The Integrated Agricultural Research for Development (IAR4D) and its Impacts on marketed crops: Data Analysis of the Kano-Katsina-Maradi Pilot Learning Site

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39- The Integrated Agricultural Research for Development (IAR4D) and its Impacts on marketed crops: Data Analysis of the Kano-Katsina-Maradi Pilot Learning Site

(KKM PLS), West Africa.

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Abstarct

Several attempts have been made by various governmental, non-governmental and international organisations to address agricultural related challenges in the sub-Saharan African region, but without any meaningful positive impact. In recent time however, FARA[1] came up with a new research paradigm known as the IAR4D[2] (which has now been tested to be a potent instrument to be used in addressing these challenges. This study is therefore conceived to among other things; evaluate the impact of the IAR4D on marketed crop outcomes, making use of the Propensity Score Matching (PSM) method of imapct Assessment. The PSM in this study makes use of the counterfactual framework via the IAR4D's Innovation Platforms. Average marketed values of cereals of the treated (IAR4D farmers) sample due to participation in the IP activities based on the PSM (ATT) was $ 249 (p<5%), for legumes, $ 192 (p<1%) and for fruits/vegetables, $ 229 (p<5%). These values are indication of the impact of the IAR4D intervention on the marketed crop outcomes. This suggests that, agricultural research and intervention programmes that make use of innovation systems approach such as the IAR4D' Innovation Platforms have a stong positive impact on marketed crop outcomes and therefore have a better potential of having much stronger and positive impact on other livelihood outcomes.

Key Words: IAR4D, KKM PLS, Propensity Score Matching, SSA CP

1.0   Introduction

[1] FARA is the acronym for Forum for Agricultural Research in Africa, whose sub Saharan Africa Challenge programme implements the IAR4D

[2] IAR4D: "Integrated Agricultural Research for Development". This makes use of the Innovation Platforms Approach to research

The productivity of the farming systems of the savannas, particularly in the Kano-Katsina-Maradi Pilot Learning Site (KKM PLS) of the sub-Saharan Africa Challenge Programme (SSA CP), West Africa is low. Results from the validation exercise conducted in the KKM PLS indicate limited adoption of improved technologies. Land degradation, diseases, insect pests, *Striga* infestation, lack of labour-saving technologies for field operations and processing, and inadequate supply of yield-enhancing inputs are serious constraints to intensification of farming systems. Market-related constraints include limited access to credit, low farm-gate prices, high cost and low quality of inputs, poor access to output markets, and weak linkages between producers, to community resources and utilization especially between farmers and pastoralists. Ineffective extension systems and lack of policy incentives have been known to also constarin agricultural intensifcation. Clearlry, these constraints reinforce each other, necessitating integrated approaches for sustainably intensifying agricultural production in the KKM PLS.

Overtime, several attempts have been made by various governmental, non-governmental and international organisations to address this other related agricultural challenges in sub-Saharan African region. But, according to Upton (1984), it is clearly not possible to develop improved production systems without first studying the existing ones. On the one hand, the performance of the existing, traditional system provides a baseline standard with which to compare proposed innovations. On the other hand, an understanding of the resource requirements and constraints of the existing system provides guidance as to which of the possible new technologies are appropriate and worth pursuing, and which are not. Much agricultural research in the past proceeded on the assumption that new technologies could be developed in the isolation of the research station and imposed on farmers from above. Realizing the need to confront these challenges head long, the Forum for Agricultural Research in Africa through its sub-Saharan African Challenge programme established three Pilot Learning Sites (PLSs) across the sub-Saharan Africa. These PLSs comprise units known as Task Forces (TFs) – 3 for each PLS- to carry out the implementation of a research paradigm known as the 'Integrated Agricultural Research for Development (IAR4D)'. The IAR4D in turn makes use of action sites known as "Innovation Platforms (IPs)"

The point of departure of IAR4D from conventional Agricultural Rsearch for Development (ARD) is that whereas the latter treats research-development-production-consumption as a linear process in which research is by far the predominant source of knowledge, IAR4D embeds research within an innovation system comprising relevant actors who interact within a network to develop, test and promote technological and institutional innovations along agricultural value chains. Unlike the linear configuration, the network (systemic) approach facilitates timely feedback to researchers and aims at promoting knowledge sharing and interactions leading to innovations (rather than research products per se). Here,

innovation refers to the activities and processes associated with putting into use of new technical and institutional or organizational knowledge. It therefore adds value to products of research thus catalyzing the achievement of development impact.

In the KKM PLS, a couple of agricultural innovations like crop and livestock innovations; social, marketing, post harvest innovations, etc have been introduced or existing ones were improved upon for the use of stakeholders. Some of the crops that were innovatively grown include cereals (sorghum, millet, guinea corn, maize and rice); legumes (cowpea, soybean, beans); vegetables (pepper, tomato, green pepper, lettuce). Most of these crops were grown by the IP farmer stakeholders and some non-IP stakeholders (we cannot rule out the possibility that non-IP farmers, either within IP environment or outside of it will not have grown crops using the technologies and innovations of the IAR4D's IPs). In this paper, we look at the differences in the values of marketed crop (cereal, legumes and fruits/vegetables) outcomes to investigate how these differences have been translated into impact on the basis of the IAR4D's IPs.

The rest of this paper is organised as follows. Section 2 describes the structure of the IAR4D and its impact pathway. In section 3, we discuss the research methodology which comprises the analytical framework and survey methodology/design and data collection procedures. In section 4, the results of the analyses are presented, described and discused and finally in section 5, the findings are summariesed by addressing some policy implications of the major findings and making appropriate conclusion and recommendations.

2.0   Structure of the IAR4D and Impact Pathway

While traditional ARD approaches *exogenously* bring innovations into the system, IAR4D instead establishes an institutional innovation—the Innovation Platform—which in turn, *endogenously* generates the innovations (technological, market, institutional and policy), summarizes the research-to-impact pathway used to hypothesize the causal relationships between research inputs, and the research outputs—the IP institutional innovation and its results (knowledge increase, behavioural change and innovations at the interfaces of processes driving productivity, environment, policies and markets); knowledge and behavioural outcomes at the household, community and market levels, and impact outcomes. This is the hypothesized generic impact pathway for IAR4D. Impact pathways for individual SSA CP taskforces exhibit minor variations depending on specificities of the problem or opportunity they address. The main outcomes at the IP level are: increased awareness, increased knowledge drawn from several IP sources, and behavioural changes at the individual and system levels. These outcomes combine to generate innovations at the interfaces of productivity, care for the environment, policies and markets with a potential to demonstrably increase the delivery of benefits to end users. This will in turn lead to outcomes at farm household, village community, and market levels. The main

outcomes at the household and community levels are: increased awareness and knowledge, behavioural outcomes (such as adoption of relevant innovations, more effective supply of inputs to satisfy demand, increased and better-expressed demand for inputs, and increased volume of input sales), market outcomes (increased and more effective supply of outputs, increased demand by consumers), efficiency outcomes (increased yields, technical efficiency and profit).

These outcomes lead to impacts in the form of welfare and equity outcomes (such as increased incomes, poverty reduction, improved health and nutrition, and equity) and environmental outcomes (for example, imputed soil fertility and erosion). It is hypothesized that evidence provided by the SSA CP's research comparing the benefits of IAR4D against conventional ARD approaches will determine whether communities and other organizations more directly involved in development will seek to adopt and scale up IAR4D. The outcomes and range of IAR4D's impact are influenced by several conditioning factors. These factors complicate the attribution of changes in impact indicators to IAR4D alone. Factors exogenous at the household level but endogenous at the community level include infrastructure (public and privately supplied), institutions (governance and market structures), policies (macroeconomic, sectoral, pricing, social), technologies, and information. Factors exogenous at the community level include agro-climatic conditions and external market conditions (world prices and access to foreign markets).

The basic IAR4D's impact pathway can be succintly summarised as follows: the first stage is the establishment of the IP where the priorities that would determine the objectives of the research are agreed upon, a concept and plan of action developed and the roles of each actor or groups of actors on the platform clearly defined. The research process would then involve the use of inputs (such as information, research staff, research collaborators and financial resources). The processes leading to impact may be broken into three phases: Identification of a common challenge (through the IP) and using inputs through an action research process to generate outputs in accordance with the project's priorities and objectives; Development of processes to deliver the outputs to beneficiaries (putting research into use — sometimes referred to as the innovation process). This involves putting into use the outputs generated by the research process. This process is facilitated by the IP and leads to incremental changes in relationships and behavior of stakeholders in particular the users of the research outputs. These incremental changes in relationships and behavior are the outcomes which could include: (a) increased awareness and knowledge; (b) behavioral outcomes (such as adoption of relevant innovations, more effective supply of inputs to satisfy demand, increased and better expressed demand for inputs, and increased volume of input sales); (c) market outcomes (increased and more effective supply of outputs, increased demand by consumers); and (d) efficiency outcomes (increased yields, technical plus allocative efficiency and profit); Out-scaling, by using agricultural

development processes leading to improved food security, income, livelihood assets, the natural resource base and resilience to shocks; i.e., impact. The mandate of IP actors ordinarily stretches beyond the IAR4D site. Accordingly, these actors serve as agents for out scaling the research approach and its outputs beyond the initial site.

Several factors such as favorable weather, macroeconomic conditions, transportation and communication systems, institutional structures, policy regimes, socioeconomic and political stability condition the agricultural development process. Factors exogenous at the household level but endogenous at the community level include infrastructure (public and privately supplied), institutions (governance and market structures), policies (macroeconomic, sectoral, pricing or social, among other), technologies, and information. Factors exogenous at the community level include agro- climatic conditions and external market conditions (world prices and access to foreign markets). The IP enables the team to internalize as much of the conditioning factors as possible so that impact can be achieved.

In the KKM PLS, all the three task forces (Northern Guinea, Sahel and Sudan Savannas) of the KKM PLS have been demonstarting the effecetiveness of innovation systems in supporting the development and adoption of market driven crop/livestock productivity-enhancing the development through widespread adoption of technology options. In order to influence development through widespread adoption of technologies and improve income of stakeholders, enabling conditions in the realms of market s and ploicy needed to be fostered, along with harmonization of distinct institutional agendas and practices among diversity of actors (e.g., farmers' associations, entrepreneurs, NGOs, CBOs, development-oriented organizations, ministries, and research and extension agencies). Because the IAR4D approach is new, the central research question of the challenge programme is realted to the proof of the IAR4D concept. Market participation by primary stakeholders in the KKM PLS has been and it is still a major focus and cardinal point of the task forces in the KKM PLS. Crop and livestock outputs are transformed into marketed outcomes through the linkage opportunities that are provided by the Innovation Platforms (IPs). According to Asfaw et al., (2012), in areas with limited market infrastructure, the argument for lack of economic transformation of agriculture towards more commercialized production is strongly embedded in the lack of incentives for private sector investment and the need for proper institutions to fill the vacuum left by the withdrawal of the state. There is a growing concern, for instance, that public programs, which traditionally provided smallholder with input supplies, extension services and credit support, have collapsed in response to several reforms (Jayne and Jones, 1997) but this is exactly what they were intended to do. The bigger concern is that the envisaged private sector participation did not materialize. The reforms have also ignored the production side of the supply chain, by focusing on trader entry in output markets (Winter-Nelson and Temu, 2005). Nonetheless, liberalization has opened a window of opportunity for smallholder producers hitherto growing diverse products

and supplying small surpluses to markets. The removal of trade barriers and increased competition has opened some flexibility for farmers to choose buyers for their products and suppliers of key inputs. But smallholder producers in sub-Saharan Africa (SSA) countries face several barriers that make it difficult for them to gain access to markets and productive assets. Market failures in rural areas of SSA countries often arise from a mix of institutional, infrastructure and policy failures.

Making use of the basic IAR4D impact pathway, we evaluate the effect of participating in the IAR4D's IP activities on the changes in the marketed crop outcomes in the KKM PLS. However, the objectives of this paper are to mainly assess the determinants of the households' decisions to participate in the IAR4D, accounting for non-participants for marketing of selected crop types (i.e., cereals, legumes and fruits/vegetables), and second, to estimate the causal impact of participating/non-participating in the IAR4D on marketed crop outcomes. In this study, we employ propensity score matching (PSM) to account for endogeneity of the participation decision due to observed and unobserved characterisitics of the farmers and their farms.

3.0 Methodology
3.1 Analytical Framework
The objective of this paper is to assess the impact of IAR4D on marketed crop outcomes among the farmers in the KKM PLS of the SSA CP in West Africa.

An impact evaluation is essentially a problem of missing data, because one cannot observe the outcomes of programme participants had they not been beneficiaries (Cameron and Trivedi 2005; Imbens and Wooldridge, 2009; Khandker et al., 2010). Without information on the counterfactual, the next best alternative is to compare outcomes of treated individuals or households with those of a comparison group that has not been treated. In doing so, one attempts to pick a comparison group that is very similar to the treated group, such that those who received treatment would have had outcomes similar to those in the comparison group in the absence of treatment. Also, if the treatment (in our case, the IAR4D technologies form which emanates the crop and livestock outputs) were randomly assigned to farmers, we could assess the impact of the IAR4D on crop and livestock outputs and in effect, on the marketed outcomes of IAR4D participants and non-participants. In such a case, the average treatment effect (ATE) can be computed as follows (Mulugeta et al. 2012):

$$ATE = E(Y_1 \mid D = 1) - E(Y_0 \mid D = 1) \tag{1}$$

This is based on the assumption that the output levels of the participants before their participation $E(Y_0 \mid D = 1)$ can reasonably be approximated by the output level of non-

participants during data collection $E(Y_0 \mid D = 0)$. Otherwise, estimation of ATE using the above equation is not possible since we do not observe $E(Y_0 \mid D = 1)$ though we do observe $E(Y_0 \mid D = 1) \, E(Y_0 \mid D = 0)$. However, technologies (in our case, within IAR4D, which leads to crop outputs/outcomes) are rarely randomly assigned. Instead, technology adoption usually occurs through self selection of farmers or, sometimes, through programme placement. In the presence of self-selection or programme placement, the above procedure may not result in a biased estimation of the impacts of IAR4D since the treated group (i.e the participants) are less likely to be statistically equivalent to the comparison groups (i.e. the non-participants) in a nonrandomized setting.

A number of different methods can be used in impact evaluation theory to address the fundamental question of the missing counterfactual. Each of these methods carries its own assumptions about the nature of potential selection bias in programme targeting and participation, and the assumptions are crucial to developing the appropriate model to determine programme impacts. Among others, few of these methods include randomized evaluations, matching methods (specifically propensity score matching-PMS), instrumental variable (IV), regression discontinuity, etc (see further discussion on these methods in Baker, 2000; Khandker et al., 2010). In this paper, we apply the method of propensity score matching-PMS). The propensity score matching (PSM) method, which was developed by Rosenbaum and Rubin (1983), has been extensively used in Economics since the 1990s to solve the above problem. According to Ravallion (2003), quoted by Mpila et al. (2011) the underlying concept with propensity score matching is that two groups are identified, the one that took part in the intervention (IAR4D in the case of this study) denoted by $H_i = 1$ for household l, and the one that did not take part in the intervention denoted by $H_i = 0$. Intervention households are matched with to non-intervention households on the basis of the probability that the non-participants would have participated in the intervention and this probability is called the propensity score. It is given by:

$$P(X_i) = \mathrm{Pr}ob(H_i = 1 \mid X_i)(0 < P(X_i) < 1) \tag{2}$$

Where X_i is vector of pre-intervention control variables. These pre-intervention control variables are those based on knowledge of the programme under evaluation and on the social, economic and institutional theories that may influence participation in the intervention. The vector can also include the pre-intervention values of the outcome variables. Proppensity score matching is not able to reproduce the results of the experimental randomisation designs if the variables that influence participation in the intervention are not properly defined.

Rosebaum and Rubin (1983) also defined 'proppensity score' as the conditional probability of receiving a treatment given pre-treatment characteristics:

$$P(X) \equiv \mathrm{Pr}\{D = 1 \mid X\} = \{D \mid X\} \tag{3}$$

Where $D = \{0, 1\}$ is the indicator of exposure to treatment and X is the multidimensional vector of pre-treatment characteristics. The PSM method is also said to be a systematic

procedure of estimating counterfactuals for thr unobserved values $\left(E(Y_i \mid D = 0)\right)$ and $\left(Y_0 \mid D = 1\right)$ to estimate impact estimates with no (or negligible) bias. The validity of the outputs of the PSM method depends on the satisfaction of two basic assumptions namely: the Conditional Independence Assumption (CIA) and the Common Support Condition (CSC) (Becker and Ichino, 2002). CIA (also known as Unconfoundedness Assumption) states that the potential outcomes are independent of the treatment status, *given* X. Or, in other words, after controlling for X, the treatment assignment is "as good as random". The CIA is crucial for correctly identifying the impact of the programme, since it ensures that, although treated and untreated groups differ, these differences may be accounted for in order to reduce the selection bias. The common support condition entails the existence of sufficient overlap in the characterisitics of the treated and untreated units to find adequate matches (or a *common support*). Hen these two assumptions are satisfied, the treatement assignment is said to be strongly ignorable.

3.2 Sampling methodology and Data

The surveys which produced the data used in this study were conducted by taskforces within the framework of the Sub-Saharan African Challenge Programme supported by the Forum for Agricultural Research in Africa (FARA) and its donors—including the European Union (EU), UK Department for International Development (DFID), and the governments of Italy and Norway. The sample frame was derived from different districts, selected to represent the three basic areas of taskforces in the KKM PLS. In each district, a sample of households was selected by taking a sample of district wards; a random sample of villages within each ward; and a random sample of households in each selected village. Finally, a household was retained in the sample if it supposed to belong to one of the 180 villages selected within the clean, conventional or IP/action sites.

The baseline and midline surveys were seperetly conducted in 2007/2008 (baseline) and 2010/2011 (midline). The surveys covered a total of 1800 households from 180 villages in 3 Task Forces (TFs). These include the Northern Guinea Savanna (NGS); the Sahel Savanna (SaS) and the Sudan Savanna (SS). Multistage stratified random sampling procedures had (earlier at the inception of implementation of the SSA CP) been applied and carried out in the three TFs within the previously selected districts (IAR4D and counterfactual to select the villages where the treatment are being applied, that is villages where IAR4D are 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 variables included in the analysis in this study are of primary importance and they include whether a household participated in the IAR4D or not, level of crop and livestock outputs and their marketed values, socioeconomic and demograhic variables such as age, gender, educational level, household size, extension visits (dummy and actual), farming experience,

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government/public institutional and infrastructural presence like boreholes and extension agencies, research insstitutions. These latter variables are used in the model as covariates.

4.0   Results and Discussion

4.1   Estimation Results of the propensity scores

The importance of estimation of the propensity score is twofold (Mulugeta et al., 2012): first, to estimate the ATT and, second, to obtain matched treated and non-treated observations. Using propensity scores for participation generated by the probit regression model, households in the intervention (IAR4D/IP) were matched on the basis of the proximity of their propensity scores of participation to households in the counterfactuals. All other households whose propensity scores for participation were different from the range of scores for the intervention households were dropped from the analysis. By dropping all the counterfactual households whose probability of participation was very different from the households in the intervention, differences in marketed outcomes were then compared between households that were more similar and therefore comparable and as such any differences in outcomes between the participants and non-participants are attributed to the intervention (Ravallion, 2003). Our results for the probit model are reported in Table 1. The results show that household size, participation in research and the Sahel task force dummy are important variables that determine the farmers' participation in IAR4D. This implies that participants in the IAR4D are likely to be farmers with large household sizes, with more participation in research but less likely be residing in the Sahel Savanna task force zone. The results also show that farmers in the conventional site are likely to be those who receive regular visits from extension agents, who participate less in research activities and enjoy government's (i.e. public institutions) presence in their zone/community. Further results indicate that farmers in the clean sites are likely to be those with smaller household sizes, who receive less extension visits, do not enjoy government presence in their zone, whose water source is not borehole and are less likely to be from either NGS or Sahel zones. Among the farmers who participated in the IAR4D, the propensity scores range from 0.1593475 to 0.6539565, with a mean score of 0.3331623. The common support assumption is thus satisfied in the region [0.1593475 to 0.6539565]. This enforces the exclusion of some non-participants.

Table 1: Results of the probit regression model of participation in the IAR4D intervention

Explanatory variables	Treated		Control (Conventional)		Control (Clean)	
	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error
Gender (1=male; 0=female)	-0.090	0.277	0.399	0.317	-0.175	0.293
Age of respondent (yrs)	0.016	0.289	-0.001	0.232	0.041	0.290
Household size	0.387*	0.23	0.133	0.247	-0.050*	0.256
Farming experience	-0.341	0.258	0.348	0.256	0.042	0.252
Education of respondent ()	-0.011	0.059	0.073	0.055	-0.512	0.060
No of times household visited extension	0.006	0.076	-0.052	0.068	0.055	0.071
No of times household received extension visits	-0.052	0.054	0.146***	0.054	-0.126*	0.075
Participation in research activities	0.795***	0.267	-0.552*	0.299	-.0340	0.273
Presence of government/pub;ic infrastructure	-0.108	0.307	0.640**	0.287	-0.581*	0.324
Availability of boreholes in village	0.046	0.024*	0.002	0.015	-0.036*	0.020
Task force dummy (NGS)	-	-	0.732	0.652	-0.342***	0.823
Task force dummy (Sahel)	-0.808	0.415*			-2.406***	0.643
Task force dummy (Sudan)	-	-				
Constant	0.534	1.187	-0.341***	1.212	3.344**	1.301
Sample size (n)	137		156		156	
R^2	0.1083		0.1242		0.1959	
Prob > χ^2	0.0398		0.0340		0.0001	
Log likelihood	-84.128		-78.691		-80.387452	

4.2   Estimation of Treatment Effects (Impact of IAR4D on marketed crop outcomes)

Significant positive differences were observed for cereals, legumes, fruits/vegetables (treatment), cereals, legumes and fruits/vegetables (conventional) and legumes (clean). The results suggest that the marketed crop outcomes after the IAR4D are generally significantly different from the outcomes before the IAR4D (The percentage differences/gains are shown on Table 2). The values of the means of the before and after intervention for the treated and the two counterfactual sites indicate that there are relatively large differences resulting from the intervention when compared with the mean difference estimations for the counterfactual and clean sites. These results indicate that though the participants in the IAR4D could be using the same market enviroment and conditions with their counterparts in the counterfactual sites, they actually had an edge over their counterpart farmers in the counetrfactual sites from the benefits they derived from their participation in the IP activities. One of these benefits is definitely related to the participating farmers' linkage to input and output markets, an activity which is one of the major focuses of most of the IPs in the study area. Generally, for the three sites of IAR4D, conventional and clean, nearly all the considered marketed crop outcomes after the IAR4D were superior to the outcomes before IAR4D.

The IAR4D impacted upon the marketed crop outcomes with statistically significant differences being observed for all the 3 crop types in the IP action sites. In 2007/2088 (baseline situation), the average marketed values of cereals, legumes and fruits/vegetables were $456, $408 and $107 respectively in the IAR4D (but inially clean) sites. At midline in 2010/2011, the average marketed values of these crop types rose to $1368, $1223 and $360 respectively for cereals, legumes and fruits/vegetables. The results further indicate that the IAR4D intervention increased the value of marketed for IP participants by $912, $815 and $252 with estimated percentage gains of 200, 199.75 and 200 percent for cereals, legumes and fruits/vegetables respectively.

The probit model results were also used to compute the propensity scores that were used in the PSM estimation of the Average Treatment Effect (ATT).The average treatment effect on the treated (ATT) was computed, using the kernel matching method. The outcome variable is marketed value of each of cereal, legumes and fruit/vegetable crops in US Dollars. The z-statistics were based on bootstrapped standard errors with 50 replications which were used to verify whether the observed effect was significant or not.

The results show that the average marketed values of cereals of the treated (IAR4D farmers) sample due to participation in the IP activities based on the PSM (ATT) was $ 249 (p<5%), for legumes, $ 192 (p<1%) and for fruits/vegetables, $ 229 (p<5%). A comparative analysis shows that the IP farmers are better than the farmers in the two counterfactuals of conventional and clean sites. As such, it can be deduced that households in the intervention (IAR4D) site had

much more better crop outputs which when translated into marketable outcomes commanded better and higher values as compared to households in the two counterfactuals (conventional and clean sites).

Table 2: Impact of IAR4D intervention on marketed crop outcomes

	ATT	% gain	BSE	Z-Value
IAR4D	Cereals (n=558) = 2.49	200	1.13	2.21**
	Legumes (n=449) = 1.92	199.75	0.74	2.60***
	Fruits/Vegetables (=146) = 2.29	200	1.05	2.18**
Conventional	Cereals (n=529) = -0.84	199.83	1.17	-0.72
	Legumes (n=451) = 0.86	148.51	0.53	1.63
	Fruits/Vegetables (n=151) = 0.13	203.33	0.25	0.54
Clean	Cereals (n=555) = -1.76	200	1.06	-1.66*
	Legumes (n=483) = 0.33	235.51	0.51	0.65
	Fruits/Vegetables (n=143) = -0.12	200	0.17	-0.75

5.0 Summary, Conclusion and recommendations

This study employed the framework of counterfactual outcomes to evaluate the impact of the IAR4D intervention on marketed crop outcomes in the KKM PLS of West Africa. Propensity scores were estimated for the purpose of computing the average treatment effect on the treated (ATT) and, then, to obtain matched treated and non-treated observations. However, mean comparison tests were initially conducted to compute the means of the marketed crop outcomes and also to make conclusions on the hypothesis of no significant differences between the (before and after) means of the various crop outcomes considered.

It is concluded, based on the results that the marketed crop outcomes after the IAR4D are generally significantly different from the outcomes before the IAR4D intervention and that generally, for the three sites of IAR4D intervention, conventional and clean, nearly all the considered marketed crop outcomes after the IAR4D intervention were superior to the outcomes before IAR4D intervention. The implication of this is that the IAR4D intervention yielded more than proportinate increase in crop outputs and these incremental changes will continue to create more linkages to input and output markets for both sellers and buyers of these crop outputs. This

will also encourage the non-participating farmers to engage in farm and non-farm activities that can lunch them into similar realm of marketing their crops as those in the intervention sites. It is important to scale out the IAR4D to the farmers in the counterfactual and clean sites since they also recorded positive though smaller increases in their crop outputs and in effect marketed outcomes. The incentives being enjoyed by the participants, if extended to these non-participants in the near future may result into more than expected change in their livelihood outcomes.

Factors that are likely to encourage households to participate in the IAR4D intervention include household size and participation in research acticvities. In summary, participants in the IAR4D are likely to be farmers with large household sizes, with more participation in research activities, but less likely to be residing in the Sahel Savanna task force zone. The implication of this is that larger household size may likely afford such household heads with more and adequate family and hired labour for farming, non-farming and off farm activities. This has a two-way benefit in the sense that in one way, some labour cost can be saved by using family labour and in the other, household members can also be used as hired labour to generate additional income to cater for other needs and to increase the equity available to expand the scope of the family's farming activities. The other factors which seem to encourage farmers in the counterfactual sites are of policy importance and they need to be looked into critically by IAR4D stakeholders and policy aspects of the IPs like local government, ministries and the NGOs which are involved in IPs.

Statistically significant differences in marketed crop outcomes were recorded for all the 3 crop types in the IP action sites. The average baseline marketed values of cereals, legumes and fruits/vegetables were $456, $408 and $107 respectively in the IAR4D (but inially clean) sites. The average marketed values of these crop types at midline rose to $1368, $1223 and $360 respectively for cereals, legumes and fruits/vegetables. This is an indication that the IAR4D intervention increased the value of marketed crops for IP participants by $912, $815 and $252 with estimated percentage gains of 200, 199.75 and 200 percent for cereals, legumes and fruits/vegetables respectively.

Average marketed values of cereals of the treated (IAR4D farmers) sample due to participation in the IP activities based on the PSM (ATT) was $ 249 (p<5%), for legumes, $ 192 (p<1%) and for fruits/vegetables, $ 229 (p<5%). These values are indication of the impact of the IAR4D intervention on the marketed crop outcomes. The implication of this is that agricultural research and intervention programmes that make use of innovation systems approach such as the IAR4D' Innovation Platforms have a stong positive impact on marketed crop outcomes and therefore have a better potential of having more stronger and positive impact on other livelihood outcomes. The implication here is of greater policy importance in the sense that even farming households which are yet to be intervened with the IAR4D's IPs recorded positive changes in the crop outcomes considered (though not positive and significant impact) as compared with their

initial outcomes before the IAR4D. This calls for further incentives from public and private stakeholders to encourage scaling out to more willing and ready farming households to adopt the innovation systems approach to farming.

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