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Impact of the Integrated Agricultural Research for Development Guidelines on Smallholders' Livelihoods in SSA CP Innovation Platforms

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About FARA

The Forum for Agricultural Research in Africa (FARA) is the apex continental organisation responsible for coordinating and advocating for agricultural research-for-development. (AR4D). It serves as the entry point for agricultural research initiatives designed to have a continental reach or a sub-continental reach spanning more than one sub-region.
FARA serves as the technical arm of the African Union Commission (AUC) on matters concerning agricultural science, technology and innovation. FARA has provided a continental forum for stakeholders in AR4D to shape the vision and agenda for the sub-sector and to mobilise themselves to respond to key continent-wide development frameworks, notably the Comprehensive Africa Agriculture Development Programme (CAADP).
FARA's vision is; "Reduced poverty in Africa as a result of sustainable broad-based agricultural growth and improved livelihoods, particularly of smallholder and pastoral enterprises" its **mission is the** "Creation of broad-based improvements in agricultural productivity, competitiveness and markets by strengthening the capacity for agricultural innovation at the continental-level"; its **Value Proposition is the** "Strengthening Africa's capacity for innovation and transformation by visioning its strategic direction, integrating its capacities for change and creating an enabling policy environment for implementation". FARA's strategic direction is derived from and aligned to the Science Agenda for Agriculture in Africa (S3A), which is in turn designed to support the realization of the CAADP vision.

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FARA Research Report (FRR) is an online organ of the Forum for Agricultural Research in Africa (FARA). It aims to promote access to information generated from research activities, commissioned studies or other intellectual inquiry that are not structured to yield journal articles. The outputs could be preliminary in most cases and in other instances final. The papers are only published after FARA secretariat internal review and adjudgment as suitable for the intellectual community consumption.

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Abstract

The proof of IAR4D efficacy was carried out in 2010, using the household income as the principal measure of impact on poverty reduction. This assessment did not take into consideration other variables that could affect livelihood outcomes. Such variables included the level of household dietary diversity, poverty intensity, income and revenues from other sources like livestock and livestock products, asset accumulation (including household and agricultural assets), Therefore, the present study was commissioned with a view to evaluate the impact of other outcomes' variables on the smallholder crop and livestock farming households. The present study also validates the hypotheses that the IAR4D: 1. Works; 2. It delivers more benefits than the conventional R&D method and 3. It can be scaled out and up for wider impact on the continent
Methods: All the outcomes considered were subjected to basic statistical test such as frequency counts, percentages, means etc. This was done to compare the levels of the outcomes for the midline and update periods. It was also done to compare the changes and percentages of changes that have accrued to the outcomes in the intervention (IAR4D/IP) sites in relation to the conventional and clean sites. The study used rigorous impact evaluation methods to determine the impact of IAR4D principles. Matching method, including propensity score matching involving control groups and matched samples and the difference-in-difference estimator were used.

Key findings: A minimum of 117.39 percent change (household assets) and up to a maximum of 1,414.04 percent increases (general assets) were recorded as improvement in asset accumulation. On income and revenue generation, results show that generally, positive increases have accrued to the three types of incomes and revenues for the program, treatments and treatments within the PLSs. Furthermore, relative reduction in low dietary diversity under the treatment (IAR4D) was 37.33% while improvement to high dietary diversity recorded about 45.06% increment. The program results show that poverty intensity for the Innovation Platform (IP) participants were 70.9% and 61.5% for midline and end line periods respectively. Poverty intensity for IAR4D participants in the end line was less than that of the midline. On asset accumulation, the IAR4D has a strong, positive and statistically significant impact at the program level. The results show that average asset index of the treated (IAR4D farmers) sample due to participation in the IP activities based on the PSM (ATT) was 0.116 ($p<1\%$). A considerable change of up to 165.71% was recorded in the asset accumulation after the program ended in 2010 till this present update. On income and revenues, positive and statistically significant income and revenue impacts from the IAR4D are present at the program level. ATTs of $766.12, $1,015.06 and $18.53 with corresponding percentage changes of 50.38%, 133.92% and 296.23% respectively for income, livestock revenue and revenues from animal products were recorded.
Conclusion and policy recommendations: All the positive and statistically significant changes that are observed in the outcomes considered are for the IAR4D/IP participants after the 2012 documentation. In as much as the IAR4D has brought about considerable positive changes in the key outcomes and that these changes far outweigh those of the conventional R&D methods, we can conveniently infer that the IAR4D works as a concept, delivers more benefits than the conventional R&D methods and that it can be scaled up and out beyond the current area of operation. The policy implications emanating from the SSA CP update/impact evaluation are important for the scaling up and out. The external validity of the SSA CP should be associated with

its scalability. Therefore, policies around the established scaling up and out protocols need to be developed. and these should centers around: (i) developing a scaling up plan (ii) establishing pre-conditions and implementing a scaling up plan process and (iii) implementing the scaling up process. Formalizing these protocols with implementing institutions, stakeholders and partners as well as stakeholders in the policy arena will help maintain a consistent and formidable scaling up and out procedure.

Introduction

Background and Motivation

It is no longer news that Africa, especially the sub-Saharan Africa region has been plagued by food insecurity, poverty and hunger. However, world hunger, according to the 2012 Global Hunger Index (GHI), has somewhat been declining since 1990 although it still remains high (von Grebmer, Ringler, Rosegrant, Olofinbiyi, Wiesmann, Fritschel, Badiane, Torero and Yohannes, 2012). Consequently, the global average masks dramatic differences among regions and countries. Regionally, the highest GHIs are in South Asia and sub-Saharan Africa. For a long time now, addressing the threat which food insecurity, poverty and hunger pause to the sustainable livelihoods of many people has been the focus of most African governments. However, sustainable livelihoods of many African people, especially in the sub-Saharan region have all along depended directly on their ability to produce and market agricultural products (Adekunle, Fatunbi, Buruchara and Nyamwaro, 2013). In effect, agricultural growth in sub-Saharan Africa has remained very fundamental for ensuring reduction in food insecurity, poverty and hunger. Consequently, revitalizing the agricultural sector is very crucial to achieving sustainable food security and alleviating poverty and hunger. In an effort at achieving this, of some policy directives regarding the halving of poverty and hunger as well as ensuring environmental sustainability by 2015 have been firmly established in the Millennium Development Goals (2015). The sub-Saharan Africa Challenge Program (SSA CP), by implementing the “Integrated Agricultural Research for Development (IAR4D)” embarked on efforts towards improving food security and reducing poverty and hunger among stakeholders, especially smallholders in the sub-Saharan Africa region.

Less than a decade after the SSA CP had passed through the stage of implementation and testing of the IAR4D, an update of the impact of the IAR4D on livelihoods, Innovation Platforms and on the IP stakeholders was deemed necessary. A midline assessment or proof of concept (Adekunle et al. 2013; Adekunle et al, 2014; Adekunle et al, 2014 and Adekunle et al 2014) was carried out where household income was used as the outcome to measure the impact of the intervention on poverty reduction. The midline assessment could not however take into consideration several other livelihood outcomes which have been hypothesized to impact on the lives of smallholders in Sub Saharan Africa (SSA,time constraint was the reason for this). Such other outcomes include awareness and adoption of generated and/ or promoted technologies, food security, multidimensional poverty, income and revenue from sources like, livestock and livestock products, assets (including household and agricultural assets, etc.), etc. Besides this, the midline assessment did not also consider the qualitative assessment of outcomes of some other stakeholders including research, extension, NGOs, marketing, institutions, etc. Therefore, the present study was commissioned to carry out an update of the IAR4D with a view to evaluating the quantitative and qualitative impact of the several outcomes on stakeholders in the SSA CP. The present study is also to validate the hypotheses that the IAR4D (i) works (ii) delivers more benefits than the conventional R&D method and (iii) can be scaled out and up beyond the current area of operation. To achieve this validation, the study in general collected, analyzed and documented recent updates on SSA CP impact building on the 2012 proof of concept documentation.

Description of the intervention and theory of change

The sub-Saharan Africa Challenge program (SSA CP) is a bold African-led initiative seeking to increase the developmental benefits from agricultural research and development (ARD) (FARA, 2009). The aim of the SSA CP is to achieve the foregoing objective by proposing, testing and evaluating an alternative to the conventional ARD approaches. It was hitherto observed that agricultural research in Africa had produced numerous excellent research outputs that had not generated the expected developmental benefits across the continent. So, the underperformance of ARD was found to be the reason behind this. Further findings then attributed the limited impact of ARD to the failure by the intended users of research outputs to put them into use beyond the local domains within which the outputs are generated and tested, leading to "islands of success". The low uptake of research outputs had in turn been attributed to some features of the way ARD was being conducted, whereby researchers, the end users of research outputs and other providers of services that support agricultural production, value addition and marketing, largely work in isolation from one another. A shift in research paradigm as an alternative to the ARD was then proposed. The alternative ARD approach proposed by the SSA CP was designed to address the institutional and other process-related impediments associated with the conventional approach. The proposed approach was known as the "Integrated Agricultural Research for Development (IAR4D)".

The IAR4D is an innovation systems-based approach involving many stakeholders and partnerships. It is a continually evolving approach that relies on ongoing interactions among actors to identify, analyze and prioritize problems, and find and implement solutions using feedback, reflection and lesson-learning mechanisms from different processes. This requires drawing on knowledge from relevant actors at each stage. IAR4D creates a network that considers technical, social and institutional constraints in an environment that facilitates learning. Its aim is to generate innovative solutions rather than mere research products or technologies. IAR4D involves complex mechanisms that may require fundamental changes in the broader policy and institutional framework. The approach largely builds on the experience of previous approaches, including the integrated soil fertility management (ISFM) and the integrated natural resource management (INRM), and encompasses market and policy domains (von Kaufmann 2007). IAR4D is an action research approach that integrates the technological, natural resource management policy and institutional components, for various actors. The goal is to find innovative commercial, social and institutional solutions to agricultural development challenges in the face of changing market and policy conditions (Hall and Yoganand 2004; Monty 2004). The strength of IAR4D lies in its ability to capture policy and market factors, in addition to fostering systemic linkages among actors under diverse contexts. Therefore, these actors can have a stake in the process of generating, disseminating and using knowledge for socio-economic impact. Although as an iterative process IAR4D resists precise definition, there have been attempts to encapsulate the concept. As summarized by Hawkins et al. (2009b), 'IAR4D comprises a set of individual and organizational behaviors that promote the integration of stakeholder concerns, knowledge, actions and learning around a theme of mutual interest'. On the other hand, FARA (2007) describes IAR4D as an action research approach for investigating and facilitating the organization of groups of stakeholders (including researchers) to innovate more effectively in response to changing complex agricultural and NRM contexts for improved developmental outcomes. In general terms, IAR4D is seen as a broad set of processes that, through their interactions, lead to the generation and use of knowledge (Hawkins et al. 2009b). The following features apply: (i) IAR4D is evolving and brings together many trends and ideas, (ii) IAR4D is about change and innovation as an outcome, not just about information, knowledge or technology as a product. It precisely aims at the use of information, knowledge, technology and inventions to generate socio-economic benefits, (iii) IAR4D places research as one of the components contributing to the development process, rather than as its only pivotal point and (v) IAR4D focuses on processes and performance rather than on products (technologies, policies). To put it another way, improved processes lead to the ultimate product, termed innovation (Adekunle *et al*, 2013; pp. 9-10). To achieve the desired outcomes, the conceptualization and practice of IAR4D needs to go beyond methods to include changes in personal skills, mindsets and attitudes, organizational practices and culture, and the way in which organizations interact as part of the wider 'innovation system'.

The IAR4D Theory of change

According to Rogers (2012), it is often helpful to base an impact evaluation on a theory or model of how the intervention is understood to produce its intended impact. Accordingly, this might be called a program theory, a theory of change (ToC), a results chain or a logic model. It is best to develop the theory of change when planning an intervention, and then to review it and revise it as necessary while planning an impact evaluation. In the case of the SSA CP, producing the intended impact of its intervention through the implementation of the IAR4D was a sufficient aim. However, a necessary motivation for achieving this was to diagnose the outstanding problem that the IAR4D was intended to solve.

Adapting from the research plan and program for impact assessment of the SSA CP (FARA, 2009), we agreed that the following represents the motivation for the SSA CP's theory: The conception of IAR4D was driven by dissatisfaction with traditional approaches for organizing ARD in Sub-Saharan Africa. These approaches are widely blamed for contributing significantly to the unsatisfactory performance of ARD in improving the livelihoods of its end-users—the smallholder farmers. The poor performance of traditional ARD approaches is manifest in low adoption rates of technologies, poor linkages among agricultural value-chain actors and the pervasive unprofitability of farm enterprises in SSA. It has been hypothesized that these indicators of unsatisfactory ARD performance are traceable to the organization of research and development as a linear process. This configuration of ARD actors limits interaction with researchers and hamper the timely intervention in research process and direction. IAR4D aims to transform this configuration by embedding research within an innovation system comprising all actors in agricultural value chains. Within such a system—a network configuration—innovation does not follow a linear path that begins with research, moves through the processes of development, transfer, diffusion, adoption, production, and ends with successful introduction and use of new products and processes. Rather, it tends to involve continuous feedback between different stages (Dantas, 2005), thus drawing on the knowledge of all relevant actors at each stage. The network configuration facilitates timely interaction and learning and aims at generating innovations (rather than research products per se). Here, innovation refers to the activities and processes associated with the generation, product distribution, adaptation, and use of new technical and institutional/organizational knowledge. It therefore adds value to products of research, thus catalyzing the achievement of development impact. IAR4D is characterized by a structure and several process principles. The aims and objectives of the IAR4D are complemented by these processes and are hypothesized to effect the desired change.

Program implementation

The SSA CP is a research program that focuses on (i) delivering international public goods concerned with best practices in relation to multi-stakeholder engagement in the generation and wide-scale adoption of agricultural innovations and (ii) evaluating whether IAR4D works and is more cost/benefit effective compared to conventional approaches. As stated earlier, the main objectives of the SSA CP are to facilitate substantially greater impact from agricultural research for development leading to improved rural livelihoods, increased food security and sustainable natural resource management throughout SSA. The SSA CP was implemented in three Pilot Learning Sites (PLS) across the continent. These were: (i*) The Kano-Katsina-Maradi* (KKM) PLS, which covers an area of 83,900 sq. km. The KKM PLS straddles Nigeria and Niger and covers most of the area under KKM administrative jurisdiction; (ii) *The Zimbabwe-Malawi-Mozambique (ZMM) PLS*, which is a 274,000 sq. km transect running from northeastern Zimbabwe through central Mozambique into southern Malawi and (iii) *The Lake Kivu PLS* which extends across 19,500 sq. km of the triangle where eastern Democratic Republic of Congo (DRC), northern Rwanda and southwestern Uganda meet. The SSA CP partners included ASARECA, CORAF/WECARD, CCARDESA and their various stakeholders at national and sub-regional levels.

The Forum for Agricultural Research in Africa (FARA) was the institution responsible for the implementation of the IAR4D through the SSA CP. The implementation of the IAR4D is explicitly explained in "The SSA CP's modular approach to implementing the IAR4D" (see FARA, 2004: Chapter 4, pages 35-56).

Update/Impact Evaluation Objectives

The general objective of the current evaluation of the IAR4D is to collect, analyze and document recent updates on the Sub-Saharan Africa Challenge Program (SSACP) by building on the 2012 proof of concept documentation. The study aimed at updating the existing database to evaluate the relative impact of the SSA CP in Africa. Specifically, the study assessed the changes that have been recorded in selected outcomes of asset accumulation, revenue and income generation, household dietary diversity and household poverty. The ultimate study assessed the average treatment effects of the outcomes on asset accumulation (general, agricultural and household assets) and revenue and income generation (total income/revenue and revenue from sale of livestock and livestock products).

Research/evaluation questions

The primary research questions guiding this present impact evaluation and the IAR4D's update are:

I. What are the changes and their percentage in the considered program outcomes that have accrued to the beneficiaries of the intervention (SSA CP/IAR4D) over the years after the program has been concluded?
II. What is average treatment effect of SSA CP/IAR4D of the considered outcomes, in the case of the update, asset accumulation (general asset, household and agricultural assets), income and revenue

(total revenue, e.g. from crop, agricultural and non-agricultural employment, from livestock and livestock products?

Methodology

Study Area

To test the IAR4D, the SSA CP was implemented in three Pilot Learning Sites (PLS) across three sub-regions of the African continent. These PLSs were: (i) *The Kano-Katsina-Maradi* (*KKM*) *PLS*, which covers an area of 83,900 sq. km. The KKM PLS straddles Nigeria and Niger and covers most of the area under KKM administrative jurisdiction; (ii) *The Zimbabwe-Malawi-Mozambique (ZMM) PLS*, which is a 274,000 sq. km transect running from northeastern Zimbabwe through central Mozambique into southern Malawi and (iii) *The Lake Kivu PLS,* which extends across 19,500 sq. km of the triangle where eastern Democratic Republic of Congo (DRC), northern Rwanda and southwestern Uganda meet. The SSA CP partners included ASARECA, CORAF/WECARD, CCARDESA and their various stakeholders at national and sub-regional levels. The Forum for Agricultural Research in Africa (FARA) was the institution responsible for the implementation of the IAR4D through the SSA CP. The implementation of the IAR4D is explicitly explained in "The SSA CP's modular approach to implementing the IAR4D" (see FARA, 2004: Chapter 4, pages 35-56).

Sampling method and Data collection

During implementation at the baseline, multistage stratified random sampling was carried out within the selected districts (IAR4D and counterfactual) to select the villages where the treatments were applied, that is, villages where IAR4D was introduced, village communities where conventional approaches were in operation, and villages where no interventions had been carried out over the last 2–5 years. The Miguel and Kremer (2004) methodology of randomizing treatments across schools (districts and village communities) and not individual farm households was used, because it captures spillover and external benefits that could be underestimated if treatment was only randomized at the individual level. All districts, local government areas and communes within the PLS were first listed and grouped according to their representation of the four development domains. Depending on the context and its specific requirements, each taskforce defined the strata within which it randomly selected the four districts that served as its IAR4D treatment sites; that is, where IAR4D was introduced. Within the IAR4D sites, a census of the village communities was conducted to develop a village sampling frame and stratify the villages into "clean" and "non-clean" villages. At least five focal villages per IAR4D site were randomly selected from "clean" villages. These villages became the theatre of action research aimed at developing innovations at the interface between productivity, care of the environment, policies and markets. Within the focal IAR4D village communities, at least 10 households per village were randomly selected for monitoring and evaluation. Four counterfactual districts/local government areas/communes that are like the IAR4D sites—that is, share the same development domain—were assigned to conventional and non-IAR4D-non-conventional ("clean" village) treatments. As for IAR4D sites, a village census was carried out and villages stratified into "clean" and "non-clean". For each counterfactual site matching an IAR4D site, five focal villages were randomly selected from "clean" villages only and assigned to the non-IAR4D-non-conventional treatments. Similarly, five focal villages were randomly sampled from "non-clean" villages and assigned to conventional approach treatment. At least 10 households per focal village were randomly selected for monitoring and evaluation.

The above describes the overall SSA CP's sampling method. For the present impact evaluation and update of the IAR4D, third of 5400 households (1800 households) randomly spread across the three PLSs and the nine Task Forces was sampled (This is for household data and information collection). The major limitation of the update survey was the inability of the team to cover all or more of the existing households, task forces and IPs in the program sample. This had to do with time and funding to cover a substantial proportion of the program population.

In the update survey, most of the data types and variables collected during the baseline and midline surveys were updated and collected. For data analysis in this update however, data and variables which included asset accumulation (general, agricultural and household assets), revenue and income from agricultural and non-agricultural activities, livestock and livestock products were used. Also used were data and variables concerning household dietary diversity and household poverty. Data collection was done at household level by using the household level questionnaire earlier designed by the SSA CP.

Data analysis

In this present update, we considered outcomes such as: (i) assets (including household and agricultural assets); (ii) income and revenue distribution, including household income, livestock revenue and revenue from animal products; (iii) household dietary diversity including the level of farming household dietary diversity and (iv) household and multidimensional poverty.

Descriptive analysis

Indices and values of the outcomes enumerated in 2.3 were either generated or computed and subjected to statistics such as frequency counts and percentages. Percentage differences and changes were also estimated. This was done to compare the levels of the outcomes for the midline and update periods and the changes and percentages of changes that have accrued to the outcomes in the intervention (IAR4D/IP) sites in relation to the conventional and clean sites since the platforms were left on their own after 2010.

Household dietary diversity

Food dietary: The study made use of descriptive statistics and composite score to effectively analyse the data collected. Composite score was used to categorize farmers into food dietary status. Descriptive statistics used include tables, frequencies and percentages. The food dietary status of the respondents was examined by considering the various varieties of food available to farmers. These ranged from cereals, legumes, vegetables, root and tubers, fruits, meats, eggs, fish, to milk. Using a composite score, the diversity of the farmers was classified into high dietary diversity for farmers who consume wide varieties of food; intermediate dietary diversity for farmers between high and low dietary diversity and low dietary diversity for farmers that consumed less variety of food in their households.

Composite Score: Respondents' responses to questions relating to types of food consumed at the household level were measured on a binary scale; that is scoring 1 point for Yes and 0 for otherwise with regards to the varieties of food consumed at household level. A respondent can score a maximum of 15 points and a minimum of 0 points. The categorization into high, intermediate and low benefit was then achieved using a composite score as used by Sirkin, (1995) and Adepoju, et. al (2012):

High category = Between Mean + S.D and 10 points
Medium (intermediate) = between lower and upper categories
Low Category = Between 0 and Mean – S.D.

Measuring poverty intensity

In measuring intensity of poverty, equation 1 was applied as follows:

$$A = \frac{\sum_{1}^{n} c}{n} \tag{1}$$

Where

c is the total weighted deprivations experienced by the poor and *n* equals the number of poor individuals. The poor individuals were adjudged to be deprived in the following indicators: employment, entrepreneurship, school enrolment, level of education, agricultural enterprise equipment, household asset ownership, land ownership, roofing, wall and floor materials and access to primary health. An individual is deprived in any of the mentioned indicators if he/she does not possess any or some of them. This study adopted the method of Alkire and Foster (2011), in computing intensity of poverty.

Table 1: Indicator, Weights and Measurements of Poverty

S/N	Indicator (Weight)	Measurement
1.	**Employment:** Having regular employment (0.1)	Absence of regular employment
2.	**Entrepreneurship:** Owning of a business (0.1)	Not owning a business
3.	**School enrolment:** Household with access to formal education (0.1)	Household head without access to formal education
	Level of education: Household head that completed at least six years education (0.1)	Household head that did not complete at least six years education
4.	**Agricultural enterprise equipment:** Household head with at least two agricultural enterprise equipment (0.1)	Household head without at least two agricultural enterprise equipment
5.	**Household asset ownership:** Household head with ownership of at least two household assets (0.1)	Household head without ownership of at least two household assets
6.	**Land ownership:** Household head with property	Household head without property rights on the

	rights on the land (0.1)	land
7.	**Roofing materials:** Household with improved roofing materials (0.1)	Household with no improved roofing materials
8.	**Wall materials:** Household with improved wall materials (0.1)	Household with no improved wall materials
	Floor materials: Household with improved floor materials (0.1)	Household with no improved floor materials
9.	**Access to primary health:** Household head with membership of health group (0.2)	Household head with no membership of health group

Impact evaluation and estimation Issues

The SSA CP's evaluation design (based on the research plan and program for impact assessment, FARA, 2009), was conceptualized as follows: To test the three hypotheses in a statistically robust fashion and empirically determine whether IAR4D works and whether it delivers more benefits than conventional approaches, a multiple-treatments experimental design was used. This design compares household-and community-level outcomes under: (i) IAR4D, (ii) the conventional approach, and (iii) no intervention. In other words, the SSA CP experiment comprised three treatments carried out in three blocks (the PLS) and nine repetitions (three per block—the taskforces). Following White and Chalak (2006) the set of *counterfactuals* were taken to be the set of all possible states of the world with outcomes taking different values under different possible states of the world. An intervention is also defined as the move from one possible state to another. So, there are as many counterfactuals as there are possible states of the world. However, under the SSA CP, the evaluation limits itself to comparing outcomes under IAR4D and under only two other possible states, namely: the conventional approach and under non-intervention. So, the set of counterfactuals is limited to the set $\{\omega_0, \omega_1, \omega_2\}$ where ω_0 is the non-intervention state consisting of having neither IAR4D nor the conventional approach in operation, ω_1 the state consisting of having the conventional approach in operation, and ω_2 is the state consisting of having IAR4D in Operation. The effectiveness and impact of IAR4D was proposed to be assessed throughout the impact pathway all the way to the farmer level. The hypothesis about whether IAR4D works was also to be tested by comparing the values of relevant knowledge, behavioral, efficiency, welfare, equity and environmental outcomes under ω_2 and under ω_0. Similarly, the hypothesis about whether IAR4D delivers more benefits than the conventional approach was to be tested by comparing the values of relevant knowledge, behavioral, efficiency, welfare, equity and environmental outcomes under ω_2 and under ω_1. The "with" and "without" IAR4D comparison was proposed to be made by comparing the values of the same outcomes as above under ω_2 and under the composite possible states "ω_0 or ω_1".

Average treatment effects on the treated (ATT) for considered outcomes

The impact evaluation update in this study focuses on the average impacts of SSA CP on the treated households in the program's intervention sites at the PLSs, or the ATT (Imbens, 2004) on two sets of the outcomes considered and targeted by program's aims and objectives: assets and income/revenue. Our impact estimations are derived from a combination of two evaluation methods: The double difference (DD) and the propensity score matching methods. The DD approach is one of the most popular non-experimental techniques in impact evaluation since it allows controlling for some types of selection in a straightforward and intuitive way, as long as baseline is available (Winters et al. 2010). In a DD model, the relevant comparison is changes in the indicator overtime. Thus, the comparison in a DD model is between the trends in the control group from before and after the project versus the trends in the treatment groups. The double difference then refers to the difference over time (first difference) and difference between the control and treatment (the second difference). If the trends are significantly greater for the treatment group (in a statistical sense), this suggests that the project had an impact. Thus, the DD estimator combines cross-sectional and over time variation to correct for differences between groups when treated and controls start at different levels.

The basic idea of propensity-score matching (PSM) on the other hand, is that in the absence of an experimental design, assignment to treatment is frequently non-random, and thus, farmers receiving treatment and those excluded from treatment may differ not only in their treatment status but also in other characteristics that affect both participation and the outcome of interest. Among the farmers not receiving the project, the PSM approach seeks to find non-treated farmers that are similar to treated farmers but did not receive project benefits. The approach does this by matching treated farmers to non-treated farmers using propensity scores. In some ways, this technique can be viewed as replicating the project selection process as long as the selection is based on observable factors. By using propensity scores to identify a control group that is like the treatment group, PSM creates what some refer to as a "quasi-experiment" since the control group is *statistically equivalent* to the treatment group.

According to Khandker et al. (2010), some variants of the DD approach have been introduced to account for potential sources of selection bias. Combining PSM with DD methods can help resolve this problem, by matching units in the common support. Controlling for initial area conditions can also resolve nonrandom program placement that might bias the program effect. As mentioned earlier, it is always recommendable to at least combine PSM with a DD approach, in order to at least remove the bias due to time-invariant unobservable characteristics (such for instance, motivation). In specific terms, given that the outcome variable cannot be observed for the treated group with and without project (Winters et al. 2010), it becomes necessary to identify a control group in order to infer what would have happened to the beneficiaries without the project. In order words, a group of farmers, units of production or agricultural households, who are statistically similar in all observed characteristics to those who received the project, are needed. The propensity score allows us to solve this problem by estimating the conditional probability or receiving the project ($P_i=1$) given a vector of observed characteristics (X) (*dimensionality problem*). Hence, all these similarities can be "aggregated" into only one number or score as follows:

$$Pr(Pi) = Pr(Pi=1|X) \qquad (2)$$

The propensity score or conditional probability of participation is calculated by using a probit or a logit model in which the dependent variable is a dummy variable equal to one, if the farmer participated in the project, and zero otherwise. The vector of covariates or independent variables should be composed of those characteristics that determined project placement in order to replicate the selection process.

We mentioned earlier that the most commonly used evaluation parameter is the so-called average impact of the treatment on the treated (ATT), which focuses explicitly on the effect on those for whom the program was actually introduced. A matching estimator, obtained via kernel (though kernel matching estimates were compared with those of nearest neighbour matching) algorithm to estimate causal impacts of IAR4D on the considered outcomes, was used. The ATT is formally defined (Imbens and Wooldridge 2009) as:

$$T_{ATT} \,|(T{=}1) = E(Y_{i1} - Y_{i0} \mid T_i = 1) = E(Y_{i1}|T_i = 1) - E(Y_{i0}|T_i = 1) \qquad (3)$$

in which T is the outcome of interest; T is an indicator variable for the treatment status which has a value of 1 for units in the treatment group, and a value of 0 for units in the control group; Y_{i1} is the outcome for each case *i* in the treated group given that it has been treated; and Y_{i0} is the counterfactual outcome for each case *i* in the treated group had it *not* been treated. The problem, however, is that Y_{i0} is not possible to observe, because a given unit receiving an intervention cannot both be treated and not treated at the same time (Imbens and Wooldridge 2009; Rubin 1974).

Under a potential outcomes framework, the ATT estimate is derived by constructing a suitable comparison or control group which represents the counterfactual outcome, or what would have been the outcome for treated units, had they not been subjected to the treatment. In non-experimental studies, in which units receiving the treatment are not randomly determined, the ATT estimate is subject to bias stemming from systematic differences between the treatment and comparison groups but can still be accurately obtained by conditioning on a vector of pretreatment covariates that determine non-random treatment assignment (Dehejia and Wahba 2002). That is, conditional on the pretreatment covariates which determine selection into treatment or not, the outcome of the control group ($Y_{i0} \mid T_i = 0$) can be substituted for the potential outcome of the treated group had it not received treatment ($Yi0 \mid Ti = 1$). In our study, assuming we have included all relevant and observable pretreatment confounders, we expect that once IAR4D/IP treatment assignment has been conditioned on the vector of pretreatment covariates, then the difference in outcomes across the IAR4D/IP treatment and control groups can be taken as an unbiased estimate of IAR4D/IP program impact. The ATT is therefore obtained as:

$$T_{ATT} = E\,[(E(Y_{i1}|Xi\,,\, T_i = 1) - E(Y_{i0}|X_i\,,\, T_i = 0)\,|\,T_i = 1] \qquad (4)$$

In which *X* represents the vector pretreatment covariates that affect selection of units into IAR4D/IP treatment or control status and also shape outcomes under IAR4D/IP treatment.

The above matching approach on post-treatment outcomes for observational studies is well-accepted as a more rigorous approach to estimating program impact than naïve comparisons of outcomes across sets of IAR4D/IP treated and control sites (Stuart 2010). To build additional robustness into our evaluation, we also used a DD model for the set of considered outcomes where data from the midline program implementation were available. The DD approach assumes that the change in mean outcomes across the IAR4D/IP treated and control villages would have followed a similar trend if IAR4D/IP had not been introduced in the IAR4D/IP treated villages. To implement the DD, we draw on midline household livelihoods data from the FARA's SSA CP midline data bank. The DD estimator compares changes in outcome measures (i.e. change from before to after the program) between project/program participants and non-participants, rather than simply comparing outcome levels at one point in time. The DD method estimates the average program impact as follows (Khandker et al. 2010):

$$DD = E\left(Y_1^T - Y_0^T \mid \mathrm{T}_1 = 1\right) - E\left(Y_1^C - Y_0^C \mid \mathrm{T}_1 = 0\right) \quad (5)$$

$T_1=1$ denotes treatment or the presence of the program at $t=1$, whereas $T_1=0$ denotes untreated areas. Unlike the PSM alone, the DD estimator allows for "unobserved heterogeneity" (the unobserved difference in mean counterfactual outcomes between treated and untreated units) that may lead to selection bias. For example, one may want to account for factors unobserved by the researcher, such as differences in innate ability or personality across treated and control subjects or the effects of nonrandom program placement at the policy-making level. DD assumes that this unobserved heterogeneity is time-invariant, so the bias cancels out through differencing. In other words, the outcome changes for nonparticipants reveal the counterfactual outcome changes as shown in equation (5).

Results and Discussion

The discussion of results in this section consists of two parts: In the first part, we describe and discuss the results from the estimation of the mean values of selected outcomes, their differences (changes) and percentage changes. These percentage changes are calculated from the midline and update mean values of the outcomes. In the second part, we describe and discuss the impact of the SSA CP's IAR4D on assets (general, agricultural and household) and on Incomes/revenues (total income, revenue from livestock sale and sale of livestock products).

Classification of the Program, Treatments (sites) and Treatments within PLS by mean outcomes and their changes (Differences)

In the following description and discussion of results, we focused on the SSA CP (the program) and the disaggregation of this into treatments and the interaction of treatments and Pilot Learning Sites (PLS). The treatments are designated as follows: Treat_1 (Clean site); Treat_2 (IAR4D site) and Treat_3 (Conventional site). The PLSs are: PLS_1 (KKM); PLS_2 (LK) and PLS_3 (ZMM). In this section, we will be considering the mean outcomes, the differences (changes) and the percentage changes in the following outcomes: (1) Assets (general), (2) Agricultural assets, (3) Household assets, (4) Income (total revenue), (5) Revenue from livestock sales, (6) Revenue from the sale of livestock products, (7) Dietary diversity and (10) household multidimensional poverty.

Asset accumulation

On Tables 2-4 are presented the means of the outcomes and the changes that have taken place on the general, agricultural and household assets. These are estimated for the program, treatments and treatments within the PLSs. Results show that a minimum midline mean asset index (0.034) was recorded for Treat_3PLS_2 (Conventional within Lake Kivu) under the general asset category while a maximum mean asset index of 0.18 was recorded for Treat_2PLS_2 (Intervention/IAR4D within Lake Kivu) under the household asset category. The update indices showed increases over those of the midline with positive percentage changes. A minimum of 117.39 percent change (household asset) and up to a maximum of 1414.04 percent increases (general asset) were recorded as improvement in asset accumulation. Quoting Mamo (2011) in his research, he asserted that "in the farming household context, assets include all livestock owned, productive assets, household assets, and consumer durable assets that belong to the household". This corroborates the context of the farming households in the SS CP's coverage areas. In the study area, assets can be listed as livestock (including cross breed and local cattle, improved and local goats/sheep/pigs and chicken). Productive assets include all assets used to produce crop and livestock like hoes/cutlasses/machetes, ox-ploughs, draft cattle/donkeys, tractor/tractor ploughs, wheel barrows, farm equipment's, water pumps, sprayers, etc. Household and consumer durable assets in the SSA CP study area include paraffin stove/other cooking materials, sewing machines, ox-cart, car, bicycle, motorcycle, radio, television, fishing boat, mobile phone, sofa chairs, etc. According to Mamo (2011), "household asset accumulation means increasing the real value of all types of assets of the household over a specified reference period. The specified period is usually the period of time for which a program or an intervention that is expected to bring asset accumulation is implemented"

Table 2: Means and differences (Changes) in Outcome: Asset (General)

		Mean			
		Update	Midline	Difference (Change)	% Change
Asset (General) index	Program	0.576	0.061	0.516	845.902
	Treat_1	0.461	0.063	0.398	631.746
	Treat_2	0.626	0.072	0.554	770.515
	Treat_3	0.641	0.046	0.595	1287.879
	Treat_1PLS_1	0.476	0.073	0.403	552.055
	Treat_1PLS_2	0.409	0.056	0.353	632.617
	Treat_1PLS_3	0.498	0.059	0.439	744.068
	Treat_2PLS_1	0.612	0.050	0.563	1130.976
	Treat_2PLS_2	0.545	0.097	0.448	462.810
	Treat_2PLS_3	0.737	0.066	0.671	1016.667
	reat_3PLS_1	0.646	0.054	0.591	1090.406
	Treat_3PLS_2	0.544	0.036	0.508	1415.042
	Treat_3PLS_3	0.750	0.050	0.700	1394.422

Table 3: Means and differences of Asset (Agricultural Asset)

	Outcomes	Update	Midline	Difference (Change)	% Change
Agricultural Assets	Program	0.605	0.112	0.493	440.179
	Treat_1	0.596	0.107	0.489	457.009
	Treat_2	0.62	0.136	0.484	355.882
	Treat_3	0.598	0.092	0.506	550
	Treat_1PLS_1	0.538	0.125	0.413	330.4

	Treat_1PLS_2	0.617	0.0939	0.523	556.976
	Treat_1PLS_3	0.643	0.1	0.543	543
	Treat_2PLS_1	0.556	0.119	0.438	368.067
	Treat_2PLS_2	0.662	0.158	0.504	318.987
	Treat_2PLS_3	0.64	0.129	0.51	395.349
	reat_3PLS_1	0.521	0.095	0.426	448.421
	Treat_3PLS_2	0.619	0.079	0.539	682.279
	Treat_3PLS_3	0.652	0.103	0.548	532.039

Table 4: Means and differences of Asset (Household Asset)

	Outcomes	Update	Midline	Difference (Change)	% Change
Household Assets	Program	0.347	0.123	0.223	181.301
	Treat_1	0.331	0.116	0.215	185.345
	Treat_2	0.392	0.147	0.245	166.667
	Treat_3	0.316	0.107	0.209	195.327
	Treat_1PLS_1	0.409	0.142	0.268	188.732
	Treat_1PLS_2	0.288	0.101	0.187	185.149
	Treat_1PLS_3	0.285	0.101	0.184	182.178
	Treat_2PLS_1	0.419	0.114	0.305	267.544
	Treat_2PLS_2	0.4	0.184	0.216	117.391
	Treat_2PLS_3	0.353	0.138	0.216	156.522
	reat_3PLS_1	0.365	0.11	0.255	231.818
	Treat_3PLS_2	0.276	0.094	0.182	193.617
	Treat_3PLS_3	0.312	0.118	0.194	164.407

Revenue and Income generation

Estimated means of the total revenue/income and revenues from the sales of livestock and livestock products (Table 5-7). The estimates of the changes/increases that have taken place from midline to the update situation and their percentages are also shown. Results show that generally, positive increases have been accrued in the three types of incomes and revenues for the program, treatments and treatments within the PLSs. A minimum of 234.87 percent change (overall income/revenue: Clean within ZMM) and up to a maximum of 1259.19 percent increases (Animal products' revenue: Intervention/IAR4D within Lake Kivu) were recorded as improvement in revenue generation. The overall revenue estimated in our study includes some income generated from off-farm activities which were discovered to be sparsely embarked upon by the respondents as they are mainly into crop and livestock farming. The off-farm income would have played a key role in improving the overall total income of the smallholders (Babatunde, 2015: page 35).

Table 5: Means and differences of Income (Overall/total revenue)

	Outcomes	Update	Midline	Difference (Change)	% Change
Overall income/Total revenue	Program	6102.7	1339.94	4762.76	355.446
	Treat_1	5061.23	1221.73	3839.5	314.268
	Treat_2	6491.55	1520.7	4970.85	326.879
	Treat_3	6768.19	1273.09	5495.1	431.635
	Treat_1PLS_1	5022.044	1322.59	3699.46	279.713
	Treat_1PLS_2	5884.12	1094.91	4789.22	437.408
	Treat_1PLS_3	4172.66	1246.07	2926.59	234.866
	Treat_2PLS_1	5504	1441.45	4062.55	281.838
	Treat_2PLS_2	8643.82	1710.11	6933.7	405.454
	Treat_2PLS_3	4821.28	1365.44	3455.84	253.094
	Treat_3PLS_1	6205.18	1251.5	4953.68	395.819
	Treat_3PLS_2	7959.95	1406.82	6553.13	465.812
	Treat_3PLS_3	5888.12	1131.08	4757.04	420.575

Table 6: Means and differences of Revenue (Livestock)

	Outcomes	Update	Midline	Difference (Change)	% Change
Livestock Revenue	Program	8020.58	990.7	7029.88	709.587
	Treat_1	8100.269	817.27	7282.99	891.136
	Treat_2	6908.49	757.98	6150.51	811.434
	Treat_3	9132.2	1434.59	7697.61	536.572
	Treat_1PLS_1	6895.86	807.63	6088.23	753.839
	Treat_1PLS_2	8975.45	833.85	8141.59	976.385
	Treat_1PLS_3	8569.21	810.7	7758.51	957.014
	Treat_2PLS_1	7271.41	776.67	6494.75	836.230
	Treat_2PLS_2	7152.66	633.96	6518.7	1028.251
	Treat_2PLS_3	6269.37	891.37	5378	603.341
	Treat_3PLS_1	8730.26	1422.35	7307.91	513.7913
	Treat_3PLS_2	9964.61	1576.87	8387.74	531.923
	Treat_3PLS_3	8561.08	1272.97	7288.11	572.528

Table 7: Means and differences of Revenue (Animal Products)

	Outcomes	Update	Midline	Difference (Change)	% Change
Animal products' Revenue	Program	70.74	8.43	62.31	739.146
	Treat_1	28.42	5.97	22.45	376.047
	Treat_2	68.43	6.27	62.16	991.388
	Treat_3	116.79	12.55	104.24	830.598
	Treat_1PLS_1	21.38	5.33	16.06	301.313
	Treat_1PLS_2	39.77	6.85	32.91	480.438
	Treat_1PLS_3	24.22	5.74	18.47	321.777
	Treat_2PLS_1	62.88	4.91	57.98	1180.855
	Treat_2PLS_2	73.94	5.44	68.5	1259.191
	Treat_2PLS_3	67.18	8.41	58.77	698.811

Treat_3PLS_1	117.32	12.31	105	852.965
Treat_3PLS_2	115.59	13.06	102.53	785.069
Treat_3PLS_3	117.89	12.1	105.79	874.298

Household dietary scores and level of dietary diversity

- **Household dietary scores**

Household dietary diversity scores (indices) were also generated for the categories of program, treatments and treatments within the PLSs. The dietary diversity indices which are necessarily the mean dietary scores are presented along the percentage changes on Table 8. Results show that dietary scores have improved from the midline to the update situations. Minimum and maximum positive values recoded are to the tune of 0.40, with a percentage change of 141.34 (Clean within Lake Kivu PLS) and 0.48 (Conventional within KKM PLS) with a percentage change of up to 198.76. These are generally indications of positive improvement and movement from low to intermediate and from intermediate to high dietary diversity categories of households. These are further described and discussed in Tables 9a and 9b.

Table 8: Means and differences of Dietary Diversity (scores)

	Outcomes	Update	Midline	Difference (Change)	% Change
Dietary Diversity Index	Program	0.699	0.26	0.439	168.846
	Treat_1	0.7	0.282	0.428	151.773
	Treat_2	0.704	0.26	0.443	170.385
	Treat_3	0.693	0.246	0.447	181.707
	Treat_1PLS_1	0.743	0.273	0.47	172.161
	Treat_1PLS_2	0.683	0.283	0.4	141.343
	Treat_1PLS_3	0.668	0.258	0.411	159.302
	Treat_2PLS_1	0.748	0.272	0.477	175.368
	Treat_2PLS_2	0.696	0.254	0.443	174.409
	Treat_2PLS_3	0.665	0.257	0.408	158.755
	Treat_3PLS_1	0.723	0.242	0.481	198.760
	Treat_3PLS_2	0.696	0.26	0.435	167.308
	Treat_3PLS_3	0.659	0.235	0.425	180.851

- **Household level of dietary diversity**

The distribution of the level of dietary diversity among the households is presented in Table 9a. The various varieties of food available to the farmers range from cereals, legumes, vegetables, root and tubers, fruits, meats, eggs, fish, to milk among others. Using a composite score, the diversity of the households was classified into high dietary diversity for households which consumed wide varieties of food; intermediate dietary diversity and low dietary diversity for those households that consumed moderate and less variety of food in their households. In the overall results, the percentage distribution of respondents decreased with increase in consumption of varying diets for the three samples considered. However, in the update results there is an improvement in the dietary status of the respondents as identified by reduction in low dietary status and increase in either intermediate or high dietary status. The results for the clean relatively reveal about 6% decrease in low dietary and 13.73% increase in high dietary. Relative reduction in low dietary diversity under the treatment (IAR4D) is 37.33% while improvement to high dietary recorded about 45.06% increment.

Results for KKM show that in the midline situation, there was increase in the percentage of households as the food dietary diversity increases. This is an indication that majority of the households from this PLS had a better dietary diversity. Nevertheless, an enhancement of this food dietary status is revealed from the update results where 79.82% increase in high dietary was experienced in the clean sites, 38.14% increase in high dietary status in conventional and 85% increase in high dietary status among farmers in the treatment (IAR4D) category.

In Lake Kivu, midline results indicate that majority of the farmers fell under the intermediate dietary diversity for all the sites. The least percentages were recorded with those in the high dietary category. Contrary to what was observed in the KKM, there was reduction in the percentage of households in the intermediate category with an exception from farmers in the treatment (IAR4D) category. The households in the low dietary diversity increased by 27.4% in the clean category, 5.8% in conventional and they decreased by 19.2% in the treatment. The percentage increase in the households that relatively moved into higher dietary diversity in the treatment (IAR4D) is over 270%. This is an indication that the intervention of IAR4D really improved the farmers' food consumption in this location.

ZMM also presented a decrease in percentage from low dietary to higher dietary in the baseline results. This implies that more farming households fell under the low food diversity in this location. Except for households in the clean sites that recorded a decrease in the percentage of farmers under the high dietary category, others showed advancement through increase in percentage of high dietary and reduction of the percentage in the low dietary profile of households in the location. The percentage reduction in the treatment (IAR4D) site for the low dietary category in the update result is about 52%. Up to 190% increase in the percentage of households in the intermediate dietary category was also observed. This buttresses the improvement that the IAR4D has brought into the households' wellbeing.

On Table 9b are presented the changes that have taken place from the midline to the update period in the IAR4D intervention sites. It should be noted that the reduction in dietary diversity levels are only observed for low and intermediate levels. This is expected and shows that households have moved from lower levels of diversity of food consumed to higher levels of food consumption.

TABLE 9a: Level of dietary diversity

	Midline						Update					
	Clean		Conventional		Intervention		Clean		Conventional		Intervention	
Dietary diversity category	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Low dietary diversity	252	43	280	47.95	249	43.15	237	40.44	161	27.57	156	27.04
Intermediate dietary diversity	188	32.08	162	27.74	175	30.33	183	31.23	244	41.78	199	34.49
High dietary diversity	146	24.91	142	24.32	153	26.52	166	28.33	179	30.65	222	38.47
Total	**586**	**100**	**584**	**100**	**577**	**100**	**586**	**100**	**584**	**100**	**577**	**100**
KKM												
Low dietary diversity	43	22.05	44	22.92	37	19.17	4	2.05	21	10.94	6	3.11
Intermediate dietary diversity	48	24.62	51	26.56	56	29.02	4	2.05	37	19.27	2	1.04
High dietary diversity	104	53.33	97	50.52	100	51.81	187	95.9	134	69.79	185	95.85
Total	**195**	**100**	**192**	**100**	**193**	**100**	**195**	**100**	**192**	**100**	**193**	**100**
LAKIVU												
Low dietary diversity	73	36.87	69	35.2	78	41.05	93	46.97	73	37.24	63	33.16
Intermediate dietary diversity	93	46.97	109	55.61	101	53.16	82	41.41	86	43.88	86	45.26
High dietary diversity	32	16.16	18	9.18	11	5.79	23	11.62	37	18.88	41	21.58
Total	**198**	**100**	**196**	**100**	**190**	**100**	**198**	**100**	**196**	**100**	**190**	**100**
ZMM												
Low dietary diversity	116	60.1	163	83.16	149	76.8	89	46.11	71	36.22	72	37.11
Intermediate dietary diversity	58	30.05	25	12.76	33	17.01	86	44.56	98	50	96	49.48
High dietary diversity	19	9.84	8	4.08	12	6.19	18	9.33	27	13.78	26	13.4
Total	**193**	**100**	**196**	**100**	**194**	**100**	**193**	**100**	**196**	**100**	**194**	**100**

TABLE 9b: Changes in level of dietary diversity

Dietary diversity category	Midline Intervention Freq.	Percent	Update Intervention Freq.	Percent	Δ	Δ%
Low dietary diversity	249	43.15	156	27.04	(0.3735)	(37.35)
Intermediate dietary diversity	175	30.33	199	34.49	0.1371	13.71
High dietary diversity	153	26.52	222	38.47	0.4510	45.10
Total	**577**	**100**	**577**	**100**		
KKM						
Low dietary diversity	37	19.17	6	3.11	(0.8378)	(83.78)
Intermediate dietary diversity	56	29.02	2	1.04	(0.9643)	(96.43)
High dietary diversity	100	51.81	185	95.85	0.85	85.00
Total	**193**	**100**	**193**	**100**		
LAKIVU						
Low dietary diversity	78	41.05	63	33.16	(0.1923)	(19.23)
Intermediate dietary diversity	101	53.16	86	45.26	(0.1485)	(14.85)
High dietary diversity	11	5.79	41	21.58	2.7272	272.72
Total	**190**	**100**	**190**	**100**		
ZMM						
Low dietary diversity	149	76.8	72	37.11	(0.5168)	(51.68)
Intermediate dietary diversity	33	17.01	96	49.48	1.9090	190.90
High dietary diversity	12	6.19	26	13.4	1.6667	166.67
Total	**194**	**100**	**194**	**100**		

*Figures in parentheses indicate reduction in the dietary diversity levels.

Household poverty results

On Table 10 are presented the level of poverty (intensity) for the midline and endline/update periods. The program poverty intensity in the midline were 72.4%, 73.4% and 70.9% for clean, conventional and IAR4D respectively. At the update/end line, poverty intensity for the program sample were 65.1% (clean), 63.5% (conventional) and 61.5% (IAR4D). At both periods, poverty intensity for IAR4D participants was less than those in the clean and conventional samples. Thus, participation in the intervention of the SSA CP's IAR4D reduced poverty intensity of the participants. The program results show that poverty intensity for IP participants were 70.9% and 61.5% for midline and update/end line respectively. Poverty intensity for IAR4D participants in the end line was less than those of the midline. Thus, the continuous participation in the intervention of IAR4D reduced poverty of the participants.

The poverty intensity for the PLSs are as follow: KKM midline=74.2% (clean), 79.2% (conventional) and 73.3% (IAR4D); update/end line poverty intensity=61.2% (clean), 61.7% (conventional) and 58.2% (IAR4D). The KKM results show that poverty intensity for IAR4D participants was 73.3% and 58.2% for midline and end line respectively. For Lake Kivu, midline poverty intensity were 68.8% (clean), 68.6% (conventional) and 67.6% (IAR4D). At the endline, in Lake Kivu, poverty intensity were 65.3% (clean), 67.6% (conventional) and 64.5% (IAR4D). Further results show that poverty intensity in Lake Kivu for IAR4D participants was 67.6% (midline) and 64.5% (end line). Poverty intensity in the midline for ZMM were 72% (clean), 71.6% (conventional) and 68.1% (IAR4D). The ZMM poverty intensity in the end line were 72.7% (clean), 65.5% (conventional) and 61.4% (IAR4D). Finally in the ZMM, poverty intensity for IAR4D participants was 68.1% and 61.4% for midline and end line respectively.. Generally, poverty intensity for IAR4D participants was less than those of both the clean and conventional sites. The poverty intensity for IAR4D participants in the end line was also in all cases, less than that of the baseline. In the overall program and PLS results, the intervention of IAR4D resulted into less intense poverty situation of the participants as compared to the poverty situation of the non-participants. This confirms the fact that participation in the SSA CP's IAR4D reduced poverty of the participants. The implication of this is that continuous participation in the intervention of IAR4D reduced poverty intensity of the participants.

Table 10: Poverty Intensity by program, PLS and Treatments

		Midline	Update
PLS	**Treatments /Control**	**(Poverty Intensity) (%)**	**(Poverty Intensity) (%)**
Pool (program)	Clean	72.4	65.1
	Conventional	73.4	63.5
	IAR4D	70.9	61.5
KKM	Clean	74.2	61.2
	Conventional	79.2	61.7
	IAR4D	73.3	58.2
LAKIVU	Clean	68.8	65.3
	Conventional	68.6	67.6
	IAR4D	67.6	64.5
ZMM	Clean	72	72.7
	Conventional	71.6	65.5
	IAR4D	68.1	61.4

Impact results: Overall SSA CP (IAR4D) effects

Our impact evaluation results are pointers to several key findings. We estimated the average treatment effects on the treated (ATT) for asset accumulation and income and the different revenues. The computation of the average treatment effects was however preceded by the estimation of the propensity scores.

Propensity Score estimation

Prior to the estimation of the average treatment effects (ATT), we estimated the propensity scores using probit regression. The selection of the covariates that we included in the model for estimating the propensity scores was based on our knowledge about the SSA CP's IAR4D. The results concerning individual covariates are shown in Table 11. Accordingly, education of the household head, education of first spouse and income at the update are significant predictors of participation in the SSA CP's IAR4D. Results indicate that participants in the SSA CP's are significantly likely to be household heads with low educational status, whose first spouse's educational status is equally low and with fairly high income at the update period. Participants in the conventional module are significantly likely to be female farmers with more income at the update period and in the Lake Kivu PLS. However, participants in the clean sites are significantly likely to be male farmers with improved educational status whose first spouse has lower educational status. They are also significantly likely to be farmers with more income at the update period and not likely to be in the LK PLS.

Regarding the distribution of the propensity scores of the IAR4D and the comparison respondents, the graphs in figures 1, 2 and 3 indicate a significant overlap between each of the two groups of (i) IAR4D versus conventional/clean, (ii) IAR4D versus conventional and (iii) IAR4D versus clean.

Table 11: Participation in the SSA CP's IAR4D: Probit regression of matched observations

		Farming	Households		In	
	Intervention (Treated/IAR4D)		Control 1(Untreated/Conventional)		Control 2 (Untreated/Clean)	
Independent/predictor Variables	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Gender	-0.042	0.099	-0.232	0.097**	0.279	0.099***
Age of household head	-0.010	0.016	-0.011	0.0155	0.0203	0.0154
Square of age of household head	0.00003	0.00015	0.00013	0.000141	-0.00016	0.00014
Farming experience	0.005	0.00505	-0.0036	0.0049	-0.00111	0.0048
Household size	-0.004	0.0065	0.0025	0.0064	0.00095	0.0063
Marital Status	-0.029	0.098	-0.0057	0.098	0.0304	0.095
Educational status of household head	-0.065	0.0190***	0.022	0.018	0.034	0.017*
Education of first spouse	0.117	0.0227***	-0.047	0.022	-0.065	0.022***
Income at the update period	0.000015	5.87E-06*	0.000011	5.89E-06*	-0.000026	6.00E-06***
KKM PLS	0.095	0.106	-0.0043	0.106	-0.081	0.103
LK PLS	0 .066	0.097	0.160	0.096*	-0.215	0.094**
Cons	-0.323	0.410	-0.123	0.401	-0.834	0.40
No of observation (n)	1266		1266		1266	
LR Chi2 (11)	41.41		19.04		46.18	
Prob.> Chi2	0.0000		0.060		0.0000	
Pseudo R2	0.026		0.012		0.0277	
Log likelihood	-771.30		-776.28		-810.92	

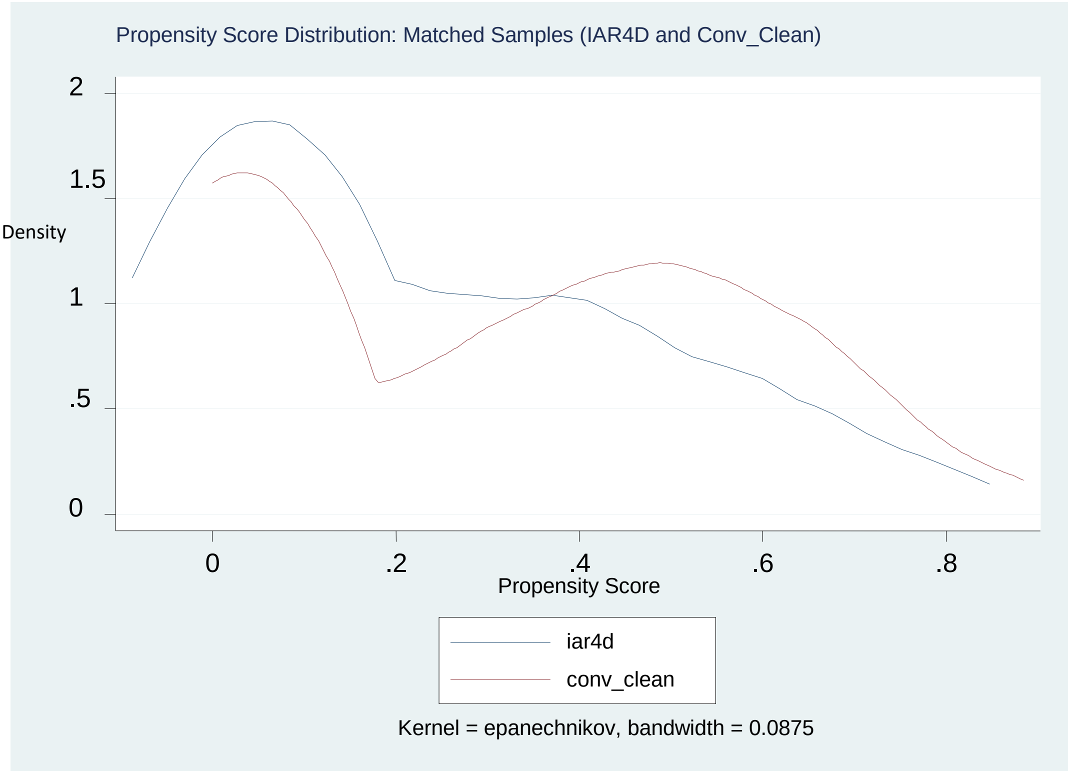

Figure 1: Distribution of Propensity Scores across IAR4D and control (Conventional and Clean) sites

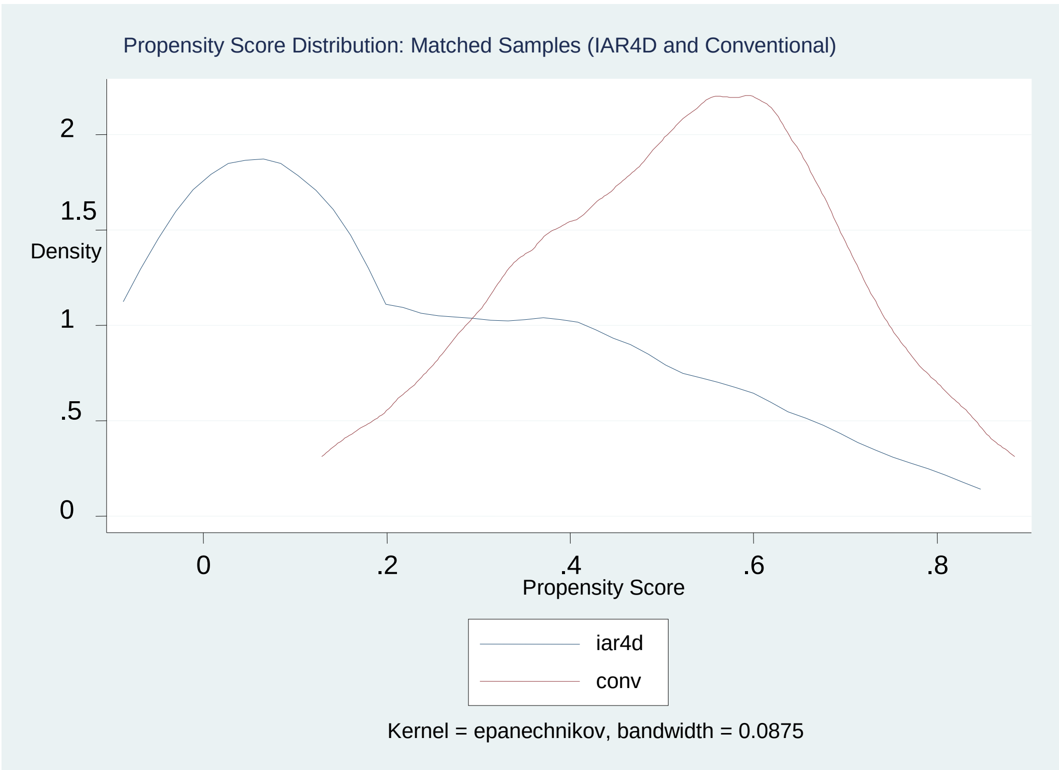

Figure 2: Distribution of Propensity Scores across IAR4D and control_1 (Conventional) sites

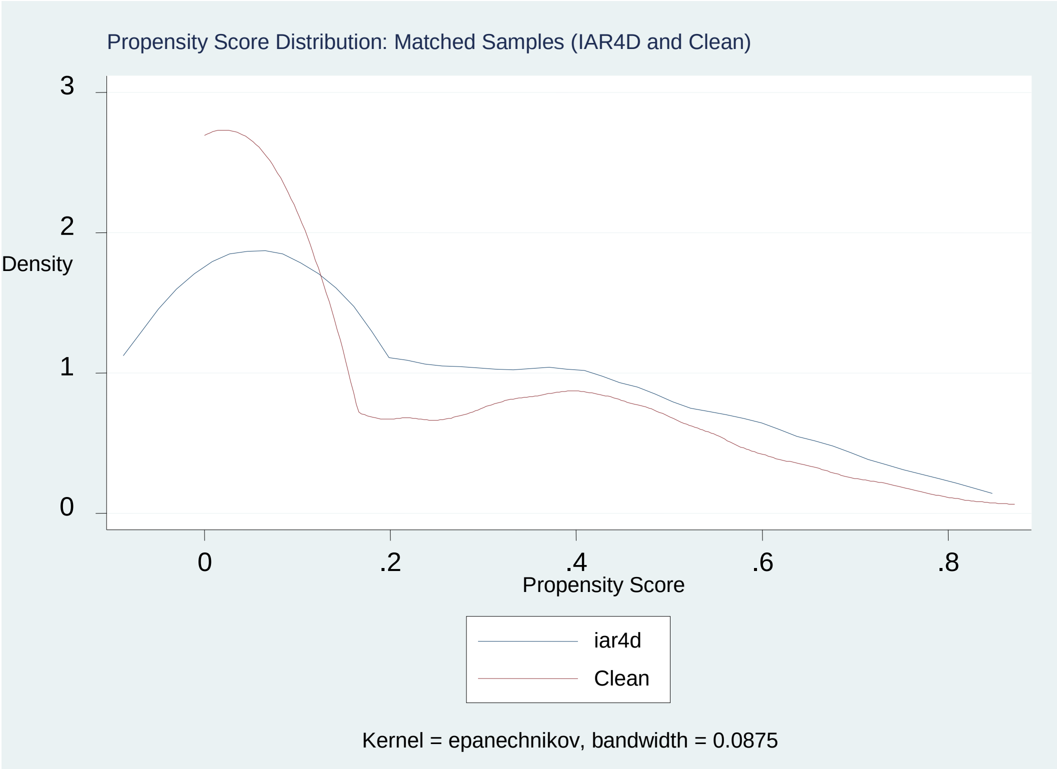

Figure 3: Distribution of Propensity Scores across IAR4D and control_2 (Clean) sites

Impact on Asset Accumulation

As earlier discussed, asset indices were constructed and computed for the three categories of assets considered in this study. The indices were computed for general assets, agricultural and household assets. The IAR4D has a strong, positive and statistically significant impact on asset at the program level. For the program estimates, the mean values of assets (general) for the midline (2010) and end line (update: 2016) periods and the intervention/IAR4D households were 0.070 and 0.628. The results show that average asset index of the treated (IAR4D farmers) sample due to participation in the IP activities, based on the PSM (ATT), was 0.116 in the case of both kernel (p<1%). A considerable change of up to 165.71% was recorded in the asset accumulation after the program ended in 2010. Positive changes in the ATT were also recorded for ATTs of agricultural and household assets, but these were not significant. In the conventional site, there was a positive and significant effect of the IAR4D on the households' asset, but a comparative analysis shows that the IP farmers are better than the farmers in the two counterfactuals of conventional and clean sites.

In the PLS, at KKM, the results show that the average asset index of the treated (IAR4D farmers) sample due to participation in the IP activities, based on the PSM (ATT), was 0.098 at p < 1%. A comparative analysis shows that the IP farmers are better (with a positive change of 196.18%) than the farmers in the two counterfactuals of conventional and clean sites. At Lake Kivu, the results show that the average asset index of the treated (IAR4D farmers) sample due to participation in the IP activities, based on the PSM (ATT), was 0.548 in the case of both the Kernel and nearest neighbor matching estimates (p < 5%). A comparative analysis shows that the IP farmers are better (with a positive change of 31.56%) than the farmers in the two counterfactuals of conventional and clean sites. At the

ZMM, the results show that the average asset index of the treated (IAR4D farmers) sample due to participation in the IP activities, based on the PSM (ATT), was 0.159 in the case of both the Kernel and nearest neighbor matching estimates (p < 1%). A comparative analysis shows that the IP farmers are better (with a positive change of 239.86%) than the farmers in the two counterfactuals of conventional and clean sites. Results are presented on Tables 12a and 12b. Though our results showed that as at the update period, smallholders in all the sites have had positive changes in their assets, the smallholders in the IAR4D sites effectively gained more. This implies that participation in the program allowed households to accumulate more assets than the non-participants (Debela and Holden, 2014).

Table 12a: Impact of IAR4D on assets of households: Asset (Program estimates)

		Midline Mean outcome	End line Mean outcome	ATT	%change
IAR4D	Assets (General)	0.070	0.628	0.116 (0.0150)***	165.71
	Agric. Assets	0.134	0.621	0.0085 (0.532)	6.34
	Household Assets	0.143	0.386	0.00412 (0.0150)	2.88
Conventional	Assets	0.0460	0.639	0.0600 (0.0171)***	
	Agric. Assets	0.091	0.597	-0.174 (0.0134)	
	Household Assets	0.106	0.315	0.0901 (0.169)	
Clean	Assets	0.0620	0.459	-0.1628 (0.191)***	
	Agric. Assets	0.106	0.597	0.00750 (0.125)	
	Household Assets	0.114	0.325	-0.116 (0.0143)	

Table 12b: Impact of IAR4D on assets of households (PLS estimates)

		Midline Mean outcome	End line Mean outcome	ATT	%change
KKM IAR4D	Assets	0.0497	0.614	0.0975 (0.0268)***	196.18
	Agric. Assets	0.1188	0.557	0.0214 (0.0214)	18.01
	Household Assets	0.114	0.412	0.0086 (0.155)	7.54
Conventional	Assets	0.0542	0.643	0.02010 (0.066)	
	Agric. Assets	0.0954	0.521	0.1537 (0.0322)	
	Household Assets	0.110	0.368	-0.0104 (0.0311)	
Clean	Assets	0.0731	0477	-0.149 (0.0226)***	
	Agric. Assets	0.125	0.541	0.0179 (0.02382)	
	Household Assets	0.142	0.405	-0.0126 (0.0212)	
LAKIVU IAR4D	Assets	0.0903	0.548	0.0285 (0.0266)**	31.56
	Agric. Assets	0.151	0.662	0.0205 (0.0206)	13.58
	Household Assets	0.173	0.396	0.0131 (0.217)	7.57
Conventional	Assets	0.037	0.543	0.0210 (0.267)	
	Agric. Assets	0.077	0.618	-0.0615 (0.0204)***	
	Household Assets	0.0913	0.273	0.01679 (0.0267)	
Clean	Assets	0.0529	0.402	-0.132 (0.0291)***	
	Agric. Assets	0.092	0.618	0.0380 (0.0150)*	
	Household Assets	0.0970	0.281	-0.0289 (0.0196)	
ZMM IAR4D	Assets	0.0663	0.737	0.159 (0.195)***	239.82
	Agric. Assets	0.129	0.639	0.00432 (0.226)	3.35
	Household Assets	0.138	0.345	0.000487 (0.0275)	0.35
Conventional	Assets	0.053	0.75	0.122 (0.0254)***	
	Agric. Assets	0.1034	0.652	-0.00979 (0.0270)	
	Household Assets	0.118	0.308	-0.0104 (0.011)	
Clean	Assets	0.059	0.500	-0.244 (0.205)***	
	Agric. Assets	0.100	0.642	0.0044 (0.0202)	
	Household Assets	0.101	0.279	0.00834 (0.0297)	

Impact on Income and Revenues

Positive and statistically significant income and revenue impacts from the IAR4D are present at the program level. ATTs of $766.12, $1,015.06 and $18.53 with corresponding percentage changes of 50.38%, 133.92% and 296.23% respectively for income, livestock revenue and revenues from animal products were recorded. These positive and significant impact and changes are obtained for the period after the midline. There is also a significant positive impact of the IAR4D on income, livestock revenue and revenues from livestock products at the task force level in the KKM, LK and ZMM. We observed that in the ZMM, there is a significant positive impact of the conventional (ARD) on revenues from animal products (ATT=$11.84; p<10%). We also observed that the clean pure control also had a significant positive impact on income (ATT=$1359.62; p<5%). In spite of this however, a comparative analysis shows that the IP farmers are still better off than the farmers in the two counterfactuals of conventional and clean sites. Results are presented in Tables 13a and 13b.

Table 13a: Impact of IAR4D on Income and revenues of households (Program estimates)

		Midline Mean outcome	End line Mean outcome	ATT	%change
IAR4D	Income	1520.7	6491.55	766.12 (376.26)**	50.38
	Livestock Revenue	757.98	5793.98	1015.06 (478.102)**	133.92
	Animal Product Revenue	6.271	52.275	18.53 (3.72)***	296.23
Conventional	Income	1273.091	6768.19	632.32 (611.10)	
	Livestock Revenue	1434.59	7627.18	-11.47 (2.87)	
	Animal Product Revenue	12.55	84.16		
Clean	Income	1221.73	5061.23	-1325.47 (350.28)***	
	Livestock Revenue	0.817.27	6743.53	220.035 (481.51)	
	Animal Product Revenue	5.966	29.18	-7.185 (3.513)**	

Table 13b: Impact of IAR4D on Income and revenues of households (PLS estimates)

		Midline Mean outcome	End line Mean outcome	ATT	%change
KKM IAR4D	Income	1441.45	5503.997	673.84 (380.47)*	46.75
	Livestock Revenue	776.67	5755.701	1331.73 (890.81)**	171.47
	Animal Product Revenue	4.905	43.13	20.84 (5.45)***	425.87
	Asset	0.0542	0.643	0.02010 (0.066)	
	Agric. Asset	0.0954	0.521	0.1537 (0.0322)	
	Household Asset	0.110	0.368	-0.0104 (0.0311)	
Conventional	Income	1251.50	6205.177	464.55 (771.32)	
	Livestock Revenue	1422.35	7441.177	-732.59 (584.11)	
	Animal Product Revenue	12.31	97.74	-8.638 (3.35)*	
Clean	Income	1322.59	5022.044	-581.80 (643.99)	
	Livestock Revenue	807.63	5622.17	-594.83 (910.20)	
	Animal Product Revenue	5.33	19.18	-11.81 (3.84)**	
LAKIVU IAR4D	Income	1710.114	8643.82	1434 (806.49)***	83.85
	Livestock Revenue	633.96	5914.69	865.78(828.42)**	136.57
	Animal Product Revenue	5.435	47.659	20.54 (6.73)***	377.92
Conventional	Income	1406.82	7959.95	-10.63 (654.73)	
	Livestock Revenue	1576.87	8238.91	-1798.35 (768.03)**	
	Animal Product Revenue	13.06	95.03	-30.60 (5.83)	
Clean	Income	1094.91	0.5884.12	- 1827.57(638.78)**	
	Livestock Revenue	0.833.85	7602.06	847.62 (842.62)	
	Animal Product Revenue	6.853	47.85	8.64 (7.13)	
ZMM IAR4D	Income	1365.44	4821.284	1197.39 (674.63)*	87.69
	Livestock Revenue	891.37	5681.83	785.49 (970.93)**	88.12
	Animal Product Revenue	8.412	60.52	11.84 (6.61)*	140.75
Conventional	Income	131.08	5888.122	352.37 (637.21)	
	Livestock Revenue	1272.97	7068.29	-1437.53 (1192.31)	
	Animal Product Revenue	12.105	65.601	11.72 (6.40)*	
Clean	Income	1246.07	4172.66	1359.62 (693.04)**	
	Livestock Revenue	810.69	7099.54	512.77 (892.50)	
	Animal Product Revenue	5.74	18.71	-20.37 (5.757)***	

Conclusion and Policy Recommendations

The update of the IAR4D proof of concept/impact analysis was to collect, analyze and document recent updates on SSA CP impact building on the 2012 proof of concept documentation. Specifically, the update was to (i) collect relevant data from the SSA CP activity locations and stakeholders to update an existing dataset (ii) further carry out an analysis of the dataset using various methods to generate the required inferences that respond partly to the three questions for the proof of the IAR4D concept but more importantly the impact assessment of the SSA CP program. Our conclusion is therefore in line with the generated inferences which in effect, have responded to and validated the three questions for the proof of the IAR4D concept. In the 2012 proof of concept documentation, the three questions were answered in the affirmative, so the present update is therefore to validate this affirmation. Each of the three questions is therefore taken and the answer that corresponds to it is discussed as follows:

- **Does the IAR4D works as a concept?**

  Looking at the results of the study, particularly the impacts estimates, it is observed that the IAR4D concept which was proved to have worked in 2012 is still working. The results of the present update have been able to show that (i) a considerable change of up to 165.71% was recorded in the asset accumulation, (ii) up to 50.38%, 133.92% and 296.23% percentage changes were also recorded for income, revenues from livestock and livestock products respectively, (iii) reduction in low dietary diversity of up to 37.33% and (iv) increase in high dietary diversity status of up to 85% occurred, (v) poverty intensity were less in the end line/update than at the midline. All the changes enumerated so far are for the IAR4D/IP participants after the 2012 documentation. In as much as the IAR4D has brought about considerable positive changes in the above key outcomes, we can conveniently infer that the IAR4D works as a concept.
- **Does the IAR4D deliver more benefits than the conventional R&D methods?**

  The impact evaluation methods employed in the update (the PSM in combination with the double difference) ensured that, besides estimating the impact values for the IAR4D/IP participants, the impact values for the matched samples of the conventional R&D and the clean sites were also estimated. In all the cases of estimation, the results for the IAR4D/IP showed positive and statistically significant impacts as compared to the conventional R&D methods. Most of the conventional and clean methods did not positively and significantly impact on non-IAR4D/IP households. The very few of the conventional R&D and clean methods which recorded positive and significant impacts were with far lesser values when compared with the values recorded for the IAR4D/IP participants. In view of this, it can also be inferred that the IAR4D delivers more benefits than the conventional R&D methods.

- **Can the IAR4D be scaled up and out beyond the current area of operation?**

  We have been able to establish that the IAR4D works as a concept and that it does deliver more benefits than the conventional R&D methods. In the case of scaling up and out the IAR4D beyond the current area of operation, our results on increased asset accumulation, income and revenue, reduction in low dietary and increase in high dietary diversity status, reduction in poverty intensities were with corresponding estimates for the clean and conventional methods. We observed that households in some of these control sites also recorded some positive changes in outcomes. Since most of the households in these control sites are matched samples of the IAR4D/IP samples, implementing the IAR4D in those clean and conventional sites can be accomplished with substantial success. Moreover, considering the fact that all the IP issues resulted in huge positive changes for the stakeholders, we can conveniently and unequivocally infer that the IAR4D can conveniently and successfully be scaled up and out beyond the current area of operation.

Policy implications and recommendations: The policy implications emanating from the foregoing are as follows: the basis for carrying out an impact evaluation of a project or program is its external validity. The external validity in turn is associated with the project/program's scalability. Since the results of the present IAR4D update have validated the proof of concept and proved that the IARD4D can be scaled up and out beyond the current area of operation, there is need to develop a scaling up plan or to modify existing ones in case there are some in the pipeline of implementing institutions and agencies. Policies around the established scaling up and out protocols are therefore recommended and needed to be developed. These centre around (i) developing a scaling up plan which consists of creating a vision, assessing scalability, filling information gaps and preparing a scaling up plan (ii) establishing pre-conditions and implementing a scaling plan process (this includes legitimizing change, building a constituency and re-aligning and mobilizing resources) and (iii) implementing the scaling up process (modifying organizational structure, coordinating action and tracking performance and maintaining momentum). By formalizing these protocols with implementing institutions, stakeholders and partners particularly, the stakeholders in the policy arena will help maintain a consistent and formidable scaling up and out procedure.

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