IDENTIFYING SOCIOECONOMIC CONSTRAINTS TO AND INCENTIVES FOR FASTER TECHNOLOGY ADOPTION: PATHWAYS TO SUSTAINABLE INTENSIFICATION IN EASTERN AND SOUTHERN AFRICA (*ADOPTION PATHWAYS*)

TANZANIA ADOPTION PATHWAYS 2013 SURVEY REPORT

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The Adoption Pathways project is supported by the Australian International Food Security Research Centre (AIFSRC) and managed by the Australian Center for International Agricultural Research (ACIAR). The project implemented and led by the International Maize and Wheat Improvement Center (CIMMYT) in collaboration with the five African countries (Ethiopia, Kenya, Tanzania, Malawi and Mozambique) Universities and Research institutes.

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1.0 Introduction

1.1 Project background

Despite tremendous improvements made in agricultural sector over years, rapid population growth combined with declining soil fertility and climate variability has resulted in dramatic fall in per capita food production in Africa. However, there is increasing evidence that agricultural intensification conditioned by the underlying socioeconomic dynamics and heterogeneity in production environment (Barrett 2008; Pretty et al. 2011) is one viable option for increasing per capita food production in this region of the world. Similarly, gender inequalities and lack of attention to gender in agricultural development has been cited as one main factor contributing to lower productivity and higher levels of poverty as well as under-nutrition in many African countries. Therefore, better understanding of constraints that condition farmers' adoption behaviour are important for designing promising pro-poor policies that could stimulate productivity change and sustainable agricultural intensification that will eventually increase per capita productivity. This requires systematic collection and analysis of socioeconomic data from representative household and village economies over a longer time frame to understand farmers' adoption and investment decisions, risk management strategies and the socioeconomic dynamics as drivers of change and the resulting inter-temporal effects on poverty and related outcomes (Doss, 2006; Wu and Babcock 1998; Yu et al. 2008).

However, lack of longitudinal and good quality farm household data especially from key maize-based farming systems has been a long term constraint in conducting such policy relevant research in sub-Saharan Africa (SSA). In order to address this knowledge gaps using more robust and rigorous tools, the Adoption Pathways Project (AP) project was conceived with the aim of building on existing dataset of ongoing sister project called SIMLESA to build longitudinal studies in sentinel villages/communities that were carefully selected under SIMLESA to represent maize-based farming systems in Eastern and Southern Africa. In eastern Africa, the project operates in Ethiopia, Kenya and Tanzania while in southern Africa project activities are in Malawi and Mozambique. In Tanzania the AP project is implemented by CIMMYT in collaboration with Sokoine University of Agriculture (SUA).

1.2 Survey sampling and data collection

In order to build a longitudinal dataset (panel) based on existing dataset of SIMLESA, the 701 households that were surveyed under the SIMLESA baseline survey in the year 2010 were targeted. During the baseline survey, one standardized household level questionnaire was administered. Beside household level data, AP survey was designed to capture also gender disaggregated data. Therefore, two sets of questionnaires were targeted for each household i.e. the general household level questionnaire administered to both wife and husband whenever it was possible (as it was done during the SIMLESA baseline survey) and the individual level questionnaire administered to husband and wife separately but at ago to avoid response contamination. Since the AP survey was following up on the households that were surveyed under SIMLESA project baseline in 2010, the survey sites remained the same though one district in the Eastern Zone of Tanzania i.e. Kilosa had been split into two i.e. Kilosa and Gairo districts.

In preparation for the survey, SUA recruited a team of 24 enumerators who were mainly MSc. Students and a few BSc. graduates who had just graduated from Department of Agricultural Economics at SUA. The recruited enumerators were taken through a rigorous in-house training on how to use the designed questionnaires to capture the sought data. The training was conducted at SUA between 30 September and 6 October by a facilitator from CIMMYT Nairobi office. After the in-house training, the enumerators were used to pretest the two questionnaires (household level and individual level) to gauge the suitability of the tool in capturing the data. This pre-testing was also used to evaluate the trainees understanding and ability to conduct the survey. Necessary adjustments were made on the questionnaires after pre-testing before production of the final copies that were to be used in the main survey. Also, after the pre-testing, the trainees were evaluated and ranked based on their understanding of the questionnaire and general management capabilities. The best four trainees were nominated as supervisors and the remaining 20 enumerators were divided into four teams of five each with one supervisor.

A total of 551 households out of the targeted 701 were successfully re-surveyed and their distribution across the survey districts was as indicated in Table 1. Therefore an attrition rate, a common problem associated with panel data, was about 21% with the highest rate being reported in the Northern Zone district of Mbulu (Table 1). Some of the reasons for the attrition rate as given by the survey supervisors included displacement of households to other villages, districts, or regions; separated/divorced; admitted to hospital; deceased; temporarily away from their village/homestead; and those who could not be located completely in their villages.

Table 1 about here

1.3 Purpose of report

The main objective of this report is to present the overall results from the AP project survey that is basically based on the second wave panel data with SIMLESA baseline survey having been the first wave. Special focus in the presented results is on adoption and impact processes of sustainable agricultural intensification practices (SAIPs) in Tanzania. The results are meant to be shared out with relevant stakeholders in order to stimulate debate on how best SAIPs in Tanzania can be disseminated more widely for greater impact in addressing food security, incomes and general poverty. The report is mainly based on descriptive statistics.

2.0 Household socioeconomic characteristics

2.1 Demographic characteristics

Out of the 701 households that were interviewed during the baseline survey in 2010, about 551 households were successfully re-interviewed in 2013 under the Adoption Pathways project. This represented an attrition rate of about 21% (Table 1). Majority of the respondents on household level questionnaires were males (63%). On the other hand, out of the 551 households that were successfully re-surveyed, two individual questionnaires (primary and spouse) were successfully administered on 242 households while only one individual questionnaire (primary) was administered on the remaining 309 households. Therefore, spouse responses constituted about 30% of the total individual level interviews. Female respondents constituted about 53% and 83% of total individual level respondents and individual level spouse responses, respectively.

At household level, majority of the re-surveyed households were male headed (86%) with Gairo district reporting the highest proportion of the male headed households while Kilosa district reporting the lowest (Table 2). The average age of the household heads was about 50 years. However, on average, Gairo district had the youngest households' heads (44 years) while Karatu district had the oldest household heads (52 years). On the other hand, the average level of formal education for the household heads was about 5 years of schooling. Mvomero district had the most educated household heads on (6 years) while Gairo district had the least educated household heads (5 years). Majority of the household heads reported farming as their primary occupation (95%). About 82% of these household heads were married and living with their spouses with only 9% who were widows/widowers. Gairo district had the highest number of household heads who were married and living with their spouse (93%) while Karatu district had the highest number of household heads who were widowed (11%) (Table 2).

Table 2 about here

The average size of the surveyed households was about 6 members. Mvomero district had the smallest family size of about 5 members while Mbulu District had the largest family size of about 7 members. However, when these household members were converted into adult equivalent, the overall average household size among the surveyed households was about 4.5 adult equivalents. On this scale of adult equivalency, Mvomero district still had the smallest size of about 4 and similarly, Mbulu district had the largest size of about 6 (Table 2). The household dependency ratio was also computed to gauge the level of resource strain across the five surveyed districts. Overall, the average dependency ratio across the five surveyed districts was about 1. This means that for every one economically active household member, there is another one household member who is not economically active. Comparison of this dependency ration across the five surveyed districts showed that Mbulu district had the highest dependency ratio of about 1.3 while Kilosa district had the lowest dependency ration of just slightly more than 0.9 (Table 2).

Results of gender analysis for selected demographic attributes of the surveyed households are presented in Table 3a and Table 3b. As shown in Table 3a, a higher proportion of household heads who reported farming as their main occupation were from male headed households (95%) compared to female headed households (94%). Also, while majority of the household heads in male headed households were married and living with their spouses (93%) compared to female headed households (13%), a higher proportion of households heads who were widows were found in female headed households (51%) compared to male headed households (2%). This shows that most of the female household heads are actually widows i.e. de jure female headed households.

Table 3a about here

Female headed households had on average older household heads (55 years) compared to male headed households (49 years). This difference in age of the household heads was statistically significant at 1%. On the other hand, male household heads had more years of formal schooling (5.4) compared to their female counterparts (4.3). This difference in education level was also found to be statistically significant at 10%. Similarly, male headed households had bigger household sizes and higher dependency ratio compared to female headed households (Table 3b). The average household size of male headed households was about 6 members and 5 adult equivalency compared to 5 and 4, respectively for female headed households. These differences in household size by gender were statistically significant at 10%.On the other hand, the average dependency ratio was about 1.1 and 0.9 among male and female headed households, respectively (Table 3b).

Table 3b about here

2.2 Asset ownership and holding

2.2.1 Land ownership

The basic productive asset in farming communities is land. Descriptive analysis of this important asset revealed that the average land holding size among the surveyed households was about 2.5 ha (Table 4a). Mbulu District had the largest average land holding size (3.3 ha) while Karatu District had the lowest average land holding size (1.6 ha). The average land holding in the lowest quartile was about 0.8 ha while the highest quartiles had 5.6 ha. This means that the lowest quartile of land holding is just slightly more than 10% of the highest land holding quartile. This is a clear indication of the high skewedness in land distribution among the surveyed households.

Table 4a about here

Further analysis of land ownership was done from a gender perspective. Overall, the results showed that male headed households owned more land (2.6 ha) than female headed households

(1.5 ha). The difference in the size of land holding between male and female headed households keep on increasing as one moves from the lower quartile to the upper quartile (Table 4b). However, it is important to note that land distribution among the male headed households was more skewed than in female headed households. The average land holding in the highest (fourth) quartile among the male headed households was almost 8 times more than the average land holding in the lowest (first) quartile. On the other hand, the average land holding among the highest (fourth) quartile for female headed households was about 4 times bigger than the lowest (first) quartile (Table 4b).

Table 4b about here

2.2.2 Ownership of other assets

A part from land, ownership of other farm assets like transport assets, information assets and productive assets are very important in improving on-farm productivity. Table 5a and 5b presents a summary ownership of selected assets by district of survey and gender of the household head, respectively. Bicycles were the most commonly owned transport assets with over 60% of the surveyed households indicating that they owned at least one bicycle. While bicycle ownership did not differ significantly across the surveyed households, a significantly higher proportion of male headed households owned bicycles compared to female headed households (table 5a and Table 5b). Another important transport asset owned by the surveyed households was donkey/ox-cart. About 10% of the households were found owning donkey-ox-carts. These ox-carts were more popular in the Northern Zone districts of Karatu and Mbulu with Mbulu district having the highest proportion of households reporting that they were owning this asset (25%) (Table 5a). Unlike bicycles that ownership differed significantly across gender of the household head and not across the surveyed districts, ownership of ox-carts differed significantly across both districts and gender of the household head. The significant difference in ownership of these important transport assets across gender of the household heads could have an important implication on adoption of farm technologies like improved seed and fertilizer that need some form of transport to avail them from the stockiest to the farm. Similarly, ownership of these transport assets could be critical in determining both the probability and intensity of output market participation by smallholder producers. This is because these assets play an important role in reducing proportional marketing costs that significantly determine both the decision and intensity of market participation (Goetz, 1992, Key et al., 2000, Alene et al., 2008). Therefore, given the fact that the results showed that a lower proportion of female headed households own this assets then it is a clear indication that a higher proportion of female headed households in Tanzania are constrained to access both the input and output markets.

Table 5a about here

On the other hand, the most widely owned information assets among the sampled households was radio then followed by mobile phone. Almost all surveyed households owned radio while about 65% owned mobile phones (Table 5a). Mobile ownership varied significantly across the surveyed districts with Gairo district reporting the highest proportion of households owning mobile phones (81%) followed by Karatu district (73%). The district with the lowest penetration of mobile telephony was Mbulu (55%). From a gender perspective, a significantly higher proportion of male headed households owned mobile phones (67%) than female headed households (50%). The wide spread of radio and mobile phone ownership in Tanzania is an indication of the development in communication technologies which can be used as a means of fast spreading and adoption of agricultural technologies i.e. extension information passed over through radio and mobile telephone is likely to reach many farmers as compared to same information when communicated through TV.

The descriptive statistics also indicate that still a substantial proportion of farming households in Tanzania still depend on animal traction for tilling their land. Almost 20% of the surveyed households were found owning ox-ploughs (Table 5a). This animal traction as proxied by ox-plough ownership was particularly important among households in the Northern Zone of Tanzania (Mbulu and Karatu districts). About 48% of the households in Mbulu district and 29% in Karatu district reported that they owned ox-ploughs – important farm equipment for cultivation. On the contrary, this asset was not widely owned in the Eastern Zone districts i.e. it was only 7% in Gairo, 3% in Kilosa and 0% in Mvomero districts (Table 5a). At the gender level, about 20% of the male headed households owned ox-ploughs compared to 12% female headed households (Table 5b). This difference in ownership of ox-ploughs across the gender of the household heads was statistically significant. Again, at this point, it is important to note that ownership of tractor, another farm equipment used for both transport and cultivation (ploughing) was only reported in the Northern Zone districts with Karatu district having the highest proportion of ownership at just slightly above 2% while Mbulu district reported just below 2% (Table 5a). Therefore, since the highest proportion of households that own both ox-plough and tractors are from the Northern Zone districts, one can impute that the main method of cultivating (ploughing) land in the Eastern Zone is by hand. In the same breadth, the main method of tilling land among female headed households is by hand hoes or other manually hand based implements. Therefore, this can be an impediment to the fast adoption of farming technologies as hand ploughing can substantially limit the cultivated area compared to oxen drawn ploughs or tractors.

Table 5b about here

2.2.3 Livestock ownership

Livestock ownership among smallholder farmers in Tanzania is very important because households derive both food and income from them. They also act as a store for wealth and sometimes act as insurance against the vagaries of weather especially the frequent droughts that usually wipe out crops in the fields. Therefore, livestock ownership by type was analyzed at district level and at gender of the household head level. The results indicated that poultry (chickens, ducks, turkeys and guinea fowl) was the most widely owned type of livestock followed by small ruminants (goats and sheep) and then cows. About 73% of the surveyed households owned poultry, 46% owned small ruminants and 37% owned cows (Table 6a).

Table 6a about here

Ownership of these livestock types differed significantly across the surveyed districts though only ownership of cows and oxen differed across the gender of the household head. Across all the five districts, the results shows that livestock ownership is more popular in the Northern Zone districts of Karatu and Mbulu as compared to the three Eastern Zone districts of Mvomerio, Kilosa and Gairo (Table 6a). Mbulu district had the highest proportion of households owning all types of livestock among the five surveyed districts. About 89% of the surveyed households in Mbulu district owned poultry, 77% owned small ruminants and 71% owned cows. On the other hand, safe for pigs, Mvomero district had the lowest proportion of households owning all the livestock types considered in this analysis (Table 6a). About 66% of the surveyed households in

Momero districts owned poultry, 16% owned small ruminants and 6% owned cows. Similar trends were observed when livestock ownership was analyzed at the level of gender of the household head. Female headed households had the lowest proportion of households owning all the livestock types considered in the analysis (Table 6b). These results could also have an implication on adoption of technologies in that because female headed households are less endowed with some of the most important assets which are also important source of livelihood, they are likely to be less adopters of some agricultural technologies and in cases where they adopt their intensity of adoption is lower compared their male counterparts. However, overall, it is important to note that Karatu district had the highest proportion of households that reported that they owned cattle (cows, oxen, bulls, heifers, calves) at almost 71% followed by Mbulu district at 44% and Mvomero district had the least at less than 6% (Table 6a).

Table 6b about here

A considerable proportion of households in Tanzania also reported that they owned pigs. The overall ownership of pigs among the surveyed households across the five districts was about 15% with Mbulu district reporting the highest proportion of households owning pigs at 37%, followed by Gairo at 15% and then Karatu and Mvomero at about 9% each. This difference in ownership across the five surveyed districts was statistically significant. In the similar trend like ownership of other livestock types discussed in the preceding paragraph, a higher proportion of male headed households were found to own pigs (15%) compared to female headed households (12% though this difference was not statistically significant (Table 6b). therefore, the extent of livestock ownership in terms of proportion of households owning these livestock types especially cattle and small ruminants including pigs have a far reaching implication on some of the sustainable agricultural intensification practices (technologies) promoted ion Tanzania through APW. Specifically, high ownership of these livestock types could have a negative implication on mulching and crop residue retention in the field because some of these crop residues especially in Northern Zone districts like Karatu are used as animal feed (Figure1). This does not mean that there are no synergies between livestock farm enterprises and some of the SAPs being promoted by APW. For example, the manure application on crops is one classic example of synergies.

Figure 1 about here

2.3 Social capital, rural networks and other networks

Due to pervasive factor and product market failures in most developing countries like Tanzania, social capital and other village level networks has become handy in handling some of these market failures. Social capital in form of membership to local farmer groups like savings and credit groups, merry go rounds and farmer production and marketing groups have been reported in past literature (Chirwa *et al.*, 19XX, Place *et al.*, 20XX , Shiferaw et al, 2008). In this particular study, over 68% of the surveyed households were found to have belonged to at least one local farmer group in Tanzania. This group membership was more common in Northern Zone districts of Karatu (81%) and Mbulu (68%) compared to Eastern Zone districts of Mvomero (53%), Kilosa (68%) and Gairo (68%). The most common farmers group among the surveyed households was savings and credit where about 15% of the surveyed households reported that they belonged to (Table 7a). The implication of this finding is that the surveyed households face serious credit access constraint in terms of lack of formal credit sources and therefore resort to informal groups to access this important service. This lack of access to formal credit could be occasioned by either lack of physical presence of formal credit institutions like banks and other micro-finance institutions or high interest rates charged on credit from these formal institutions in combination of other red tape.

Table 7a about here

From a gender perspective, the descriptive statistics indicated that a higher proportion of female headed households belonged to these informal groups compared to male headed households. Again this could be pointing to the fact that there could be either intended or un-intended discrimination of female headed households in accessing some of the services provided by these informal groups from formal institutions. More importantly, it is very revealing to note that while a higher proportion of female headed households were found being members of credit groups like savings and credit and merry-go-rounds compared to male headed households, the reverse was true when it came to input supply, seed production groups and group marketing groups. Though these statistics were not found to be statistically different across the gender groups, they vividly indicate that female headed households are disadvantaged in terms of accessing crucial services that are necessary for increasing agricultural technology adoption and improving farm level productivity. Credit is very important in accessing improved sustainable agricultural intensification practices/technologies like improved seed, chemical fertilizer and even adoption of minimum tillage practices like use of herbicides.

On the other hand, analysis of other farm level local networks revealed that surveyed households had stayed in the villages where they were interviewed for about 36 years on average. This is substantially long time enough to build networks in terms of making friends and having better knowledge on where to find essential livelihood services. The surveyed households also had on average about 5 dependable relatives and non-relatives who were found in the same village or outside their village of residence. These are people they can dependent on in times of need and they can act as insurance in the event of a negative livelihood shock. Theoretically, the higher the number of dependable people in and outside the village, the more risk-taking the households is likely to be – because of presence of reliable fall back.

It is also important to note that about 68% of the surveyed households reported that they trust the grain traders in the village, 54% had confidence in the skills of government officials and about 48% reported that they could rely on government support in terms of need like when there was total crop failure. Trust in grain traders is very important in rural farming communities because it is these traders that can avail improved technologies to farmers and it is through the same traders that farmers can access product markets for their farm produce. Therefore, if the SAP technologies like improved seed, fertilizer and chemicals are to reach target farmers, then a concerted effort to enhance the capacity of the grain traders and create more farmer-trader trust must be put in place. This is particularly important considering that gender level analysis showed that more men male that female headed households had trust in traders (Table 7b).

Table 7b about here

3.0 Adoption of Sustainable Agricultural Intensification Practices (SAIPs)

3.1 Overview of SAIPs

With dwindling available land for farming occasioned by rapid population increases, crop cultivation has started extending into more fragile agro-ecologies. In the traditional high potential agro-ecologies, the land is under intense pressure to produce more food for the ever increasing population. This has led to what is literally referred as nutrient mining of the soils in these high potential areas. If this trend of nutrient mining is not reversed, the future of crop reduction particularly food crops is very bleak. One way to address this eminent catastrophe is adoption of sustainable agricultural practices like use of improved seeds, use of chemical fertilizer and a host of other research approved agronomic conservation agriculture practices like cereal/legume intercropping and rotation, minimum tillage, retention of crop residue in the field, crop rotation and what is popularly known as conservation agriculture (CA) among many more others (Table 8a and Table 8b).

3.2 Adoption spread of SAIPs

Adoption spread of these SAIPs among the surveyed households was as shown in table 8a and Table 8b. The most widely adopted SAIP was improved maize varieties (58%), followed by maize/legume intercropping and crop residue retention at 54% each (Table 8a). the adoption spread of CA as defined by mutual agreement included use of minimum/zero tillage excluding 1 plough plus crop residue retention and intercropping all at the same time on the plot. With this strict definition of CA, adoption rates reported in Tanzania were very low i.e. just about 7% (Table 8a). Adoption of improved maize varieties seem to be higher in the Northern Zone districts compared to the Eastern Zone districts Karatu district located in the Noetrhern Zone and Mbulu district too had the highest rate of improved maize varieties at 67% and 64%, respectively, while Giaro district and Mvomero district in the Eastern Zone had the lowest adoption at 42% and 49% respectively. Similar trends were observed in the adoption of maize/legume intercropping technology with a higher proportion of households from Northern Zone districts adopting this technology compared to those in Eastern Zone (Table 8a). On the other hand, the reverse trend was observed when it came to adoption of crop residue retention on the farms i.e. a higher proportion of households in Eastern Zone practiced crop residue retention compared to those in the Northern Zone districts. While reasons for the differences in adoption of improved maize varieties and maize legume intercropping technologies across the two surveyed zones are not clear at this point, the differences in crops residue retention on the farms could be related to livestock keeping difference across the two zones. These low levels of crop residue retention on the farmers in the Northern Zone districts could be closely related to livestock ownership. As earlier discussed, a higher proportion of households in the Northern zone keep livestock especially cattle and small ruminants, which they use crop residue to feed

(Figure 1). In fact field observation showed an active market of crop residue, especially maize and wheat stover in Karatu district to feed livestock.

Table 8a about here

Further analysis on the adoption spread of selected SAPs by gender of the household was conducted and results presented in Table 8b. Male headed households had a higher proportion of households that had adopted the three most widely adopted SAPs compared to the female headed households. While about 59% of the male headed households had adopted improved maize varieties, 55% adopted maize/legume intercropping technology and 54% adopted crop residue retention practice, about 49% of the female headed households had adopted improved maize varieties, 53% adopted maize/legume intercropping and 54% adopted the crop residue retention practices (Table 8b). The difference in adoption of improved maize varieties between male and female headed households is strikingly high i.e. over 10% point difference. This clearly points to the fact that there are critical issues that inhibit female headed households from adopting improved maize varieties that need thorough and rigorous analyses to understand them. Another striking observation from these descriptive analyses is the low levels of inorganic/chemical fertilizer adoption in Tanzania. Less than 10% of the surveyed farmers were found to have adopted chemical fertilizers. Definitely, these low adoption levels of chemical fertilizer in Tanzania needs a thorough analysis too.

Table 8b about here

It is important to note that the preceding discussion on adoption spread of SAIPs is based on descriptive statistics. However, more rigorous econometric analysis of adoption of different SAIPs in Tanzania will conducted using the multivariate probit (MVProbit) model to bring out the real drivers of adoption of SAIPs. The proposed methodology is preferred to others because it is hypothesized here that adoption of SAIPs is in combinations and not separately. Besides, this MVProbit will be fit on the panel data for more robust results. The process of paneling SIMLESA baseline dataset with AP dataset is on-going and almost complete.

3.3 Adoption intensity of SAIPs

Adoption intensity of SAIPs in terms of number of SAIPs that a household had adopted was computed at the district level and also across the gender of the households as presented in Table 9a and Table 9b. Overall, each household adopted an average of about 2 SAIPs. The results also showed that Northern Zone districts of Karatu and Mbulu had on average a higher number of SIPs adopted per household compared to the Eastern Zone districts. Karatu district had the highest average number of adopted SIPs per household at about 2.1 while Gairo district had the lowest rate of about 1.6 (Table 9a). Gender analysis of intensity of adopting SAIPs revealed that male headed households had on average adopted more SAIPs than female headed households (Table 9b). Male headed households adopted on average about 2 SAIPs while female headed households adopted ion average about 1.8 SAIPs.

Table 9a about here

Table 9b about here

3.3.1 Impact of household resources on adoption of SAIPs

Further analysis was conducted to understand household level drivers of adoption intensity of SAIPs. This is because though SAIPs have proved to be important in increasing farm level productivity while maintaining the environment; their adoption levels in sub-Saharan Africa (SSA) and particularly in Tanzania remain very low. It is therefore important to thoroughly analyze the data to find out the factors that stimulate of inhibit adoption intensity levels.
In this section, we present the results from non-parametric analysis of how households level resource endowment can impact adoption of SAIPs i.e. we seek answers to the question: - who or which households are adopting SAIPs more intensively from a resource endowment point of view. The main resource of focus here was total owned farm size and household labour abundance.

Starting with farm size, kernel density analysis as shown in Figure 2 revealed generally a negative relationship i.e. as farm size increases, the number of SAIPs adopted decreases. Initially, there was a limited short term positive relationship before it changed to generally long progressive negative relationship (Figure 2). This is understandable given the fact that it is more likely that farmers who have small farmers are the ones who have the incentives to intensify their agricultural production activities compared to those who have large pieces of land. Same trends were observed when number of SAIPs was compared with household per capita farm size.

Figure 2 about here

On the other hand, one of the arguments put forward in theory that is subject to empirical study is that SAIPs are labour intensive and thus labour constrained households are less likely to adopt them as a package. In this pursuit, we present in Figure 3 the non-parametric results of the relationship between household labour endowment (man equivalent) and the total number of SAIPs adopted. The results shows a positive relationship between the number of SAIPs adopted and the amount of labour available at the household. However, this does not necessarily mean that this labour is used in the SAIPs and thus further thorough and more targeted analysis should be conducted to affirm this.

Figure 3 about here

3.3.2 Impact of SAIPs on household welfare

The household welfare impacts of SAIPs are analyzed using the kernel density approach. The main household welfare outcomes targeted in this analysis were maize productivity, total household income from crops and food security probability outcome. Starting with household total value of crops produced, the results showed a positive relationship between the number of SAIPs adopted and the value of crops produced on the farm (Figure 4). This means that those households that have adopted more SAIPs were likely to have higher crop income compared to otherwise. Definitely this relationship is more related to farm level productivity than prices of the different crops that were valued.

Figure 4 about here

Similarly, the results of the relationship between the adoption intensity of SAIPs and household food security was positive i.e. as those who had adopted more SAIPs were more food secure than those who had adopted less (Figure 5). While the overall number of SIPs adopted among the surveyed households was about 1.6 (Table 9a), the chronically food insecure households had adopted about 1.4; transitory food insecure households had adopted about 1.6, break-even had adopted about 1.5 and the foo secure households had adopted about 1.7 (Figure 5). Again, these results could be suggesting that those who have adopted more SAIPs are likely to realize high productivity especially among the main staple cereals like maize thereby making them more food secure compared to those adopting less SAIPs.

Figure 5 about here

To explore more on the impact of SAIPs on household income and food security, a kernel density analysis was carried out to gauge the relationship between the number of SAIPs adopted and the productivity of the main staple food crop, maize. This analysis was carried at plot level. The results were as depicted in Figure 6. Clearly, the results showed that there is a positive relationship between the number of SAIPs adopted in the plot and productivity of maize in that particular plot. This means that SAIPs are more beneficial in terms of boosting farm level productivity if they are used in combinations rather than individually as demonstrated by Teklwold *et al.*, (2014). Therefore, extension messages should be packaged in a way that delivers these SAIPs as a package and not as disjointed information.

Figure 6 about here

3.4 Adoption of conservation agriculture (CA)

Conservation agriculture was broadly defined to include three parameters i.e. minimum/zero tillage, crop residue retention and maize legume intercropping. A household was considered to have adopted conservations agriculture if he/she was found at least practicing the four technologies at ago in at least one of his/her plots. About 7% of the surveyed households in the five districts had adopted CA. Karatu district had the highest proportion of households that had adopted CA while Mvomero district in eastern Zone had the lowest proportion (Figure 23). From a gender perspective, a higher proportion of female headed households had adopted CA (10%) compared to male headed households (6%).

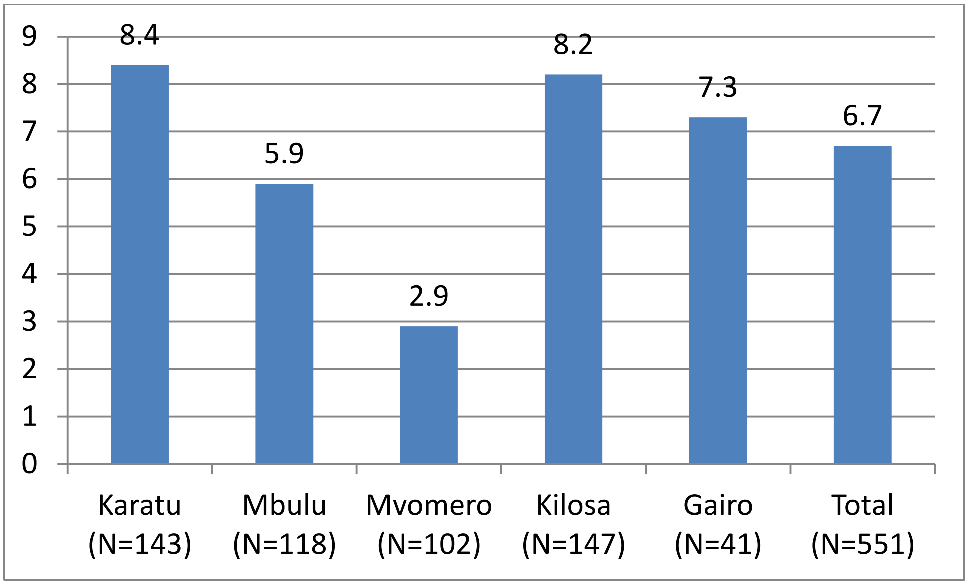

Figure 23 Adoption of CA by district (% households)

3.5 Adoption spread of improved maize varieties

Maize is the main staple food crop of Tanzania with per capita consumption of more than 100 kg per year. The crop is grown widely in the country especially in the main consumption areas. About 98% of the surveyed households were found to have grown maize during the survey reference period. The variation of the proportion of households growing maize across the surveyed districts and gender of the household head did not vary significantly (Table 10a and Table 10b). This lack of variation across districts and gender of the household head indicates that the crop is widely grown among the surveyed households.

There are quite a number of improved maize varieties grown by farmers in Tanzania. These improved varieties are both hybrids and open pollinated varieties (OPVs). The most widely grown type of maize varieties among the sampled farmers was the OPVs. About 31% of the households sampled had adopted improved OPVs while almost 28% had adopted improved hybrid maize varieties (Table 10a). The proportion of farmers adopting different types of improved maize varieties varied significantly across the surveyed districts. Clearly, the results showed that improved hybrid maize varieties were more popular in the Northern Zone districts of Karatu and Mbulu while on the other hand, the improved OPVs were mostly adopted by farmers in the Eastern Zone districts of Mvomero, Kilosa and Gairo. Mbulu district had the highest rate of adoption of improved hybrid maize varieties at 61% followed by Karatu district at almost 52% - both districts are in the Northern Zone. On the other hand, Kilsa district had the lowest rate of adoption of improved hybrid maize varieties at just 1%, Gairo district at 2% and Mvomero district at 3% - all the three districts are in the Eastern Zone of the country.

Table 10a about here

Overall, the adoption spread of improved maize varieties in Tanzania was about 58% with Karatu district having the highest adoption rate of 67%, followed by Mbulu at 64% then Kilosa at 55%. The reasons for the differences in adoption of different improved maize variety types across the districts and particularly across the two survey zones are not clear. This calls for an in-depth analysis of the data to tease out the drivers for wide adoption of improved hybrid maize varieties in the Northern Zone and OPVs in the Eastern Zone. Also, it is important to note that there is need to carry out a rigorous analysis of the economic benefits of these varieties in each zone to address the following two pertinent questions: - a) what is the current economic profitability (yield) of hybrid and OPVs in each zone? Why are hybrids more popular in Northern Zone than OPVs and the vice versa for Eastern Zone?

The descriptive statistics of gender analysis of the adoption spread of improved maize varieties are presented in Table 10b. A statistically significant higher proportion of male headed households had adopted improved hybrid maize varieties compared with female headed households. About 29% of the male headed households were found to have adopted improved hybrid maize varieties compared to 19% among the female headed households. On then o0ther hand, while 32% of the male headed households had adopted improved maize varieties compared to 29% female headed households, this difference in proportions was not statically significant. However, the overall adoption of improved maize varieties (hybrid and OPVs) showed some significant difference between male and female headed households. Almost 60% of the surveyed male headed households had adopted improved maize varieties in general while almost 50% female headed households adopted these improved maize varieties. At this point of analysis, one can only speculate the reasons for the differences in adoption of improved maize varieties between male and female headed households. Therefore, a more rigorous analysis is needed to shade light on why more male headed households have generally adopted improved varieties than their female headed counterparts.

Table 10b about here

Among the broad hybrid maize varieties category, SC627 and DK8031 were the most widely adopted specific maize varieties among the sampled households. Similarly, in the broad group of OPVs, Staha and Situka M-1 were the two most widely varieties. About 13% of the surveyed households had adopted DK8031 while 12% had adopted SC627 (Table 11a). The adoption of these specific hybrid varieties varied significantly across the surveyed districts. DK8031 was more popular in Karatu district (20%) followed by Mbulu district (33%). Similar trends were observed for the SC627 where Karatu district still had the highest rate of adoption at 27% and then followed by Mbulu district at 22% (TTable 11a). For the OPVs, Staha was completely not grown in the two Northern districts of Karatu and Mbulu. The district with the highest proportion of households that had adopted Staha was Mvomero at 34%, followed by Kilosa at 27% and then Gairo at about 20% (Table 11a). Kilosa district had the highest proportion of households that had adopted Situka at 22% followed by Karatu at 15% and then Mvomero and Gairo at about 7% each while Mbulu had the least adoption rate of just about 2%. However, when the analysis of adoption of these specific varieties was carried out from the gender perspective, the difference in adoption rates across the gender of the household heads was not there was no statistically different (Table 11b)

Table 11a about here
Table 11b about here

3.6 Adoption intensity of improved maize varieties

This section presents the results of adoption intensity of improved maize varieties among the sampled farmers i.e. the proportion of the maize area that was under improved maize varieties by district and gender of the household head. These results are also presented in two broad categories: - unconditional adoption (full sample of all households surveyed including non-growers of maize) and conditional adopters (only maize growers included in the analysis).

From the unconditional analysis, the results showed that about 82% of the cultivated land among the surveyed households was under maize. However, the Northern Zone districts (Karatu and Mbulu) seem to have higher proportions of cultivated land allocated to maize crop compared to Eastern Zone districts of Mvomero, Kilosa and Gairo (Table 12a). Overall, the improved maize variety adoption intensity (% maize area under improved varieties) among the surveyed households was about 39%. Northern Zone districts had the highest adoption intensity (>60%)

compared to the Eastern Zone districts (<55%). Just like what was observed in the improved maize varieties adoption spread results discussed in the preceding section, Karatu and Mbulu districts in the Northern Zone had a higher adoption intensity of improved hybrid maize varieties than the Eastern Zone districts. Similarly, the Eastern Zone districts of Movemero, Kilosa and Gairo had a high adoption intensity of improved OPV maize varieties than their Northern Zone counterparts (Table 12a)

Table 12a about here

Further analysis at the gender level revealed that male headed households had a higher adoption intensity of improved maize varieties compared to female headed households. About 58% of the maize area in male headed households was under improved maize varieties compared to 47% in female headed households. This difference in adoption intensity between male and female headed households was statistically different. Similarly, the difference in adoption intensity of hybrid maize varieties between male and female headed households was statistically different. Male headed households reported an adoption intensity of hybrid maize varieties of about 28% compared to slightly over 18% among the female headed households (Table 12b). However, though male headed households had a higher adoption intensity of improved OPV maize varieties than female headed households, the difference was not statically different. Therefore, could it be that female headed household have constraints to access improved hybrid maize technologies compared to OPV ones or could it be that OPV maize varieties have some intrinsic characteristics that endear well with female headed households than male headed households? This question can be well answered with more rigorous data analysis at the gender disaggregated level.

Table 12b about here

In this report, the analysis was further narrowed down to specific improved maize varieties that were more popular or widely adopted among the surveyed households. Coincidentally, the four most widely adopted improved maize varieties consisted of two varieties that were hybrids and two varieties that were OPVs. The two most widely adopted hybrid maize varieties in Tanzania were SC627 and DK8031 while the two most widely adopted OPV maize varieties were Staha and Situka M-1. About 14% of the surveyed households had adopted Staha and 11% had adopted

Situka M-1 (Table 13). These OPV varieties were mainly adopted in the Eastern Zone districts. In fact, no household in the two Northern Zone districts had adopted Staha variety (Table 13). However, it is important to note that about 14% of the surveyed farmers in Karatu district in Northern Zone had adopted Situka M-1 variety that is an OPV. Analysis of the adoption intensity of these specific improved varieties by gender of the household head did not show any significant difference and thus not reported herein.

Table 13 about here

Finally, the results of conditional intensity adoption of improved maize variety were as presented in Table 14a and Table 14b. This conditional analysis is based on the sub-sample of those households who grew those particular varieties only. Overall, about 83% of the cultivated land by maize growers was under maize (Table 14a) compared to about 82% of the full sample (Table 12a). Those households who grew improved maize varieties had put about 96% of their maize area under improved maize varieties. On the other hand, about 95% and 96% of total maize area had been put under improved hybrids and OPV maize varieties by those farmers who grew those particular varieties, respectively (Table 14a).

Table 14 a about here

Results for gender analysis of conditional adoption intensity of improved maize varieties were as presented in Table 14b. There was statically significant difference in the proportion of cultivated land that was under maize across male and female headed households. While male headed households had allocated about 84% of their cultivated land to maize, female headed households had allocated about 78%. The difference in adoption intensity of improved maize varieties did not vary significantly across male and female headed households (Table 14b).

Table 14b about here

Conditional adoption of the most popular specific improved maize varieties showed that more than 90% of the maize area was allocated to these varieties for those households who grew them except Situka M-1 that was just about 90% (Table 15a). On the other hand, gender level analysis showed that it was only Situka M-1 that had adoption intensity that varied significantly across the gender of the household head. Female headed households who grew Situka M-1 allocated

100% of their maize area under this particular variety compared to about 88% for male headed households (Table 15b).

Table 15a about here

Table 15b about here

3.7 Factors affecting adoption of improved maize varieties

In this section, we present the results from non-parametric methods used to analyze the relationship of key hypothesized variables on adoption and productivity of improved maize varieties. The key variable investigated in this respect was access to information about improved maize varieties proxied by distances to main information sources i.e. seed stockists and agricultural extension.

Information about improved agricultural technologies is very important in the adoption process. If fact, Shiferaw et al., (2008) have empirically demonstrated that information barrier is usually the first hurdle in the adoption process. Empirical and theoretical literature has shown that proximity to information sources in many cases reduces transaction costs considerably thereby enabling technology adoption. Since direct measurement of transaction costs is complicated, the most commonly used proxy variable for these costs in empirical literature has been distance to various information sources. In this report, we present some non-parametric results depicting the relationship between distance to main markets from farms and the probability of adopting improved maize varieties. We also show the relationship between distance to the nearest government agricultural extension office and adoption intensity of improved maize varieties.

The results shown in Figure 7 attests to the fact that adopters of improved maize varieties are more likely to be found in locations closer to main markets compared to otherwise. For example about 80% of adopters are found within roughly about 75 minutes walking time from the main market while 80% of non-adopters are found within almost 250 minutes walking time from the main market (Figure 7). This could be attributed to the fact that the main stockists of improved seeds are found at the main markets thus reducing fixed and variable transaction costs involved in accessing improved maize varieties. Fixed transactions costs that inhibit adoption of such improved agricultural technologies mainly involve information access while variable (proportional) transactions costs consist majorly of transportation, processing and other associated technology (seed) handling costs. Therefore, farmers located near the main markets are able to access information about improved varieties from stockists more easily than otherwise. Transportation costs (variable/proportional transaction cost) of seed is also lower for farmers located closer to main markets compared to otherwise. The implication of these findings is that increased network of seed stockists in rural Tanzania is important in improving technology adoption which will lead to increased productivity that will eventually increase incomes and reduce poverty. However, for this network of seed stockist to increase, targeted policies should be created to attract investors in those rural set-ups e.g. tax incentives and better public infrastructure like road networks, electricity, water etc.

Figure 7 about here

Apart from access information from stockists, another important source of information about improved maize varieties is the government extension. A non-parametric test to find out the relationship between distance to the nearest extension office and adoption intensity of improved maize varieties was carried out and the results were as presented in Figure 8. The results showed a negative relationship i.e. those households that were closer to agricultural extension office had a higher proportion of their cultivated land under improved maize varieties compared to otherwise. The implication of this finding is that proximity to extension office is likely to positively impact on the ability to receive accurate information about improved seeds and also the ability to acquire that seed thus improving adoption rates.

Figure 8 about here

3.8 Productivity of maize

Maize productivity is influenced by a host of factors including crop variety, soil characteristics (slope, fertility etc.), management practices and weather conditions among others. The productivity of maize was estimated by yield in term of kg/ha. The overall maize yield among the surveyed farmers was about 1,173 kg/ha. However, improved varieties had a higher yield of about 1,372 kg/ha compared to local varieties that had 926 kg/ha (Table 17a). Among the improved varieties, the hybrid varieties had a higher yield (1,663 kg/ha) than the OPVs (1,154 kg/ha). Generally, the yields of maize for all varieties (hybrids, OPVs, all improved and local) are higher in the Northern Zone districts than in Eastern Zone districts. For example, considering the overall yields, the two Northern Zone districts had on average over 1,400 kg/ha while the three Eastern Zone districts had less than 1,000 kg/ha (Table 17a).

Table 17a about here

From a gender perspective, the overall analysis of maize yields showed that female headed households had a statically significant lower yield (988 kg/ha) compared to male headed households (1,201 kg/ha). Though yield figures for specific maize varieties showed consistently higher figures for male headed households, female headed households had a higher yield for improved hybrid varieties though this difference was not statically significant (Table 17b). The general lower maize yields attained by female headed household could be associated by the fact that most of them have not adopted improved maize varieties. Even those female headed households that grew local varieties achieved lower yields than male headed households that grew the same local varieties thus raising concerns on other factors that could be limiting the general maize productivity by female headed households. As such, a more rigorous analysis is needed to shade more light on the causes of lower maize yields among female headed households.

Table 17b about here

3.9 Economics of maize production

Maize production consists of use of various inputs with ultimate goal of harvesting grain. The grain is used as a staple food for producing households and even those who do not produce, especially the urbanite population. The economic importance of maize production will therefore be well understood if an exhaustive analysis of gross margins is carried out. In this study, data was collected on all variable cost items, bought and non-bought, used in maize production. However, in computing gross margins reported herein, only purchased/bought variable costs were used due to difficulties associated with imputing the prices for non-tradable goods in agricultural production. In fact, it has been controversially argued in literature that family labour in African setting has no opportunity costs.

In constructing these gross margins, all the maize produced on the farm was valued at the district level average prices collected from secondary sources (Ministry of Agriculture at the district level). The variable costs considered were as shown in Table 18a and Table 18b. Overall, the maize gross margins among the surveyed households were about TSh. 433,920. The distribution of these gross margins across the surveyed districts almost mimics the maize productivity trends in the sense that the Northern Zone districts returned the highest gross margins compared to the Eastern Zone districts (Table 18a). Mbulu district had the highest gross margins (TSh. 625,536), followed by Karatu district (TSh. 468,027) then Kilosa district (TSh. 353,949). Momero istrict was fourth in term of maize gross margins (TSh. 344,090) and the Gairo district had the lowest maize gross margins among the five surveyed districts (TSh. 267,377). This distribution of gross margins could imply that the prices of maize and its production costs might not be varying significantly across the five surveyed districts.

Table 18a about here

The maize gross margins were also analyzed from the gender perspective as shown in Table 18b. Female headed households had significantly lower maize gross margins than male headed households. While female headed households had an average of about TSh. 369,608 in maize gross margins, male headed households had TSh. 444,754 (Table 18b). Also, value of the maize crop produced and the cost of seed used in maize production varied significantly between male headed and female headed households. Male headed households had a higher value of the maize produced than their female headed households and similarly, male headed households had a higher value of the cost of seed that they used for maize production than what female headed households used. The higher value of maize produced by male headed households is attributed to higher productivity among male headed households since same district average price was used to value the crop. On the other hand, the higher average cost of bought seed used in maize production could be attributed to male headed households using more improved seed that they usually buy compared to female headed households who are likely to have used more of local non-bought seed or even recycling of hybrids or over recycling of OPVs. At this point, it is important to note that in this analysis any hybrid seed that was recycled by a household was considered local and any OPV recycled more than 3 times was also treated as local.

Table 18b about here

A quick analysis of the variable cost items importance in overall variable costs was conducted and results were as shown in Figure 9. In Tanzania, hired labour constituted the highest proportion of total labour cost (41%) followed by seed (21%) and then cost of hiring tractor (17%). Fertilizer accounted for only 6% of the total variable costs.

Figure 9 about here

3.10 Adoption of inorganic fertilizer

As farms are tilled year in and year out, soil nutrients are mined and soil fertility keep on deteriorating. This situation is worsened by sometimes heavy rainfalls that leach the uppermost soil of the little nutrients that could be left there. To curb this, soil nutrient replenishing agricultural practices have been put in place. One of the most common soil nutrients replenishing practice has been the application of inorganic/chemical fertilizers. However, in most of the sub-Saharan Africa countries like Tanzania, the adoption rate in terms of spread and intensity use of fertilizer is very low.

3.10.1Fertilizer adoption spread

In Tanzania, the survey results showed an adoption spread of fertilizer at 8% with high rates being reported from the Eastern Zone district of Mvomero (21%) followed by Karatu district in the Northern Zone (5%) and then Kilosa district in the Eastern Zone (7%). There was no fertilizer adoption in Mbulu and Gairo districts (Table 19a). However, at Zonal level, fertilizer seemed to be more widely used in the Eastern Zone compared to the Northern Zone. This is in sharp contrast to use of improved hybrid maize varieties that were more popular in the Northern than in the Eastern Zone. Top dressing fertilizer was slightly more spread among the surveyed households (6%) compared to the basal fertilizer (5%).

Table 19a about here

A higher proportion of male headed households used fertilizer compared to female headed households. About 9% of the male headed households among the surveyed households had adopted fertilizer compared to about 5% among the female headed households (Table 19b). Also, within the male headed households, a high proportion of households used to dressing fertilizer (7%) compared to basal fertilizer (5%). On the other hand, within the female headed households, a high proportion of households used basal fertilizer (4%) than top dressing fertilizer (3%).

Table 19b about here

3.10.2 Fertilizer adoption intensity

Both unconditional and conditional adoption intensity of fertilizer was analyzed. Unconditional fertilizer adoption intensity results showed that sampled household used about 7 kg/ha of fertilizer. A higher rate of top dressing fertilizer was reported compared to basal. While basal fertilizer application rate was about 5 kg/ha, top dressing fertilizer application rate on the other hand was about 6 kg/ha (Table 20a). Karatu district reported the highest unconditional fertilizer application rate of about 11 kg/ha, followed by Mvomero district at 9 kg/ha and then Kilosa district at 7 kg/ha. There was no fertilizer use in Gairo district. Mbulu district reported adoption intensity of just 1 kg/ha thereby being the district with the lowest adoption intensity among the four districts that had reported at least use of fertilizer (Table 20a).

Table 20a about here

Same analysis of unconditional fertilizer adoption was conducted across male and female headed households with results presented in Table 20b. the unconditional adoption intensity follows the trends of adoption spread whereby male headed households have on average high rates of adoption intensity than female headed household (Table 20b). About 8 kg/ha of fertilizer was applied by male headed households compared to 2 kg/ha by female headed households.

Table 20b about here

The conditional adoption rates were analyzed and results come from this analysis were as presented in Table 21a and Table 21b. At the district level, the average fertilizer application rate was about 110 kg/ha with Karatu district reporting the highest of about 138 kg/ha followed by 123 kg/ha in Kilosa district, 88 kg/ha in Mvomero district and then about 82 kg/ha in Mbulu district (Table 21a). The application rates for top dressing fertilizer remained higher than basal fertilizer even under the conditional analysis framework just the way it was in unconditional analysis i.e. about 86 kg/ha of top dressing fertilizer was applied compared to 77 kg/ha of basal fertilizer.

Table 21a about here

On other hand, conditional adoption intensity showed that male headed households had an average fertilizer application rate of 115 kg/ha which was higher than 52 kg/ha that was applied by female headed households. Same trends of male headed households applying higher rates of fertilizer than female headed households were observed for both basal and top dressing fertilizers. The average basal and top dressing fertilizer application rates for male headed households were about 81 kg/ha and 90 kg/ha, respectively. On the other hand, female headed households applied about 40 kg/ha and 39 kg/ha of basal and top dressing fertilizer, respectively (Table 21b).

Table 21b about here

3.11 Fertilizer application on maize

Maize is a very important crop in the farming systems of smallholder farmers in Tanzania as a whole and more specifically among the farmers in the surveyed district. It is grown as a food crop and whenever surpluses are realized then it is sold for cash. Therefore its productivity is a big determinant of household food security and income in general. However, due to deteriorating soil fertility, maize productivity has been declining and not keeping pace with increasing demand mainly driven by fast growing population. Apart from use of improved varieties as one of the SAIPs, fertilizer use is very important in boosting maize productivity. The study therefore carried out descriptive statistics to find out the level of fertilizer use on maize crop in the five surveyed districts and across the gender of the household head.

About 6% of the total sampled farmers applied some fertilizer on their maize crop. Mvomero district had the highest proportion of households that applied fertilizer on maize crop followed by Karatu district and then Kilosa district. Farmers in Mbulu and Gairo district did not apply any fertilizer on their maize crop (Table 22a). The proportion of the surveyed households that applied basal and top dressing on their maize crop was about 4% each. Mvomero district had the highest proportion of households that applied both basal and top dressing fertilizer on their maize crop.

About 10% and 11% of Mvomero district farmers applied basal and top dressing fertilizer on their maize crop, respectively. On the other hand, about 3% and 6% of household surveyed in Karatu district applied basal and top dressing fertilizer, respectively, on their maize crop. Lastly, the proportion of households that applied basal and top dressing fertilizer on maize crop in Kilosa district was about 4% and 3%, respectively.

Table 22a about here

From a gender perspective, about 7% of the male headed households applied fertilizer on their maize crop compared to 3% of the female headed households. Top dressing fertilizer was more popular in both male and female headed households compared to basal fertilizer (Table 22b). While basal and top dressing fertilizer was applied on maize crop by about 4% and 5%, respectively, of the male headed household, 1% and 3% of the female headed households applied basal and top dressing fertilizers on their maize crop respectively.

Table 22b about here

Fertilizer application intensity on maize crop was also analyzed and results presented in Tables 23a – 24b. Unconditional analysis showed that farmers in the surveyed district applied about 5 kg/ha of fertilizer on their maize crop. The fertilizer with the highest application rate was top dressing (2.8 kg/ha) and then 2.5 kg/ha for the basal fertilizer. Further analysis to show adoption intensity of fertilizer on maize crop across the districts showed that Mvomero district had the highest adoption rate of about 13 kg/ha followed by Karatu at 6.5 kg/ha and then Kilosa at 2.7 kg/ha (Table 23a). It is important to note that while Mvomero district has the widest spread of adoption and highest intensity of fertilizer adoption on maize crop; it does not have the highest yield of maize among the surveyed households. In fact, Mbulu district is the leading in maize productivity but its fertilizer adoption is zero. This raises the question of whether maize variety is more important in explaining productivity compared to fertilizer adoption. This is an empirical question that requires further rigorous analysis.

Table 23a about here

On the other hand, unconditional fertilizer adoption intensity on maize crop from a gender angle showed that male headed households had higher rates of adoption (5.7 kg/ha) compared to female headed households (2.3 kg/ha). The average adoption rates of basal and top dressing fertilizers among male headed households was about 3 kg/ha each while among the female headed households it was about 1 kg/ha each (Table 23b).

Table 23b about here

Finally some conditional adoption of fertilizer on maize crop was carried out and results showed that the average application rate was about 98 kg/ha. Just like in the unconditional adoption results, conditional adoption analysis showed that top dressing fertilizer was highly adopted (75 kg/has) compared to basal (70 kg/ha). Mvomero district had again, like under unconditional adoption analysis, a higher adoption rate followed by Karatu and then Kilosa (Table 24a). At specific fertilizer adoption analysis level, Karatu and Kilosa districts showed the same trends of having higher adoption rates of top dressing fertilizers compared to basal. However, the reverse was true in Mvomero district where conditional adoption showed higher rates for basal than top dressing.

Table 24a about here

Gender analysis of conditional adoption rates showed that male headed households had a higher adoption rate of about 99 kg/ha compared to female headed households who had about 77 kg/ha (Table 24b). While male headed households applied more top dressing (79 kg/ha) than basal (72 kg/ha) under conditional adoption analysis, female headed households applied more basal (49 kg/ha) than top dressing (44 kg/ha).

Table 24b about here

3.12 Factor affecting adoption of inorganic fertilizer

Fertilizer is an important driver of agricultural productivity, and therefore it is important to understand factors that influence the decision to adopt fertilizer and also those factors that influence the amount of fertilizer adopted conditional on having decided to adopt. A host of factors could be at play in explaining the adoption decision and adoption intensity. However in this analysis, like in the improved maize variety, we apply the non-parametric kernel density methods to shade more light on who among the surveyed farmers in Tanzania have adopted fertilizer. The main variable investigated here is distance to main market. This variable is very important in explaining adoption of fertilizer not only because of its positive impact on information access about fertilizer, but also because fertilizer is a bulky commodity whose transportation costs can be prohibitive.

From the left hand side graph in Figure 10, it can be seen that the amount of fertilizer adopted in the surveyed districts keeps on reducing with increase in distance from the main market. Similarly, from the right hand side graph, the amount of fertilizer adopted reduces with increase in distance from the nearest agricultural extension office. Therefore, the low fertilizer adoption rates in far flanked households could be attributed to lack of information about fertilizer or high transportation costs of fertilizer from the market to the farm. The lack of information about fertilizer could be particularly linked to distances from agricultural extension office while prohibitive transport costs can be attributed to long distance from the nearest main markets. Concerted efforts to bring extension services closer to farmers are one way that this information gap can be bridged. Going hand in hand with extension information is the need to avail these types of technologies (fertilizer) to farmers physically by way of increasing the distribution network into the rural areas closer to farmers. Definitely, infrastructure development in terms of roads, electricity and even macroeconomic fiscal policies like taxation are some of the avenues to achieve all these.

Figure 10 about here

4. Agricultural input use

Agricultural production involves various inputs that can broadly be categorized as labour and non labour. Labour inputs can be provided by the family and or hired. It is also informative to analyze labour inputs from a gender perspective especially disaggregating it in the broad female and male categories. This gender analysis could be also more informative if it is analyzed at specific farm activities level i.e. each gender’s contribution of labour in each farm activity. On the other hand, non-labour inputs include seed, fertilizer and even chemicals used to control pests and diseases among others.

A gender disaggregated analysis of labour used in crop production was undertaken and results presented in Table 25 and Figure 11. The results presented in Table 25 showed that women contribute about 40% of the total farm labour used in crop production while the remaining 47% and 13% was contributed by male and children, respectively. A higher proportion of women labour was used in Eastern Zone districts compared to Northern Zone districts. Over 40% of crop production labour in all Eastern Zone districts was provided by women while in Northern Zone districts it was less than 40% (Table 25). This means that males in the Northern Zone are more involved in crop production activities compared to their counterparts in the Eastern Zone. Alternatively, this could be associated with high mechanization of crop production in the Northern Zone districts like Karatu where tractors are commonly used and even combiner harvesters for households that grow wheat.

Figure 11 about here

Also, the descriptive statistics presented in Table 25 showed that most of the labour used in crop production is provided by the family. Almost 80% of the total crop production labour was family labour while only 20% was hired labour. The limited use of hired labour could be as a result of lack of off-farm livelihood earning activities among the surveyed households or the cost of hiring farm labour is more expensive for the farming households.

Table 25 about here

Further analysis of crop production labour sources by gender of the household was conducted and results were as presented in Figure 11. The results showed that children provided relatively higher proportions of crop production labour in female headed households compared to male headed households. Understandably, male labour was almost 50% in male headed households and female labour was also almost 50% in female headed households. There was no stark difference in the contribution of both hired and family labour used in crop production between male and female headed households (Figure 11)

Descriptive statistics of crop production labour sources by activity was as shown in Table 26a and Table 26b.

5 Household Welfare Outcomes

5.1 Household food security

Subjective food security based on household's own assessment of its food security status was carried out. The results presented in Figure 12 indicated that transitory food insecurity was the highest (44%) followed by break-even (39%), food surplus (11%) and then chronic food insecurity (6%). From a broad perspective, these results showed that about 50% of the households in the surveyed districts were food insecure (i.e. they were either chronically food insecure or they were suffering from transitory food insecurity). With almost 50% households facing food insecurity, this calls for urgent concerted efforts to increase agricultural productivity because most of these households depend on own home produced food.

Figure 12 about here

Across the surveyed districts, the descriptive statistics showed that eastern Zone districts have generally higher proportions of households that were suffering from chronic food insecurity compared to Northern Zone districts (Table 27). Overall, almost 50% of the surveyed households were food secure. Mbulu district had the highest proportion of the households that were food secure (53%), followed by Kilosa (50%) and then Karatu district (48%). Momero district had about 47% households that were food secure while Gairo district had the least proportion of food secure households at about 42% (Table 27).

Table 27 about here

Further descriptive statistics were conducted to get a gender perspective of food security among the surveyed households. The results indicated that a higher proportion of female headed households were food insecure compared to the male headed households. While on 32% of the female headed households had either food surplus or break-even food availability over 50% of the male headed household had food surplus or break-even point food security situation (Figure 13). The proportion of female headed households that were chronically food insecure (11%) was almost double that of male (6%). On the other hand, the proportion of female headed households that had food surplus throughout the year was almost a half that of male headed households (Figure 13).

Figure 13 about here

Given the fact that maize is the main staple food grain in Tanzania, further analysis was conducted on the per capita consumption of maize among the surveyed households. This consumption is from own produced, bought, gifts etc. The results showed that the per capita maize consumption was about 140 kg/adult equivalent. The Northern Zone districts had a higher per capita consumption of maize compared to the Eastern Zone districts (Table 28). Mbulu district had the highest per capita consumption of maize at 182 kg/adult equivalent followed by Karatu district with almost 141 kg/adult equivalent. In the Eastern Zone, Mvomero district had the highest per capita consumption at 134 kg/adult equivalent and then Kilosa and Gairo districts had about 115 kg/adult equivalent each.

Table 28 about here

From a gender perspective, the maize consumption results showed that female headed households had a higher [per capita maize consumption compared to male headed households. While the per capita maize consumption among the male headed households was 138 kg/adult equivalent, female headed households had 147 kg/adult equivalent (Figure 14). Interestingly, the same data showed that male headed households had a higher amount of maize consumed annually. This clearly points to the fact that male headed households are bigger in size than female headed households. Also, the same data have shown that male headed households are more food secure than female headed households (Figure 13) yet it is the later that has a higher per capita consumption of the main staple. The implication of this later finding could be that male headed households might be proving alternative food stuffs for their family while maize seems to be the only available food among the female headed households. Therefore improved maize productivity is bound to improve the food security of female headed households significantly.

Figure 14 about here

5.2 Household poverty

Poverty as a welfare outcome can be measured using consumption or expenditure data. It can also be measured using oncome. However, income approach has been criticized on the basis of respondents having higher chances of cheating on their true incomes. Again as Coudouel *et al.,* (2002) argues, consumption/expenditure is a far much better measure of household wellbeing because it does not only capture more accurately household income but also indicates household's ability to access its needs. One can have income but fail top access essential needs due to market failures and many other reasons. For these reasons, we adopted household annual cash expenditure on food and non-food items as a proxy measure of wellbeing (poverty). To standardize the measure across all households for ease of comparison, the annual cash expenditure was normalized to per capita adult equivalent.

The descriptive results of annual cash expenditure on food and non-food items as a proxy measure of household poverty were as presented in Table 29. On average, the surveyed households spend about TSh. 2 million per month on food and non-food items. However more cash money was spend on food (TSh. 1.1 millions) compared to non-food items (TSh. 0.9 million). The average annual household per capita expenditure on food and non-food items in terms of adult equivalent was about TSh. 479,792. This translates into about TSh. 1,314 per day that is far below 1 USD using the foreign exchange rate of 1 USD = TSh. 1,600. Therefore, overall, the surveyed households are living below the internally defined poverty line. To improve this dire situations, there is need to look into the income portfolios of these households and see which income sources can easily be built on to boost their income which will definitely boost their consumption expenditure.

Table 29 about here

Poverty analysis from gender angle showed that female headed households were generally poorer than male headed households. Though female headed households showed consistently higher average expenditures in absolute terms, they returned lower average annual expenditures when these expenditures were normalized by adult equivalent (Figure 15). This clearly indicates that female headed households could be having bigger household sizes.

Figure 15 about here

6. Household income, risks and livelihood shocks

Rural farming households in developing countries like Tanzania have a portfolio of incomes from where they derive their livelihoods. Though, they are farmers by broad definition, they are also involved in other income generating activities to supplement their agricultural incomes. In this section, we analyze the various sources of household incomes and the proportion that each source contributes in overall household income. We also present descriptive statistics of the various risks and shocks that these households face in these livelihood earning activities.

6.1 Sources of household livelihoods

As already mentioned, households have a portfolio of incomes. This portfolio approach, rather than specializing in one specific activity, could be associated with the high risks involved in different livelihood activities and lack of insurance against those potential risks. Broadly put, farming households derive their income from three main sources i.e. crops, livestock and non-farm activities.

6.1.1 Crop income

Crop income is very important in rural farming households. These households produce food crops and sometimes cash crops. Even the so called food crops are also sometimes marketed for cash whenever surpluses are realized on when there is pressing cash needs. At the same time, sometimes a bit of the so called cash crops are also consumed at home (von Braun et al., 1994). Therefore, household crop income is the summation of what is derived from both the food crops and cash crops.

The descriptive statics from the surveyed households showed that the average crop net income for each household was about TSh. 1.2 million (Figure 16). This net crop income is based on total gross value of crops produced that was about TSh. 1.4 million and cash or bought variable costs of about TSh. 0.2. Across the five surveyed districts, Kilosa district had the highest gross value of all crops produced (TSh. 1.7 million) while Gairo and Mbulu had the lowest at TSh. 1.2 million each (Figure 16). Kilosa district had also the highest net crop income among the surveyed districts (TSh. 1.4) while Gairo district had the least net crop income (TSh. 1 million).

Figure 16 about here

From a gender perspective, the results showed that male headed households had by far a higher value of all crops harvested compared to female headed households. While the value of all crops harvested by male headed households was about TSh. 1.5, female headed households had less than TSh. 1 million (Figure 17). Similar trends were observed in variable costs and even the net crop income.

Figure 17 about here

A cost structure of crop production based on purchased inputs was constructed at the household level with results as presented in Figure 18. The biggest cost component was hired, followed by the cost of hiring tractor then seed. About 43% of the total variable costs in crop production were hired labour while 21% was tractor hiring. Seed as a variable cost seemed to be more significant in Mbulu district than any other district while at the same time hired labour was the highest variable costs in all the surveyed districts except Mbulu district (Figure 18). These results points to the fact that technologies that reduce farm labour could be very appropriate for the farming households in the surveyed districts.

Figure 18 about here

6.1.2. Livestock income

While data on livestock marketing was not collected, there was information on the value of the livestock owned by the time of the survey. Overall, the average value of livestock owned by the surveyed households was about TSh. 1.9 million (Figure 19). The Northern Zone districts had a higher value of livestock owned compared to the Eastern Zone districts. Mbulu district in the Northern Zone had the highest average household value of livestock owned at over TSh. 4 million while Kilosa district had the lowest at TSh. 0.5 million. Therefore, livestock keeping is more popular in Northern Zone compared to Eastern Zone.

Figure 19 about here

The descriptive statistics at the gender level showed that male headed households owned livestock that was worth 3 times that one owned by female headed households (Figure 20).

This could be due to the fact that female headed households could owning mainly poultry and a few numbers of small ruminants. On the other hand, it is likely that male headed household have more cattle.

Figure 20 about here

6.1.3. Overall household income sources

Due to lack of data on livestock sales, we treat the data presented in section 5.1.2 above as an assessment of household asset holding and not income. For that matter, we present in this section household income from all sources except of livestock and livestock sales which data is lacking. The overall, about two thirds of the household income in the surveyed districts is from crops. Crop income is followed by self-employment which accounts for a paltry 17%, then agricultural wages at 7%, while non-agricultural wages and transfers account for 6% and 5%, respectively, (Figure 21). These statistics shows clearly how important crop farming is in the livelihoods of the surveyed households. The implication of these results is that any effort targeted at improving crop productivity will have a far reaching positive impact on the welfare of smallholder farmers in the surveyed districts.

Figure 21 about here

Across the surveyed district, crop income was the main contributor to household income though it was highest in Mbulu district (72%) and lowest in Karatu district (61%). In general, Gairo district had the least amount annual household income at TSh. 1.8 million while Mvomero district had the highest annual household income of almost TSh. 2.6 million. The higher household income for Mvomero district could be associated with its proximity to the zonal headquarters of Eastern Zone, Morogoro city. Due to this proximity to the zonal headquarters, the households have higher chances of getting off-farm employment opportunities or their relatives who send remittances back. This is probably why Mvomero district had the highest proportion of transfers than any other surveyed district (Table 30a).

Table 30a about here

From the gender perspective, the average household annual income for male headed households was about TSh. 2.6 million compared to TSh. 1.7 million for female headed households (Table 30b). However, female headed households derived most of their income from crops (68%) compared to male headed households (66%). Also, female headed households derived a higher proportion of their households' income from agricultural wages than male headed households. However, male headed households had a higher proportion of their income coming from non-agricultural wages and self-employment (Table 30b). This means that improvement in agricultural productivity is bound to improve the welfare of female headed households by not only offering them higher incomes from their farms but also opening more opportunities for more off farm agricultural wage employment.

Table 30b about here

6.2 Risks and livelihood shocks

Rural farming household do face a myriad of market and non-market livelihood shocks and risks. The most common long term non-market shocks and risks include droughts, crop and livestock pests and diseases and even floods among many others. These long term shocks and risks were evaluated over 10 year period while short term risks and shocks like crop and livestock pests and diseases and price shocks were evaluated over 5 years' experience.

Starting with long term shocks and risks, the descriptive statistics showed that drought was the most important climate change related shock/risk while hailstorm was the least important shock/risk. Overall, in the last ten years, almost 94% of the surveyed households reported to have been experienced drought at least once, 64% experienced crop pests/diseases at least once, 38% experienced too much rain at least once and only 15% reported that they had experienced hailstorms at least once (Table 31). While there were no outright stark differences in the proportion of households that had reported drought experience in the last 10 years across the five surveyed districts, the proportion of the households that reported to have experienced too much rain and crops pests/diseases was evidently higher in the Eastern Zone districts than the Northern Zone districts (Table 31).

These results imply that drought is a general household livelihood shock/risk across all the surveyed sites and mitigation measures should be designed and targeted in all the five surveyed districts. However, too much rain affecting more households in the Eastern Zone could be associated with flooding that is often experienced in this part of the country compared to Northern Zone. This is flooding could in turn be directly linked to the comparably flat terrain in the Eastern Zone as opposed to the Northern Zone that is relatively hilly. On the other hand the high incidences of crop pests/diseases experienced by a higher proportion of households in the Eastern Zone compared to the Northern is again probably associated with the fact that the former Zone is low altitude and wormer (near the coastline) compared to the later which is highland with relatively lower temperatures that suppress microorganisms associated with crop pests and diseases.

Table 31a about here

The surveyed farmers respond to these climate change related shocks/risks in different ways. While some have not adopted any coping mechanisms, other households have copping strategies they apply before and or after the occurrence of the shock/risk. In this section, we present and discuss the results from descriptive analysis of long term climate change related risks/shocks that the surveyed households experience.

Starting with coping strategies before the risk/shock occurs; the results showed that about 48% , 67%, 69% and 72% of the surveyed households adopted no preventive strategy against drought, too much rain, crop pests/diseases and hailstorms, respectively (Table 32). However the most widely adopted adaptation strategy before drought occurs was changing of crop varieties (17%) followed by early planting (10%) and then food preservation (8%). This means that households preferred to plant the same crops but opt for the more drought tolerant or drought escaping varieties – early maturing varieties. On the other hand, the three most important copping strategies before the occurrence of too much rain was change of crop varieties (7%), soil and stone bunds (6%) and early planting (5%). Similarly early planting was the most widely adopted preventive strategy mechanism against crop pests/diseases (10%) followed by change in crop varieties (6%) and then increased seed rate and food preservations at 2% each (Table 32). Finally, preventive strategies against hailstorms were mainly early planting (6%), tree planting (5%) and change in crop varieties (Table 32). Overall, change in crop varieties seems to among the top three most important copping strategies before the risk/shock occurs across the board. This implies that availing improved crop varieties to the surveyed farmers could be an important strategy to boost their ability to adapt to climate change related risks/shocks.

Table 32 about here

Further analysis was conducted to find out the copping strategies of the surveyed households to climate change related risks/shocks after the occurrence of these risks/shocks. The descriptive statistics showed that about 25%, 41%, 47% and 61% of the surveyed households did not apply any copping strategy after the occurrence of drought, too much rain, crop pests/diseases and hailstorms, respectively (Table 33). For drought risk/shock, change of crop varieties was the widely adopted copping strategy after the occurrence of drought (22%) followed by replanting (21%) and then use of more off-farm casual work (7%). Replanting was the widely adopted copping strategy after the occurrence of too much rain (31%) followed by more on-farm casual work (7%) and change of crop varieties (5%). On the other hand, about 22% of the surveyed households used replanting strategy after the occurrence of crop pests/diseases, 7% changed crop varieties and 6% applied chemicals/pesticides (Table 32). Lastly, the most commonly applied copping strategies after the occurrence of hailstorms were replanting (13%), on-farm casual work and off farm casual work at about 8% each. Again, like in the copping strategies before the occurrence of the risk/shock, changing crop varieties was among the top single approach the farmers used to cope with long term climate related risks after they occur.

Table 32 about here

List of tables

Table 1. Household sample

District	SIMLESA 2010 survey	AP 2013 survey	Attrition rate (%)
Karatu	168	143	15
Mbulu	181	118	35
Mvomero	136	102	25
Kilosa	216	188	13
Total	701	551	21

Table 2. Household demographic characteristics

Variable	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
Male respondents (% households)	59.4	57.6	63.7	70.1	68.3	63.3
Male headed households (%)	85.3	89.0	84.3	82.3	95.1	85.8
Age of household head (years)	52.0	48.1	50.4	50.6	43.8	49.9
Education level of the household head (years)	5.0	5.3	5.6	5.2	4.9	5.2
Main occupation of the household head (% households)						
Agriculture self-employed (Farming)	92.3	94.1	95.1	98.0	97.6	95.1
Salaried employment	3.5	3.4	1.0	0.0	0.0	1.8
Self-employed off-farm	0.7	0.8	0.0	0.7	2.4	0.1
Others	3.5	1.7	3.9	1.3	0.0	3.0
Marital status of the household head (% households)						
Married living with spouse	80.4	84.7	80.4	78.2	92.7	81.7
Married but spouse away	4.2	5.1	2.0	2.7	0.0	3.3
Never married	0.7	0.0	2.0	2.0	2.4	1.3
Divorced/separated	4.2	2.5	6.9	7.5	0.0	4.9
Widow/widower	10.5	7.6	7.8	9.5	4.9	8.7
Household size (absolute numbers)	6.3	6.9	5.0	5.2	5.3	5.8
Household size (adult equivalent)	5.3	5.7	4.2	4.4	4.3	4.9

Table 3a. Demographic characteristics by gender of the household head

Variable	Female (N=78)	Male (N=473)	Total (N=551)
Main occupation of the household head (% households)			
Agriculture self-employed (Farming)	93.6	95.3	95.1
Salaried employment	0.0	2.1	1.8
Self-employed off-farm	0.0	0.8	0.1
Others	6.4	1.8	3.0
Marital status of the household head (% households)			
Married living with spouse	12.8	93.0	81.7
Married but spouse away	9.0	2.3	3.3
Never married	2.6	1.1	1.3
Divorced/separated	24.4	1.7	4.9
Widow/widower	51.3	1.7	8.7

Table 3b. Demographic characteristics by sex of the household head

Variable	Female (N=78)	Male (N=473)	Total (N=551)	t-value
Age of household head (years)	54.8	49.1	49.9	3.188***
Education level of the household head (years)	4.3	5.4	5.2	-1.947*
Household size (absolute numbers)	4.6	6.0	5.8	-4.450***
Household size (adult equivalent)	3.9	5.0	4.9	-4.256***
Dependency ratio	0.90	1.07	1.05	-1.6
Number of indigenous cows owned	0.9	2.7	2.5	-2.345**
Number of oxen owned	0.2	0.6	0.5	-2.430**
Number of small ruminants owned	4.4	4.7	4.7	-0.2
Number of poultry owned	5.7	6.7	6.6	-1.0
Tropical Livestock Units (TLU)	1.6	3.8	3.5	-2.782***

NB: *; **; *** means 10%; 5%; and 1% level of significance

Table 4a. Farm size distribution in survey districts by quartiles (ha)

Quartile	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
First quartile	.54	.80	.98	.82	1.09	.79
Second quartile	1.07	1.34	1.54	1.58	1.70	1.39
Third quartile	1.51	1.89	2.20	2.50	2.39	2.05
Fourth quartile	3.06	3.52	3.98	4.07	3.72	3.65
Total	1.55	1.90	2.19	2.25	2.26	1.98

Table 4b. Farm size distribution by quartiles by gender of the household head (ha)

Quartile	Male (N=473)	Female (N=78)	Difference
First quartile	0.79	0.62	0.18
Second quartile	1.43	1.09	0.34
Third quartile	2.17	1.50	0.67
Fourth quartile	3.86	2.66	1.19
Total	2.07	1.48	0.58

Table 5a. Ownership of non-livestock assets by district (% households)

Variable	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)	X^2-value	p-value
Transport assets								
Bicycle	56.60	62.70	55.90	67.30	70.70	61.70	6.459	0.167
Motor bike	13.30	2.50	6.90	7.50	14.60	8.30	12.312	0.015
Donkey/ox cart	12.60	25.40	0.00	1.40	9.80	9.80	56.767	0.000
Push cart	10.50	12.70	1.00	3.40	2.40	6.70	19.155	0.001
Tractor	2.10	1.70	0.00	0.00	0.00	0.90	5.723	0.221
Wheel-barrow	5.60	4.20	2.00	0.70	0.00	2.90	8.541	0.074
Information assets:								
Mobile phone	73.40	55.10	60.80	61.90	80.50	64.60	15.187	0.004
Radio/cassette	100.00	100.00	100.00	99.30	100.00	99.80	2.753	0.600
TV	4.90	4.20	2.90	4.10	2.40	4.00	0.878	0.928
Other assets:								
Ox-plough	28.70	47.50	0.00	3.40	7.30	19.10	121.311	0.000
Water pump	0.70	0.80	2.90	1.40	2.40	1.50	2.736	0.603

Table 5b. Ownership of non-livestock assets by gender of the household head (% households)

Variable	Male (N=473)	Female (N=78)	Total (N=551)	X^2 value	p-value
Transport assets:					
Bicycle	64.70	43.60	61.70	*12.620*	0.000
Motor bike	9.70	0.00	8.30	8.277	0.004
Donkey/ox cart	11.00	2.60	9.80	5.382	0.020
Push cart	7.60	1.30	6.70	4.282	0.039
Tractor	1.10	0.00	0.90	0.832	0.362
Wheel-barrow	3.40	0.00	2.90	2.717	0.099
Information assets:					
Mobile phone	67.00	50.00	64.60	7.482	0.004
Radio/cassette	99.80	100.00	99.80	0.650	0.684
TV	4.40	1.30	4.00	1.742	0.187
Other assets:					
Ox-plough	20.30	11.50	19.10	3.329	0.068
Water pump	1.70	0.00	1.50	1.339	0.247

Table 6a. Livestock ownership by district (% households)

Variable	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)	X^2-value	p-value
Cows	65.70	71.20	5.90	9.50	19.50	37.40	204.271	0.000
Oxen	21.00	40.70	0.00	3.40	9.80	15.80	95.083	0.000
Small ruminants	63.60	77.10	15.70	24.50	41.50	45.60	129.515	0.000
Poultry	69.20	89.00	65.70	69.40	65.90	72.60	20.887	0.000
Pigs	8.40	37.30	8.80	6.10	14.60	14.50	64.634	0.000
Some cattle (cows, etc.)	70.60	44.10	5.90	10.20	26.80	40.70	229.147	0.000

Table 6b. Livestock ownership by gender of the household head (% households)

Variable	Male (N=473)	Female (N=78)	Total (N=551)	Chi-square value	p-value
Cows	40.60	17.90	37.40	14.666	0.000
Oxen	17.10	7.70	15.80	4.480	0.034
Small ruminants	46.30	41.00	45.60	0.751	0.386
Poultry	72.90	70.50	72.60	0.198	0.656
Pigs	15.00	11.50	14.50	0.650	0.420
Some cattle (cows, etc.)	43.80	21.80	40.70	13.394	0.000

Table 7a. Social capita and other networks by district

Variable	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)	X^2-value	p-value
Social capital:								
Belong to a savings and credit group	16.1	14.4	18.6	16.3	4.9	15.4	4.530	0.339
Belong to a merry go round	4.2	2.5	12.7	12.9	0.0	7.4	20.180	0.000
Belong to farm input supply group	2.1	0.8	2.9	3.4	0.0	2.2	3.209	0.523
Belong to crop or seed production group	2.1	0.8	3.9	2.7	2.4	2.4	2.379	0.667
Belong to farm crop marketing group	3.5	0.8	2.0	0.7	0.0	1.6	5.123	0.275
Belong to any agricultural production network	7.7	2.5	6.9	6.8	2.4	5.8	4.553	0.336
Belong to any group	81.1	67.8	52.9	68.0	68.3	68.6	22.076	0.000
Other networks:								
Years respondent living in village	38.1	35.5	34.9	36.7	30.7	36.0	na	na
Number of dependable relatives in the village	5.4	4.5	5.5	4.6	5.9	5.0	na	na
Number of dependable non-relatives in the village	5.9	4.8	6.1	4.7	3.1	5.2	na	na
Number of dependable relatives outside the village	5.5	4.1	5.7	5.9	4.9	5.3	na	na
Number of dependable non-relatives outside the village	3.5	2.5	5.1	2.9	1.8	3.3	na	na
Number of grain traders known in the village	2.3	2.1	2.6	3.0	3.0	2.6	na	na
Number of grain traders known outside the village	2.3	1.4	2.3	2.8	2.2	2.2	na	na
Friends or relatives in leadership positions	21.7	19.5	37.3	21.1	17.1	23.6	13.4	0.0
Grain traders trustworthy	66.4	73.8	63.6	67.1	76.9	68.3	4.1	0.4
Can rely on government support	55.2	53.4	36.3	44.2	43.9	47.5	11.1	0.0
Confident of the skills of government officials	55.2	47.5	54.9	58.2	43.9	53.5	4.8	0.3

Table 7b Social capita and other networks by gender of the household head

Variable	Male (N=473)	Female (N=78)	Total (N=551)	X^2-value	p-value
Social capital:					
Belong to a savings and credit group	15.2	16.7	15.4	0.107	0.743
Belong to a merry go round	5.9	16.7	7.4	11.229	0.001
Belong to farm input supply group	2.3	1.3	2.2	0.342	0.559
Belong to crop or seed production group	2.3	2.6	2.4	0.017	0.898
Belong to farm crop marketing group	1.7	1.3	1.6	0.070	0.792
Belong to any agricultural production network	6.3	2.6	5.8	1.747	0.186
Belong to any group	68.5	69.2	68.6	0.017	0.897
Other networks:					
Years respondent living in village	35.1	41.8	36.0	3.413	0.001
Number of dependable relatives in the village	5.3	3.3	5.0	-2.431	0.015
Number of dependable non-relatives in the village	5.3	4.3	5.2	-1.050	0.294
Number of dependable relatives outside the village	5.6	3.3	5.3	-2.499	0.013
Number of dependable non-relatives outside the village	3.5	2.1	3.3	-1.716	0.087
Number of grain traders known in the village	2.7	2.0	2.6	-2.421	0.016
Number of grain traders known outside the village	2.4	1.4	2.2	-2.923	0.004
Friends or relatives in leadership positions	25.4	12.8	23.6	5.850	0.016
Grain traders trustworthy	69.0	64.4	68.3	0.618	0.432
Can rely on government support	47.6	47.4	47.5	0.000	0.983
Confident of the skills of government officials	55.5	41.0	53.5	5.643	0.018

Table 8a. Adoption sustainable agricultural practices (SAPs) by district (% households)

SIP	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
Improved maize variety	67.1	63.6	49.0	55.1	41.5	57.9
Inorganic fertilizer	7.7	0.0	20.6	7.5	0.0	8.0
Maize legume intercropping	73.4	78	33.3	38.1	31.7	54.4
Maize legume rotation	6.3	0	6.9	8.8	17.1	6.5
Mechanized	46.9	8.5	24.5	31.3	31.7	29.2
Minimum tillage excluding one plow	21	16.1	40.2	40.1	36.6	29.8
Conservation agriculture	8.4	5.9	2.9	8.2	7.3	6.7
Crop residue on the farm	46.9	51.7	52.9	62.6	58.5	54.1
Terraces	28.7	20.3	14.7	13.6	22	19.8
Mulching	2.8	11.9	5.9	2.7	2.4	5.3
Trees on boundaries	9.8	7.6	6.9	3.4	2.4	6.5
Soil bunds	8.4	10.2	3.9	2	4.9	6

Table 8b. Adoption sustainable agricultural practices (SAPs) by gender of household head (% households)

SIP	Male (N=473)	Female (N=78)	Total (N=551)
Improved maize variety	59.4	48.7	57.9
Inorganic fertilizer	8.5	5.1	8.0
Maize legume intercropping	54.8	52.6	54.4
Maize legume rotation	6.8	5.1	6.5
Mechanized	29.6	26.9	29.2
Minimum tillage excluding one plow	28.1	39.7	29.8
Conservation agriculture	6.1	10.3	6.7
Crop residue on the farm	54.1	53.8	54.1
Terraces	19.7	20.5	19.8
Mulching	5.7	2.6	5.3
Trees on boundaries	7	3.8	6.5
Soil bunds	5.9	6.4	6

Table 9a. Number of SIPs adopted by district

Quartile	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
First quartile	2.0	2.1	2.0	1.5	1.3	1.9
Second quartile	2.4	1.9	1.8	1.7	2.0	2.0
Third quartile	2.2	2.1	2.0	1.9	1.7	2.0
Fourth quartile	2.3	2.2	1.4	1.7	1.4	1.9
Total	2.3	2.1	1.8	1.7	1.6	1.9

Table 9a. Number of SIPs adopted by district

Quartile	Male (N=473)	Female (N=78)	Difference
First quartile	2.0	2.0	0.0
Second quartile	2.0	1.6	0.4
Third quartile	2.1	1.9	0.2
Fourth quartile	1.8	1.9	-0.1
Total	2.0	1.8	0.1

Table 10a Adoption of improved maize varieties by district (% households)

Maize variety	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)	X^2-value	p-value
Grew maize	99.3	98.3	97.1	98.0	97.6	98.2	1.866	0.760
Improved hybrid	51.7	61.0	2.9	1.4	2.4	27.6	202.414	0.000
Improved OPV	17.5	3.4	46.1	54.4	39.0	31.2	103.639	0.000
All improved (hybrid/OPV)	67.1	63.6	49.0	55.1	41.5	57.9	14.867	0.005

Table 10b Adoption of improved maize varieties by gender of the household head (% households)

Maize variety	Male (N=473)	Female (N=78)	Total (N=551)	X^2-value	p-value
Grew maize	97.9	100.0	98.2	1.680	0.195
Improved hybrid	29.0	19.2	27.6	3.175	0.075
Improved OPV	31.5	29.5	31.2	0.126	0.823
All improved (hybrid/OPV)	59.4	48.7	57.9	3.139	0.076

Table 11a Adoption of the most common improved maize varieties by district (% households)

Maize variety	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)	X^2-value	p-value
Staha	0.0	0.0	34.3	27.2	19.5	15.1	93.419	0.000
Situka M-1	14.7	1.7	7.8	22.4	7.3	12.2	30.202	0.000
SC627	26.6	22.0	2.0	0.7	2.4	12.3	69.375	0.000
DK8031	19.6	33.1	1.0	0.7	2.4	12.7	85.845	0.000

Table 11b Adoption of the most common improved maize varieties by gender of the household head (% households)

Maize variety	Male (N=473)	Female (N=78)	Total (N=551)	X^2-value	p-value
Staha	15.2	14.1	15.1	0.006	0.798
DK8031	13.1	10.3	12.7	0.491	0.484
SC627	13.1	7.7	12.3	1.815	0.178
Situka M-1	11.8	14.1	12.2	0.321	0.571

Table 12a Unconditional adoption intensity of improved maize varieties by district (% of maize area)

Maize variety	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
Maize (% cultivated area)	87.4	93.2	66.1	78.5	80.1	81.8
Improved hybrid	49.3	58.2	2.9	1.2	2.4	26.3
Improved OPV	16.6	2.8	44.7	53.2	36.3	30.1
All improved (hybrid/OPV)	66.0	61.1	47.7	54.5	38.7	56.4

Table 12b Unconditional adoption intensity of improved maize varieties by gender of the household head (% of maize area)

Maize variety	Male (N=473)	Female (N=78)	Total (N=551)	t-value	p-value
Maize (% cultivated area)	82.3205	78.4562	81.7735	-1.201	0.230
Improved hybrid	27.6087	18.5470	26.3259	-1.709	0.088
Improved OPV	30.3124	28.8462	30.1048	-0.264	0.792
All improved (hybrid/OPV)	57.9211	47.3932	56.4307	-1.766	0.078

Table 13 Unconditional adoption intensity of the most common improved maize varieties by district (% of maize area)

Maize variety	Karatu	Mbulu	Mvomero	Kilosa	Gairo	Total (N=551)
Staha	0.0	0.0	33.2	25.5	19.5	14.4
Situka M-1	14.2	1.1	6.5	20.0	5.8	10.9
SC627	25.2	21.2	2.0	0.7	2.4	11.8
DK8031	17.5	30.8	1.0	0.4	2.4	11.6

Table 14a Conditional adoption intensity of improved maize varieties by district (% of maize area)

Maize variety	Karatu	Mbulu	Mvomero	Kilosa	Gairo	Total
Maize (% cultivated area)	88.0	94.8	68.1	80.1	82.1	83.3
Improved hybrid	95.3	95.5	100.0	89.3	100.0	95.4
Improved OPV	95.1	83.3	97.1	97.8	93.0	96.4
All improved (hybrid/OPV)	98.3	96.1	97.2	98.8	93.4	97.5

Table 14b Unconditional adoption intensity of improved maize varieties by district (% of maize area)

Maize variety	Male	Female	Total	t-value	p-value
Maize (% cultivated area)	84.1	78.5	83.3	-1.92	0.06
Improved hybrid	95.3	96.4	95.4	0.27	0.79
Improved OPV	96.2	97.8	96.4	0.53	0.60
All improved (hybrid/OPV)	97.5	97.3	97.5	-0.12	0.91

Table 15a Unconditional adoption intensity of improved maize varieties by district (% of maize area)

Maize variety	Karatu	Mbulu	Mvomero	Kilosa	Gairo	Total
Staha			96.7	93.9	100.0	95.6
Situka M-1	97.0	66.7	82.7	89.0	79.2	89.7
SC627	94.8	96.2	100.0	100.0	100.0	95.6
DK8031	89.2	93.3	100.0	60.0	100.0	91.4

Table 15b Unconditional adoption intensity of improved maize varieties by district (% of maize area)

Maize variety	Male	Female	Total	t-value	p-value
Staha	95.0	100.0	95.6	1.05	0.30
DK8031	87.6	100.0	89.7	1.80	0.08
SC627	95.2	100.0	95.6	0.78	0.44
Situka M-1	91.1	93.3	91.4	0.28	0.78

Table 17a. Maize productivity by district (kg/ha)

Maize variety	Karatu	Mbulu	Mvomero	Kilosa	Gairo	Total
Improved hybrid	1,637	1,784	640	506	420	1,663
Improved OPVs	1,431	2,093	1,102	1,102	1,032	1,154
All improved	1,585	1,799	1,077	1,092	1,008	1,372
Local	1,104	1,264	860	757	755	926
All varieties	1,426	1,597	954	937	864	1,173

Table 17b. Maize productivity by gender of the household head (kg/ha)

Maize variety	Male	Female	Total	t-value	p-value
Improved hybrid	1,651	1,766	1,663	0.476	0.634
Improved OPVs	1,183	941	1,154	-1.391	0.166
All improved	1,386	1,257	1,372	-0.882	0.378
Local	958	753	926	-1.617	0.107
All varieties	1,201	988	1,173	-2.142	0.033

Table 18a. Maize cost structure by district (TSh/ha)

Item	Karatu (N=142)	Mbulu (N=116)	Mvomero (N=99)	Kilosa (N=144)	Gairo (N=40)	Total (N=541)
Value of maize produced	605,592	695,918	428,075	434,280	371,493	529,568
Herbicides	1,809	0	414	1,160	51	863
Pesticides	1,596	77	266	115	0	515
Planting fertilizer	4,455	0	6,074	1,181	0	2,595
Top dressing fertilizer	4,512	0	6,885	1,162	0	2,754
Manure	745	491	0	267	709	424
Hired oxen	31,511	15,469	230	3,508	7,859	13,145
Hired tractor	22,753	3,331	15,141	20,462	12,241	15,809
Hired labour	36,357	16,408	46,950	44,361	79,772	39,358
Seed	33,827	34,607	8,026	8,117	3,482	20,186
Total cash variable costs (TVC)	137,566	70,383	83,986	80,331	104,116	95,648
Total maize gross margin	*468,027*	*625,536*	*344,090*	*353,949*	*267,377*	*433,920*

Table 18b. Maize cost structure by gender of the household head (TSh/ha)

Item	Male (N=463)	Female (N=78)	Total (N=541)	X^2-value	p-value
Value of maize produced	542,166	454,786	529,568	-1.818	0.070
Herbicides	1,008	0	863	-0.725	0.469
Pesticides	597	24	515	-1.173	0.242
Planting fertilizer	2,968	380	2,595	-0.860	0.390
Top dressing fertilizer	3,056	961	2,754	-0.979	0.328
Manure	387	647	424	0.586	0.558

Hired oxen	13,765	9,465	13,145	-0.996	0.320
Hired tractor	15,440	17,994	15,809	0.604	0.546
Hired labour	38,981	41,596	39,358	0.184	0.854
Seed	21,209	14,111	20,186	-1.928	0.054
Total cash variable costs (TVC)	97,412	85,178	95,648	-0.661	0.509
Total maize gross margin	*444,754*	*369,608*	*433,920*	-1.635	0.103

Table 19a. Adoption spread of fertilizer by district (% households)

Fertilizer	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
Planting (basal)	3.5	0.0	11.8	5.4	0.0	4.5
Top dressing	5.6	0.8	15.7	5.4	0.0	6.0
Any inorganic fertilizer	7.7	0.0	20.6	7.5	0.0	8.0

Table 19b. Adoption spread of fertilizer by gender of the household head (% households)

Fertilizer	Male (N=473)	Female (N=78)	Total (N=551)
Planting (basal)	4.7	3.8	4.5
Top dressing	6.6	2.6	6.0
Any inorganic fertilizer	8.5	5.1	8.0

Table 20a. Unconditional adoption intensity of fertilizer by district (kg/ha)

Fertilizer	Karatu (N=236)	Mbulu (N=161)	Mvomero (N=322)	Kilosa (N=315)	Gairo (N=88)	Total (N=1122)
Planting (basal)	2.3	0.0	4.2	3.6	0.0	2.7
Top dressing	8.9	1.0	4.8	3.4	0.0	4.3
Any inorganic fertilizer	11.1	1.0	9.0	7.0	0.0	7.0

Table 20b. Unconditional adoption intensity of fertilizer by gender of household head (kg/ha)

Fertilizer	Male (N=962)	Female (N=160)	Total (N=1122)
c	3.0	1.0	2.7
Top dressing	4.8	1.0	4.3
Any inorganic fertilizer	7.8	2.0	7.0

Table 21a. Conditional adoption intensity of fertilizer by district (kg/ha)

Fertilizer	Karatu	Mbulu	Mvomero	Kilosa	Gairo	Total
Planting (basal)	66.4	na	74.8	86.5	na	77.0
Top dressing	149.3	82.3	57. 6	77.3	na	85.9
Any inorganic fertilizer	137.9	82.3	87.9	122.6	na	110.0

Table 21b. Conditional adoption intensity of fertilizer by gender of the household head (kg/ha)

Fertilizer	Male	Female	Total
Planting (basal)	81.2	40.1	77.0
Top dressing	89.5	39.1	85.9
Any inorganic fertilizer	115.3	52.8	110.0

Table 22a. Adoption spread of fertilizer use on maize crop by district (% households)

Fertilizer	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
Planting (basal)	2.80	0.00	9.80	4.10	0.00	3.60
Top dressing	5.60	0.00	10.80	3.40	0.00	4.40
Any inorganic fertilizer	7.00	0.00	14.70	5.40	0.00	6.00

Table 22b. Adoption spread of fertilizer use on maize crop by gender of the household head (% households)

Fertilizer	Male (N=473)	Female (N=78)	Total (N=551)
Planting (basal)	4.00	1.30	3.60
Top dressing	4.70	2.60	4.40
Any inorganic fertilizer	6.60	2.60	6.00

Table 23a. Unconditional adoption intensity of fertilizer use on maize crop by district (kg/ha)

Fertilizer	Karatu (N=236)	Mbulu (N=161)	Mvomero (N=322)	Kilosa (N=315)	Gairo (N=88)	Total (N=1122)
Planting (basal)	2.1	0.0	7.0	1.5	0.0	2.5
Top dressing	4.4	0.0	6.3	1.1	0.0	2.8
Any inorganic fertilizer	6.5	0.0	13.4	2.7	0.0	5.3

Table 23b. Unconditional adoption intensity of fertilizer use on maize crop by gender of the household head (kg/ha)

Fertilizer	Male (N=962)	Female (N=160)	Total (N=1122)
Planting (basal)	2.7	1.0	2.5
Top dressing	3.0	1.3	2.8
Any inorganic fertilizer	5.7	2.3	5.3

Table 24a. Conditional adoption intensity of fertilizer use on maize crop by district (kg/ha)

Fertilizer	Karatu	Mbulu	Mvomero	Kilosa	Gairo	Total
Planting (basal)	65.9		84.4	46.0		70.3
Top dressing	100.2		71.1	48.0		74.6

Any inorganic fertilizer	99.8		112.4	62.5		97.7

Table 24b. Conditional adoption intensity of fertilizer use on maize crop by gender of the household head (kg/ha)

Fertilizer	Male	Female	Total
Planting (basal)	72.0	49.4	70.3
Top dressing	79.0	43.9	75.3
Any inorganic fertilizer	99.4	76.8	97.7

Table 25. Total crop production labour sources by district (%)

Labour source	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
Children	13.3	16.1	11.1	11.1	10.5	12.7
Male	50.1	45.7	46.7	45.7	47.1	47.1
Female	36.6	38.2	41.2	43.2	42.3	40.0
Family	71.8	86.1	81.4	77.8	84.9	79.2
Hired	28.2	13.9	17.7	22.2	15.1	20.6

Table 26a. Farm labour participation by district (percent gender contribution)

Farm activity	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
Land preparation & planting:						
Children	14.5	14.1	9.2	9.7	4.8	11.4
Male	53.7	51.1	46.7	48.9	56.6	50.8
Female	31.8	33.2	42.2	40.7	36.1	36.7
Family	73.9	88.2	80.4	76.8	74.1	79.0
Hired	26.1	10.1	17.6	22.6	23.4	20.0
Weeding:						
Children	11.9	14.3	9.2	9.0	7.4	10.8
Male	51.7	46.9	48.1	46.9	47.2	48.4
Female	36.4	37.0	41.7	44.1	45.4	40.2
Family	67.6	82.6	81.4	76.1	87.6	77.1
Hired	32.4	15.7	17.6	23.9	12.4	22.4
Harvesting:						
Children	13.5	16.7	15.6	10.8	16.2	14.1
Male	51.6	42.7	44.9	44.0	45.3	45.9
Female	34.2	40.5	38.5	43.2	38.5	39.1
Family	72.5	86.2	85.6	78.2	85.6	80.4
Hired	26.8	13.8	13.4	19.7	14.4	18.7
Threshing:						
Children	18.3	19.4	13.4	14.2	14.1	16.2

Male	41.0	41.1	34.7	38.7	43.0	39.4
Female	38.6	37.8	35.2	37.6	35.5	37.3
Family	78.7	89.1	73.0	77.8	74.9	79.3
Hired	19.2	9.2	10.4	12.7	17.8	13.6

Table 26b. Farm labour participation by gender of the household head (percent gender contribution)

Farm activity	Male (N=473)	Female (N=78)	Total (N=551)	t-value	p-value
land preparation & planting by children	10.7	15.8	11.4	2.056	0.040
land preparation & planting by male	52.8	38.3	50.8	-4.814	0.000
Land preparation & planting by female	35.2	45.9	36.7	4.019	0.000
Land preparation & planting by family	79.5	75.9	79.0	-952.000	0.342
Land preparation & planting by hired	19.3	24.1	20.0	1.340	0.181
Weeding by children	10.5	12.5	10.8	0.851	0.395
Weeding by male	50.3	37.1	48.4	-4.763	0.000
Weeding by female	38.8	49.2	40.2	4.123	0.000
Weeding by family	77.1	76.9	77.1	-0.066	0.947
Weeding by hired	22.5	21.9	22.4	-0.152	0.880
Harvesting by children	13.4	18.0	14.1	1.674	0.095
Harvesting by male	47.0	39.3	45.9	-2.657	0.008
Harvesting by female	38.5	42.7	39.1	1.649	0.100
Harvesting by family	80.5	79.5	80.4	-0.281	0.779
Harvesting by hired	18.4	20.5	18.7	0.591	0.555
Threshing by children	15.3	21.9	16.2	2.158	0.031
Threshing by male	41.3	27.7	39.4	-3.894	0.000
Threshing by female	36.4	42.7	37.3	1.987	0.047
Threshing by family	79.4	78.8	79.3	-0.144	0.885
Threshing by hired	13.6	13.5	13.6	-0.028	0.977

Table 27b. Recycling of hybrid maize varieties and OPVs beyond 3 times (% households)

Maize variety	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)
Hybrids	7.7	1.7	2.9	0.7	7.3
OPVs	0.0	0.0	10.8	9.5	12.2

Table 27 Household food security status by district (% households)

Consumption item	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
Chronic food insecurity	4.2	5.1	9.8	6.1	7.3	6.2
Transitory food insecurity	47.6	41.5	41.2	42.9	48.8	43.9
Break-even food security	39.2	39.0	35.3	40.8	29.3	38.1
Food surplus throughout	8.4	14.4	11.8	8.8	12.2	10.7
Overall food secure	47.6	53.4	47.1	49.7	41.5	48.8

Table 28. Annual maize consumption among the surveyed households

Consumption item	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
Total amount of maize consumed (kg)	797.1	1186.7	578.5	537.0	609.4	756.7
Per capita maize consumption (kg/household member)	165.8	217.4	159.2	135.5	142.1	165.8
Per capita maize consumption (kg/adult equivalent)	140.6	182.5	134.4	114.6	115.0	139.6

Table 29. Annual household cash expenditure on food and non-food items

Consumption item	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
Food items	1,180,711	893,856	1,136,936	1,089,424	952,624	1,069,850
Non-food items	1,073,957	850,782	765,074	867,096	724,741	887,810
Total	2,254,668	1,744,638	1,902,010	1,956,520	1,677,366	1,957,659
Per capita total (TSh/absolute numbers)	443,757	278,645	448,449	452,814	338,567	403,855
Per capita total (TSh/adult equivalent)	529,363	331,659	522,211	538,340	417,787	479,792

Table 30a. Contribution of different sources to household income by district (%)

Income source	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)
Total annual income (TSh)	2,492,627	2,541,554	2,595,417	2,419,414	1,816,479
Crops	60.6	72.2	66.6	65.4	69.5
Non-agricultural wages	10.5	4.9	2.9	2.8	8.1
Agricultural wages	7.4	4.5	7.1	7.6	7.6
Self-employment	16.5	16.6	16.1	17.6	14.1
Transfers	4.2	1.8	7.2	5.9	0.7

Table 30b. Contribution of different incomes sources by gender of the household head (%)

Income source	Male (N=473)	Female (N=78)
Total annual income (TSh)	2,578,494	1,686,965
Crops	65.9	67.8
Non-agricultural wages	6.1	2.8
Agricultural wages	6.1	10.7
Self-employment	17.4	11.4
Transfers	4.0	7.3

Table 31a. Climate change related shocks/risks experienced by district (% households)

Climate shock/risk	Karatu (N=143)	Mbulu (N=118)	Mvomero (N=102)	Kilosa (N=147)	Gairo (N=41)	Total (N=551)
Drought	97.2	90.7	92.2	94.6	90.2	93.6
Too much rain	28.0	28.8	47.1	49.7	29.3	37.6
Crop pests/diseases	61.5	55.9	70.6	66.7	63.4	63.5
Hailstorm	12.6	9.3	25.5	14.3	14.6	14.9

Table 31b. Climate change related shocks/risks experienced by gender of the household head (% households)

Climate shock/risk	Male (N=473)	Female (N=78)	Total (N=551)
Drought	93.9	92.3	93.6
Too much rain	38.1	34.6	37.6
Crop pests/diseases	63.4	64.1	63.5
Hailstorm	15.6	10.3	14.9

Table 32. Copping strategies before long term climate related risk/shock occurs (% households)

Strategy	Drought (N=510)	Too much rain (N=200)	Crop pests and diseases (N=338)	Hailstorms (N=78)
Change crop varieties	16.5	7.0	5.9	3.8
Early planting	10.0	5.0	10.1	6.4
Crop diversification	4.5	2.0	3.0	1.3
Tree planting	1.0	2.0	0.3	5.1
Change from crop to livestock	1.0	1.0	0.6	2.6
Minimum tillage	0.6	2.0	0.9	1.3
Soil and stone bunds	0.0	6.0	0.0	1.3
Increased seed rate	2.2	2.0	2.4	1.3
More on-farm casual work	2.9	1.5	0.9	0.0
More off-farm casual work	2.2	0.0	0.3	0.0
Savings in cash	2.2	1.0	1.8	1.3

Savings in-kind	0.6	0.5	0.3	0.0
Food preservation	7.6	3.0	2.4	2.6
None	48.2	67.0	69.2	71.8
Apply pesticides	0.2	0.0	2.1	1.3
Irrigation	0.2	0.0	0.0	0.0
Late planting	0.2	0.0	0.0	0.0

Table 33. Copping strategies after long term climate related risk/shock occurs (% households)

Strategy	Drought (N=502)	Too much rain (N=203)	Crop pests/diseases (N=327)	Hailstorms (N=80)
Change crop varieties	22.3	4.9	6.7	1.3
Replanting	21.5	30.5	22.3	12.5
Selling livestock	5.6	2.5	2.1	3.8
Selling land	0.2	1.0	0.9	2.5
Rent out land	0.8	0.0	0.6	0.0
Selling other assets	0.0	0.0	0.6	0.0
Change from crop to livestock	1.2	2.0	0.9	1.3
Eat less	2.6	1.0	1.5	0.0
Reduce meals	3.2	1.5	0.6	1.3
Out migration	1.0	1.5	0.9	0.0
Stop sending children to school	0.2	0.5	3.7	7.5
More on-farm casual work	6.4	6.9	3.1	7.5
More off-farm casual work	6.8	4.4	0.0	0.0
None	25.9	41.4	46.8	61.3
Waiting for long rains	0.6	0.0	0.0	0.0
Resort to off-farm business	0.8	0.0	0.0	0.0
Irrigation	0.8	0.0	0.0	0.0
Buying food	0.2	0.0	0.0	0.0
Change crops	0.0	0.0	0.3	0.0
Apply pesticides	0.0	0.0	5.5	0.0
Uprooting affected plants	0.0	0.0	0.6	0.0
Resort to off-farm business	0.0	0.0	0.3	0.0
Seek extension services	0.0	0.0	1.8	0.0
Increase security	0.0	0.0	0.3	1.3
Tree planting	0.0	0.5	0.0	0.0
Rent in more land	0.0	0.5	0.0	0.0
Increase weeding frequency	0.0	1.0	0.3	0.0

Table 34.

Risk/shock	Karatu	Mbulu	Mvomero	Kilosa	Gairo	Total
Food production:						
Drought	45.8	39.5	47.5	50.1	49.7	46.2
Too much rain	28.3	33.5	22.4	31.0	22.1	28.4
Pests/diseases	32.6	24.7	30.7	30.5	25.7	29.6
Hailstorm	18.6	13.4	15.5	21.6	36.2	19.0
Household income:						
Drought	42.7	38.8	43.1	46.2	48.6	43.3
Too much rain	26.8	34.1	22.1	30.8	22.1	28.0
Pests/diseases	30.3	25.6	31.4	29.4	24.0	28.9
Hailstorm	21.5	19.2	13.8	18.6	33.0	18.8

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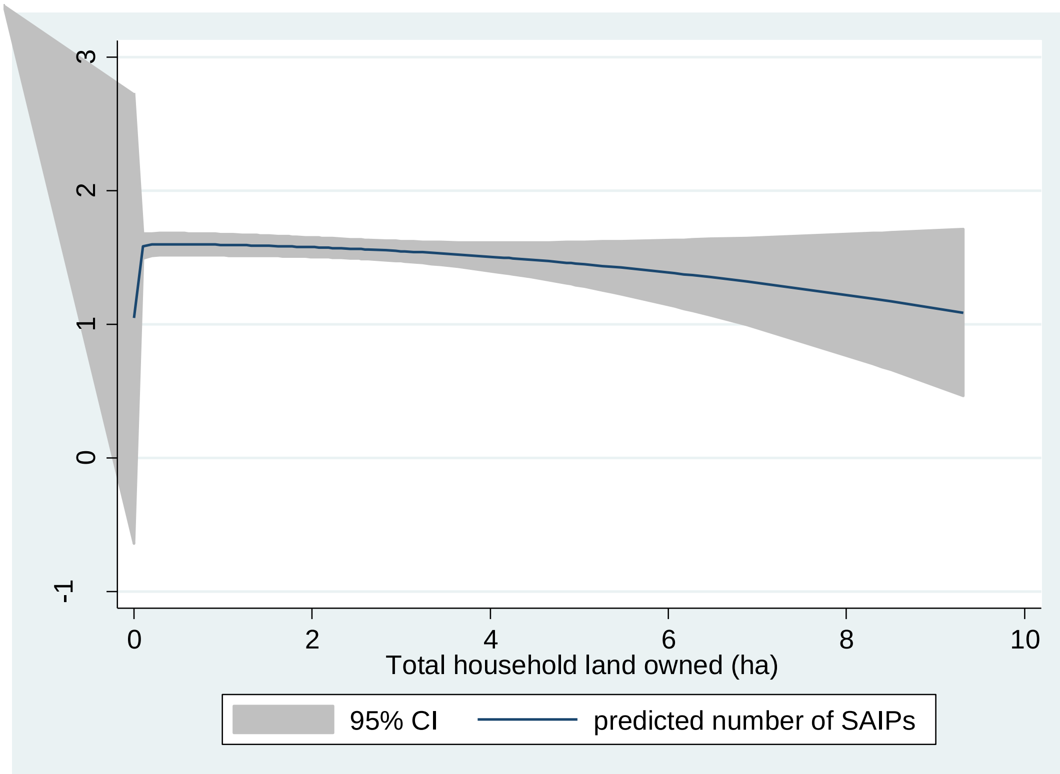

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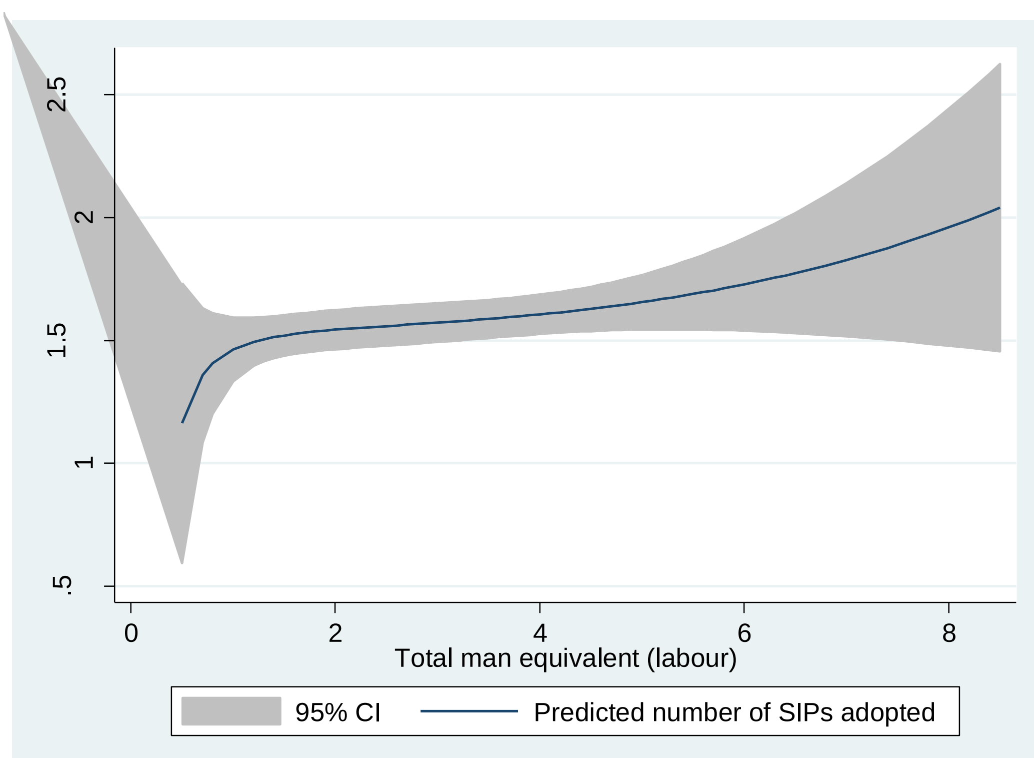

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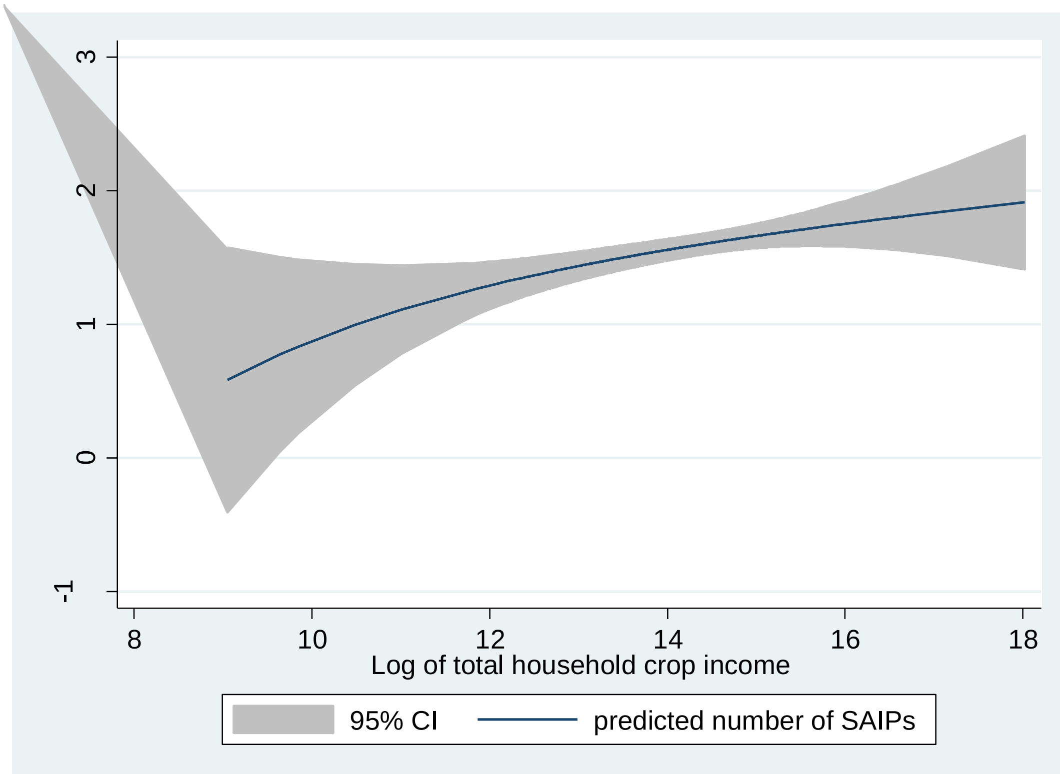

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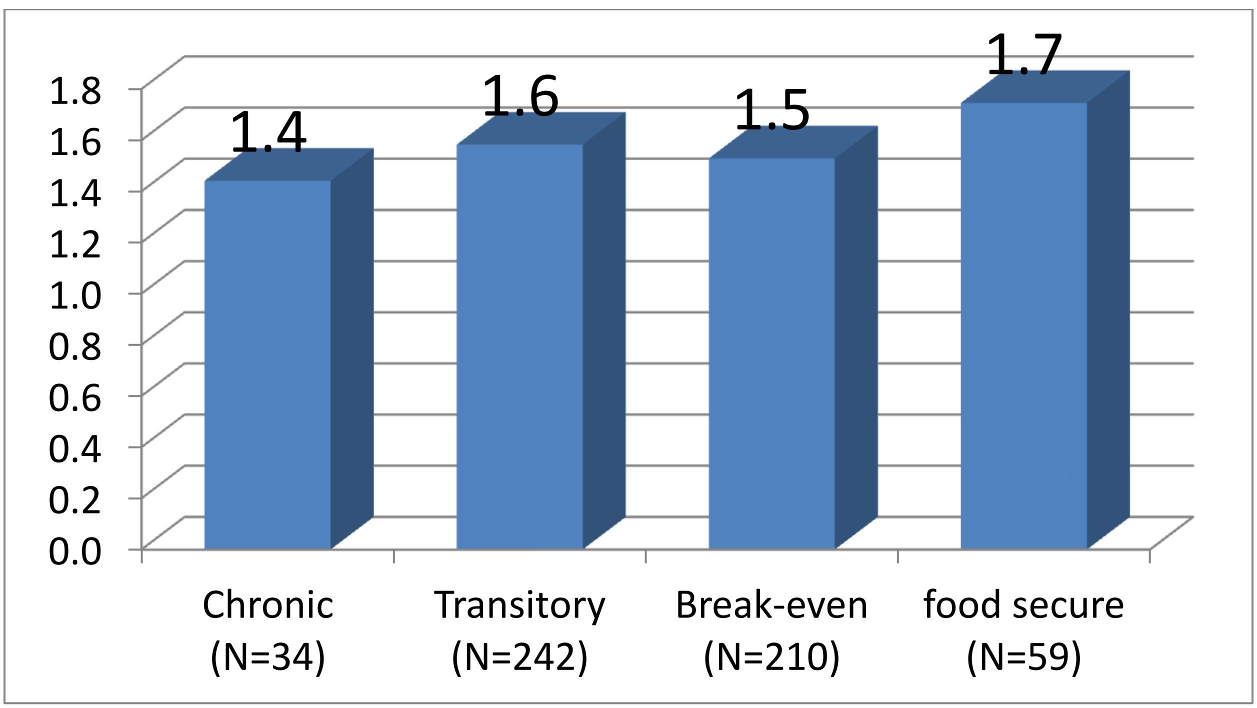

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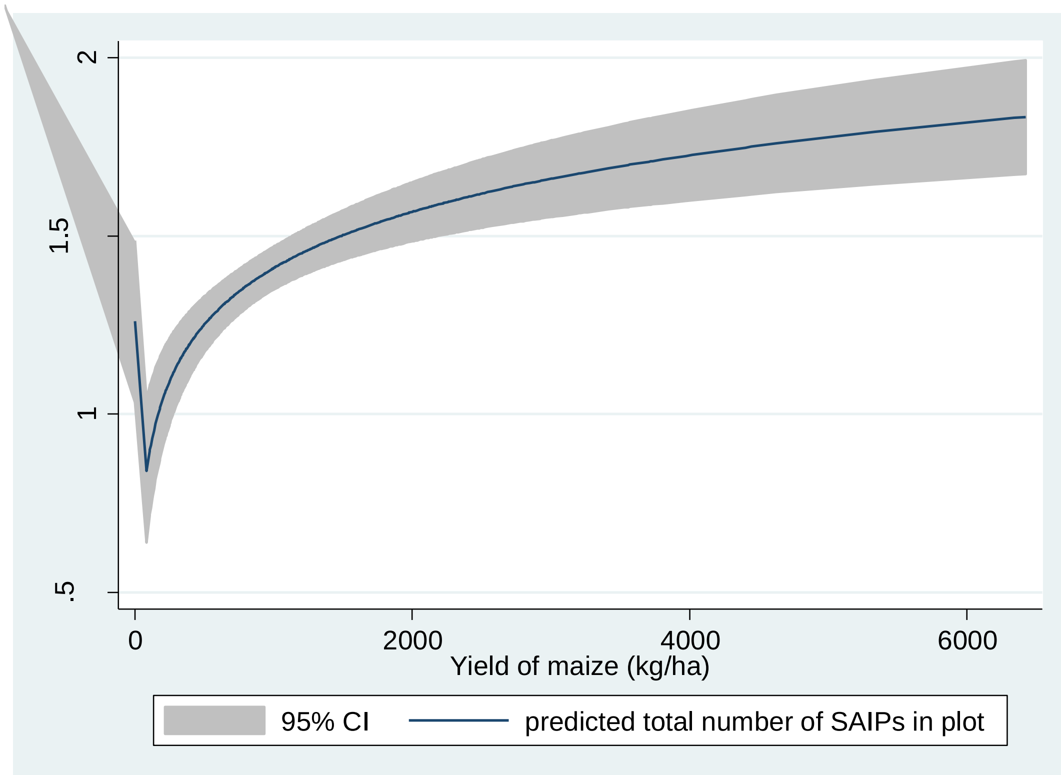

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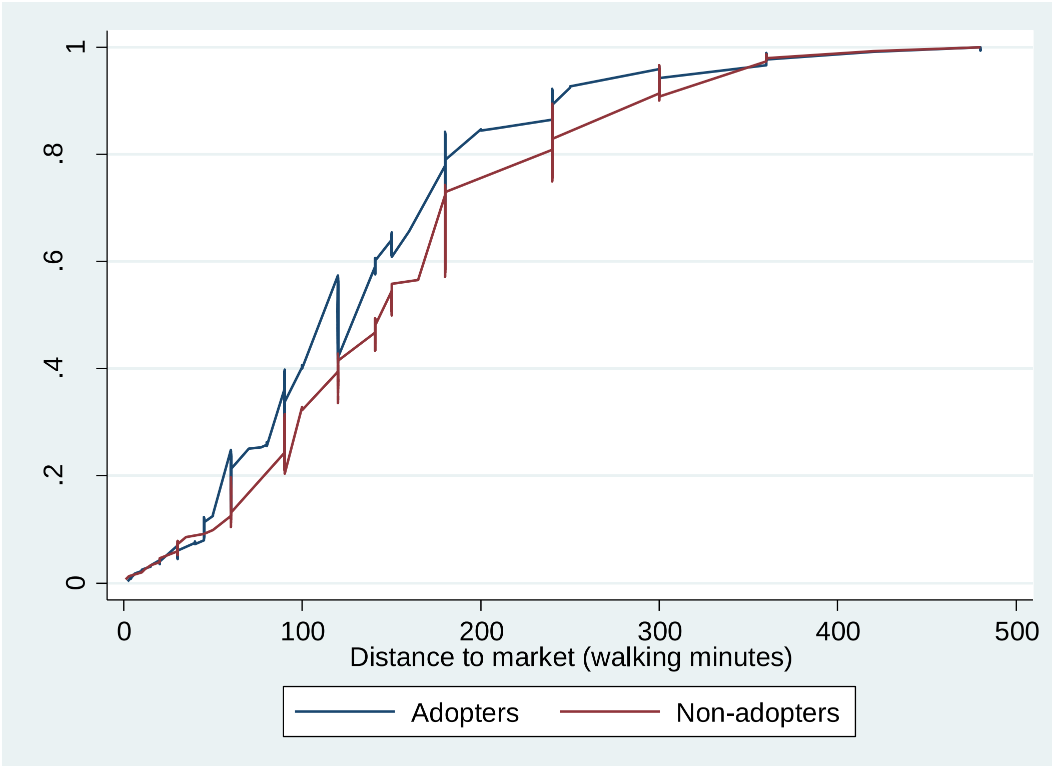

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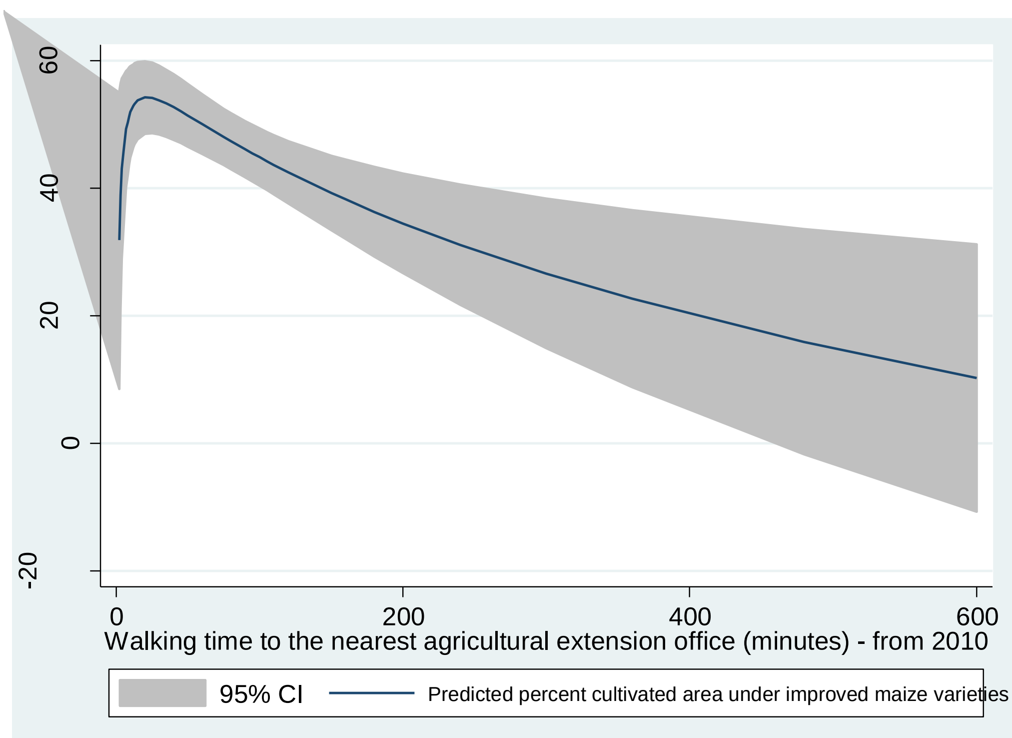

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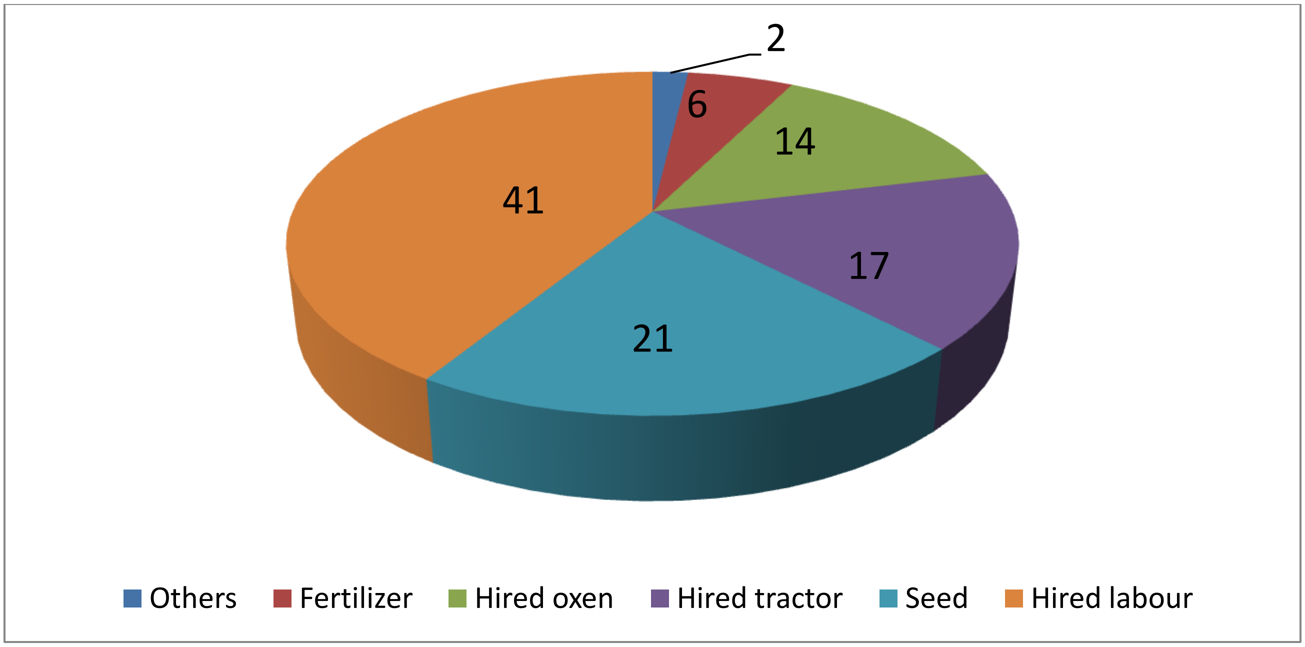

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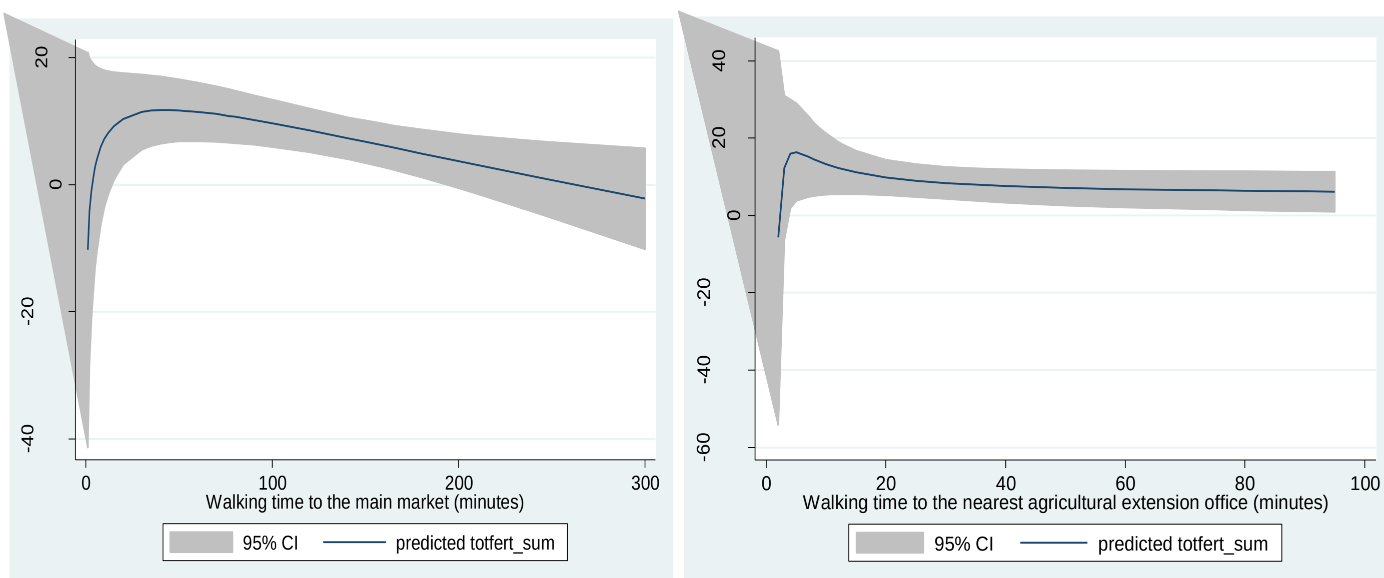

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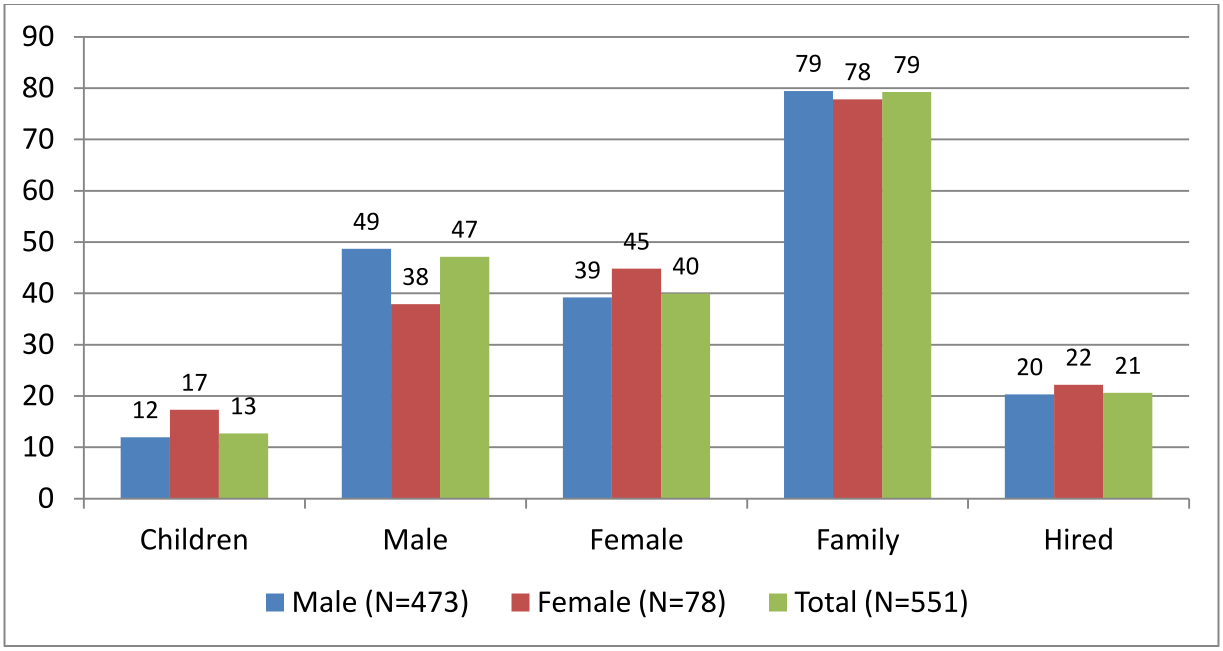

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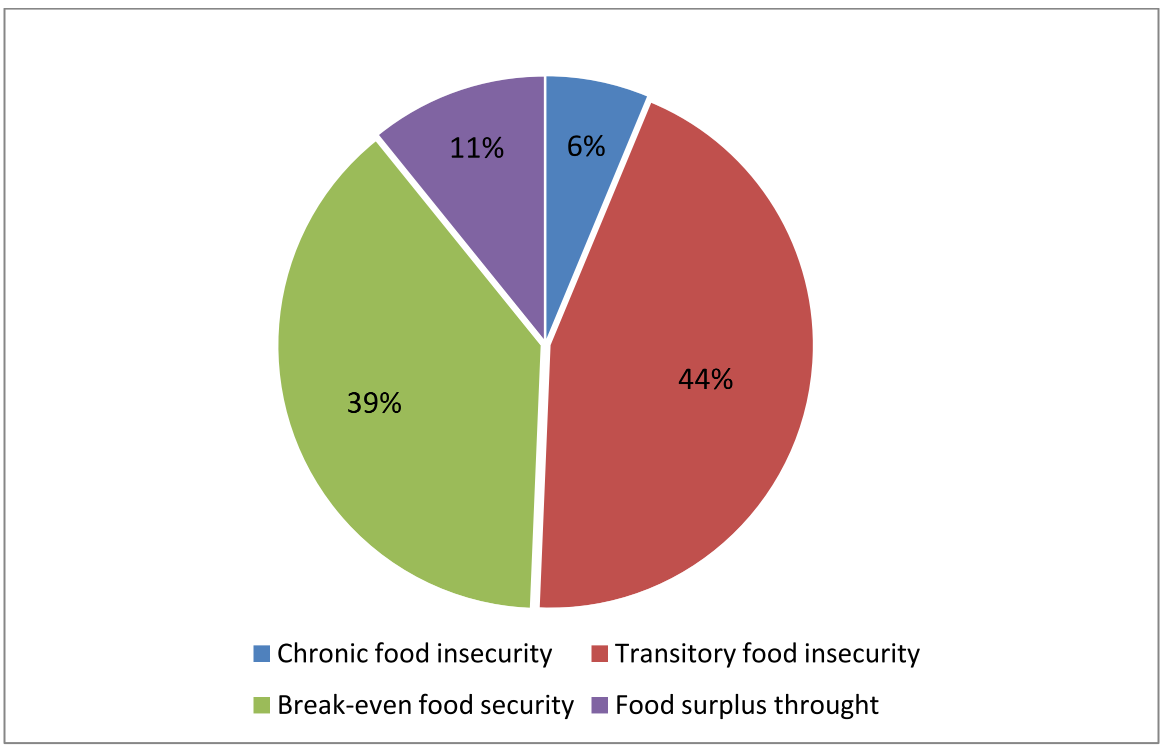

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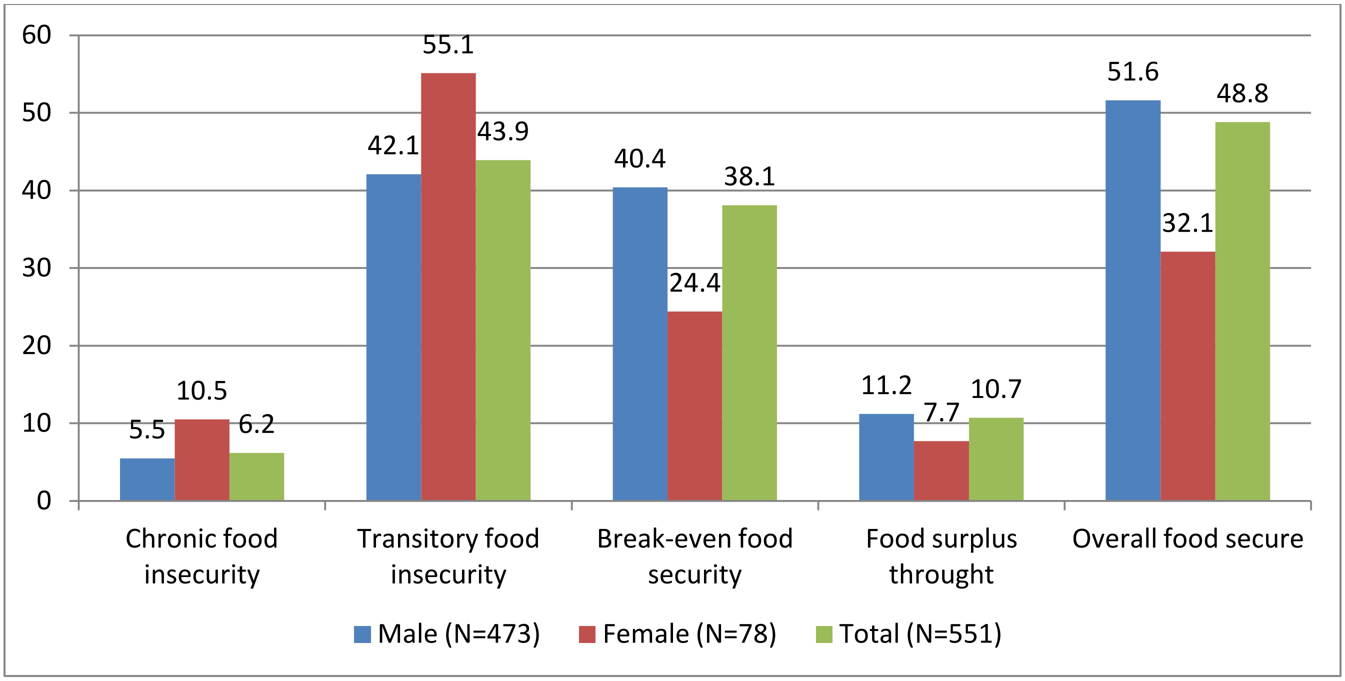

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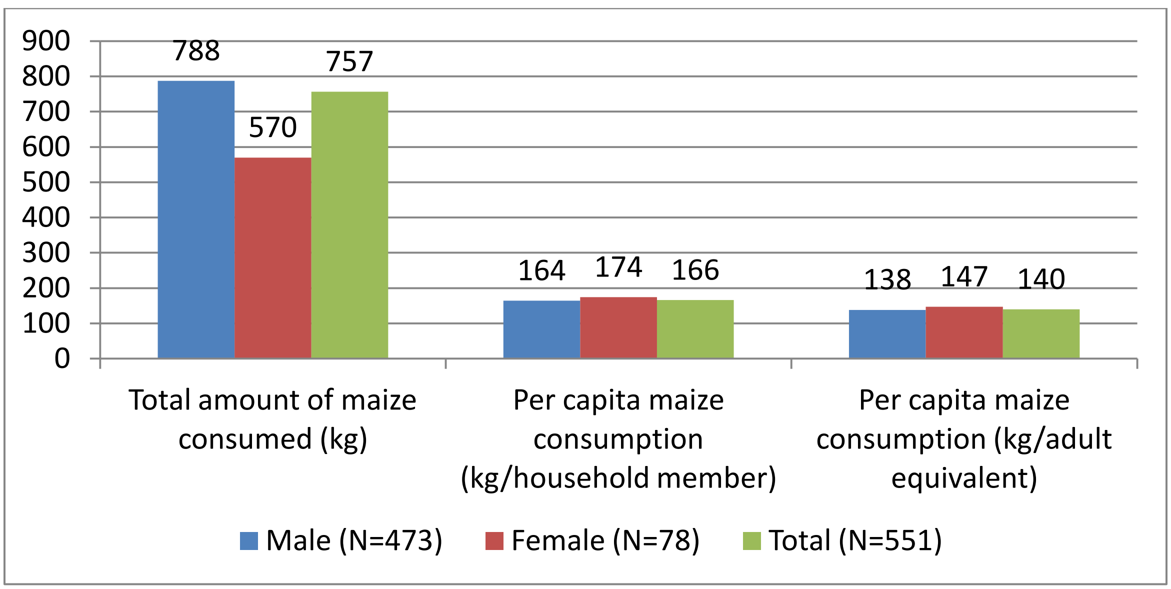

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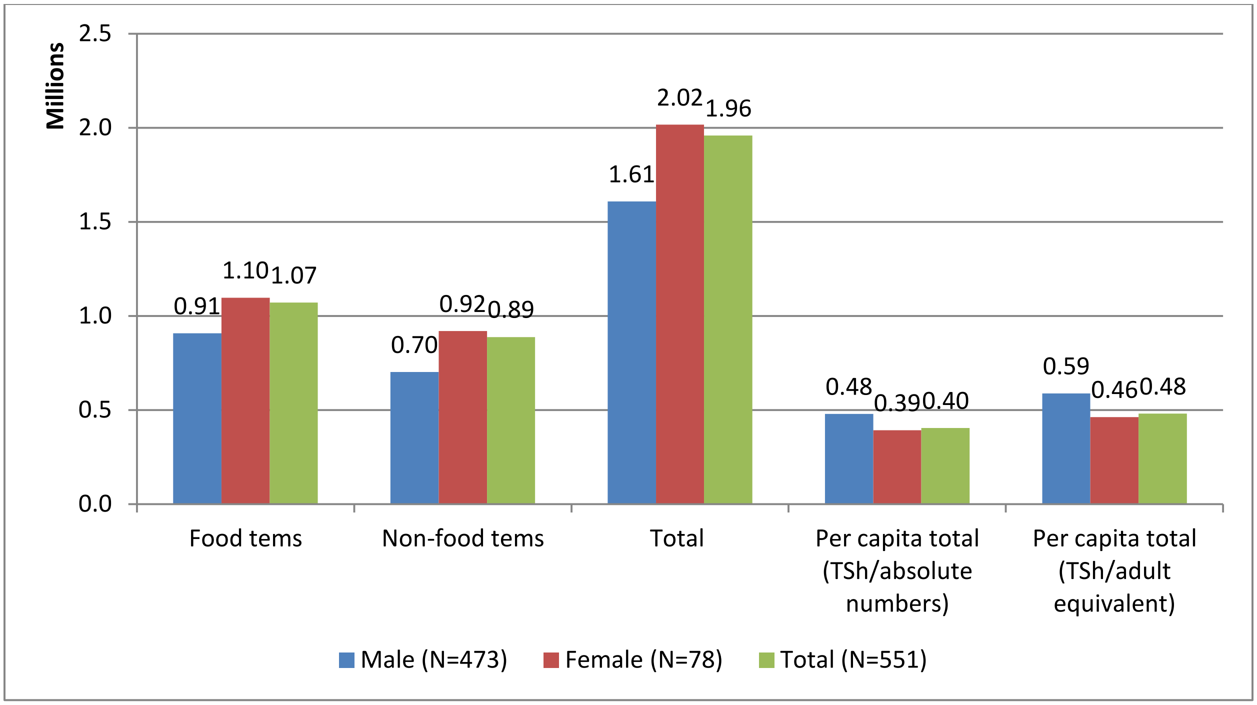

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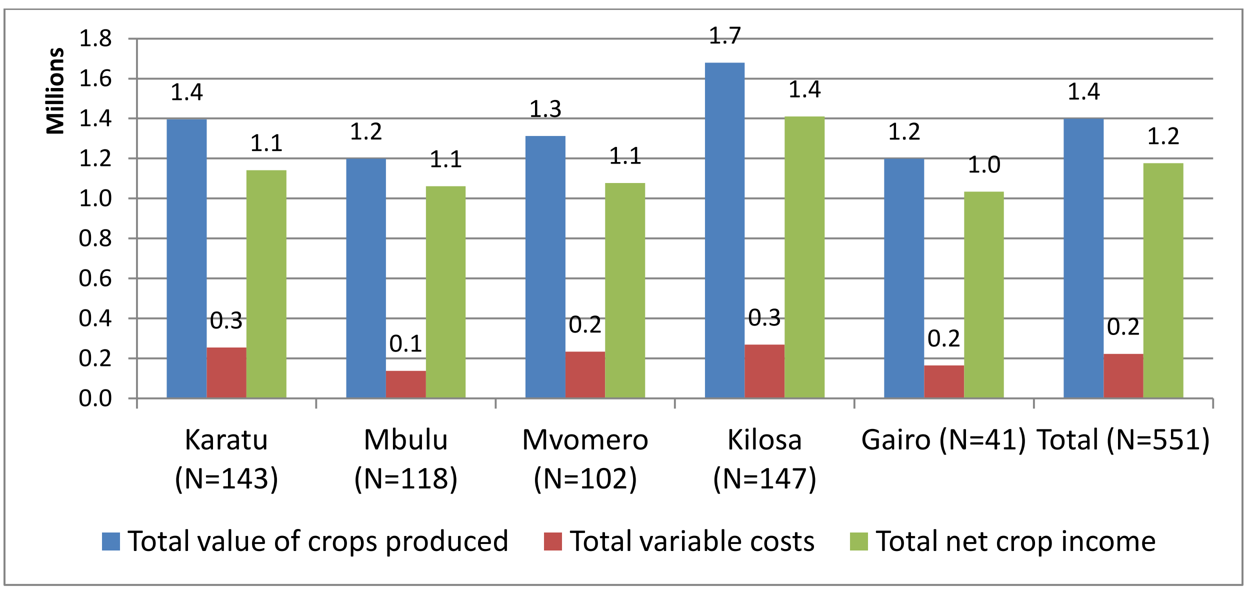

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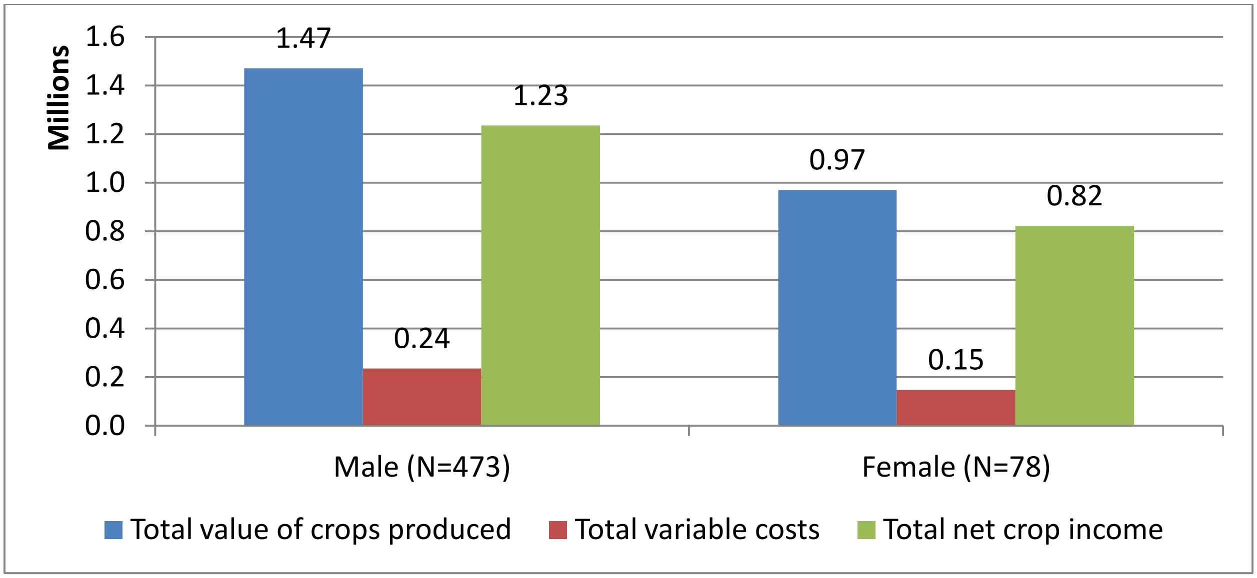

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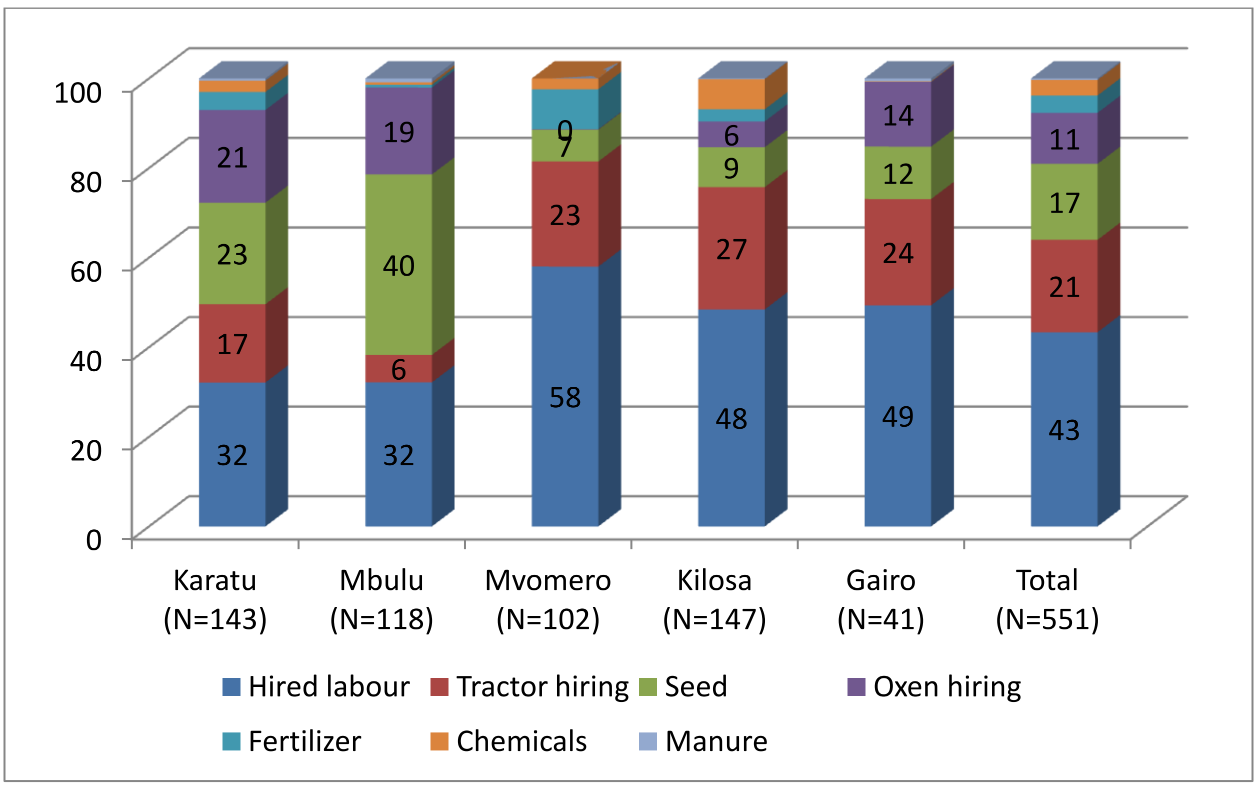

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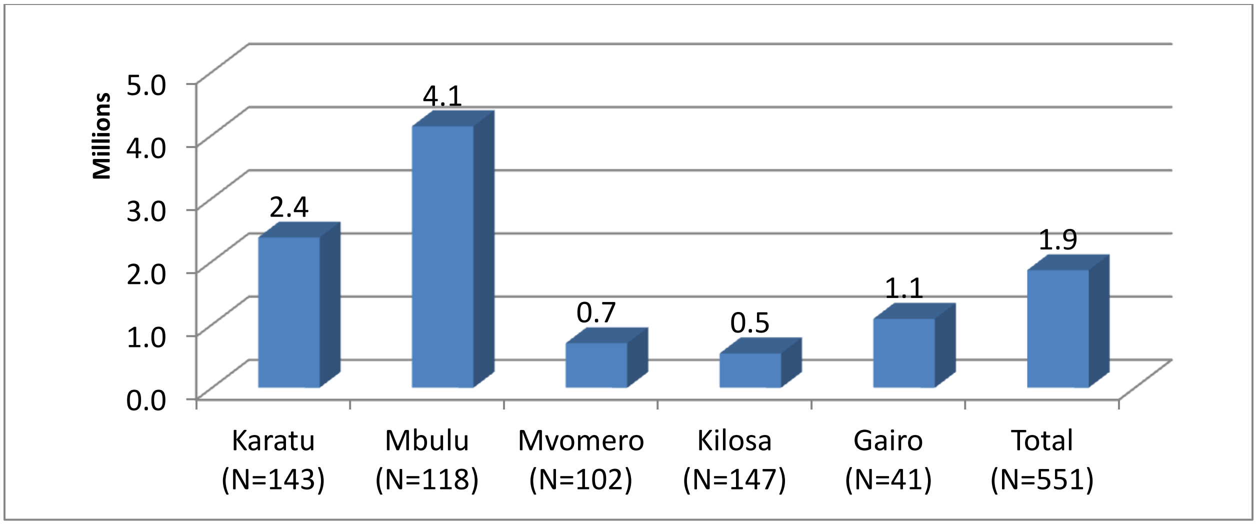

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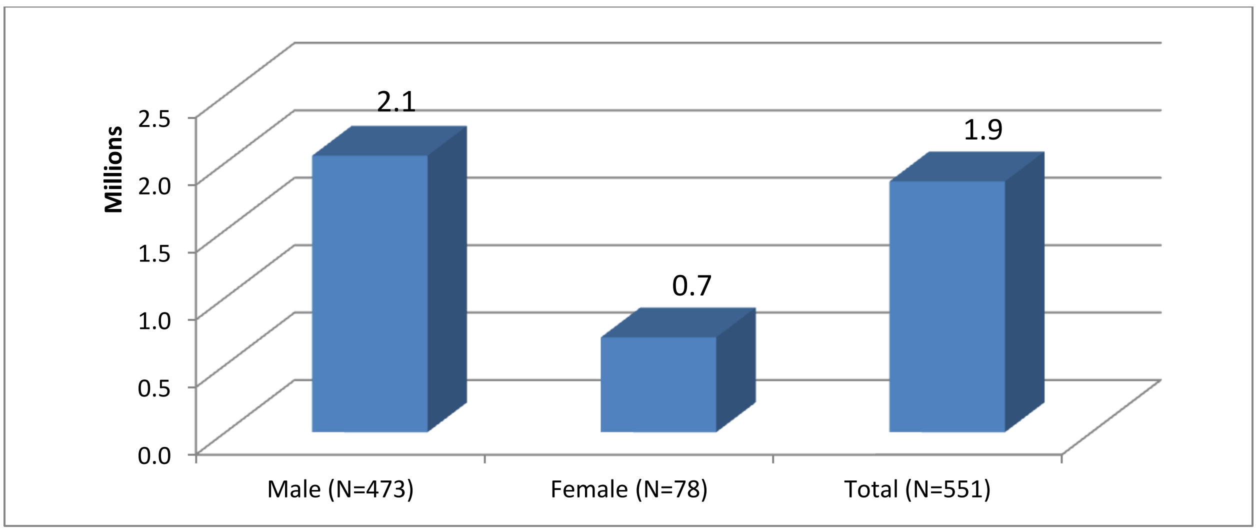

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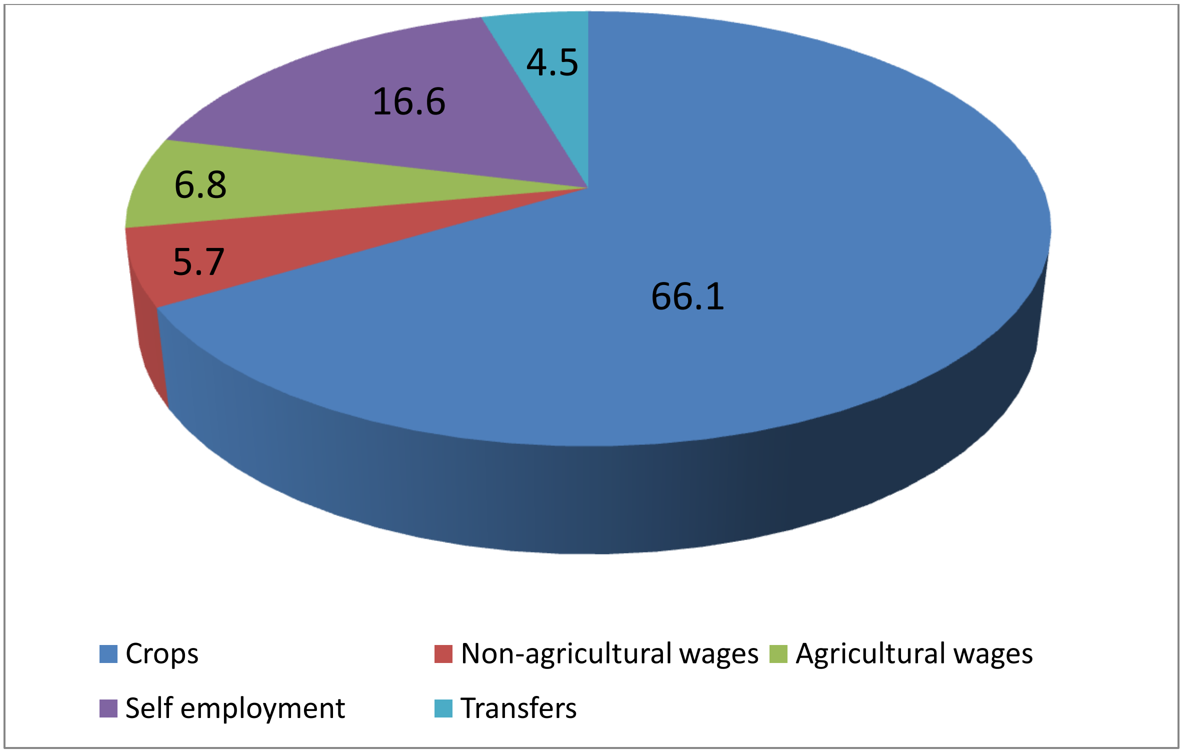

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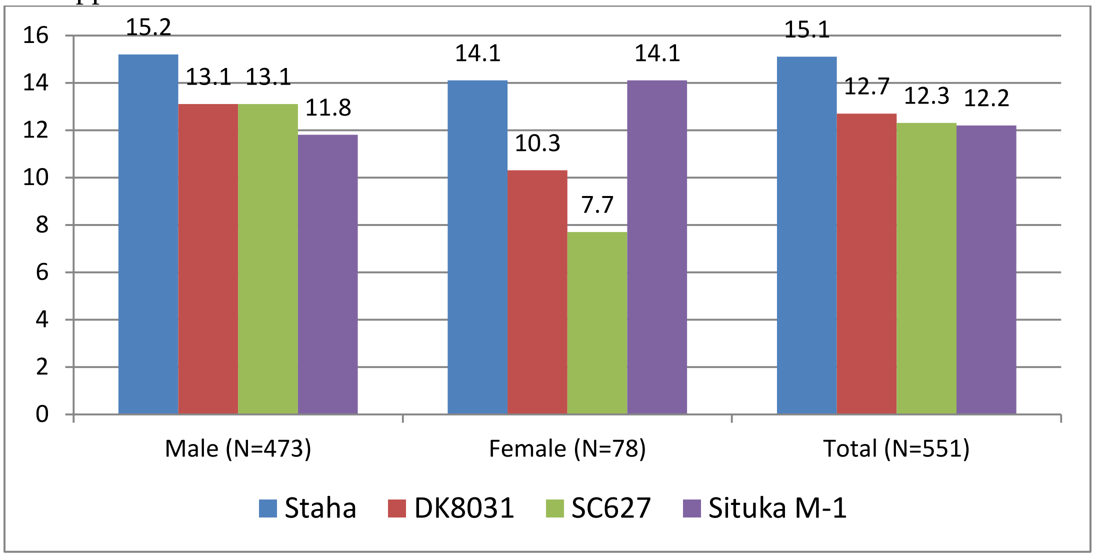
Appendix 2



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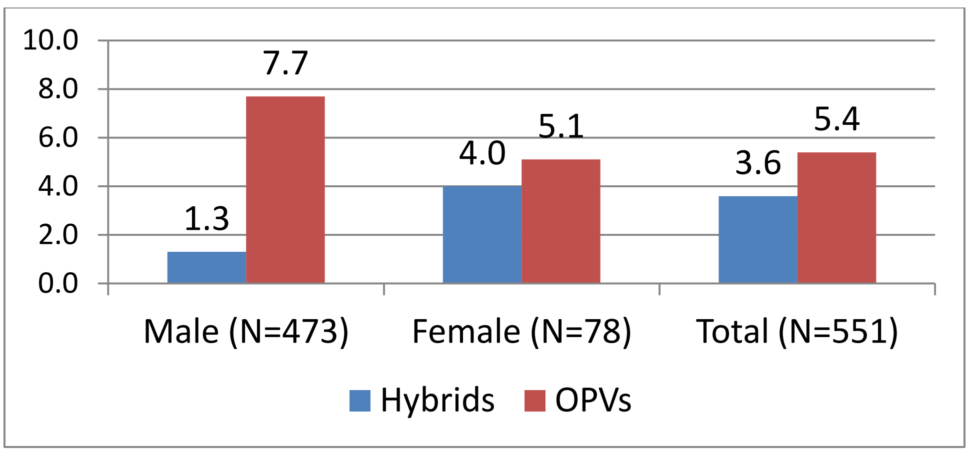

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