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# Heterogeneity in agricultural innovation systems' impact on food security: Evidence from Sub-Saharan Africa

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*A relatively new view to boost agricultural growth relies on the innovation system perspective. The Integrated Agricultural Research for Development Approach (IAR4D) adopted this as its main approach through the implementation of local decentralized Innovation Platforms (IPs) in eight countries. Previous research indicates considerable heterogeneity in IP impact. In this paper we show that this heterogeneity might have resulted from heterogeneity in implementation: IPs have equally implemented the principles of the IAR4D approach. We quantify the five defining principles of IAR4D into an IAR4Dness index and find that the index is correlated positively and significantly to the food security Looking at the sub-components of this index, it seems that especially participation in information sharing activities and field visits is crucial. Our analysis indicates that the effect of IAR4Dness on FSC does not operate through increased use of agricultural technologies or household social capital, two potential channels of impact.*

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## 1. Introduction

Agricultural growth is considered an important factor for sustainable alleviation of poverty (Haggblade et al. 2007; Ligon & Sadoulet 2007; World Bank 2007; Christiaensen et al. 2011). Policy makers have applied a wide variety of strategies to boost agricultural productivity and production in developing countries. A relatively new view in those strategies is the implementation of the innovation system perspective to support agricultural research and development for resource-poor farmers. The innovation system approach is a multi-stakeholder and participatory method integrating the knowledge of stakeholders from the value chain via so called "innovation platforms (IPs)". At IPs, the stakeholders are expected to come together to find solutions to local bottlenecks and to design and implement policies at the local level (Leeuwis & Van den Ban, 2004; Hall et al. 2006; Knickel et al. 2009). Many IPs have recently been introduced to enhance agricultural production and productivity of resource poor farmers through adoption of suitable and efficient agricultural techniques (Nederlof et al. 2011).

Few evaluation studies have quantitatively explored the impact of these IPs. Exceptions are studies that assessed the effect of the Sub Saharan African Challenge Program (SSA CP). The SSA CP adopted the Integrated Agricultural Research for Development (IAR4D) approach as its main philosophy through the implementation of local decentralized IPs. Pamuk et al (2014a) shows that, on average, the program does not have an impact on food consumption. Pamuk et al (2014b) and van Rijn and Nkonya (2012) also suggest that IPs have mixed impact on agricultural innovation and social capital. Moreover, the outcomes at IP level are highly variable: ranging from significantly positive to non-significant to significantly negative.

The policy evaluation literature suggests two answers to explain differences in impact at the IP level. First, the impact of any policy may be a function of characteristics of the region where the project is implemented (Heckman et al. 1997; Deaton 2010). Second, even if the policy is implemented among the same population, its outcomes may still vary if the policy is implemented by different organisations; the organisations may possess different organisational and managerial capacities and have different efficiency levels (Heckman et al. 1997; Deaton, 2010; Allcott & Mullainathan 2012; Sandefur et al. 2013). The aforementioned studies

evaluating the impact of IPs investigate the first factor: heterogeneity across target populations. This paper investigates the role of the latter: heterogeneity in implementation.

We explore heterogeneity in implementation of the SSA CP, and the effects thereof on program impact. We argue that differences in program impact might be explained by the extent to which IPs actually adopted the core principles of IAR4D. The objective of this study is twofold. First, to capture heterogeneity in implementation, we quantify the IAR4D principles and summarise them into an overall "IAR4Dness" index. Second, we analyse whether differences in impact result from differences in the level of IAR4Dness.

We analyse differences in impact by using data from West, Central and Southern Africa collected by SSA-CP and econometric techniques as well as correlation analysis. The way the IAR4D approach was implemented may be correlated with (1) the baseline characteristics 2) change in those characteristics (e.g. poverty, income, FCS, etc.) during the implementation. To control for these confounding factors, we utilize the panel feature of our data set, a large number of relevant control variables, and an instrumental variables approach.

Results indicate that implementation matters. The extent to which IPs were implemented and operated according to IAR4D is positively related to food security of intended beneficiaries, our main outcome variable after controlling for regional time trends. We find that two out of five principles related to attendance of stakeholders in program activities – in particular to information sharing activities and field visits – determines how successful IPs are in increasing household food consumption. Although our results do not explain entire IP level heterogeneity in program impact on food consumption, which is found by Pamuk et al. (2014a), they explain some part of the it within each region or country: Other factors constant, we observe higher food consumption score for the IPs at which attendances to the field and information sharing activities are higher. Nevertheless, we do not find evidence that this relationship results from the adoption of agricultural technologies, marketing strategies or changes in levels of household social capital - three of the potential impact channels.

This paper is organized as follows. Section 2 gives a brief conceptual framework including a description of the Sub Saharan African Challenge Program. In section 3 we present our data set. In section 4, we describe the IAR4Dness indices, explain how they differ across IPs, and discuss their correlation with baseline characteristics of innovation systems. In section 5

we introduces the identification strategy, and then analyse whether the index explains differences in impact of the IPs on food security and discuss robustness of the results. In Section 6, we explore whether the impact of IAR4Dness stems from selected impact channels. Finally, Section 7 concludes.

## 2. Conceptual framework

IAR4D was introduced as part of the SSA CP in 2004. The approach is based on the paradigm of innovation systems. According to this perspective, innovation is the result of the integration of knowledge from various actors and stakeholders (e.g. Leeuwis and Van den Ban 2004). With IAR4D this approach was shaped by the creation of decentralized IPs; coalitions of stakeholders to identify and address local bottlenecks to agricultural development. Representatives of farmers' associations, traders, researchers, extension workers, NGOs, and government policy makers regularly meet at these platforms, articulate their views, and negotiate joint strategies for action (FARA 2008).[1]

To promote external validity, IAR4D was implemented in three African project learning sites (PLSs): (*i*) "Lake Kivu (LK)" in Eastern and Central Africa, (*ii*) "Kano-Katsina-Maradi (KKM)" in West Africa, and (*iii*) "Zimbabwe-Malawi-Mozambique (ZMM)" in Southern Africa. Each region was divided into three sub-regions and in each sub region 4 IPs were implemented covering various villages. In total, 32 IPs became operational.[2] The overall program has been coordinated by the Forum for Agricultural Research in Africa (FARA). However, different agencies have been responsible for the implementation and facilitation of the IPs (see Appendix for an overview).

IPs had to fulfil five criteria to abide with the IAR4D approach (FARA 2008; Hawkins et al. 2008): (1) IPs should be representative, inclusive and with diverse partnerships, (2) there should be non-linear, collective and collaborative interaction among IP actors, (3) research addresses key constraints and opportunities agreed upon by IP members in the context of entire value chains, (4) the research process is multidisciplinary and participatory, and (5) there is

[1] Please see section 2.3 for further details of the program.
[2] Although 36 IPs were to be established 4IPs in ZMM never became operational and data were not collected for those IPs.

institutional and human capacity building for IAR4D actors to effectively participate. We define the extent to which IPs abide with these criteria "in the field" as the level of "IAR4Dness". Because of the decentralized nature of the IPs and the different implementing agencies, we expect to find variation in the level of IAR4Dness across platforms.

As explained by Pamuk et al. (2014a), Pamuk et al. (2014b) and van Rijn et al. (2012), the IAR4D approach as implemented may have an impact on poverty through increased agricultural technology adoption, changes in marketing strategies, and increased levels of social capital. Adoption of modern technologies is a candidate channel through which IAR4D could enhance agricultural production and reduce poverty. Agricultural innovation can have a direct influence on agricultural production by increasing productivity, by decreasing production cost, or by reducing risk associated with adoption (De Janvry & Sadoulet 2002). Changing marketing strategies is another important intermediate outcome of the IAR4D policy. This could enable specialization and the creation of surpluses. However, the immediate impact of IAR4D is perhaps not to directly influence agricultural technology or marketing strategies, but to create an enabling setting in which such intermediate outcomes may materialize (see van Rijn et al. 2012 for an overview of how social capital and agricultral innovation are linked). Therefore, household social capital conceptualised the interaction of households with other agents is also considered an important intermediate outcome variable, which is in line with the innovation system perspective.

## 3. Data description

### *3.1 Sample*

The IAR4D program was implemented as a large experiment, where some communities "received" IPs (treatment communities) and others did not (control communities). Even though details of the sampling design vary slightly across the different regions, it generally followed a randomized controlled trial approach (see FARA 2009; Pamuk et al. 2014b for details on the sampling frame). Within each village, a random sub-sample of 5-15 respondents (households) was drawn from treatment and control villages. Baseline and midline data were collected at village and household level in 2008/2009 and 2010/2011. In this study, we now focus on the

subsample of treatment villages because we are interested in differences in impact within these treated communities. Hence we do not use data from conventional and control villages

### *3.2 IAR4Dness*

To determine the level of IAR4Dness we used the data collected in a small survey among IP coordinators by e-mail in mid-2012 (see Appendix for details of the survey).[3] This survey included questions capturing the extent to which the five IAR4D principles were respected during the implementation stage. The first principle is captured by the number of different types of stakeholders involved.[4] The second principle was captured by the level of involvement of the stakeholders in different activities, and the variance in involvement of different types of stakeholders. The third principle was captured by the percentage of different stakeholders involved in problem identification and the percentage of problems prioritized and acted upon. The fourth principle was captured by stakeholders' involvement and implementation of activities and the percentage of different stakeholders involved in the policy design. The fifth indicator was captured by stakeholders' involvement in capacity building activities including information sharing, training and field visits. For all indicators we calculate the average of those stakeholders involved and/or those problems identified, and normalise data from 0 to 100. Summary statistics are provided in Table 1, where higher values mean higher scores in terms of IAR4Dness.[5]

*<< Insert Table 1 about here >>*

### *3.3. Outcome variables*

Lacking income data as a proxy for poverty for various IPs, we use household food security as our main outcome variable (see Panel A of Table 2). We use agricultural technology, marketing strategies, and household social capital variables as intermediary outcome variables (see Table A.1 in the Appendix for details). To measure household food security, we employ the Food Consumption Score (FCS) index measuring weekly consumption of food items, weighted by the

[3] All IP coordinators responded to the e-mail.
[4] Stakeholder include farmers, researchers, extension agents, marketing organisations, policy makers, NGOs, input suppliers, traders, private businesses and others.
[5] We observe that in particular Principle 2a and Principle 4a have a similar distribution.

nutritional value added. To test the mechanism behind the impact of IAR4Dness on food security, we use three different sets of dummy variables for agricultural technology adoption, marketing strategies and social capital variables.

*<< Insert Table 2 about here >>*

### *3.4 Household and village characteristics*

To control for differences in IP context, and for the potential influence on project implementation, we use various household and village level variables (see Panel B and C of Table 2). Our household level variables include gender, age, formal education level of household head, and household size. Our village level variables include a list of village amenities. To explore whether the level of cohesion in the community affects IP performance we include a third set of variables, namely baseline village social capital (Panel D of Table 2). These are different indicators than the social capital outcome variable mentioned earlier, which was measured and defined at the household level. Information regarding village level social capital was collected during community discussions by asking participants to evaluate social cohesion in their village (on a 0-4 point scale). These questions do not include information about interaction of villagers with others. Instead, they measure the quality of and order in social life.

## 4. Constructing an "IAR4Dness" index

We used three approaches to capture the level of IAR4Dness at the IP level. IAR4Dness is an aggregate index of the indicators, or an unweighted average of the five Principles. This reflects the idea that IAR4Dness is best captured by the different components rather than by its separate components. However, we also want to explore whether certain components matter more. Therefore, we also decompose the aggregate IAR4Dness index into the five principles listed before. This means we create a principle-specific average of principle 2a and 2b, 3a and 3b, and 4a and 4b. A third, and more data-driven approach, is to look at correlation between the different IAR4Dness variables, and create new components based on factors extracted via principal factor analysis. The number of factors (components) is determined by the variance extracted within each factor, or eigenvalue. According to the Kaiser criterion, only factors with an eigenvalue

above 1 are retained. We use a varimax rotation method to maximize the variance across factors (see Kaplan 2008 for more technical details).

The IAR4Dness indices are presented in Table 3. The table reports the descriptive statistics for IAR4Dness, principle specific averages and factor variables - Principles 1 and 5 have also been reported in Table 1. There is little variance in aggregate IAR4Dness index, with a mean of 0.74 and a standard deviation of only 0.07. However, there is more variation when zooming in on individual principles, indicating some differences in implementation across IPs. The factor analysis results in two factors. The first factor mainly captures participation in activities organised by the IP. The second factor captures the number of stakeholders involved and equality of involvement. Both factors are also correlated with the percentage of stakeholders involved in problem identification or policy formulation –albeit negatively. This indicates that, perhaps not surprising, even though more stakeholders are involved in the IP, not all stakeholders are represented when it comes to problem identification or policy formulation.

*<< Insert Table 3 about here >>*

### *4.1 Correlation analysis*

To investigate which factors explain the general variation in the change in FCS and IAR4Dness variables and check the exogeneity of the project implementation quality to baseline characteristics, we examine the IP level correlation between (1) the change in FCS and IP characteristics and (2) the quality of project implementation and IP characteristics in this section

For the first correlation analysis, we calculate the change in FCS by subtracting midline IP level average of FCS from baseline IP level averages and estimate its correlation with IAR4Dness variables, baseline household and village characteristics at IP level and regional dummies. Table 4 reports the pair-wise correlation coefficient estimates between the change in FCS and those variables. The results shows that the change in FCS is positive and significant at the IPs where duration of field activities are longer, share of male household head and larger household size are higher, and spirit of helping and abiding to the norms and bylaws are more developed. In addition it seems that there is regional correlation in the direction of change in

FCS at IP level as the correlation estimates are high and statistically significant for DRC and Sudan Savannah.

*<< Insert Table 4 about here >>*

Do baseline characteristics affect the quality of project implementation? If the answer to this question is "Yes", the quality of project implementation may not be exogenous to baseline IP characteristics. We again answer this question by estimating pair-wise correlation coefficients between baseline household and village characteristics as well as region dummies at IP level and IAR4Dness index. Table 5 presents the estimates. Results indicate there is a correlation between most of the IAR4Dness principles and baseline characteristics, and implementation quality differs in the regions. This may reflect the fact that the performance of IPs is correlated with the development level of and social cohesion in the villages surrounding IPs. As some of those factors are also correlated with our outcome variables (see Table 4 above,) we will design our identification strategy accordingly to estimate the impact of IAR4Dness on food security (see below for details).

*<< Insert Table 5 about here >>*

## 5. IAR4Dness and FCS

### *5.1 Identification strategy*

We now summarize the identification strategy that we use to investigate the effect of IAR4Dness on outcome variables. To control for the potentially confounding effect of household, village and IP level characteristics on our outcome variable and IAR4Dness, we use data from the baseline survey conducted in 2008 and the midline survey conducted in 2010/2011, and define our outcome variables at the household level whereas our IAR4Dness variables are defined at IP level. We also use clustered robust standard errors at the IP level for the estimations to control for within IP correlation of error terms.

If the IAR4Dness was random across IPs, we could estimate the following model, for outcome variable $Y_{iprt}$ and test the hypothesis that $\alpha_2 \neq 0$:

(1) $$Y_{iprt} = \alpha_0 + \alpha_1 T_t + \alpha_2 I_{pt} + R_r + R_r T_t + \gamma_p + \gamma_p T_t + u_{iprt}$$

where subscripts *i, p, r* and *t* denote household, IP, region and period respectively. $I_{pt}$ represents our main variable of interest, the IAR4Dness indices, and equals zero for the baseline period because IAR4D was introduced after the baseline period. We use rescaled values for indices identified in Table 3 (and Table 1 when necessary) having a mean of zero and a standard deviation of one to ease the interpretation of the estimates. $T_t$ is a dummy variable, equals to 1 for midline survey, and controls for the general trend between two survey periods. $R_r$ is a region fixed effect, $R_r T_t$ is region trend, $\gamma_p$ is IP fixed effect, and $\gamma_p T_t$ is a IP level trend. $u_{ivprt}$ is the random error term. To eliminate the IP and region level fixed effects, we use balanced sample of households and write (1) in first differences:[6]

$$\Delta Y_{iprt} = Y_{ipr,t} - Y_{ipr,t-1} = \alpha_1 + \alpha_2 I_p + R_r + \varepsilon_{iprt} \quad (2)$$

where $(\gamma_p + \Delta u_{iprt}) = \varepsilon_{iprt}$ is the error term in our regression. To control for $R_r$, we use region level dummy variables in the estimations.[7] We also add baseline household and village characteristics to the estimations to control for $\gamma_p$.[8] If there is any correlation between $I_p$ and $\gamma_p$, we assume that this is controlled for through the control variables used in our main specifications. In robustness checks (see below), we will relax this assumption by using an instrumental variable strategy, and test the robustness of our results.

We start our analysis by estimating (2) for the overall index. Then, to explore through which principles and factors the impact of the index is driven, we refine our results by estimating (2) for each principle and factor separately.[9] Separate estimation of the models prevents the inflation of standard errors in the estimations as some of the IAR4Dness principles are highly correlated. These correlations between the principles result from the definition and the construction of the variables (see section 3).

[6] In the main estimations, we use 31 IPs instead of 32 since we cannot identify the households balanced household for an IP due to missing household identifier variables in the dataset. However, our results are robust to using unbalanced sample and an alternative specification to first difference where we control for IP level fixed and region trends. The results are available upon request.
[7] In the data, there is substantial heterogeneity at region level, and therefore our estimation results are sensitive to adding region level dummy variables. Our estimates are not statistically significant if we do not control for them.
[8] We do not control for the village characteristic in panel D of Table 2 in our main estimation results because they were only collected in 28 IPs in baseline surveys. However, our main results are robust to estimating our models for only 28 IPs and controlling for these village level social capital variables.
[9] Our results are robust to the inclusion of the two factor variables in one model.

*5.2 Baseline estimation results for food security*

The estimation results of model (2) for our main outcome variable, FCS, are summarized in Table 6. We report the estimates for our coefficients of interest: average IAR4Dness, principles and factors at each column. The results show that FCS levels are higher in the villages where the level of IAR4Dness is higher. One standard deviation in the IAR4Dness index increases the change in FCS by 6.42. To explore which principles matter most, we repeat model (2) for each principle in columns (2-6). The relation between IAR4Dness and FCS mainly stems from two of the five IAR4Dness principles: non-linear, collective and collaborative interaction (principle 2) and institutional and human capacity building for IP actors (principle 5). These results are in line with the results shown in column 7 and 8. IPs with active participation to the activities, factor 1, have higher levels of FCS. On the other hand, estimated $R^2$ do not vary between models; this implies that most of the variation in FCS is explained by region dummies, and IAR4Dness explain a small part of the variation. This limits the interpretation of our analysis.

*<< Insert Table 6 about here >>*

To explore the key factors behind our main result we next explore the correlation between FCS and the sub indicators concerning involvement in IP activities: Principle2a, Principle2b, Principle4a and Principle5. We predict that specific sub-components of the indices might be the key factors behind the positive correlation between FCS and the principles. To test whether our conjecture is true, we estimate (2) for four additional specifications. We replace $I_p$ with the average involvement in listed activities (Principle 2a), difference in average participation (Principle 2b), average involvement in planning and joint implementation (Principle 4a) and average involvement in information sharing activities and field visits (Principle 5) (see Table 7).

*<< Insert Table 7 about here >>*

The results in Table 7 confirm our conjecture that average participation in the activities is positive and significantly correlated with FCS. Moreover, the type of activities seems to be key in improving food security. Participation in information sharing activities and field visits is more important than participation in activities concerning joint planning and implementation as the

estimates are bigger and statistically more significant for the former. Finally, equal participation of stakeholders to these activities does not seem to be a critical factor for our results.

### *5.3 Robustness checks*

Our identification strategy rests on two assumptions. First, clustering standard errors at the IP level gives correct estimates for standard errors. Second, the level of IAR4Dness is not correlated with IP level time trends that may also influence our outcome variables. In this section, we relax these assumptions and test the consistency of our estimates. In Table 8 and 9, we report the estimates from alternative models specified to test the robustness of our main results. We focus on the impact of Principle 2a, Principle 4a and Principle 5 on FCS because we found that our results are mainly driven by attendance to IP activities.

*<< Insert Table 8 about here >>*

As a first robustness test we re-estimate model (2) at IP level. Although the standard errors of our main model are clustered at the IP level, household level analysis still might produce low standard errors, and overstate the significance of our estimates because IAR4Dness is measured at the IP level (Wooldridge 2003). For this analysis, we use the difference of IP level average of FCS as the dependent variable, and drop household and village level controls. Columns 1, 2 and 3 of Table 8 show that estimates for *Principle 2a* and *Principle5* are statistically significant and are in line with our previous estimates but the estimate for *Principle4a* is not statistically significant.

As a second robustness analysis, we estimate a 2SLS model to isolate the potential impact of unobserved time varying determinants at IP level. Unobserved factors such as economic and income shocks that happened after the baseline period may have directly affected both FCS and IAR4Dness. This might create an endogeneity problem for our estimates. To address this concern, we employ exogenous variation in the duration of field activities of IPs as an instrument (see Panel E in Table 3 for variable descriptions). Some IPs started their field operations later than others due to organisational challenges. Hence, (more) mature IPs had more opportunity to organize IAR4Dness activities. Besides, to our knowledge, the start-ups of IPs were not delayed by IP level shocks; therefore we argue that the duration is not correlated with other unobserved time varying factors. However, having more time to influence the

adoption of improved technologies or other innovations, households can benefit more from the intervention and have higher food consumption levels; therefore a direct effect of the duration of exposure to the IAR4Dness program on FCS may exist which causes concern about the validity of the instrument. To circumvent this concern, before presenting the 2SLS estimates below, we will first conduct a weak exogeneity test for the instrument by inserting it to the IP level estimations, together with the main explanatory variables. If the duration of field activities has a direct impact (not an indirect impact only through the Principles) on FCS, the coefficient estimates for the instrument will not be statistically significant in those estimations.

The specification of 2SLS model employed is as follows. The following is the first stage equation via which we predict the *Principle2a*, *Principle4a* and *Principle5*:

(3) $$I_p = \beta_1 + \beta_2 D_p + R_r + \varepsilon_{prt}$$

where $R_r$ is region fixed effect and $\varepsilon_{prt}$ refers to error term. $D_p$ denotes our excluded instrument which equals 0 in baseline survey period as there is no field activity and 1 when years of field activities for corresponding IP is more than 1.5 years (median level) in midline survey period.[10] Again, we control for region fixed effects by adding region dummy variables into our models. We justify the use of the same IV for both principles because they both relate to attendance (in fact Principle5 and Principle4a are sub elements of Principle 2a), and years of field activities should explain both. As our instrument is at the IP level, the predicted values for $I_p$ from (3) are used again to estimate (2) at IP level for Principle2a, Principle4a and Principle5 by using 2SLS estimation.

*<< Insert Table 9 about here >>*

Before presenting the 2SLS estimates, we also assess how relevant the endogeneity concerns are by using Durbin-Wu-Hausman test proposed by Davidson and Mckinnon (1993). Test results show that we cannot reject the null hypothesis - there are no endogeneity in the estimates for the Principle 2a, 4a and 5 (at 27, 12, and 39 percent significance levels). Hence the concerns regarding endogeneity of our main explanatory variables, in particular for Principle 5, should be limited. Yet we provide the results for the exogeneity tests, first stage estimation

[10] We use dummy variable as instrument to increase the precision of the estimates. When we use actual years of field activities but not dummy variable as the instrument, then our coefficient estimates are very close but imprecise and thereby not statistically significant.

results, and 2SLS estimates in Table 9. Columns 1, 2, and 3 show the estimation results for the exogeneity tests where $D_p$ is added as an additional explanatory variable to the original models presented in Table 8. The coefficient estimates for the duration of field activities are insignificant in the estimations; it is therefore not correlated to FCS directly (only through the Principles) and satisfies the exclusion restriction. Columns 4, 5 and 6 report the first stage estimates for Principle2a, Principle4a and Principle5 respectively. A longer period of field activities enhances the information sharing activities and field visits but not average involvement in other activities (F-statistics for Principle 5 equals 7.31). Finally, columns 7, 8 and 9 present the 2SLS estimates for Principle2a, Principle4a and Principle5 respectively. The estimates are positive and statistically significant for only Principle 5. Hence, results only confirm that our estimates for Principle 5 is consistent when we isolate the impact of unobserved time varying factors using years of field activities as an instrument.

To summarize, the results imply that the IPs that have been more successful in enhancing participation in information sharing and field activities may perform better in improving food consumption at region level . For instance Gataraga and Bufindi from Lake Kivu are among the IPs having highest participation rate to the activities, and Pamuk et al. (2014a) has shown that they have performed better than other IPs located in the same countries in enhancing FCS. Hence our results also shed some light on the heterogeneity within each region in terms of the program impact on FCS, but do not completely explain the source of the heterogeneity.

## *6.* ***Examining the mechanism: Impact of Participation to Field Activities on Intermediate Outcomes***

How does participation in information sharing and field activities (Principle 5) increase food security? To probe this question, we tentatively investigate the effect of Principle 5 on three sets of intermediate outcome variables: agricultural technology, marketing strategies, and social capital variables (see section 3.3 for variable details). We use the 20 intermediate outcome variables introduced in Table A.1, and estimate (2) for each of them separately. To economize on space we do not report these estimates, but they are available upon request.

We find mixed results concerning the impact of Principle 5 on intermediate outcome variables. Households seem to change their preferences for agricultural technology adoption in IPs with more participation in field activities. First, estimates show that increased participation in field activities promotes the adoption of two agricultural technologies: adoption of mulching and chemical fertilizer usage. However, it is negatively correlated with the adoption of animal manure and three post-harvest technologies – threshing and shelling equipment, storage facilities and pest control. Second, households change where they market their products as a result of information sharing and field activities. Estimates for marketing strategies indicate that households in "high Principle 5 IPs" are less likely to sell their products on-farm to consumers and or local/village market in the villages. Finally it appears that field activities did not promote interaction among households with others, as Principle 5 is not significantly correlated with any of the social capital variables at household level.

Because Principle 5 is positively related with only mulching and chemical fertilizer usage, we tentatively test whether Principle 5 leads to an increase in food security through the adoption of those technologies. To do this, we estimate two new specifications of (2) in which we respectively use changes in the adoption of mulching and chemical fertilizer as explanatory variables (in addition to Principle 5). If the impact of Principle 5 on FCS stems from adoption of those technologies, adding those technology variables to the specifications should result in smaller coefficient estimates for Principle 5, and technology variables will be significantly correlated with FCS. Also we note that we cannot use the estimate for Principle 5 reported in Table 5 to compare with our new estimates, because samples used for the new estimations are smaller due to missing values for the technology variables. Therefore we obtain two new benchmark estimates for Principle 5 for comparison by estimating (2) for Principle 5 by using the households for which observations for change in mulching and chemical fertilizer usage are not missing respectively.

*<< Insert Table 10 about here >>*

Table 10 reports the results for the impact of Principle 5 and change in the adoption of mulching and chemical fertilizer on FCS. Estimates for Principle 5 in column 1 and 3 serve as the new benchmarks for the estimates in column 2 and 4 respectively. Results show that the

increase in the adoption of these technologies did not cause the increase in food security since the estimates for the change in technology usage are not statistically significant, and the estimate for Principle 5 in column 2 and 4 are not smaller than the ones in column 1 and 3 respectively. These results may imply that adoption of technologies by itself may not improve food security, and should be supported by other policies which we do not observe and identify here.

Several caveats are relevant. First, the power of our estimates for technology variables is low as there are only 32 IPs. So we may fail to reject a false hypothesis and may not identify a potential mechanism. Second, our intermediate outcome variables are far from perfect as we do not observe the intensive margin - usage frequencies or levels - for them. For instance households may produce and sell more agricultural goods in high Principle 5 IPs. However, our intermediate outcome variables cannot capture such changes as they are binary variables. Third, the list of intermediate outcome variables may be incomplete as we do not have information concerning intermediate outcomes such as improved variety usage, employment levels and access to finance of households which may directly affect food security. Last but not least it may be difficult to detect the exact mechanism due to decentralized policy design and implementation processes of IPs. In the decentralized innovation systems, each IP focuses on a different technology or marketing strategy, reflecting the needs and opportunities of the villages.

## 7. Conclusion

There is considerable heterogeneity in the impact of the innovation system approach on resource poor farmers at IP level. In this study, we argued this may be because there is heterogeneity in implementation: IPs may not have equally implemented the principles of the IAR4D approach. We explore heterogeneity in implementation, and the effect thereof, by quantifying the five defining principles of IAR4D into an IAR4Dness index and linking these to the main survey data. We find that the IAR4Dness index is correlated positively and significantly to FCS, our proxy for food security.

This relation between IAR4Dness and FCS mainly stems from an IAR4D sub principle: institutional and human capacity building for IP actors. Looking at the sub-components of the principle, especially participation in information sharing activities and field visits is crucial.

Success of IPs thus seems to depend on the attendance and contributions of stakeholders to the activities of the IP; Thus IPs which are better at making stakeholders participate to those meetings have higher food consumption levels than those IPs that are less succesful in increasing participation . Yet we cannot argue that this factor is the only reason among the heterogeneity between IPs, as the level of participation to information sharing and field activities explain only a small part of the variation in the FCS between IPs.

More specially, we believe this result may indicate that IPs only become beneficial for villagers when they (and other IP stakeholders) participate in capacity building events such as field visits and information sharing activities. Recent case study evidence from improved maize legume and production systems in Nigeria supports our findings, and explains how capacity building activities help the platform perform. Dangbegnin et al. (2011) state that the platform organised capacity building activities on IAR4D and team building to enhance problem solving, team working and learning skills of platform members. They argue that these activities "enabled platform members to work as equal partners" (p. 92).

It is also interesting to note that other IAR4Dness (sub) indicators of IAR4D do not seem to matter in terms of impact on FCS. For example, the different types of stakeholders involved or equal participation of these stakeholders to activities. Apparently average participation is more important than diversity per se. In fact it is easy to imagine some sort of trade-off between the number of stakeholders involved in an IP and the average participation of these stakeholders. This was supported by our factor analysis. It could well be that this means that IPs with less diverse partnerships, but overall higher average participation because of this, are more successful than IPs with many additional but low participating partners. Perhaps it becomes more difficult to manage the IP as it becomes bigger: i.e. it might be harder to align different goals and objectives and coordinate the IP.

We also find that the effect of IAR4Dness on FCS does not operate through increased use of agricultural technologies, increased use of different marketing strategies or increased levels of household social capital. However, we only investigate three potential channels through which IPs can boost FCS. There are many other potential channels such as improved variety or access to finance. There is need for future research to shed light on these channels.

Finally, we note three methodological issues regarding our results. First of all, we show that researchers can investigate the heterogeneity in the implementation of a project and the performance of the project partners by applying a survey to the partners after the treatment. However, we are aware of the fact that our IAR4Dness measures might be subject to measurement errors as we utilize a set of objective questions directed to platform members after two to three years of project implementation . To minimize the error, a better approach might be collecting data from all stakeholders through a consistent monitoring and evaluation (M&E) survey during implementation. Secondly, we use data from baseline and midline surveys conducted merely two to three years after the platforms are established. This means that our results reflect only the short-term effects of IAR4Dness from early maturing platforms. An end-line survey is scheduled for late 2014. By using the new data set from matured platforms, follow up research should probe the robustness and sustainability of the preliminary results presented here. Future work should investigate whether the results we obtain are consistent with additional data to be collected in 2014.

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## Tables

### Table 1: IAR4Dness variables

| Principle | Definition | Obs. | Mean | Std. | Min | Max |
|---|---|---|---|---|---|---|
| Principle 1 | Number of different stakeholders involved | 32 | 75.3 | 14.9 | 50.0 | 100.0 |
| Principle 2a | Average involvement in listed activities | 32 | 78.0 | 13.6 | 54.5 | 100.0 |
| Principle 2b | Difference to average participation* | 32 | 76.6 | 17.1 | 27.1 | 100.0 |
| Principle 3a | % Of stakeholders involved in problem identification | 32 | 32.6 | 19.9 | 8.3 | 100.0 |
| Principle 3b | % Of problems identified being prioritized and addressed | 32 | 100.0 | 0.0 | 100.0 | 100.0 |
| Principle 4a | Average involvement joint planning and implementation | 32 | 77.3 | 13.1 | 54.5 | 100.0 |
| Principle 4b | % Of stakeholders involved in policy formulation | 32 | 45.4 | 26.7 | 8.3 | 100.0 |
| Principle 5 | Average involvement in information sharing and field visits | 32 | 77.3 | 16.3 | 44.0 | 100.0 |

Note: all variables are normalised in the range [0,100]

*this indicator is rescaled so that smaller variances (more equality) is reflected by higher scores

**Table 2: Outcome variables and household, village and social capital variables**

| Variable | Definition | Obs[†]. | Mean | Std. | Min | Max |
|---|---|---|---|---|---|---|
| *Panel A: Outcome variables* | | | | | | |
| FCS | Weekly food consumption score | 3322 | 48.0 | 21.4 | 0 | 108.5 |
| *Panel B: Household characteristics* | | | | | | |
| gender | Equals to 1 if household head is male, 0 otherwise | 3456 | 0.7 | 0.4 | 0 | 1 |
| Age | Age of household head | 3433 | 46.6 | 14.7 | 16 | 105 |
| Education | Education level of household head | 3242 | 3.3 | 2.3 | 1 | 10 |
| Size | Household size in logarithms | 3436 | 1.9 | 0.6 | 0 | 4.8 |
| *Panel C: Village Characteristics* | | | | | | |
| school | Equals to if there is a school at the village, 0 otherwise | 332 | 0.66 | 0.47 | 0 | 1 |
| hospital | Equals to if there is a hospital at the village, 0 otherwise | 322 | 0.30 | 0.46 | 0 | 1 |
| worship | Equals to if there is a worship place at the village, 0 otherwise | 339 | 0.81 | 0.39 | 0 | 1 |
| socialhall | Equals to if there is a social hall at the village, 0 otherwise | 302 | 0.22 | 0.42 | 0 | 1 |
| roads | Equals to if village is connected with weather road(s), 0 otherwise | 315 | 0.73 | 0.44 | 0 | 1 |
| mobilenetwork | Equals to if village has mobile network connection, 0 otherwise | 336 | 0.88 | 0.33 | 0 | 1 |
| Panel D: Village social capital | | | | | | |
| Participation | Participation in community activities (0-4) | 129 | 2.8 | 1.0 | 0 | 4 |
| Trust | Extent of trust among people (0-4) | 128 | 2.6 | 1.0 | 0 | 4 |
| Cooperation | Cooperation among people (0-4) | 126 | 2.7 | 1.0 | 0 | 4 |
| Gift exchange | Extent of giving or exchanging gifts (0-4) | 130 | 2.2 | 1.1 | 0 | 4 |
| Contrcomm | Extent of financial contribution for community activities/problems (0-4) | 130 | 2.4 | 1.2 | 0 | 4 |
| Contributgr | Extent of financial contribution to group activities (0-4) | 128 | 2.3 | 1.2 | 0 | 4 |
| Helping | Spirit of helping others especially the poor (0-4) | 129 | 2.0 | 1.4 | 0 | 4 |
| Conflicts | Extent of settling conflicts or disputes among people (0-4) | 128 | 2.9 | 1.0 | 0 | 4 |
| Norms | Extent of abiding by the norms and byelaws (0-4) | 131 | 2.6 | 1.1 | 0 | 4 |
| Womenconfid | Women confidence to speak in public (0-4) | 131 | 2.5 | 1.0 | 0 | 4 |
| Consdwomen | Men's respect and consideration of women (0-4) | 131 | 2.7 | 1.0 | 0 | 4 |
| *Panel E: Instruments* | | | | | | |
| Dyearinfield | Equals to 1 if number of years passed after the IP started field activities is more than 1.5, 9 otherwise | 32 | 0.34 | 0.48 | 0 | 1 |

[†] We report number of households and villages for the outcome variables/household characteristics and village characteristics/social capital variables respectively. For instruments, numbers of IPs are shown.

**Table 3: IAR4Dness indices**

| Variable | Definition | Mean | Std. | Min | Max |
|---|---|---|---|---|---|
| IAR4Dness | Aggregate index | 71.5 | 7.4 | 55.6 | 82.4 |
| Principle 1 | Representative, inclusive and diverse | 75.3 | 14.9 | 50.0 | 100.0 |
| Principle 2 | Non linear, collective and collaborative | 77.3 | 11.4 | 54.3 | 94.9 |
| Principle 3 | Key constraints and opportunities addressed | 66.3 | 10.0 | 54.2 | 100.0 |
| Principle 4 | Multidisciplinary and participatory | 61.3 | 16.0 | 41.4 | 96.8 |
| Principle 5 | Capacity building | 77.3 | 16.3 | 44.0 | 100.0 |
| Factor 1 | Increase with participation in activities and decrease with involved in problem identification. | 0.0 | 1.0 | -1.7 | 1.8 |
| Factor 2 | Increase with # of stakeholders and decrease with involvement in policy formulation | 0.0 | 1.0 | -2.5 | 1.6 |

**Table 4: Pair-wise correlation estimates for the change in FCS (ΔFCS) and selected variables**

| | |
|---|---|
| *IP characteristics* | |
| IAR4Dness | 0.03 |
| Principle 1 | -0.27 |
| Principle 2 | -0.19 |
| Principle 3 | 0.12 |
| Principle 4 | 0.24 |
| Principle 5 | 0.13 |
| Year in field | 0.51* |
| *Household characteristics* | |
| Gender | -0.33* |
| Age | 0.26 |
| Education | 0.12 |
| Size | 0.30* |
| Village Amenities | |
| School | 0.27 |
| Hospital | 0.21 |
| Worship | 0.13 |
| Socialhall | -0.12 |
| Roads | 0.30 |
| Mobile network | -0.07 |
| Village social capital | |
| Participation | 0.24 |
| Trust | 0.16 |
| Cooperation | 0.09 |
| Gift exchange | 0.24 |
| Contrcomm | 0.27 |
| Contributgr | 0.31 |
| Helping | 0.40* |
| Conflicts | 0.22 |
| Norms | 0.32* |
| Women confid. | 0.10 |
| Consd. women | 0.31 |
| Regions | |
| DRC | -0.34* |
| Malawi | -0.18 |
| Mozambique | -0.24 |
| Norther Guinea Savannah | 0.18 |
| Rwanda | 0.02 |
| Sudan Savannah | 0.44* |
| Sahel | 0.10 |
| Uganda | -0.09 |
| Zimbabwe | 0.10 |

* statistically significant at 10 percent level.

**Table 5: Pair-wise correlation estimates between IAR4Dness, Principles and baseline characteristics**

| | IAR4Dness | Principle 1 | Principle 2 | Principle 3 | Principle 4 | Principle 5 |
|---|---|---|---|---|---|---|
| *Household characteristics* | | | | | | |
| Gender | 0.18 | 0.17 | 0.08 | 0.24 | -0.48* | 0.14 |
| Age | 0.23 | 0.28 | 0.27 | 0.19 | 0.05 | 0.20 |
| Education | 0.12 | 0.11 | 0.03 | 0.27 | 0.33* | 0.16 |
| Size | 0.04 | 0.18 | 0.22 | 0.38* | 0.16 | 0.06 |
| Village Amenities | | | | | | |
| School | 0.21 | 0.01 | 0.01 | 0.12 | 0.38* | 0.10 |
| Hospital | 0.33* | 0.05 | 0.08 | 0.07 | 0.52* | 0.04 |
| Worship | 0.24 | 0.15 | 0.10 | 0.04 | 0.33* | 0.07 |
| Socialhall | 0.09 | 0.05 | 0.03 | 0.16 | 0.20 | 0.24 |
| Roads | 0.24 | -0.45* | -0.47* | 0.34* | 0.25 | 0.13 |
| Mobile network | 0.09 | 0.01 | 0.09 | 0.24 | 0.17 | 0.10 |
| Village social capital | | | | | | |
| Participation | 0.09 | 0.29 | 0.22 | 0.25 | 0.25 | 0.18 |
| Trust | 0.06 | 0.20 | 0.16 | 0.27 | 0.39* | 0.14 |
| Cooperation | 0.10 | 0.15 | 0.10 | 0.25 | 0.41* | 0.23 |
| Gift exchange | 0.05 | 0.27 | 0.16 | -0.32* | 0.39* | 0.04 |
| Contrcomm | 0.28 | -0.43* | -0.35* | 0.21 | 0.08 | 0.09 |
| Contributgr | 0.29 | -0.54* | -0.42* | 0.26 | 0.17 | 0.03 |
| Helping | 0.12 | -0.42* | -0.35* | 0.16 | 0.39 | 0.23 |
| Conflicts | 0.05 | 0.17 | 0.09 | -0.32* | 0.05 | 0.19 |
| Norms | 0.30 | -0.54* | -0.52* | 0.17 | 0.24 | 0.05 |
| Women confid. | 0.06 | 0.15 | 0.15 | 0.00 | 0.05 | 0.17 |
| Consd. women | 0.02 | 0.08 | 0.06 | 0.20 | 0.02 | 0.17 |
| Regions | | | | | | |
| DRC | 0.41* | 0.58* | 0.57* | -0.29 | -0.14 | 0.31* |
| Malawi | 0.03 | 0.06 | 0.06 | -0.01 | -0.04 | 0.03 |
| Mozambique | 0.19 | 0.18 | 0.19 | 0.19 | 0.01 | 0.01 |
| Northern Guinea Savanna (Nigeria) | -0.42* | -0.22 | -0.42* | 0.47* | -0.12 | -0.62* |
| Rwanda | -0.29 | -0.38* | -0.35* | 0.12 | -0.10 | -0.05 |
| Sudan Savannah (Nigeria and Niger) | 0.36* | -0.17 | 0.05 | -0.39* | 0.70* | 0.49* |
| Sahel (Nigeria) | 0.04 | 0.21 | 0.09 | 0.03 | -0.22 | 0.04 |
| Uganda | -0.08 | -0.11 | -0.03 | -0.19 | 0.13 | -0.06 |
| Zimbabwe | -0.31* | -0.15 | -0.18 | 0.13 | -0.30* | -0.21 |

* statistically significant at 10 percent level.

**Table 6: Regression estimates for IAR4Dness and food security**

| Dependent variable: | ΔFCS (1) | ΔFCS (2) | ΔFCS (3) | ΔFCS (4) | ΔFCS (5) | ΔFCS (6) | ΔFCS (7) | ΔFCS (8) |
|---|---|---|---|---|---|---|---|---|
| IAR4Dness | 6.42*** | | | | | | | |
| | (1.51) | | | | | | | |
| Principle 1 | | 1.44 | | | | | | |
| | | (1.64) | | | | | | |
| Principle 2 | | | 3.41* | | | | | |
| | | | (1.68) | | | | | |
| Principle 3 | | | | 2.56 | | | | |
| | | | | (3.16) | | | | |
| Principle 4 | | | | | 1.10 | | | |
| | | | | | (2.29) | | | |
| Principle 5 | | | | | | 5.18** | | |
| | | | | | | (2.09) | | |
| Factor 1 | | | | | | | 4.94*** | |
| | | | | | | | (1.43) | |
| Factor 2 | | | | | | | | -0.22 |
| | | | | | | | | (1.66) |
| Constant | 25.30*** | 16.11** | 17.66*** | 14.96** | 17.46** | 23.04*** | 23.27*** | 15.79** |
| | (6.19) | (6.27) | (6.23) | (6.43) | (8.22) | (6.89) | (6.72) | (6.37) |
| Observations | 1335 | 1335 | 1335 | 1335 | 1335 | 1335 | 1335 | 1335 |
| R-squared | 0.16 | 0.14 | 0.15 | 0.15 | 0.14 | 0.16 | 0.16 | 0.14 |

Notes: * p<0.10, ** p<0.05, *** p<0.01, Robust standard errors clustered at IP level are in the parentheses. All regressions include regional dummy variables. We present estimates for the variables of interest to economize on space

**Table 7: Involvement indicators and food security**

| Dependent variable: | ΔFCS (1) | ΔFCS (2) | ΔFCS (3) | ΔFCS (4) |
|---|---|---|---|---|
| Principle 2a | 5.37*** | | | |
| | (1.50) | | | |
| Principle 2b | | -0.54 | | |
| | | (1.58) | | |
| Principle 4a | | | 3.31* | |
| | | | (1.69) | |
| Principle 5 | | | | 5.18** |
| | | | | (2.09) |
| Constant | 23.95*** | 15.99** | 20.08*** | 23.04*** |
| | (6.68) | (6.51) | (7.16) | (6.89) |
| Observations | 1335 | 1335 | 1335 | 1335 |
| R-squared | 0.16 | 0.14 | 0.15 | 0.16 |

Notes: * p<0.10, ** p<0.05, *** p<0.01, Robust standard errors clustered at IP level are in the parentheses. All regressions include regional dummy variables. We present estimates for the variables of interest to economize on space.

**Table 8: IP level estimates**

| | IP level estimates | | |
|---|---|---|---|
| Dependent variable: | ΔFCS (1) | ΔFCS (2) | ΔFCS (3) |
| Principle 2a | 6.12** | | |
| | (2.59) | | |
| Principle 4a | | 2.24 | |
| | | (2.98) | |
| Principle 5 | | | 6.60* |
| | | | (3.41) |
| Constant | 17.22*** | 13.51** | 16.36** |
| | (6.05) | (6.34) | (6.11) |
| Observations | 32 | 32 | 32 |
| R-squared | 0.46 | 0.41 | 0.47 |

Notes: * p<0.10, ** p<0.05, *** p<0.01, Robust standard errors clustered at IP level are in the parentheses. All regressions include regional dummy variables. We present estimates for the variables of interest to economize on space.

**Table 9: First stage estimates, exogeneity checks and 2SLS estimates**

| | Exogeneity checks | | | First stage estimates | | | 2SLS | | |
|---|---|---|---|---|---|---|---|---|---|
| Dependent variable: | ΔFCS | ΔFCS | ΔFCS | Principle 2a | Principle 4a | Principle 5 | ΔFCS | ΔFCS | ΔFCS |
| | (4) | (5) | (6) | (1) | (2) | (3) | (7) | (8) | (9) |
| Principle 2a | 5.25** | | | | | | 20.43 | | |
| | (2.44) | | | | | | (12.87) | | |
| Principle 4a | | 2.51 | | | | | | -64.03 | |
| | | (2.84) | | | | | | (189.38) | |
| Principle 5 | | | 5.59 | | | | | | 12.91* |
| | | | (3.40) | | | | | | (7.44) |
| Years in field (dummy) | 7.65 | 10.71 | 5.84 | 0.50* | -0.16 | 0.80** | | | |
| | (6.83) | (6.73) | (6.70) | (0.28) | (0.55) | (0.30) | | | |
| F-stat for the instruments | | | | | | | 3.29 | 0.89 | 7.31 |
| Observations | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| R-squared | 0.48 | 0.45 | 0.49 | 0.71 | 0.57 | 0.72 | 0.14 | -9.32 | 0.41 |

Notes: * p<0.10, ** p<0.05, *** p<0.01, Robust standard errors clustered at IP level are in the parentheses. All regressions include regional dummy variables. We present estimates for the variables of interest to economize on space.

**Table 10: Test for mechanism**

| Dependent variables: | ΔFCS | ΔFCS | ΔFCS | ΔFCS |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Principle5 | 5.53*** | 5.54*** | 6.40*** | 6.35*** |
| | (1.80) | (1.77) | (1.89) | (1.86) |
| ΔMulching | | -0.17 | | |
| | | (1.45) | | |
| ΔChemical Fertilizer | | | | 0.99 |
| | | | | (2.10) |
| Constant | 18.51*** | 18.59*** | 24.15*** | 23.82*** |
| | (6.33) | (6.31) | (7.45) | (7.39) |
| Observations | 1,054 | 1,054 | 1,188 | 1,188 |
| R-squared | 0.13 | 0.13 | 0.13 | 0.13 |

Notes: * p<0.10, ** p<0.05, *** p<0.01, Robust standard errors clustered at IP level are in the parentheses. All regressions include regional dummy variables. We present estimates for the variables of interest to economize on space.

## Appendices

*Appendix: Project learning sites, countries, implementing agents and IPs*

West Africa (KKM): Niger and Nigeria

- INRAN: IPs related to livestock-feed, millet-cowpea, vegetables, and groundnut.
- IFDC: IPs related to livestock-feed, maize-legume-livestock, vegetables, and rice
- IITA: IP related to maize-cowpea-livestock, and 2 related to sorghum-cowpea-livestock

East Africa (LK): DRC, Rwanda and Uganda

- CIAT: IPs related to banana, Irish potatoes, beans and cassava
- ISAR: IPs related to NRM, livestock, milk, seed potato and maize
- Makerere/ICRISAT: IPs related to potato, soil and water conservation, pineapple and sorghum

Southern Africa (ZMM): Zimbabwe, Malawi, Mozambique

- CIAT: IPs related to conservation agriculture
- Bioversity International: IPs related to horticulture

*Appendix: Characterization of IAR4D as implemented by FARA*

Please note this is a modified version of the actual 2.5 page survey. All data collected is listed, but to economize space, the structure has been revised. The text in italic between brackets refers to pre-defined answer categories.

Identification IP

Name of the organisation; Name of the Innovation Platform (IP); Country of the IP; District of the IP; Sub country/other of the IP; When was the IP formed (month and year).

Identification respondent

Your Name; E-mail address; Your position in the organisation; Your role in the IP.

IP formation and functioning

How did the IP originate? (*from scratch, builds on existing networks, already fully existed)*

How is the IP facilitated? (*researchers, by local stakeholders, jointly)*

How are participants selected for the IP?

IP participation of stakeholder

Which of these stakeholders are represented in the IP? *(yes, no - see footnote* 4 *for list of stakeholder )*

How often (approximately) do the following partners in your IP conduct or attend a) joint planning of

activities; b) joint implementation of activities; c) information sharing; d) field visits or workshops; e) seminars and training events? (*daily, weekly, monthly, every six month, every year or less)*

Problems addressed

Is the problem area addressed in IP? *(yes, no)* a) low agricultural technology use; b) access to inputs; c) market access and strategy problems; d) land related problems; e) other.

Who identified the problem *(list of stakeholders in footnote 4)*

Was the problem prioritized *(yes, no)*

Was an action implemented *(yes, no)*

Who designed the policy *(list of stakeholders in footnote 4)*

What is the action?

*Appendix: Additional Table*

**Table A.1: Summary statistics for intermediate outcomes**

| | | Obs | Mean | Std. Dev. |
|---|---|---|---|---|
| Mulching | equals 1 if a household uses mulching , 0 otherwise | 3129 | 0.32 | 0.47 |
| Trenches/terraces | equals 1 if a household uses trenches/terraces, 0 otherwise | 3070 | 0.29 | 0.45 |
| Water harvesting | equals 1 if a household uses water harvesting, 0 otherwise | 2754 | 0.17 | 0.38 |
| Irrigation | equals 1 if a household uses irrigation techniques, 0 otherwise | 3090 | 0.27 | 0.44 |
| Conservation farming | equals 1 if a household uses conservation farming, 0 otherwise | 2892 | 0.24 | 0.43 |
| Animal manure | equals 1 if a household uses animal manure 0 otherwise | 3260 | 0.69 | 0.46 |
| Cover crops | equals 1 if a household uses cover crops, 0 otherwise | 2803 | 0.29 | 0.45 |
| Crop rotation | equals 1 if a household uses crop rotation, 0 otherwise | 3085 | 0.60 | 0.49 |
| Inter cropping | equals 1 if a household uses inter cropping, 0 otherwise | 2609 | 0.56 | 0.50 |
| Rhizobiainoculation | equals 1 if a household uses Rhizobiainoculation , 0 otherwise | 2502 | 0.03 | 0.17 |
| Chemical fertilizer | equals 1 if a household uses chemical fertilizer , 0 otherwise | 3259 | 0.55 | 0.50 |
| Row planting | equals 1 if a household uses row planting , 0 otherwise | 3067 | 0.67 | 0.47 |
| Plant spacing | equals 1 if a household uses plant spacing, 0 otherwise | 2988 | 0.58 | 0.49 |
| Organic pesticide | equals 1 if a household uses organic pesticide, 0 otherwise | 3029 | 0.25 | 0.44 |
| Inorganic pesticide | equals 1 if a household uses inorganic pesticide, 0 otherwise | 3115 | 0.48 | 0.50 |
| Drying | equals 1 if a household uses drying, 0 otherwise | 3137 | 0.75 | 0.43 |
| Threshing/shelling | equals 1 if a household uses threshing shelling equipment, 0 otherwise | 3104 | 0.47 | 0.50 |
| Improved storage facil. | equals 1 if a household uses improved storage facilities, 0 otherwise | 3062 | 0.24 | 0.43 |
| Pest control | equals 1 if a household uses pest control, 0 otherwise | 3142 | 0.47 | 0.50 |
| Grading | equals 1 if a household uses grading, 0 otherwise | 2957 | 0.47 | 0.50 |

**Table A.1 (continued): Summary statistics for intermediate outcomes**

| | | Obs | Mean | Std. Dev. |
|---|---|---|---|---|
| Marketing Strategies | | | | |
| Consumers | equals 1 if household sold at least one type of product on farm to consumers, 0 otherwise | 2861 | 0.24 | 0.42 |
| Middleman | equals 1 if household sold at least one type of product on farm to middleman, 0 otherwise | 2861 | 0.17 | 0.37 |
| On the roadside | equals 1 if household sold at least one type of product on the road side, 0 otherwise | 2861 | 0.09 | 0.28 |
| Local market | equals 1 if household sold at least one type of product at the local/village market, 0 otherwise | 2861 | 0.36 | 0.48 |
| District town | equals 1 if household sold at least one type of product at the district town market, 0 otherwise | 2861 | 0.17 | 0.37 |
| Distant market | equals 1 if household sold at least one type of product at a distant market, 0 otherwise | 2861 | 0.16 | 0.37 |
| Household level social capital | | | | |
| Development Projects | Equals 1 if household participated in community development projects, 0 otherwise | 2968 | 0.81 | 0.40 |
| Collective problem | Equals 1 if household financially contributed to community activities or collective problems, 0 otherwise | 2883 | 0.74 | 0.44 |
| Conflict | Equals 1 if household involved in settling conflicts or disputes among people, 0 otherwise | 2835 | 0.69 | 0.46 |
| Visit within farmers | Equals 1 if household visited other farmers within community to learn about agriculture, 0 otherwise | 2809 | 0.57 | 0.50 |
| Visit outside farmers | Equals 1 if household visited other farmers outside community to learn about agriculture, 0 otherwise | 2738 | 0.38 | 0.49 |
| Visit research station | Equals 1 if household visited a research station to learn about agriculture, 0 otherwise | 2691 | 0.21 | 0.40 |
| Visit extension office | Equals 1 if household visited an extension office to learn about agriculture, 0 otherwise | 2699 | 0.26 | 0.44 |