information of this type can be challenging, beginning with the definition of the sample unit: in fact, while production is often linked to multiple plots and crops, the decision-making process takes place at the household level. While the full logic of an agricultural project should be considered, certain indicators can be more readily attributed to a given project and an IE focuses on these results. Projects may also contribute to achieve some wider scope results, such as a reduction in poverty rates, which may be very difficult to attribute to the project. Additionally, different indicators require being measured and estimated at distinct time intervals. For instance, the adoption of new practices is often a short-run measure while 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 AYMT demonstration plots relating to intermediate outcomes such as knowledge acquisition, adoption and diffusion of technology, and final outcomes such as output (tonnes), agricultural yields (output/ha), household income, and poverty status, food security and poverty status and output (tonnes).

The structured questionnaires were administered by enumerators under supervisors, all trained in different methodology workshops which were organized by IITA M&E team. More details could be found in YIIFSWA working paper No 7 (Mignouna et al. 2016). The trainings were followed by pre-testing questionnaires and subsequently were modified based on feedback received.

Field data collection, data entry and database management

A field data collection schedule was then developed with the assistance of agents from the Ministry of Food and Agriculture (MoFA) to organize teams and assign villages/communities per geographic

position. After a preliminary tour of one week organized in surveyed areas to set the potential enumerators' recruitment process, 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 the 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, are used to identify impact. For YIIFSWA, the quasi-experimental design is used.

Difference-in-Differences Approach

The Difference-in-Differences (DD) approach is one of the most popular non-experimental techniques in IE since it allows controlling for some types of selection in a straight forward 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 name[1]. 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 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 difference-in-differences or double-difference estimator.

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

Table 3. The Difference-in-Differences (DD) 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
			$DD = (\Delta T - \Delta C)$

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

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 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, 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 reaching 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, its allow for higher gross output and is recommended to producers as package including AYMT and the associated best management practices. We focus however here on the "seed" component of the technology, for two reasons. First, much of IITA-funded research consists of the development of better planting materials. Second, 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 evaluated rigorously and there is a lack of panel data which could be utilized to empirically trace adoption since the 1980s. Moreover, several studies which have attempted to address the areas (Ironkwe et al. 2007; 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 evidently convincing (Aighewi et al. 2002). This technology has not been adopted by farmers, and 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.

More details on 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 could be found in the project working paper No 7.

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 adoption choice of 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 "0" otherwise. Then, the response probability by household i (*Pi*) can be expressed as follows.

$$Pi = F(zi) = F(\beta xi) = \{1 /[1+ exp(-zi)]\} = [exp(zi)] / [1 + exp(zi)]$$

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

$$zi = \beta 0 + \beta 1\, xi1 + ... + \beta k\, xik + \varepsilon i$$

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). It was hypothesized that a farmer's decision to adopt or reject a technology at any time is 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

Farming experience (EXP) measured in terms of the number of years since a respondent started farming on his own. The experience of the farmer is likely to have a range of influences on adoption. 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 over vital production resources than women 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. It is expected, therefore, that a larger household size will affect positively the decision of adopting AYMT.

Also, large households have higher demands that motivate the adoption of new farm technologies in order 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 on having a large 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 the technique not well known. Thus, 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 hence reduce the urgency of adopting new technology. Therefore, a negative relationship was hypothesized between land and AYMT adoption.

Institutional Factors

Access to extension visits (NEXT): it was hypothesized that access to extension agents received by a farm would increase farmers' likelihood of accepting AYMT after increasing farmers' exposure to awareness. Therefore, access to extension contact was hypothesized to have a positively influence on farmer's adoption of AYMT.

Membership to a social group (MBER): belonging to a social group enhances social capital allowing trust, idea 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 centre significantly and positively influence the adoption decision of improved maize.

Data analysis

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

Data analysis at the first level made use of computations which generated secondary variables such as indices and yields and more on a number of aggregate measures of poverty could be found in the project working paper No 7 for any interested reader.

Estimation of number of poor lifted out of poverty

The actual number of individuals lifted out of poverty as result of adopting AYMT is estimated following Dontsop-Nguezet et al. *Forthcoming* and Feleke et al. 2016.

$$N_{ind} = \left[\frac{P_r * N_h * P_s}{P_f} \right] * H_s$$

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 socioeconomic characteristics of households at the endline survey are covered and presented in reference to the baseline.

Selected characteristics of sampled households

The main characteristics of sample households are related to the distribution of heads of households by gender, age and 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 anticipated.

The Fig. 2 summarizes the results of baseline and endline surveys by general household characteristics. Due to the brief lapse of time between the two surveys and that the same households were visited we did not expect to see major changes in such demographic characteristics. The different characteristics are expected to remain relatively constant over time, as not necessarily dependent on the project intervention.

At the end of the project the family heads had almost the same average age compared with the baseline. More household heads have attended school with a slightly higher number of years of schooling from 2.7 to 2.9 years at the last round compared to the pre-project. Regarding the sex of the household head, the percentage of male household heads continues to be majority and increasing as characteristic of most of the African rural households. Experience in yam growing has increased from about 23 to 25 years from baseline to endline. Also, the average household size indicating the availability of the household labour supply has slightly increased between the study periods. These changes are due to reasons like illness, death or other reason for heads to be replaced by younger and more literate ones. These changes might relate to the replacement of prime age adults that alter the household composition.

In general, socio-economic household characteristics did not change significantly between both assessment periods though positive changes that were reported could certainly be associated to the project interventions.

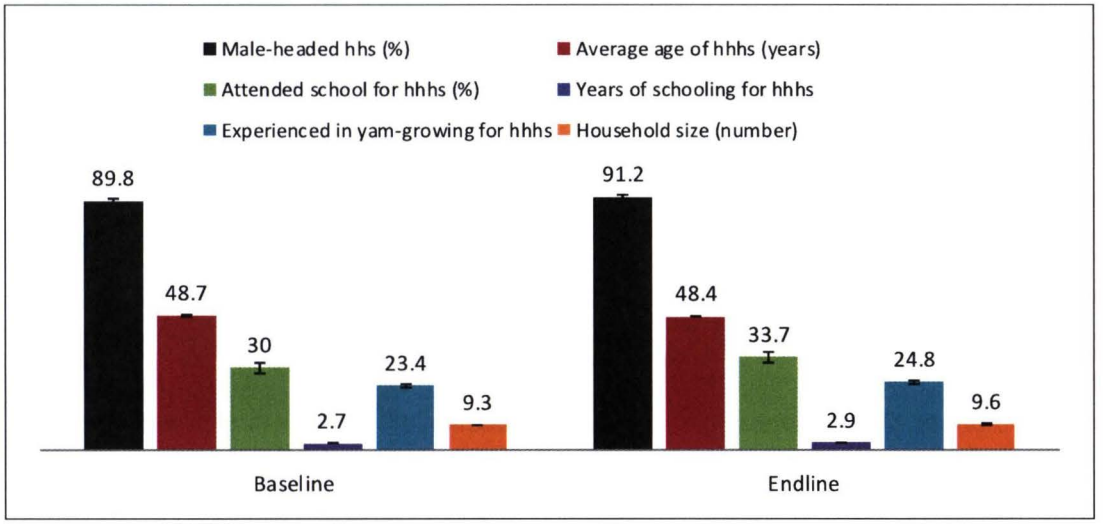

Figure 2. Households' characteristics, baseline and endline survey rounds.

Changes in Livelihood Assets/Capitals

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

Changes in land allocation

Land is one important factor of production influencing livelihood of farmers. Land use issue plays an important role in Ghana as a substantial majority area of the country is under agriculture which employs substantial majority of Ghana population. The change in farming system, such change in land use, can affect farmer livelihoods and farmer's livelihoods strategies.

The average farm sizes in the study area are presented (Fig. 3). A striking finding shown in Fig. 3 is the disparity between the minimum and the maximum farm sizes. The total own land allocated to crops has increased between the baseline and endline and new forest lands suitable for yam production in terms of high fertility soil, low incidence of yam pests and diseases, and the availability of yam stake trees are being used under a shifting cultivation system.

In general, the average farm sizes in the project area shows large disparities among farming households and the total farming land has increased as a result of add up of share of lands under yam. Land under yam increases and such changes in land would have been required for yam cultivation as rational decision following potential yield gains experienced from interventions introduced by YIIFSWA project.

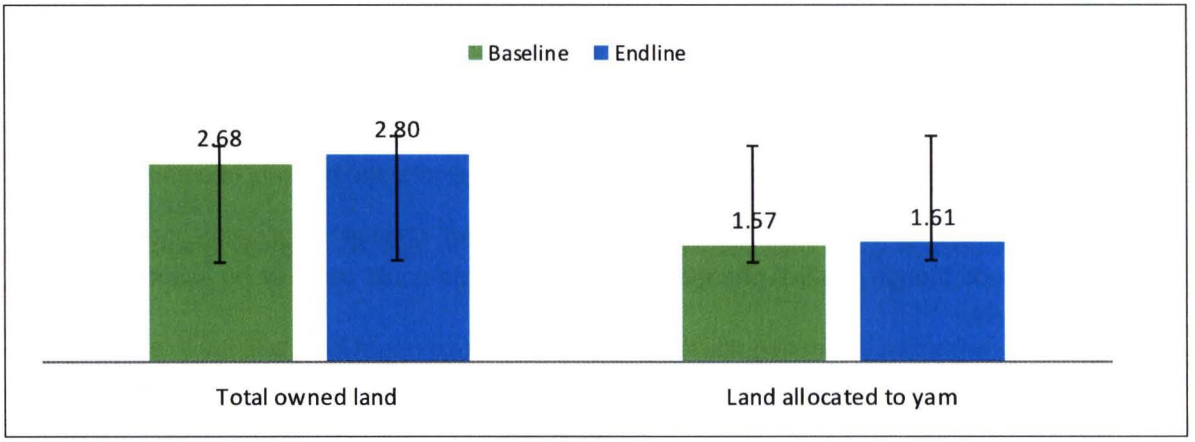

Figure 3. Changes in land holding (ha).

Changes in housing conditions

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

Regarding the main walling material of main residential houses in the surveyed areas, important positive changes are observed. From the pre-project to the end, households have increased of 5% points from 6% to 11% with concrete blocks; 6% points from 4% to 10% with unburned bricks; 1% point for mud bricks. On the other hand, noticeable reduction of households is reported of 12% points from 20% to 8% using pole and mud. Also, fewer households used stick and grass, and iron sheet (Fig. 4).

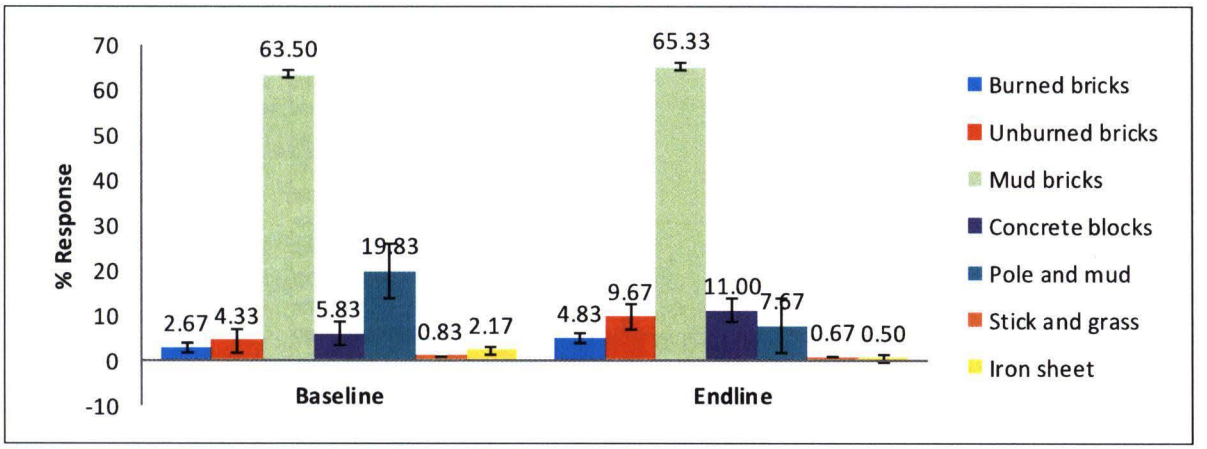

Figure 4. Changes in distribution of households per main walling material.

Noticeable reduction of households living in houses built with poor walling materials is reported against increasing households using better materials like concrete blocks during the project period.

The type of roofing is a good indicator of improvement of housing conditions. Proportion of households using grass thatched during endline as compared to baseline has reduced of 20% points from about 60% to 40% while proportion of households using iron sheets increased of the same level (Fig. 5). This translates that important proportion of households used grass thatched before replaced them with iron sheets. Moreover, few households have started the use of tiles during the project period.

Important improvements on house roofing of main residential houses in the surveyed areas are reported after the project interventions.

About sanitation, proper excreta disposal and minimum levels of personal and domestic hygiene are essential for protecting public health. Safe excreta disposal and handling is being achieved through different types of sanitary toilet facilities existing in the surveyed areas. More households used ordinary pit latrine private and shared during endline as compared to baseline. More importantly the proportion of households without toilet reduced of 11% points from about 67% to 56% (Fig. 6).

Good changes are depicted from the surveyed areas regarding the sanitation toilets used in the surveyed areas. More households have access to sanitation toilets after the project implementation. The project might have contributed to the improvement of sanitation, and hygiene practices of the target population.

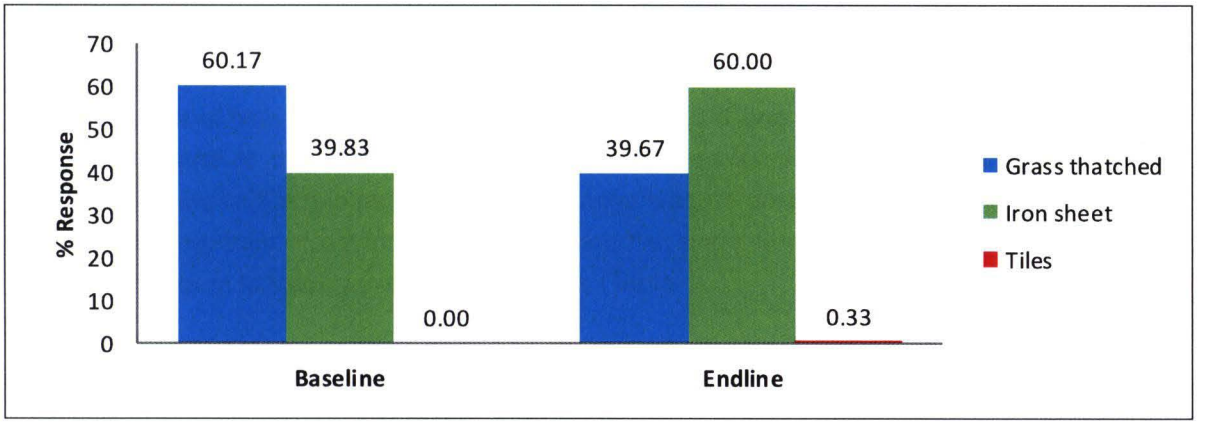

Figure 5. Changes in main roofing material of main residential house.

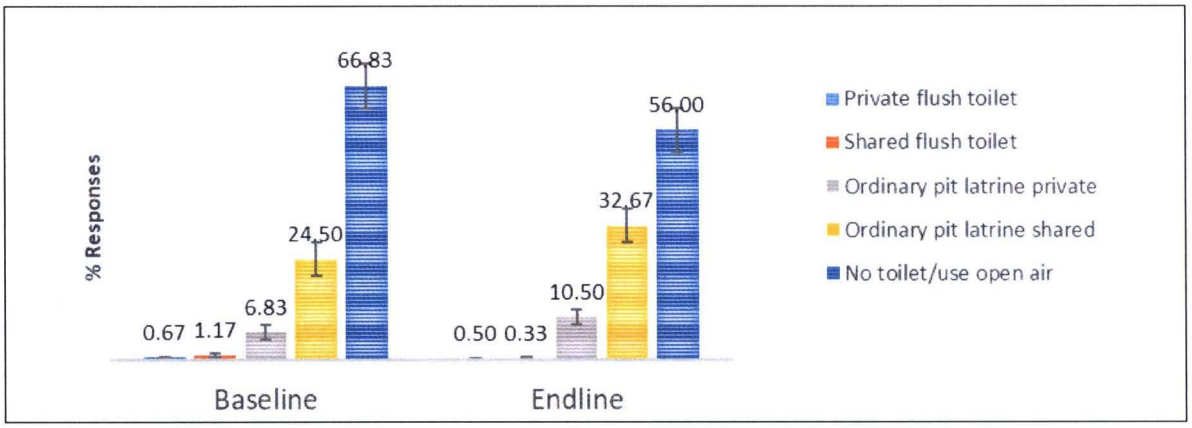

Figure 6. Changes in distribution of households per types of sanitation.

The results show that positive changes were made regarding the housing conditions in the project target areas. This might not bse unconnected with the project as contributing factor.

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 agricultural and non-agricultural assets currently owned by the farming households. The most common productive assets possessed by the households are hoes and cutlasses. For such farming implements this is understandable, as these are required for productive activities. Possession by the households of chairs, tables and beds, seemed higher compared with any other household utility. Certain types of assets including jewellery, radio, are identified as wealth indicators followed by others like axes, sprayers and cellphones. It might be expected that better-off households accumulate such items. Households' possession of items like tractor, stove, grain mill is negligible while other household assets such as car, cart, fish pond are inexistent.

In conclusion, households covered in the study still relied on hand implements in their farming activities and significant changes in different assets or household items are reported in the next section.

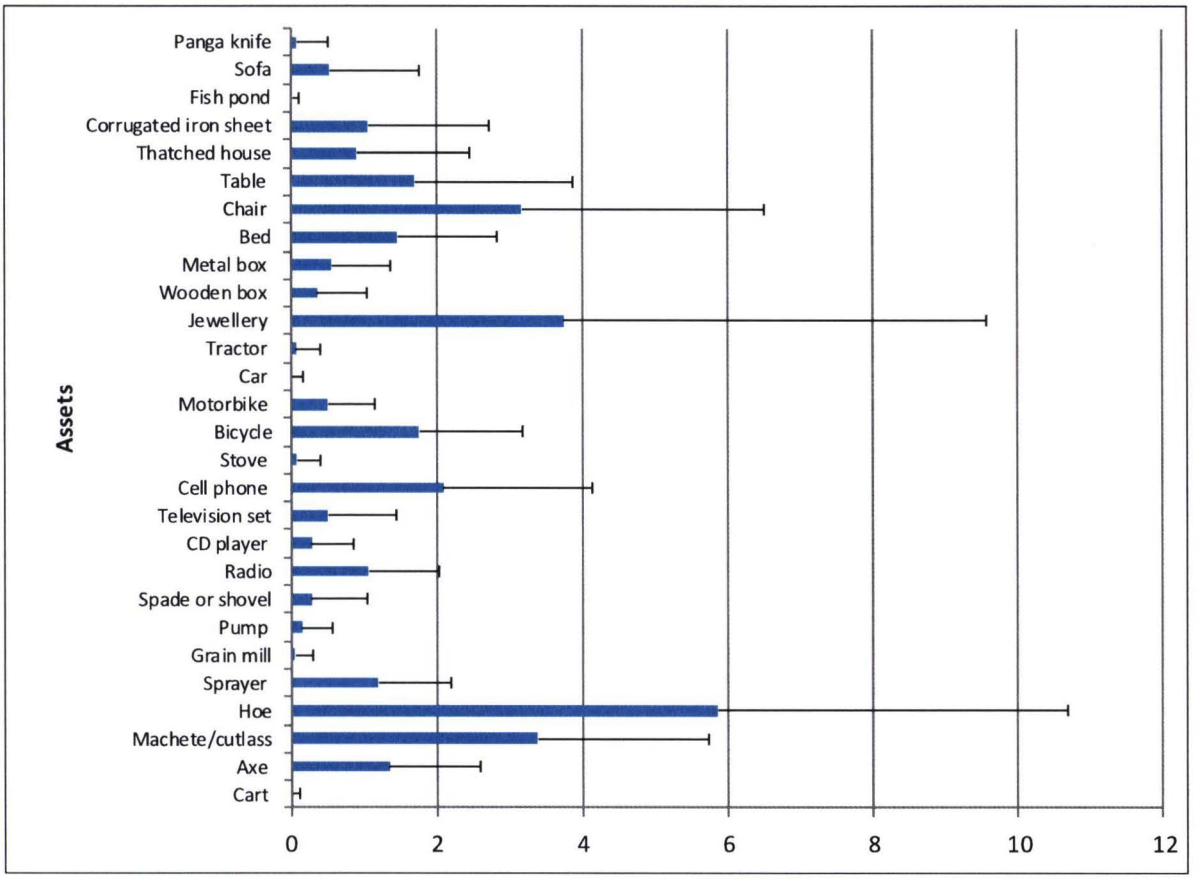

Figure 7. Household assets ownership.

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 among households in the various AEZs. This approach is based on the idea that treated and control households may have experienced overall 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 differ from the changes of other households.

The following Tables 4, 5, 6, & 7 compare household agricultural assets of interest of the treated with the control. Some agricultural assets were found to be significantly different among the control and the treated.

Changes were observed with the farm equipment in the pooled sample (Table 4). The total reported number owned of hoe and sprayer increased between 2011 and 2015 for participants in YIIFSWA project compared to non-participants (Table 4). Some equipment like axe, machete and spade decreased between the two periods but the change was not statistically significant except for the axe. Other categories of equipment such as cart, fish pond were not accompanied with enough degree of freedom to make assertive statements (Table 4).

Table 4. Farm equipment.

AEZ	Outcome variable	Cart	Axe	Machete	Hoe	Spade	Sprayer	Fish pond
All (N=600)	Baseline							
	Control	0.00	0.82	3.32	6.30	0.15	1.59	-0.00
	Treated	-0.00	1.50	3.42	4.58	0.33	1.17	0.00
	Diff (T-C)	-0.00	0.68*	0.10	-1.72	0.18	-0.42	0.00
	Endline							
	Control	0.04	1.48	3.85	5.37	0.22	1.33	0.00
	Treated	0.01	1.41	3.37	5.85	0.31	1.39	0.01
	Diff (T-C)	-0.03	-0.07	-0.48	0.48	0.09	0.05	0.01
	Diff-in-Diff	-0.03	-0.75*	-0.58	2.20	-0.10	0.47	0.01
SGS (N=12)	Baseline							
	Control	0.00	2.00	2.00	4.00	-0.00	1.00	0.00
	Treated	0.00	2.00	2.00	4.00	-0.00	1.00	0.00
	Diff (T-C)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Endline							
	Control	0.00	1.82	3.73	8.36	0.09	0.91	0.00
	Treated	0.00	1.82	3.73	8.36	0.09	0.91	0.00
	Diff (T-C)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Diff-in-Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DS (N=438)	Baseline							
	Control	-0.00	0.63	3.22	5.70	0.18	1.08	0.00
	Treated	0.00	1.50	3.38	3.88	0.50	1.25	-0.00
	Diff (T-C)	0.00	0.87**	0.16	-1.83	0.32	0.17	-0.00
	Endline							
	Control	0.05	1.21	3.32	5.53	0.26	1.21	-0.00
	Treated	0.01	1.33	3.11	5.86	0.25	1.12	0.01
	Diff (T-C)	-0.04	0.12	-0.21	0.33	-0.01	-0.09	0.01
	Diff-in-Diff	-0.04	-0.75	-0.36	2.15	-0.33	-0.26	0.01
HF (N=150)	Baseline							
	Control	0.00	1.69	3.77	9.08	-0.00	1.46	0.00
	Treated	-0.00	1.33	4.00	6.67	0.00	1.00	0.00
	Diff (T-C)	-0.00	-0.36	0.23	-2.41	0.00	-0.46	0.00
	Endline							
	Control	0.00	2.13	5.13	5.00	0.13	1.13	0.00
	Treated	0.02	1.61	4.07	5.62	0.48	1.53	0.00
	Diff (T-C)	0.02	-0.51	-1.05	0.62	0.35	0.41	0.00
	Diff-in-Diff	0.02	-0.16	-1.28	3.03	0.35	0.87	0.00

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

Main productive assets like hoe owned by the households increased in number substantially among the participants than non-participants after the intervention.

Regarding the other farm equipment and housing appliances, some level of increase in household assets due to YIIFSWA's intervention had been experienced. All other farm and housing appliances except CD player and pump have increased as result of YIIFSWA intervention (Table 5) and change in assets ownership varies across AEZs.

Table 5. Other farm equipment & housing appliances.

AEZ	Outcome variable	Pump	Grain mill	Radio	CD Player	TV set	Cell phone
All	Baseline						
	Control	0.30	0.07	0.88	0.19	0.22	1.48
	Treated	0.08	-0.00	0.83	0.17	0.25	1.58
	Diff (T-C)	-0.22	-0.07	-0.04	-0.03	0.03	0.10
	Endline						
	Control	0.19	0.04	0.67	0.33	0.44	2.04
	Treated	0.13	0.06	1.12	0.30	0.56	2.21
	Diff (T-C)	-0.05	0.02	0.47**	-0.03	0.11	0.17
	Diff-in-Diff	0.16	0.09	0.50	-0.01	0.08	0.07
SGS	Baseline						
	Control	0.00	-0.00	3.00	-0.00	-0.00	3.00
	Treated	0.00	-0.00	3.00	-0.00	-0.00	3.00
	Diff (T-C)	0.00	0.00	0.00	0.00	0.00	0.00
	Endline						
	Control	0.00	0.09	1.46	0.36	0.46	4.55
	Treated	0.00	0.09	1.46	0.36	0.46	4.55
	Diff (T-C)	0.00	0.00	0.00	0.00	0.00	0.00
	Diff-in-Diff	0.00	0.00	0.00	0.00	0.00	0.00
DS	Baseline						
	Control	0.27	0.07	0.95	0.15	0.18	1.42
	Treated	0.13	-0.00	0.63	0.25	0.25	1.25
	Diff (T-C)	-0.14	-0.07	-0.33	0.10	0.07	-0.17
	Endline						
	Control	0.16	0.05	0.58	0.37	0.37	2.11
	Treated	0.16	0.07	1.06	0.28	0.54	2.08
	Diff (T-C)	0.00	0.02	0.48**	-0.09	0.17	-0.03
	Diff-in-Diff	0.15	0.09	0.80**	-0.19	0.11	0.14
HF	Baseline						
	Control	0.46	0.08	0.54	0.39	0.39	1.77
	Treated	0.00	0.00	0.67	0.00	0.33	2.00
	Diff (T-C)	-0.46**	-0.08	0.13	-0.39	-0.05	0.23
	Endline						
	Control	0.25	0.00	0.88	0.25	0.63	1.88
	Treated	0.06	0.02	1.28	0.35	0.61	2.37
	Diff (T-C)	-0.19	0.02	0.40	0.10	-0.01	0.50
	Diff-in-Diff	0.27	0.09	0.28	0.48	0.04	0.27

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

Many more other farm equipment & housing appliances owned by the households have increased more substantially among the participants than non-participants after the intervention.

Regarding other consumer durables except stove and motorbike, they increased because of the project's interventions (Table 6). However, there was yet to be any significant difference in productive assets owned before and after the project among the participants and non-participants.

Table 6. Other consumer durables.

AEZ	Outcome variable	Panga knife	Stove	Bicycle	Motorbike	Car	Tractor	Jewelry
All	Baseline							
	Control	0.08	0.07	1.43	0.56	-0.00	0.03	4.82
	Treated	-0.00	0.17	1.50	0.67	-0.00	0.00	3.17
	Diff (T-C)	-0.08	0.10	0.08	0.11	0.00	-0.03	-1.66
	Endline							
	Control	0.00	0.04	1.15	0.59	0.00	0.00	4.85
	Treated	0.09	0.09	1.87	0.50	0.03	0.08	3.54
	Diff (T-C)	0.09	0.05	0.72**	-0.10	0.03	0.08	-1.31
	Diff-in-Diff	0.18	-0.05	0.64	-0.20	0.03	0.11	0.34
SGS	Baseline							
	Control	-0.00	0.00	3.00	2.00	0.00	0.00	-0.00
	Treated	-0.00	0.00	3.00	2.00	0.00	0.00	-0.00
	Diff (T-C)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Endline							
	Control	0.27	0.00	2.64	1.00	0.09	0.00	6.55
	Treated	0.27	0.00	2.64	1.00	0.09	0.00	6.55
	Diff (T-C)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Diff-in-Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DS	Baseline							
	Control	0.08	0.03	1.50	0.55	0.00	0.03	4.65
	Treated	-0.00	0.00	1.63	0.50	-0.00	0.00	4.75
	Diff (T-C)	-0.08	-0.03	0.13	-0.05	-0.00	-0.03	0.10
	Endline							
	Control	-0.00	0.05	1.37	0.63	-0.00	-0.00	4.68
	Treated	0.10	0.08	1.88	0.48	0.02	0.06	3.11
	Diff (T-C)	0.10	0.03	0.52	-0.16	0.02	0.06	-1.58
	Diff-in-Diff	0.18	0.06	0.39	-0.11	0.02	0.09	-1.68
HF	Baseline							
	Control	0.08	0.23	1.08	0.62	0.00	-0.00	5.62
	Treated	0.00	0.67	0.67	0.67	-0.00	0.00	0.00
	Diff (T-C)	-0.08	0.44*	-0.41	0.05	-0.00	0.00	-5.62
	Endline							
	Control	0.00	-0.00	0.63	0.50	0.00	0.00	5.25
	Treated	0.06	0.12	1.75	0.51	0.02	0.14	4.49
	Diff (T-C)	0.06	0.12	1.13**	0.01	0.02	0.14	-0.76
	Diff-in-Diff	0.14	-0.32	1.54	-0.04	0.02	0.14	4.86

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

All assets related to house and furniture owned except chair and corrugated house in Table 7 increased among the treated and the control before and after YIIFSWA's intervention. On average, there was a statistically significant increase for only thatched house (Table 7).

As shown in Tables 4 to 7 above, more assets were owned as a result of project interventions in Ghana implying that the project has started contributing to the livelihoods of the farming households.

In summary, the livelihood impacts shown by the positive changes of most of the household assets between the beginning of the project and the time of the survey are the echo of the project interventions.

Table 7: House and furniture.

AEZ	Outcome variable	Wooden box	Metal box	Bed	Chair	Table	Sofa	Thatched house	Corrugated roofed house
All	Baseline								
	Control	0.27	0.41	1.14	2.01	1.30	0.56	1.00	0.73
	Treated	0.08	0.17	1.25	3.50	1.08	0.42	0.42	1.67
	Diff (T-C)	-0.19	-0.24	0.11	1.49	-0.22	-0.15	-0.58	0.94*
	Endline								
	Control	0.48	0.37	1.19	2.85	1.11	0.48	0.56	1.15
	Treated	0.37	0.61	1.54	3.37	1.82	0.54	0.93	1.10
	Diff (T-C)	-0.11	0.24	0.35	0.52	0.71*	0.06	0.37	-0.05
	Diff-in-Diff	0.08	0.49	0.24	-0.97	0.93	0.20	0.96*	-0.99
SGS	Baseline								
	Control	-0.00	1.00	2.00	2.00	0.00	2.00	1.00	1.00
	Treated	-0.00	1.00	2.00	2.00	0.00	2.00	1.00	1.00
	Diff (T-C)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Endline								
	Control	0.18	1.00	2.27	2.73	1.91	0.46	0.82	0.73
	Treated	0.18	1.00	2.27	2.73	1.91	0.46	0.82	0.73
	Diff (T-C)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Diff-in-Diff	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DS	Baseline								
	Control	0.25	0.42	1.22	1.95	1.18	0.65	1.05	0.77
	Treated	0.13	-0.00	1.38	3.38	1.13	0.38	0.50	1.75
	Diff (T-C)	-0.13	-0.42	0.16	1.43	-0.06	-0.28	-0.55	0.98
	Endline								
	Control	0.63	0.47	1.21	3.11	1.00	0.47	0.53	1.42
	Treated	0.35	0.64	1.44	3.27	1.89	0.43	0.91	1.10
	Diff (T-C)	-0.29*	0.17	0.23	0.16	0.89	-0.04	0.39	-0.32
	Diff-in-Diff	-0.16	0.58	0.08	-1.26	0.95	0.23	0.94	-1.30*
HF	Baseline								
	Control	0.39	0.39	0.77	2.31	1.85	0.15	0.77	0.54
	Treated	0.00	0.33	0.67	4.33	1.33	0.00	0.00	1.67
	Diff (T-C)	-0.39	-0.05	-0.10	2.03	-0.51	-0.15	-0.77	1.13
	Endline								
	Control	0.13	0.13	1.13	2.25	1.38	0.50	0.63	0.50
	Treated	0.46	0.49	1.73	3.71	1.63	0.85	0.98	1.11
	Diff (T-C)	0.34	0.37	0.61	1.46	0.25	0.35	0.36	0.61
	Diff-in-Diff	0.72	0.42	0.71	-0.57	0.77	0.50	1.12	-0.52

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

Changes in Livelihood contexts and Strategies

This section assesses changes in livelihood contexts and strategies among yam-growing households in Ghana 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. Technology adoption as a consistent process is the basic to enabling doubtful users to successfully adopt and use technology. There is no perfect definition of technology adoption. This is mostly due to the remarkable variability in types of technology and conditions under which people adopt them. Adoption can have several definitions but is important to have an agreed one so that the criteria for measurement are acceptable to all concern. A simplistic definition of adoption is basically the use of a technology (Langyintuo 2008). Rogers (2003) defines rate of adoption as the relative speed with which an innovation is adopted by members of a social system. The rate of adoption is the percentage of farmers who have adopted a given technology (Nkonya et al. 1997). Per Van den Ban and Hawkins (1988), the rate and pattern of adoption of innovations vary per type of crop, location and specific innovation. There are several definitions of an adopter which also vary widely across studies depending on the complexity of technology at hand. For 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). Armed with 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 technology acceptance through to usage.

Farmers' knowledge and practices before and after the intervention by the project were assessed in Ghana to estimate the influence of the technology awareness, knowledge and understanding. Yam farmers were asked if they were aware of the AYMT that had been promoted by the YIIFSWA project. Few (less than 5%) heard of it before the project entailing to have heard the technology promoted for more than three decades ago but could not been adopted (Figure 8). An important proportion of households was aware of the adaptive technology introduced and vigorously promoted by the project and about 43% of households surveyed planted the technology while the awareness rate was about 87%. Furthermore, the proportion of adopters among the exposed/aware farming households was about half confirming that awareness/exposure is important in achieving a high rate of AYMT adoption.

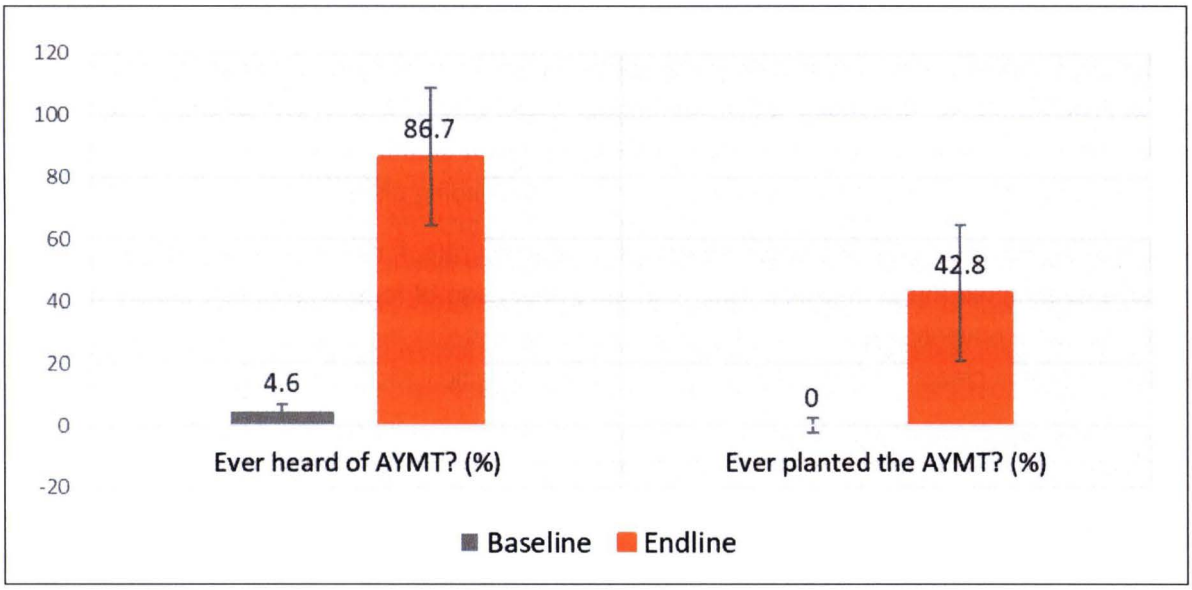

Figure 8: Percentage distribution of households by awareness and adoption of AYMT.

Disaggregating the endline data on a gender perspective basis (Fig. 9,) female-headed households have been less active in terms of technology awareness and adoption. Moreover, they have low representation in the sampled households.

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

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

We will further investigate these differences and findings to be published to inform whoever might be interested in such results.

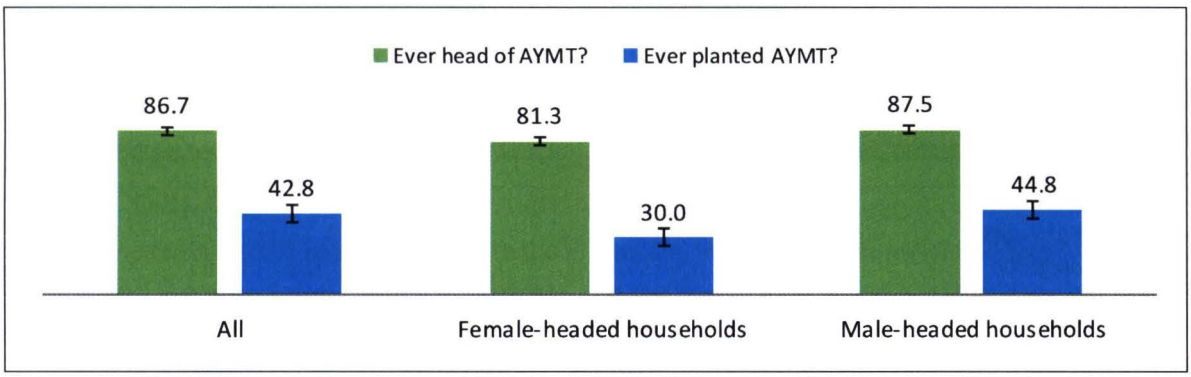

Figure 9. Distribution of households by awareness and adoption of AYMT by gender.

Adoption of AYMT from project target areas

No adoption was reported at the baseline study and with the endline data, great variation in the rate of AYMT adoption is noticed within the project target areas. The AYMT adoption rate in the whole sample as shown in Table 8 is about 43% as revealed earlier meaning that the adoption of technology had made an important headway with Mion as leading district.

In Ghana, the adoption of AYMT is portrayed by the adoption rate. A bit less than half of the sample households adopted the technology. This is a good prediction of formalizing seed supply system to reverse the conventional production system in dominance in the region for farmers to make headway towards cleaning their seed banks for better production and productivity.

Table 8. AYMT Adoption rate by district.

DISTRICT/COUNTRY	Estimated population (2010)	AYMT Adoption rate (%)	# AYMT Beneficiaries (Individuals)	# AYMT Beneficiaries (Households)
0	1	2	3=(1*2)/100	4=3/Hh size
Ghana	585,126	42.8	250,434	26,928
Ejura/Sekyedumasi	85,446	42.7	36,485	3,923
Atebubu-Amantin	105,938	42.8	45,341	4,875
Kintampo	176,480	33.3	58,768	6,319
East Gonja	81,812	43.5	35,588	3,827
Mion	135,450	65.0	88,043	9,467

Sources of information on AYMT

Households that were aware of the AYMT were further asked about where they had learnt about the technique. Table 9 captures the responses. The most important source of information (about 67%) is IITA along with its contracted NGOs. This could be a result of the ability of these households to have face-to-face contact with these sources. It is also that they participate and observe the field demonstrations conducted. Moreover, these sources allow a two-way process of communication. Sources like local leaders, friends from other communities and government extension from MoFA who were directly in touch with farmers are also important in farmers' exposure. The other sources are in minority or inexistent.

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

Source of information	All	SGS	DS	
N	600 (518)	12 (11)	438 (371)	150 (136)
Government extension	19.5	36.4	17.5	23.5
Farmers' coop/group	0.8	0.0	0.5	1.5
IITA, NGOs	66.8	54.6	69.6	60.3
CRI, GLDB	1.9	0.0	2.2	1.5
Seed company/grain stockist	0.2	0.0	0.3	0.0
Relative/neighbor	5.2	0.0	5.4	5.2
Radio/newspaper/TV	1.0	0.0	1.1	0.7
Others	4.6	9.1	3.5	7.4

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

Institutional sources 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 the impact.

Reasons for non-adoption of AYMT

The perception of farmers gave an insight into the factors likely limiting the adoption. Apart from the households who planted and which were not aware, others responded to this question and gave a number of reasons for their non-adoption. Other reasons like chemical availability, fear of technology failure, conventional practice being better were the most important reasons for non-adoption (Fig. 10). This was followed by non-availability of the technology, lack of technical know, lack of cash/credit to acquire the technology satisfaction with the current technology and lack of associated skills. Analyses have shown that many households were aware of the technology. Therefore, there is a need to address potential constraints to their uptake. Approaches should include linking them with credit providers; change their mentality about the existing technologies and facilitating training on requisition of relevant skills.

There is a need to address potential constraints to their uptake trough effective mass communication strategies as significant predictors of the decision to adopt AYMT.

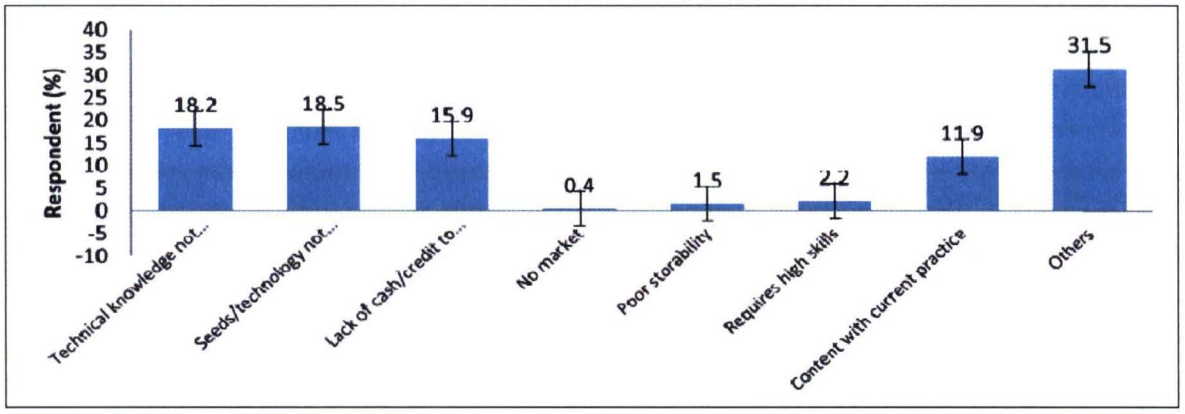

Figure 10. Reasons for non-adoption of AYMT.

Determinants of Adoption of AYMT

Understanding the factors influencing technology adoption helps us predict and manage who adopts, when, and under what conditions. The adoption of new technologies, particularly in subsistence farming is affected by a complex set of determinants such as farm-specific, institutional and technology-related factors.

The study uses a logistic model to estimate the probability that a given household adopts AYMT. The *p-value* and the associated *chi-square* indicate that the model as a whole is statistically significant and has a good fit.

Two out of eight explanatory variables tested were significant in explaining the adoption of AYMT (Table 10). The significant variables were yam faming experience of household head and membership of social group. The positive association of yam farming experience and adoption indicates that the more experienced farmers become in yam growing, the greater the chances of adopting AYMT. Similar relation was found with the membership of social group. The two main factors had significant influence on AYMT adoption. Adoption increased with farmers' membership to social group, and yam farming experience.

Table 10. AYMT adoption determinants.

Variable	Coef.	Std. Err.	z	P>|z|
Household specific factors				
EXP	0.041631	0.020912	1.99	0.047*
EDUC	-0.03445	0.056612	-0.61	0.543
GEN	1.076299	1.30138	0.83	0.408
HSIZE	-0.08946	0.051283	-1.74	0.081
Farm specific factors				
FSIZE	-0.01248	0.093808	-0.13	0.894
Institutional factors				
MBER	1.658634	0.471788	3.52	0.000***
ACCESS_EXT	0.186451	0.560693	0.33	0.739
DIST_LMRKET	0.001349	0.00311	0.43	0.664
constant	-2.17337	1.414062	-1.54	0.124

Model summary	
Model	Logit
Dependent variable	AYMT Adoption
Number of observations	115
Software used	STATA
LR chi^2 (df)	22.59 (8)
Prob > chi^2	0.0039
Pseudo R^2	0.1440
Log likelihood function	-67.1552

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

Experience in yam farming and membership to social group are responsible for increasing the probability of AYMT adoption. This suggests strengthening of social group and facilitation of farming households into networks will stimulate and sustain the promotion and dissemination of the technology for increased update and enhanced livelihood impacts.

Changes in yield

The impact of YIIFSWA interventions including AYMT on total yam productivity was assessed by comparing productivity differential between the baseline and the endline. Because during the two surveys the same 600 households were surveyed under the same conditions in the same area and period, the likely source of productivity variation was the interventions through YIIFSWA project.

Incremental yield estimates from recall-based information

Yam harvests were estimated using farmers' memory recall on the quantity/number of tubers harvested. The average weight of a randomly sampled series was captured in respective surveyed area at the end exactly as done during the baseline (Mignouna et al. 2014).

The Table 11 indicates that the mean productivity at the endline is higher than that in the past amounting to about 13% productivity advantage in Ghana. This confirms the positive contribution in yam output from adopting AYMT and other YIIFSWA research options. The positive change has been reduced in DS due to weather conditions in some of the areas. A key factor in production is weather and drought occurred in much of the areas within DS. As community leaders indicated, losses were often catastrophic for yam. Since the drought affected some villages, the impact is expected to lower production across the zone, explaining the yield differential in DS.

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

Country	AEZ	Yield (t ha^{-1})		Difference	
		Baseline	Endline	t ha^{-1}	%
Ghana	All	6.8 (6.9)	7.7 (6.4)	0.9	13.2
	SGS	5.4 (7.7)	5.8 (5.7)	0.4	7.4
	DS	7.6 (7.2)	6.9 (6.0)	-0.7	-9.2
	HF	4.4 (4.9)	9.9 (7.0)	5.5	125

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

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 exact procedure at the end exactly as done during the baseline (Mignouna et al. 2014).

Yield from the field measurement at the endline was higher than that at the baseline (Table 12). The difference reflects positive contribution of YIIFSWA project with weather pressure to explain the situation painted in DS.

An attempt was made to disaggregate results by AEZ however the observations with respect to SGS were not accompanied with enough degree of freedom to make assertive statements. Therefore, this was dropped.

In conclusion, yam yields measured were higher than those reported through recall-based information and for the endline than that at the baseline. This might not be unconnected with the freshness of tubers with high water content and farmers' inability to recall accurately. The difference could also be linked to farmers milking pattern. Most farmers milked their fields before actual harvests. This procedure leaves an unaccounted substantial part of their harvests on the fields which were not taken into consideration in yield estimation.

The yam yield has increased due to YIIFSWA's interventions on a pooled sample and in all AEZs (Table 13) translating the positive difference between the control and treated groups.

Table 12. Incremental yield from field measurement between baseline and endline.

Country	AEZ	Yield (t ha^{-1})		Difference	
		Baseline	Endline	t ha^{-1}	%
Ghana	All	18.2 (8.7)	21.1 (8.9)	2.9	15.9
	DS	20.3 (8.3)	19.9 (8.5)	-0.4	-2.0
	HF	12.2 (7.1)	24.8 (9.8)	12.6	103.3

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

Table 13. Yield difference-in-differences estimation results.

AEZ	Outcome variable	Yield	S. Err.	t	P>|t|
All (N=600)	Baseline				
	Control	7741.46			
	Treated	6502.54			
	Diff (T-C)	-1.2e+03	2004.15	-0.62	0.54
	Follow-up				
	Control	7357.48			
	Treated	7693.08			
	Diff (T-C)	335.597	1271.99	0.26	0.79
	Diff-in-Diff	1574.51	2373.73	0.66	0.51
SGS (N=12)	Baseline				
	Control	1.6e+04			
	Treated	1.6e+04			
	Diff (T-C)	0.00	-	-	-
	Follow-up				
	Control	7223.32			
	Treated	7223.32			
	Diff (T-C)	0.00	-	-	-
	Diff-in-Diff	0.00	-	-	-
DS (N=438)	Baseline				
	Control	7645.99			
	Treated	6874.03			
	Diff (T-C)	-771.971	2391.16	-0.32	0.75
	Follow-up				
	Control	6828.14			
	Treated	7512.84			
	Diff (T-C)	684.70	1496.39	0.46	0.65
	Diff-in-Diff	1456.67	2820.79	0.52	0.61
HF (N=150)	Baseline				
	Control	8182.04			
	Treated	2370.58			
	Diff (T-C)	-5.8e+03	4327.65	-1.34	0.18
	Follow-up				
	Control	8614.67			
	Treated	8236.18			
	Diff (T-C)	-378.48	2463.46	-0.15	0.88
	Diff-in-Diff	5432.97	4979.68	1.09	0.28

Means and Standard Errors are estimated by linear regression
Note: *** p<0.01; ** p<0.05; * p<0.1

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 has been criticized as being more difficult to measure accurately. Subsequently the use of expenditure as a poverty indicator has been preferred. Household expenditure, which is the cost of goods and services acquired for private use during both surveys, is a suitable substitute. This is because it requires relatively less variable 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 shock experienced by most households across the surveyed areas. This type of vulnerability was drawn from the 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 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 own households had sufficient food during the previous year. The Fig. 11 shows how households perceive food security status. The households' perception of food security was different between the two rounds of surveys.

From baseline to the endline, the remarkable observations are that the proportion of households reported occasional food shortage decreased of 27% points from about 62% to 35% while households reported increased food surplus of 26% points from about 8% to 34%. These proportions are important, probably because of the increase in productivity attributed to interventions of YIIFSWA project. They are a good indication of food security improvement in the region as YIIFSWA contribution.

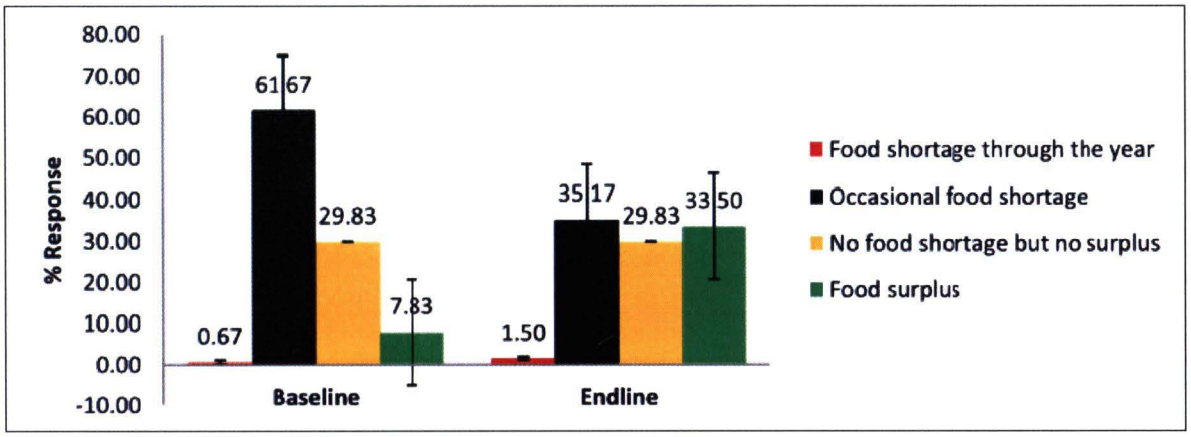

Figure 11. Change in family food consumption status in the last 12 months.

This translates the contribution of the project in reducing vulnerability to food insecurity among rural households in the surveyed areas.

Lastly, we assess whether the YIIFSWA project affected the level of expenditures on food and non-food items.

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.

Using the relative poverty, households disaggregated by treatment presents interesting poverty findings (Table 14). The incidence of poverty is found to be 10% points less for the treated group as compared to their counterparts. Likewise, the poverty depth for the control group is estimated to be 59% while the corresponding figure for the treatment group is 36%. In a similar fashion, the severity of poverty for the control group is found to be almost twice that of the treatment group.

In terms of gender (Table 14) the incidence of poverty for male-headed households is 16% points less for the treated as compared to the non-treated. As reference to female-headed households, it is 11% points, lower than that of the male-headed households.

These findings might be due to the higher and relatively stable income generated by the treatment group as a result of project interventions.

Table 14. Poverty indices by treatment.

Category	Headcount		Poverty gap index		Poverty severity index	
	Non-treated	Treated	Non-treated	Treated	Non-treated	Treated
All	0.66	0.56	0.59	0.36	0.57	0.31
MHH	0.70	0.54	0.62	0.35	0.60	0.29
FHH	0.59	0.70	0.46	0.45	0.41	0.39

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 matching strategy, Table 15 shows that the Average Treatment on Treated (ATT) of YIIFSWA project on per capita expenditure of beneficiaries was Ghana Cedis 498.07. This implies that yam beneficiaries that profited directly or indirectly from YIIFSWA project has greater per capita expenditure compare with non-beneficiary. Furthermore, the results show that YIIFSWA project increases per capita expenditure and has the potential to bring rural yam farmers out of poverty.

Table 15. Impact of YIIFSWA on per capita expenditure.

Parameter	YIIFSWA Beneficiaries	YIIFSWA Non-beneficiaries	Difference	
Radius Matching				
Unmatched	1640.85	1296.40	344.45	377.01
ATT	1651.02	1152.95	498.07	340.03
ATU	1179.36	1666.93	487.56	.
ATE			492.07	.

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

Changes in food security using propensity score matching

Food security is defined commonly as 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 of food security; namely (i) availability of sufficient quantity and appropriate quality of food supplied through own production or otherwise; (ii) access by all households and individuals to adequate resources to acquire such food; and (iii) utilization of these food through adequate diet, water, sanitation and health care (Timmer 2012). In subsistence economies, household food security is largely linked to availability of food from households' home-grown or own production. Gifts and transfers from friends and relatives also play important roles. Food purchases are also common but limited due to lack of liquidity.

The results of the PSM presented in Table 16 show that the ATT of YIIFSWA project on food security (per capita expenditure on food) of beneficiaries was Ghana Cedis 174.16. This implies that the project beneficiaries that profited directly or indirectly from YIIFSWA project are better food secured than the non-beneficiary farmers.

In summary, we are interested in this study in 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 of the project 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 builds up into poverty reduction in the region.

Table 16. Impact of YIIFSWA on food security.

Parameter	YIIFSWA Beneficiaries	YIIFSWA Non-beneficiaries	Difference	S.E.
Nearest Neighbour Matching				
Unmatched	1323.35	1166.17	157.18	331.50
ATT	1328.47	1154.31	174.16	325.23
ATU	1175.90	1334.72	158.82	.
ATE			165.40	.

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

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 yam technology by estimating the population of adopting households and applying the FGT headcount indices of poverty computed from DD technique.

The Table 17, provides estimates of the total number of people lifted out of poverty due to the adoption of the AYMT in Ghana. Results revealed that adoption of AYMT resulted in poverty reduction among rural population by 10% points translating respectively into 25,040 individuals or 2,608 households being lifted out of poverty in the region.

This is consistent with the findings in 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 17. Poverty-reduction impact of AYMT adoption.

No	Variable	
1	Sample for each zone *[1]*	600
2	Adoption rate (%) *[2]*	42.8
3	Poverty rate in the treated group *[3]*	56
4	Poverty rate in the non-treated group *[4]*	66
5	Poverty reduction rate (% point) *[5=4-3]*	0.10
6	Adopting households (number) *[6=1*2/100]*	256.8
7	Average household size *[7]*	9.6
8	Population in sampled households *[8=1*7]*	5,760
9	People out of poverty from sample (number) *[9=5*6*8]*	246.5
10	Population size of sampled area *[10]*	585,126
11	Poor lifted out of poverty (number) [11=9/8*10]	25,040

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 districts from 2010 POPULATION AND HOUSING CENSUS

FINAL RESULT.S GHANA STATISTICAL SERVICE 2012. See Annex 4
http://www.statsghana.gov.gh/docfiles/2010phc/2010_POPULATION_AND_HOUSING_CENSUS_FINAL_RESULTS.pdf

Source: Author's calculations using YIIFSWA survey data, 2015.

Conclusions and Implications

The analysis of the Baseline and Endline Survey results demonstrate various aspects of positive impact of YIIFSWA Project. This study attempted to document adoption at the farm level of YIIFSWA promoted technologies and assesses factors affecting their adoption. It also estimated the early impacts, positive and negative, primary and secondary that result from the project. The study assessed the direct and indirect contribution of the project on smallholder yam farmers, whether intended or unintended thereby drawing lessons from the project that may be useful in the design and implementation of a possible second phase of the project or any other future project of a similar nature. Following the baseline survey, the survey for this study was based on a multistage, random sampling procedure, drawing on the total households from yam-growing areas of Ghana. A total of 600 households were selected with equal probability from each community. Data were collected using structured questionnaires including community, household and field, and a set of qualitative approaches including focus groups and interviews with selected beneficiaries and other key informants. The structured questionnaires were administered by trained enumerators under skilled supervisors after 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.

Results indicated in general that socio-economic household characteristics did not change significantly between both assessment periods though positive changes that were reported could certainly be associated to the project interventions.

The average farm sizes in the project area show large disparities among farming households and the total farming land has increased because of add ups of share of land under yam. Land under yam increases and such changes in land would have been required for yam cultivation as rational decision following potential yield gains experienced from interventions introduced by YIIFSWA project.

The state of the housing in which families live reflects the level of endowment with assets. The assets can provide leverage for catalysing agricultural resources transformation into livelihood outcomes. With the project, noticeable reduction of households living in houses built with poor walling material is depicted against increasing households using better materials like concrete blocks during the project period.

Important improvements in house roofing of main residential houses in the surveyed areas are reported after the project interventions. Proportion of households using grass thatched during endline as compared to baseline has reduced of 20% points from about 60% to 40% while proportion of households using iron sheets increased of the same level. More worthy changes are illustrated from the surveyed areas regarding the sanitation toilets used in the surveyed areas with few households started the use of tiles during the project period. On the same subject of sanitation, more households used ordinary pit latrine private and shared during endline as compared to baseline. More importantly the proportion of households without toilet reduced of 11% points from about 67% to 56%. The results show that positive changes were reported regarding the housing conditions in the project target areas. This might not be unconnected with the project as contributing factor.

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. Most of the assets in the project areas were owned as a result of project interventions implying that the project has started contributing to the livelihoods of the farming households. In summary, the livelihood impacts shown by the positive and significant changes of most of the household assets are the echo of the project interventions though households covered still relied on hand implements in their farming activities.

This study focused mainly on providing an answer to the question of how much impact the project has had on rural farm households' income and food security how it has contributed to the reduction of poverty in Ghana. We started by documenting the rate of AYMT adoption and awareness among the sampled farmers. The result showed that the AYMT adoption rate was about 43%, while the awareness rate was 87%. Furthermore, the proportion of adopters among the exposed/aware farmers was half confirming that awareness/exposure is important in achieving a high rate of AYMT adoption. Therefore, policy and programmes that would further increase the farmers' awareness should be implemented and thoroughly monitored. In addition, the existing extension program should be well funded to improve the performance of the extension agents and increase the number of contacts with farmers. This is a good prediction of formalizing seed supply system to reverse the conventional production system in dominance in the region for farmers to make headway towards cleaning their seed banks for better production and productivity. On gender perspective, female-headed households have been less active in terms of technology awareness and adoption. Moreover, they have low representation in the sampled households. The most important source of information (about 67%) being IITA along with its contracted NGOs. This could be a result of the ability of these households to have face-to-face contact with these sources. It is also that they participate and observe the field demonstrations conducted. Moreover, these sources allow a two-way process of communication. Sources like local leaders, friends from other communities and government extension from MoFA who were directly in touch with farmers were also important in farmers' exposure. The other sources were in minority or inexistent.

The perception of farmers gave an insight into the factors likely limiting the adoption. Chemical availability, fear of technology failure, conventional practice being better were the most important reasons for non-adoption followed by non-availability of the technology, lack of technical know, lack of cash/credit to acquire the technology satisfaction with the current technology and lack of associated skills. Analyses have shown that many households were aware of the technology. Therefore, there is a need to address potential constraints to their uptake. More effective mass communication approaches and strategies should be initiated including linking farmers with credit providers; change their mentality about the existing technologies and facilitating training on requisition of relevant skills as significant predictors of the decision to adopt AYMT. Significant drivers behind AYMT adoption are experience in yam farming and membership of social group. This emphasises on strengthening communication among farming households which will stimulate and sustain the promotion and dissemination of the technology for increased update and enhanced livelihood impacts.

The mean productivity at the endline is higher than that in the past. This confirms that there is a positive contribution in yam output from adopting AYMT and other YIIFSWA research options. Yield from the field measurement at the endline was higher than that at the baseline which reflected

positive support of YIIFSWA project. Yam yields measured were higher than those reported through recall-based information and for the endline than that at the baseline. The yam yield has increased due to YIIFSWA's interventions on a pooled sample translating the positive difference between the control and treated groups.

After the project implementation, the proportion of households reported occasional food shortage decreased of 27% points from about 62% to 35% while households reported food surplus increase of 26% points from about 8% to 34%. These proportions are important, probably because of the increase in productivity attributed to interventions of YIIFSWA project. They are a good indication of food security improvement in the region as YIIFSWA contribution. This translates the influence of the project in reducing vulnerability to food insecurity among rural households in the surveyed areas.

The incidence of poverty is found to be 10% points less for the treated group as compared to their counterparts. Likewise, the poverty depth for the control group is estimated to be 59% while the corresponding figure for the treatment group is lowered to 36%. In a similar fashion, the severity of poverty for the control group is found to be almost twice that of the treatment group. In terms of gender the incidence of poverty for male-headed households is 16% points less for the treated as compared to the non-treated. As reference to female-headed households, it is 11% points, lower than that of the male-headed households. These findings might be due to the higher and relatively stable income generated by the treatment group because of project interventions.

The results show a positive effect of the project 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 builds up into poverty reduction in the region.

Yam beneficiaries that profited directly or indirectly from YIIFSWA project had greater per capita expenditure compare with non-beneficiaries. Furthermore, the results show that YIIFSWA project increases per capita expenditure and has the potential to bring rural yam farmers out of poverty. Also, project beneficiaries that profited directly or indirectly from YIIFSWA project are better food secured than the non-beneficiary farmers. Results revealed that adoption of AYMT resulted in poverty reduction among rural population by 10% points translating respectively into 25,040 individuals being lifted out of poverty in the region.

With a good level in terms of AYMT adoption and clean planting materials availability and dissemination to reach even beyond yield target, the project has started generating positive impacts that calls for concerted efforts towards implementation and out-scaling of key breakthroughs of YIIFSWA. These include the implementation of quality standards approved by the regulatory bodies of the two countries using the quality management protocol for certification of pre-basic, basic and certified yam planting materials; improved seed health management methods incorporating virus elimination techniques and indexing for certification; use of the novel high ratio propagation technologies for production of high quality planting materials, especially at pre-basic level by partners in the breeding institutions. This will be followed by the production of basic and certified planting materials by registered producers in the private sector using practices including single-node vine cuttings and the adaptive yam minisett technique. Also, there will be a need of establishing appropriate business models and strengthening business skills of the registered commercial seed producers. The specialization of actors along the seed yam value chain will promote competitiveness and sustainability of the commercial seed system.

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Annexes

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

Characteristics	All	1	2	3	4	5
N	*600*	*138*	*96*	*180*	*60*	*126*
Ever heard of AYMT? (%)	86.7	92.9	85.5	87.5	80.0	95.0
Ever planted the AYMT? (%)	42.8	45.2	43.5	42.7	33.3	65.0

N= Number of respondents; 1= Atebubu; 2= *East-Gonja; 3= Ejura; 4 = Kintampo; 5= Mion*

Annex 2. YIIFSWA Project Communities in Ghana.

Regions	Districts	Communities
ASHANTI	Ejura-Sekyedumase	Bisiw 1
ASHANTI		Bisiw 2
ASHANTI		Bompa
ASHANTI		Ejura Nkwanta
ASHANTI		Hiawoanwu
ASHANTI		Kasei
ASHANTI		Kramokrum
ASHANTI		Krampong
ASHANTI		Kropong
ASHANTI		Leafu Kura
ASHANTI		Mesuo
ASHANTI		Nkrama
ASHANTI		Nokreasa
ASHANTI		Nyinasei
ASHANTI		Samari Nkwanta
ASHANTI		Sunkwae
BRONG-AHAFO	Atebubu-Amantin	Akyeremade
BRONG-AHAFO		Amanfrom
BRONG-AHAFO		Asanteboa
BRONG-AHAFO		Badukrom
BRONG-AHAFO		Boniafo
BRONG-AHAFO		Densi
BRONG-AHAFO		Duabone 1
BRONG-AHAFO		Duabone 2
BRONG-AHAFO		Kafaano
BRONG-AHAFO		Kumkumso
BRONG-AHAFO		Lailai
BRONG-AHAFO		Mem
BRONG-AHAFO		Morochusu
BRONG-AHAFO		Nwowam
BRONG-AHAFO		Old kronkrompe
BRONG-AHAFO		Patuda
BRONG-AHAFO		Praprabon
BRONG-AHAFO		Primukyea
BRONG-AHAFO		Sampa
BRONG-AHAFO		Tintare
BRONG-AHAFO		Watro

Regions	Districts	Communities
BRONG-AHAFO	Kintampo	Aduma
BRONG-AHAFO		Alassankura
BRONG-AHAFO		Asantekwa
BRONG-AHAFO		Asuma Kura
BRONG-AHAFO		Attakura
BRONG-AHAFO		Bablioduo-Kokomba
BRONG-AHAFO		Badu Krom (Kofi)
BRONG-AHAFO		Basabasa
BRONG-AHAFO		Ben Krum
BRONG-AHAFO		Busuama
BRONG-AHAFO		Chiranda
BRONG-AHAFO		Dawadawa
BRONG-AHAFO		Gulumpe
BRONG-AHAFO		Kadelso
BRONG-AHAFO		kaka
BRONG-AHAFO		Kandige
BRONG-AHAFO		Kawampe
BRONG-AHAFO		Kurawura Akura
BRONG-AHAFO		Mansira
BRONG-AHAFO		Miawani
BRONG-AHAFO		Nante Zongo
BRONG-AHAFO		Nyamebekyere 1
BRONG-AHAFO		Nyamebekyere 2
BRONG-AHAFO		Sogliboi
BRONG-AHAFO		Suronuasi
BRONG-AHAFO		Taidifufuo
BRONG-AHAFO		Techira 1 /Ebenezer
BRONG-AHAFO		Techira 2
BRONG-AHAFO		Yaara
BRONG-AHAFO		Yabraso
NORTHERN	East Gonja	Abrumase
NORTHERN		Adamupe
NORTHERN		Bau
NORTHERN		Bunjai
NORTHERN		Dagbabia
NORTHERN		Grunshie Zongo
NORTHERN		Jemitutu
NORTHERN		Kakoshi
NORTHERN		Kalande
NORTHERN		Katanga 1? /Mbawupe
NORTHERN		Katanga 2
NORTHERN		Kigbatito
NORTHERN		Kijewu
NORTHERN		Kitoe
NORTHERN		Kpolo
NORTHERN		Kumburupe
NORTHERN		Latinkpa
NORTHERN		Masaka
NORTHERN		Mbawudo
NORTHERN		Nakpaye
NORTHERN		shishipe
NORTHERN		Talkpa
NORTHERN		Tunga
NORTHERN	Mion	Gunsi
NORTHERN		Kulunkpegu
NORTHERN		Mahakpi
NORTHERN		Mbatinga
NORTHERN		Ndiyuriyili
NORTHERN		Puriya
NORTHERN		Salankpang
NORTHERN		Sang
NORTHERN		Sanze
NORTHERN		Zakpalsi

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 districts in Ghana

Districts	Population
Ejura-Sekyedumase	85,446
Atebubu-Amantin	105,938
Kintampo	176480
East Gonja	135,450
Mion	81,812
Total	**585,126**