The impact of Agricultural Innovation Systems interventions on rural livelihood outcomes in Malawi

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This paper presents on a study conducted in the central region of Malawi to assess the impact on rural livelihoods of the use of agricultural research innovation system concepts in implementing research initiatives. The analysis applied propensity score matching as a means of establishing a counterfactual and differencing to measure impact. Using the Enabling Rural Innovation initiative as a case study, the study establishes that rural livelihood outcomes pertaining to crop and livestock production, household income, asset ownership, and fertilizer use are significantly impacted upon by agricultural innovation systems interventions. In depth analysis however demonstrates that although participating households have more robust livelihoods during the intervention, phasing out of the research *program reduces the effects on livelihoods. Recommendations are that there should be greater capacity building of local extension agents and increased budgetary support to ensure understanding and application of agricultural innovation systems concepts by public agricultural extensionists to sustain positive effects.*

Key words: Agricultural innovation systems, rural livelihoods, Malawi, enabling rural innovation, impact evaluation

1. Introduction

The complexity of rural livelihoods and poverty in many third world countries like Malawi, has led to a shift in global agricultural research systems from the strengthening of national research systems towards systems that are geared to enabling greater individual and community innovation, proper knowledge utilization and overall transformation (Sanginga et al., 2009; World Bank, 2007a; CTA, 2010). This shift towards an innovation systems orientation was precipitated by the realization that despite stronger national research systems, agricultural productivity remained low as a result of not only the lack of appropriate technologies and the lack of access to those technologies, inputs, credit and access to markets and rural infrastructure; but also because of gaps in information and skills that prevented rural producers from effectively utilizing and adopting technologies. The new prevailing agricultural research paradigm entails that agricultural research innovation system approaches feature highly in national strategies for many countries working towards promoting long term agricultural development (Sanginga et al*.,* 2009).

For Malawi, this has been the case as the government has created an enabling environment for the work of agriculture research and development agencies who through the use of agricultural innovation systems concepts, recognize that there is potential for improving rural livelihoods by enabling rural innovation amongst smallholder producers and hence reducing rural poverty. This has become critical as nearly 40% of the total population lives in dire poverty (World Bank, 2007b) due mainly to the prevalence of smallholder agriculture which is characterized by complete reliance on rain fed farming which is prone to shocks arising from unfavorable weather conditions and low land holding sizes (World Bank, 2007b).

Empirical studies that specifically assess the impacts of agricultural innovation systems on the ability of rural people's ability to better utilize the natural resource base and thus enhance their production (Gildemacher et al., 2009; UN, 2008); increase food security and nutrition (Morris et al*.,* 2007) and diversify their livelihoods and preserve the ecosystem (UN, 2008) in an African context are few in the literature. For those that exist, the analytical methods employed are mainly qualitative and they lack the rigor of the quantitative and qualitative methods applied to the study of the impacts of innovation systems as used in developed countries (Spielman et al., 2009). Furthermore no empirical studies exist in the literature which applies rigorous quantitative methods to examine the impacts of agricultural innovation systems interventions on the livelihood outcomes of rural producers in Malawi.

This paper therefore presents the findings of an empirical study whose objective was to assess the impact that agricultural innovation systems interventions have on rural livelihoods in Malawi. The paper contributes towards the on-going debate pertaining to the impacts of agriculture innovation systems on rural development and it aims to provide credible evidence of the impacts of agricultural innovation systems interventions on rural livelihoods which can be used to inform policy.

2. The concept of agricultural research innovation systems

An innovation system is a network of actors and organizations that are linked by a common theme with the aim of developing new technologies, methods and new forms of organization for use by the ends users to tackle identified problems (World Bank, 2007b). An innovation system is governed by the prevailing institutions and policies that affect performance of the actors involved and the regulation of the technologies developed (World Bank, 2007b). Hence agricultural research innovation systems are those research platforms whose main focus is solving challenges pertaining to agriculture. The innovation systems concept embraces not only the researchers and scientists who are traditionally involved in agricultural research but also the end users of technologies and the interactions that take place between all the actors in the research process (IAC, 2004:141).

The agricultural innovation platform (Figure 1) represents an interface where different actors including interdisciplinary teams of scientists, end users, extension agents, and agribusinesses interact in order to identify problems for which innovations need to be developed. The interaction in the innovation platform is non-linear with the different actors networking freely with a component for institutional and human capacity development being key (Jones, 2008).

Once problems are identified, actors work together to develop and adapt technologies to the local environment and this leads to improved production and ultimately enhanced livelihoods.

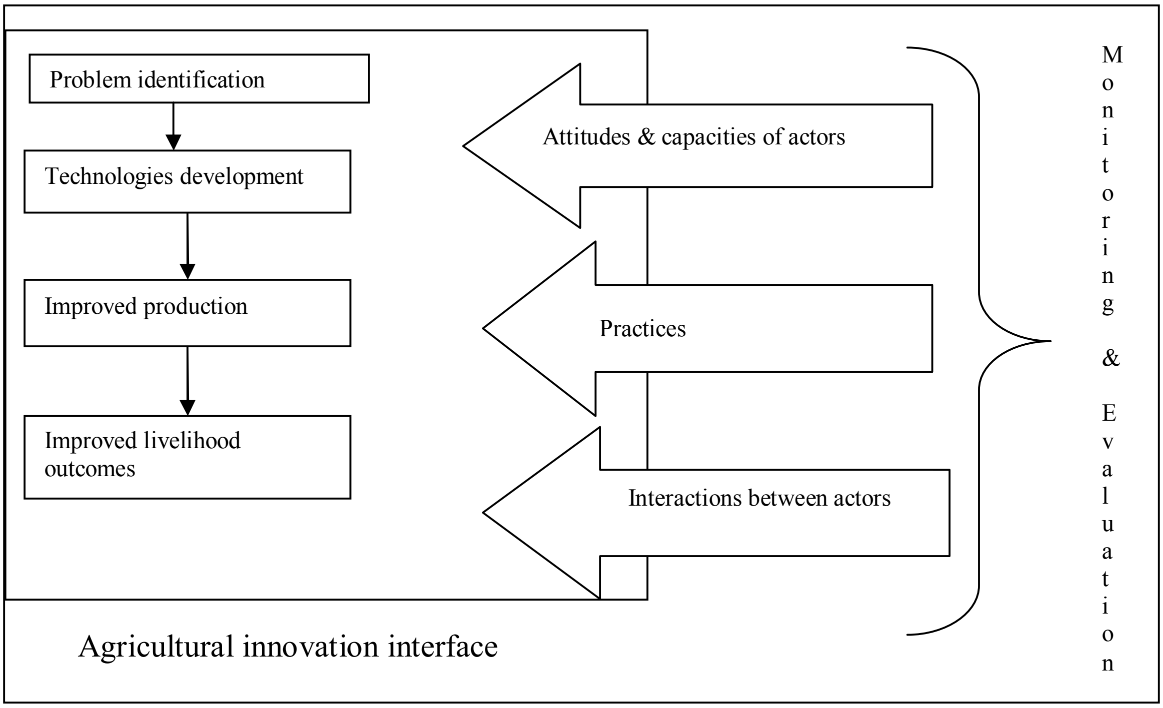

Figure 1: Representation of an Agricultural Innovation platform (author compilation)

Throughout this process, there is constant feedback using mechanisms that are put in place at the onset of the innovation platform. In addition the changes in the attitudes, knowledge and skills taking place between actors are monitored and the results are used to develop strategies for improving the capacity of actors to innovate.

3. The Enabling Rural Innovation (ERI) Initiative

The Enabling Rural Innovation (ERI) initiative was the innovative agricultural research intervention which was under study in this research. It was developed by the International Centre for Tropical Agriculture (CIAT) and in Malawi it was piloted in three districts of Dezda, Lilongwe and Kasungu. ERI is an innovative research framework for linking smallholder farmers to markets and it focuses on strengthening the capacity of resource poor smallholder farmers to access market opportunities. The main aim of ERI is to create an entrepreneurial culture in rural communities of Africa.

The ERI approach is governed by the resource to consumption framework which has the following principles (Kaaria et al*.,* 2008):

1. Technology development and research agenda setting are based on the needs of beneficiaries, existing interests and available market opportunities.
2. Technology development is guided by a comprehensive community assessment which aims to identify the different intra-household allocation and control over resources and responsibilities with the aim of understanding the constraints and opportunities to technology adoption and reinvestments in natural resources.
3. Gendered differences in roles and perceptions as well as differences of roles of stakeholders are explicitly integrated into the technology development process to ensure equity in accessing technology and in as the distribution of benefits.
4. It works to enhance the ability of the communities to identify and match market opportunities with existing community assets.

In addition according to Kaaria et al. (2009) the ERI approach has six key components which govern its implementation:

- Agro-enterprise development and participatory market research
- Farmer participatory research and natural resources management
- Social and human capital development
- Gender equity and empowerment of women
- Community based participatory monitoring and evaluation
- Effective development and management of partnerships

Using the ERI guiding principles CIAT established one of three pilot innovation platforms in Malawi in Ukwe Extension Planning Area (EPA) in Lilongwe District which consisted of a multi-disciplinary team of CIAT social scientists; extension agents from the Department of Agricultural Extension Services (DAES) as well as local extension staff based in the community; researchers from the Department of Agricultural Research Services (DARS); and other agricultural social scientists from the Ministry of Agriculture based in Lilongwe Agricultural Development Division (ADD). The innovation platform worked together to select an appropriate community within the Extension Planning Area for piloting the ERI initiative based on a criteria that included all year round road accessibility; availability of a

motivated local level extension agent; willingness of other development partners working in the community to take an active role in the initiative and the existence of interest in the community for further agricultural development and intensification (Sangole et al., 2003).
Once the community was selected, the innovation platform together with the community conducted a participatory diagnosis of the community challenges and opportunities as well as varying development options. This process was the initial way of engaging the communities in order to not only sensitize them on the ERI initiative but also to develop a shared vision for the future of the community (CIAT, 2007). The outcome of the participatory diagnosis was the development of a collective plan of action for overcoming identified problems using the available community resources and assets.

After the participatory diagnosis, the Ukwe innovation platform implemented the community action plan by starting with the formation of farmer research and market groups within the community and the leaders from these groups represented the community in the innovation platform. This was followed by a participatory market analysis of existing market opportunities which culminated in selection of an agro-enterprise based on existing social and wealth differences as well gender preferences within the community. The farmer market group that had been selected was trained in market research and their capacity to conduct market research was a key aspect of this process. In the study area, piggery was chosen as the agro-enterprise to be developed under the ERI initiative.

Finally the innovation platform through the farmer research groups planned and implemented simple research experiments around various other agro-enterprises in order to build capacity of the community to conduct research experiments to enable them to better understand their farming enterprises and in so doing to demystify the process of agricultural research experimentation and hence build their ability to innovate.

4. Study methodology

4.1 Place of study and data collection

The study was conducted in Ukwe Extension Planning Area in Lilongwe district in the Central region of Malawi. Households were sampled from Katundulu, Mphamba and Kango villages. Katundulu and Mphamba villages formed the intervention communities while Kango village was the area where a counterfactual was established. Katundulu village was amongst the first villages in which the ERI initiative was piloted under the work of the innovation platform described above; while Mphamba village is one in which the local agricultural extension officers who had worked with CIAT in the pilot site, used the principles and concepts of ERI to implement similar interventions.

Purposive random sampling was used to select study participants from the intervention while simple random sampling was used to select study participations from the counterfactual. A total of 303 households were sampled in the study area with the counterfactual sample size being double that of the intervention sample size in order to allow for better matching of households (Ravallion, 2003). Households from the counterfactual that did not match with those in the intervention in terms of social economic and farming systems characteristics were dropped from the analysis.

4.2 Data analysis

The key to a good impact evaluation is the estimation of what would have occurred in the absence of an intervention (Martinez, 2009). Since impact evaluations are carried out after the program has started or finished, as is the case of the intervention in this research; *ex-post* changes in outcome variables are used as a measure of impact. The problem with this is that there are many other observable and non-observable time variant characteristics which may alter outcome variables for participants and as such it becomes difficult to attribute changes in the outcome variables to a specific intervention. This is because comparison of the before and after changes in the outcome variable can lead to either over or under estimation of program impacts.

To overcome the 'attribution' problem, it therefore becomes necessarily to use data on outcome variables from non-intervention participants also known as the counterfactual. A valid counterfactual must have identical observed characteristics to the intervention participants with the only difference being program participation. For this study, the observed characteristics included the socio-economic and farming system characteristics of the households. The availability of data from non-participations is however in itself also not sufficient for attributing differences in outcomes variables to an intervention as changes in the outcome variables for participants may also arise from 'selection bias' in that participants may have been purposively selected (Ravallion, 2003;2005).

This entails that non-participants that are used for comparison purposes must in addition to having identical characteristics be those that would have had an equal chance of being selected for participation in the intervention hence overcoming the problem of selectivity bias. In the absence of randomization, which equalizes the probability of participation in an intervention and which removes selection bias; propensity score matching becomes the solution to the establishment of a valid counterfactual (Baker, 2000; Ravallion, 2003;2005)

According to Ravallion (2003) the underlying concepts with propensity score matching is that two groups are identified, one that took part in the intervention denoted $H_i = 1$ for household i and another that did not participate in the intervention demonstrated $H_i = 0$. Intervention households are matched 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:

$$P(X_i) = \text{Prob}(H_i = 1 | X_i) \quad (0 < P(X_i) < 1) \qquad (1)$$

Where

X_i is vector of pre-intervention control variables

These pre-intervention control variables are those which are based on knowledge of the program 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. Propensity score matching is not able to reproduce the results of experimental randomization designs if the variables that influence participation in the intervention are not properly defined.

In this study propensity scores for each household in the sample were estimated using logit regression modeling. Using the estimated propensity scores, matched pairs were established on the basis of the proximity of propensity scores of the probability of participation in the ERI initiative between the intervention and non-intervention samples. Unmatched non-intervention households were dropped from the analysis in order to remove bias and to increase robustness (Rubin & Thomas, 2000 in Ravallion, 2003).

A logit regression model of participation in ERI was estimated in order to determine the probability of a household participating in the intervention. Participation was modeled as a dichotomous dependant variable determined by a set of exogenous variables that determined participation in ERI and this included frequency of contact with extension agents prior to the

ERI intervention, the sex of the household head, an index of previous participation in other development initiative, and the size of the household.

5. Results and discussions

5.1 Validation of the logit model of Enabling Rural Innovation (ERI) program participation

In general the logit model of ERI participation that was estimated was found to be a good predictor of participation as demonstrated by the results of two alternative tests of goodness of model fit, the Hosmer and Lemeshow (H-L) static and the chi square test. The H-L goodness of fit test static was 10.310 and it was non-significant (*p*=0.244) indicating that the model is a good fit as the rule of thumb for accepting a logit model is that the H-L static must be greater than 0.05 and it should show non-significance (Hosmer & Lemeshow, 1989). Secondly the model has a chi-square static of 23.747 which is statistically significant at the 1% confidence level therefore implying that all the predicators that have been included in the model are capable of jointly predicting participation in the ERI initiative.

Table 1: Results of the logit model of participation in the Enabling Rural Innovation Intervention

	Coefficient (β)	Significance (ρ)	Odds ratio (Exp β)
Constant	-1.426	0.136	0.240
PRE_EXT_CONT	-.157	0.019	0.855
SEX_HHEAD	.571	0.118	1.771
HH_SIZE	.092	0.087	1.092
PART_PREVIOUS		0.003	
PART_PREVIOUS(1)	-.559	0.310	.572
PART_PREVIOUS(2)	1.486	0.068	4.419
Chi square	*23.747****		
H-L chi square	*10.310 (p=.244)*		
Total households	303		

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

Using propensity scores for participation generated by the logit regression model, households in the intervention were matched on the basis of the proximity of their propensity scores of participation to households in the counterfactual. 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 livelihood outcomes were then compared between households that were more similar and therefore comparable and as such any differences in outcome variables between the participants and non-participants are attributed to the intervention (Ravallion, 2003).

5.2 Impact of ERI on Production outcomes

The ERI intervention impacted upon many aspects of household production with statistically significant differences being observed for livestock production, upland crop production, value of maize production and assets ownership. Differences in maize yields were however found to not be affected by participation in the ERI intervention.

Table 2: Impact of the Enabling Rural Innovation intervention on production outcomes

Production outcomes (USD)	Intervention		Counterfactual		Effect
	Mean	Standard Deviation	Mean	Standard Deviation	
Total value of livestock	445.03	1620.99	144.82	926.47	300.12*
Total value of upland crop production 2007/08	1349.48	0.016	537.14	0.0114	812.34***
Total value of upland crop production 2008/09	992.24	0.0179	365.14	0.0084	627.10**
Value of maize harvest 2007/08	259.35	308.77	180.01	340.24	79.33
Value of maize harvest 2008/09	506.76	0.013	219.66	490.80	287.09*
Maize yield 2007/08 (Tons/hectare)	0.84	1.00	0.85	1.47	0.0055
Maize Yield 2008/09 (Tons/hectare)	1.17	2.61	0.88	1.33	0.287
Total value of assets	550.74	3008.51	159.65	581.58	391.00*

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

An analysis of the value of all upland crops for the households in the study, finds that the ERI intervention increased the value of crops produced for participating households by USD812.34 and USD627.10 for the 2007/08 and 2008/09 cropping seasons respectively (see table 2). The differences in the value of all upland crops were found to be statistically significant at the 1% and 5% confidence levels for the 2007/08 and 2008/09 seasons respectively.

Secondly the study also finds that in the 2008/09 season, the value of maize produced by intervention households was statistically higher than for households in the counterfactual by USD287.09. This was however not the case for the 2007/08 cropping season as it was found that differences in maize production between the intervention and counterfactual households were not statistically significant. The difference in value of maize production in the 2008/09 season cannot be attributed to higher maize prices for producers in the 2008/09 season which were at USD295.89 per ton as compared to prices in the 2007/08 season of USD125.99 per ton; or to price differentials between the intervention and counterfactual as an analysis of the farm gate prices for the different communities showed that all households in the study area are at the same farm gate prices[1]. Secondly differences in maize production in the 2008/09 season cannot be attributed to yield differences as the results indicate that there were no statistically significant differences in the yields of maize between households in the intervention and counterfactual.

The significant differences in maize production between the intervention and counterfactual can therefore mainly be attributed to that households in the intervention planted more land than their counterparts in the counterfactual. This is evidenced by statistically significant differences in the total land holding sizes and the total number of separate farm plots that households in the intervention owned and planted as compared to households in the counterfactual. With households in the intervention having on average 3.1 hectares of land while the counterfactual households had 2.2 hectares of land; and households in the intervention planting on average 1.72 separate pieces of farm plots while counterfactual households planted 1.23 separate pieces of land. The differences in the land ownership and the separate pieces of cultivated farm plots between the intervention and counterfactual were statistically significant at the 1% and 5% confidence level respectively.

Further analysis showed that the ERI initiative was significant in increasing the value of households' total assets and livestock ownership by USD391.00 and USD300.12 respectively. Hence households in the intervention had higher valued assets than households in the counterfactual. An analysis of the differences in livestock prices showed that there were small differences between the market prices of the three major types of livestock traded in the study area with the average price for the 2008/09 season of chickens, pigs and goats being at USD5; USD54 and USD57 for households in the intervention respectively; while the counterfactual had USD3; USD68 and USD62 as the average prices for chickens, pigs and goats respectively. Statistical analysis however demonstrated that any differences in the livestock prices between the two communities were not statistically significant at any level.

[1] An analysis of the farm gate prices for different households showed that there were no statistically significant differences between the prices of maize in either community.

As such it can be deduced that households in the intervention had larger numbers of livestock as compared to households in the counterfactual and this is confirmed by statistical analysis which showed that households in the intervention owned on average 3.7 more chickens and one extra pig and goat each as compared to households in the counterfactual and the differences in the ownership of all three classes of livestock were found to be highly statistically significant at the 1% confidence level. Hence these larger livestock numbers accorded intervention households that owed livestock with greater value.

A major contributing factor to the larger livestock numbers in the intervention especially in terms of pig ownership is that piggery was the agro-enterprise that was chosen as the intervention under the ERI. And because of this, participation in ERI entailed that households made more investments in the piggery through improved housing, feeding and hygiene; and improved their day to day management by keeping a record of all activities pertaining to the piggery. Participating households were trained in the construction of appropriate housing, feed formulation and in pest and disease control. In addition, farmer participatory research was put in place to test different feeding options and the cultivating of various types of feeds (Njuki et al., 2007). These changes together with greater market access arising from the establishment of a marketing committee in the community which was responsible for sourcing markets lead to the establishment of a stable market most notably for piglets and this resulted in increased incomes. From informal interviews with participating households it was revealed that this increased income in combination with changes in the decision making processes of participating households enabled them to invest more in household assets as well as other livestock especially poultry such as chickens.

5.3 Impact of ERI on household income

Further analysis indicates that the ERI intervention positively influenced incomes in both the 2007/08 and 2008/09 cropping seasons for the households who participated in the intervention. In rural areas of Malawi and in this study, household income is not synonymous with cash income but is a computed value which includes cash income earned from various on and off employment; the imputed value of non-cash income earned from the sale of own labor; cash income earned from the marketing of agricultural crops and livestock and the imputed value of all crops harvested which are retained either for home consumption or which are used as payment for farm workers. In this study ten different sources of household income were identified and used to compute a household's total income.

As can be seen in Table 3 below, households who participated in the intervention had on average USD280.21 and 340.54 more total income than their counterparts in the counterfactual in the 2007/08 and 2008/09 cropping seasons respectively.

Table 3: Impact of the Enabling Rural Innovation intervention on household incomes

Household income (USD)	Intervention		Counterfactual		Effect
	Mean	Standard Deviation	Mean	Standard Deviation	
Total income for 2007/08 season	511.49	0.0072	231.28	465.61	280.21**
Total income for 2008/09 season	636.21	0.0088	299.56	655.75	340.54**
Total cash income from livestock sales 2008/09	51.34	138.48	23.60	186.08	27.78

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

Both these differences in household incomes were statistically significant at the 10% confidence level. Increased cash incomes can be attributed to that the ERI intervention focused on assisting farmers to develop profitable agro-enterprises in order to meet existing market opportunities as opposed to them marketing any surplus that they grew for subsistence. Hence intervention communities conducted an analysis of existing market opportunities prior to the onset of the cropping year in order to determine the type of agro-enterprises that would be most profitable. Through this analysis the community identified a piggery and dry bean cultivation as the most profitability agro-enterprises (Njuki et al, 2007). Improved farmer market linkages through the ERI process have also been found to increase incomes of rural households in other communities in not only Malawi but also Uganda (Kaaria et al., 2008).

5.4 Impact of ERI on fertilizer use patterns

The impact of the ERI intervention on fertilizer use patterns in the intervention was assessed by analyzing the differences in the number of 50kg bags that farmers used per hectare of farm land. Inorganic fertilizers, in combination with hybrid seeds and good rainfall, play a crucial role in ensuring high maize production and food security in Malawi. Hence purchasing inorganic fertilizer demonstrates a household's decision making patterns in terms of reinvestment in their farm enterprise. Table 4 below, shows that there exist significant differences between the amounts of inorganic fertilizer applied between intervention and counterfactual households in the 2004/05, 2005/06 and 2006/07 agricultural seasons at the 1%, 5% and 10% confidence levels respectively. Between the 2004/05 and 2006/07 cropping seasons, intervention households applied on average nearly one extra 50kg bag of inorganic fertilizer as compared to households in the counterfactual. This difference can be attributed to the ERI intervention as the increased market outcomes acted as incentives for households to reinvestment in their farm enterprise, in order to sustain their agro-enterprise. In general, the study finds that all households in both the intervention and counterfactual were applying an amount of fertilizer that is below the recommended rates for Lilongwe Agricultural Development Division where the communities are located. The recommended fertilizer rate for home consumption for Lilongwe is the application of two bags of 23:21:0+4S and three bags Urea (with 46% nitrogen); while for production for the market, the recommended application rate is one bag each of 23:21:0+4S and Urea (Benson, 1999). Table 4 below shows that it is only households in the intervention that were close to reaching the recommendation for the market production with a mean of 1.92 bags of inorganic fertilizer being applied per hectare for the 2008/09 year.

Table 4: Impact of the Enabling Rural Innovation intervention on fertilizer use patterns

Fertilizer use patterns (no. of 50kg bags of inorganic fertilizer)	Intervention		Counterfactual		Effect
	Mean	Standard Deviation	Mean	Standard Deviation	
2004/05	1.24	0.62	0.567	0.44	0.679***
2005/06	1.38	0.63	0.624	0.11	0.761**
2006/07	1.50	0.63	0.858	0.32	0.644*
2007/08	1.68	0.68	1.38	1.22	0.297
2008/09	1.95	0.90	1.77	1.70	0.171

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

Further analysis shows that in more recent years, the differences in the amount of fertilizers applied are less distinct and in the 2007/08 and 2008/09 cropping seasons the differences are non-significant. This can be attributed to the increased availability of inorganic fertilizer in rural areas due to the implementation of a fertilizer subsidy program in the country. The implementation of a fertilizer subsidy program in Malawi increased the availability of and accessibility to inorganic fertilizers throughout the rural areas of the country hence increasing the opportunity for all farmers to access and use inorganic fertilizer.

5.5 Impact of ERI on trainings and group membership

An assessment of the ERI initiative's impact on membership into farmer groups and the number of trainings attended by a household was also carried out. Table 5 below indicates that five years ago when ERI was in implementation, households in the intervention attended on average 1.62 more trainings than households in the counterfactual and this difference was statistically significant. These results are an indication that the ERI initiative provided participating communities with significantly more training opportunities than is provided by the local agricultural extension officers.

Table: 5: Impact of the Enabling Rural Innovation intervention on trainings and group membership

Trainings and group membership	Intervention		Counterfactual		Effect
	Mean	Standard Deviation	Mean	Standard Deviation	
Total number of farmer groups per household	0.35	.0.865	0.49	.0743	-0.139
Average number of trainings five years ago	2.64	5.67	1.02	3.86	1.62*
Average number of trainings in 2007/08	1.92	5.29	1.26	3.66	0.66
Average number of training 2008/09	1.14	4.43	1.22	3.55	-0.08

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

Further analysis however shows that after the ERI initiative phased out in the 2006/07 season, it can be seen that in the 2007/08 and 2008/09 cropping seasons there were no statistically significant differences in the number of trainings attended by households in the intervention and counterfactual. This can be attributed to that phasing out of the ERI intervention led to the local agricultural extension officers reverting to pre-ERI training strategies in the intervention communities and these entailed less training. The results therefore indicate that the ERI initiative during its implementation had a positive impact in that it increased the number of trainings that a household attended. But after phasing out; the number of trainings for individuals in the participating communities and the counterfactual were not statistically different.

Further analysis shows that the ERI initiative did not have a statistically significant impact on household's membership into farmer groups. Implying that household's participation in farmer groups between the two communities was not statistically different. This finding is surprising as the ERI initiative worked towards establishing and strengthening farmer organizations as it recognized that the most important success factor for increasing market access was well established farmer organizations (Kaaria et al. 2008).

6. Conclusions and recommendations

It is the conclusion of this paper that agricultural research interventions that use an innovations systems approach have a strong positive impact on some but not all aspects of rural livelihoods with stronger positive impacts been seen for incomes, upland crop production and fertilizer use given the absence of government policies that provide subsidized fertilizers. In the presence of a subsidized fertilizer policy, innovative research interventions have a weaker positive impact on fertilizer use. In addition, weaker positive impacts are seen for maize production and training opportunities given similarities in the geographical location. Innovative agricultural research interventions therefore have the potential to positively influence the production, incomes, and training opportunities of rural households.

Sustainability of program effects is however threatened by phasing out of the interventions as local agricultural extension agents lack the human and financial capacity to maintain the higher level of contact and innovative strategies employed in implementing intervention using agricultural innovation systems concepts. Hence to ensure sustainability of the positive effects on rural livelihoods and the use of agricultural innovation systems concepts, there is the need for agricultural research organizations to invest more in building the capacity of local public extension agents for understanding and applying agricultural innovation systems concepts. Secondly there is the need to mainstream agricultural innovation systems concepts in all public agricultural development initiatives. This will however require that there be deliberate and greater budgetary support towards innovation systems mainstreaming in all public agricultural extension and research programs. In order for mainstreaming to be effective, it must be done concurrently with the capacity building efforts and budgetary support; without which mainstreaming of innovation systems concepts in public agricultural policies runs the risk of becoming rhetorical with no real implementation.

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