An Analysis of Use of Good Agricultural Practices in Rice Production: A Case Study of Bagamoyo and Dakawa Areas, Tanzania.

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Declaration

This dissertation is my original work and has not been presented for a degree in any other University

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Dedication

I dedicate this paper to my family which has always been supportive to me all the time. To my mum, Agnes (RIP), I will always cherish the love and care you showed me. I owe it to God for the opportunity to study for my MSc degree.

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List of Abbreviations

AfricaRice	Africa Rice Centre
3ADI	Africa Agribusiness and Agro-Industries Development Initiative
AIC	Akaike's An Information Criterion
BIDP	Bagamoyo Irrigation Development Project
DRC	Dakawa Research Centre
FAO	Food and Agricultural Organization
FFS	Farmer Field Schools
FP	Farmer Practice
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GM	Gross Margin
GoT	Government of Tanzania
ICIPE	International Centre of Insect Physiology and Ecology
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency
JKUAT	Jomo Kenyatta University of Agriculture and Technology
Kg	Kilogram

N-P-K	Nitrogen-Phosphorus- Potassium
NRDS	National Rice Development Strategy
PID	Project Information Document
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
SSA	Sub Saharan Africa
SPSS	Statistical Package for Social Sciences
SRI	System of Rice Intensification
TSH	Tanzanian Shillings (USD1=TSH1575 at time of the study)
USD	United States Dollar

Abstract

One major outcome of the challenges in rice production in Tanzania is low yield. One intervention to help improve rice yield is adoption of Good Agricultural Practices (GAP). However, little information exists about farmersô awareness of GAP and its application under farmer circumstances. A study was conducted in 2012 growing season at Bagamoyo and Dakawa. The objectives of the study were to establish differences between constrained and unconstrained farmersô choices of rice production management practices, assess whether training on GAP affects farmersô choices of rice production management practices and to identify factors that influence farmersô adoption of GAP in rice production. Findings from the study have shown that farmers in Bagamoyo are already aware of improved practices of nutrient management, seed establishment method and weed management method. Farmers in Bagamoyo actually used improved practices that they had indicated they would use in establishment method and nutrient management in 2012. However, these farmers did not use improved practices in weed management despite the awareness.

There was significant influence of training on farmersô unconstrained choices of nutrient management (p-value = 0.016) seed establishment method (p-value <0.001) and weed management method (p-value = 0.012) in Dakawa. Despite this awareness, most trained farmers did not use improved practices in establishment method, nutrient management method and bunding/ non-bunding (bunding is the construction of ridges in rice fields to conserve soil moisture). Dakawa recorded 43 percent adoption rate . The study further concluded that there is no evidence suggesting that training influenced farmersô adoption of GAP at Dakawa.

Chapter 1

Introduction

1.1 The Role of the Agricultural Sector in Tanzania

Tanzania, with a population of approximately 40 million people, has a total land area of 94.5 million hectares of which, 44 million hectares are suitable for agriculture. It is estimated that only 10.1 million ha (23percent) is under cultivation (GoT-NRDS, 2009). The agriculture sector is the main contributor to the economy. It accounts for about 27 percent of the Gross Domestic Product (GDP) and 35 percent of foreign exchange earnings (GoT-Basic Data, in press). Agriculture remains the main economic activity of the labor force in Tanzania absorbing 77 percent of the labor force (Parry, 2011) with 77 percent of women and 72 percent of men employed in the sector (Kweka and Fox, 2011). Furthermore, an estimated 87 percent of the poor live in rural areas and 75 percent of rural income is earned from agricultural activities (GoT-PID, 2011).

The agricultural sector provides 95 percent of the national food requirements (GoT-NRDS, 2009) and 80 percent of the population depends on agriculture for their livelihood (GoT-3ADI, 2010). The main food crops include maize, rice, sorghum, millet, wheat and legumes. It is estimated that 18 percent of the households in agriculture are engaged in rice production (GoT-NRDS, 2009) with an estimated 99 percent of the rice in the country being grown by smallholder farmers with farm sizes ranging between 0.5 to 3 hectares (Hamilton, 2010).

1.2 Rice Production in Tanzania

Rice is the most important food crop of the developing world and the staple food of more than half of the world's population (Sinha and Talati, 2006). More than 3.5 billion people worldwide depend on rice for food. In Tanzania, it is estimated that 60 percent of the population consumes rice or rice products each day (Bucheyeki, *et al*., 2011). In Tanzania, rice is grown under three major ecologies; irrigated, rain-fed lowland and upland ecologies with the total potential area suitable for rice cultivation estimated at 21 million hectares. The irrigated ecology covers 8 percent of this potential with yields ranging from 2.5 to 4.0 tons of paddy per hectare, while the lowland rain-fed ecology covers 72 percent of potential with yields ranging from 1.5 to 2.0 tons of paddy per hectare. The upland ecology covers 20 percent of this potential with yields ranging from 0.5 to 0.8 tons of paddy per hectare (GoT-NRDS, 2009). Table 1 summarizes rice production from the three ecologies for the 2008 production year.

Table 1. Tanzania Rice Production by Ecology

Ecology	Cropped area (ha)	Cropped area % of potential	Area % of actual	Estimated yield (t/ha)	Production (tons)	% of production
Irrigated	200,000	11.9	29	0.2.13	426,000	47
Rain-fed lowland	463,000	3.1	68	1.0	464,000	52
Upland	17,000	0.4	0.3	0.5	9,000	0.1
Total	680,000	3.2	100	1.3	899,000	100

(GoT-NRDS, 2009)

In 2008, only 3.2 percent of the area potentially suitable for rice production was cropped to rice (Table 1). During the same year, irrigated area constituted 29 percent of total area but accounted for 47 percent of production. The rain fed lowland ecology accounted for 52 percent of production from 68 percent of the area cropped to rice. Production from the upland ecology is still relatively insignificant.

For the 2009/2010 growing season, the total area under rice production was estimated to be 1,136,287 hectares (GoT-Basic Data, in press) constituting only 5 percent of the 21 million hectares potentially suitable for rice production (GoT-NRDS, 2009). Milled rice production in the period 1999 to 2009 ranged between 530,000 and 851,000 tons. During the 2009/10 growing season, the highest paddy production was recorded in Arusha region followed by Morogoro, Shinyanga, Rukwa, Mbeya, Mwanza, Kilimanjaro and Ruvuma. Together, these areas produced an estimated 2,212,918 tons of paddy, which is equivalent to 84 percent of the national total paddy production in 2009/10 season (GoT-Basic Data, in press).

Despite this production of rice, there is still a gap in terms of production and quantity required for consumption. On a wider scale, the gap between demand and supply of rice in sub-Saharan Africa (SSA), where rice is grown and eaten in 38 countries, reached 10 million tons of milled rice in 2008. This cost the region an estimated USD3.6 billion for imports (FAO, 2003) which is very expensive and unsustainable. For Tanzania, rice production has failed to meet demand with an estimated 30 per cent annual national deficit (Mbalamwezi, 2011). This has been caused by rapid population growth and urbanization leading to increased consumption of rice so that domestic rice production is unable to meet demand (Kijima, *et al*., 2010). To meet the domestic demand for rice, between 2001-2005, the government of Tanzania had been importing on average 193,300 tons of milled rice translating to about USD26.01 million per annum (GoT-NRDS, 2009) thereby draining foreign currency. This shows how imperative it is to find strategies for increasing rice production in the country. It must be pointed out that rice is a major cereal crop that has great potential for increases in productivity in SSA (Kijima, et al., 2012).

Despite failure to meet demand for rice, Tanzania has potential to improve rice production. These include rain fed upland, lowlands and irrigated lowlands eco-systems; a range of small, medium and large scale producers and comparative advantage of rice over other food crops for income generation and enhancing household food security (GoT-NRDS, 2009). In addition, there is availability of some improved rice production technologies and dissemination channels (GoT-NRDS, 2009).

There are several opportunities for expansion of rice production in Tanzania as elaborated in the National Rice Development Strategy (NRDS) (GoT-NRDS, 2009). Tanzania is endowed with abundant water resources which include underground water, rivers and lakes that can be used for irrigation. Furthermore, there is political will from the Government of Tanzania to enhance production and productivity of rice by introducing a conducive policy environment, such as exemption of taxes on agricultural inputs including machinery and fertilizers as well as subsidy on agricultural inputs like fertilizers and improved seeds and pesticides (GoT-NRDS, 2009).

The need to improve rice production has also been part of the agenda for the government of Tanzania, which has set a high priority in production of rice as one of the means of meeting the countryøs food security needs as well as economic growth in both rural and urban areas. The government has set its aim at improving rice production in irrigated lowland, upland ecosystem and rain-fed lowland ecosystems. With this in mind, the government developed the NRDS in 2009. The NRDS is aimed at improving the livelihood of the majority rural communities through enhancing household food security and incomes. The general objective of the NRDS is to double rice production by 2018 from 899,000 tons of paddy rice to 1,963,000 tons (GoT-NRDS, 2009). As of 2010, data shows a sharp increase in total rice production with estimated 2.6 million tons of paddy recorded in 2010 growing season (GoT-Basic Data, in press). It is believed that the NRDS would facilitate increasing national food security and enhancing income generation at household level.

One of the major challenges facing rice production in Tanzania is low yield (GoT-NRDS, 2009). Reasons for low rice yield include use of genetically low yielding varieties, drought, low soil fertility, weed infestations, prevalence of insect pests and diseases and birds (GoT-NRDS, 2009). In addition, nutrient depletion of cultivated land, climate variability and use of inappropriate husbandry practices also contribute to low rice yield (Balasubramanian, et al., 2007).

Rice yield can be increased by, improving agronomic practices such as timely planting, proper spacing, timely weeding, timely and correct use of fertilizers and insecticides, timely harvesting ,reducing post harvest losses (Bucheyeki, *et al*., 2011) and adoption of new technologies. Technological change in agriculture can be a powerful force in reducing poverty (de Janvry and Sadoulet, 2001). Poverty can be reduced with the introduction of agricultural technology which helps farmers to increase production for home consumption, increase gross revenues from sales and lower production costs (de Janvry and Sadoulet, 2001). Improved agricultural productivity leads to a reduction in the percentage number of people living on less than USD1 per day (Thirtle1, *et al*., 2001), thereby reducing poverty.

Through the adoption of GAP farmers can improve rice production. In the context of this study, In the context of this study GAP represents a basket of good agricultural farming practices from which farmers can choose the most appropriate practices that suite their physical and socio-economic circumstances so as to increase yield. The focus of GAP includes the use of improved cultivars, nutrients, and weed and bunding/ non-bunding technologies. By following GAP, farmers can obtain healthier yields of rice (IRRI, 2010).

As one way of taking part in improving rice production in Tanzania, AfricaRice and the International Rice Research Institute (IRRI) conducted a joint experiment which also served as a demonstration aimed at testing combination of improved cultivars, nutrient, weed and bunding/ non-bunding technologies under GAP in a lowland rain-fed and an irrigated site in Tanzania. The experiment was conducted in two areas, namely, Bagamoyo (the irrigated site) and Dakawa (the lowland rainfed site) during the 2011 growing season. The objective of the experiment was to determine the yield gains emanating from GAP. Before the experiment was conducted, baseline data were collected to find out prevailing farmer practices in rice production in the two areas. The experiment also involved training of farmers on use of GAP in rice production as a way of increasing farmersô awareness of these improved practices.

1.3 Statement of the Problem

The main challenge facing rice production in Tanzania is low yield. This is attributed to use of genetically low yielding varieties, drought, low soil fertility, weed infestations, prevalence of insect pests and diseases and birds (GoT-NRDS, 2009). One of the interventions to improving rice yield is use of GAP. By following GAP, farmers can obtain healthier yields of rice (IRRI, 2010). Despite the benefits of GAP in rice production, there is little information known about farmersô awareness of the improved practices and their adoption. Appreciating farmersô awareness of GAP and its adoption is imperative if rice production is to be improved. Farmersô awareness of the GAP in rice production is a pivotal step towards adoption of the practices.

1.4 Justification

Farmersô awareness and application of GAP in rice production are of great importance in helping improve yield. This could be one of the areas of focus that will help the Government of Tanzania achieve the goal of doubling rice production by 2018. By gathering information on GAP and knowing whether training or demonstration help farmers change their attitude towards improved farming practices, it will assist in incorporating more effective and well informed strategies in programs meant to improve rice production in Tanzania. Furthermore, by finding out factors that influence farmersô adoption of GAP in rice production, it will help stakeholders make informed decisions in coming up with corrective measures in tacking factors that negatively affect adoption of GAP. Consequently, this will help increase rice productivity, improve food security and reduce poverty among farmers.

1.5 General Objective

To gain an understanding of farmersô knowledge and application of GAP in rice production in lowland rain-fed and irrigated areas.

1.5.1 Specific Objectives

I. To establish differences between constrained and unconstrained farmersô choices of rice production management practices.

II. To determine the role of training on the choice of rice production practices.

III. To identify factors influencing adoption of GAP in rice production.

1.6 Hypotheses

I. Farmersô constrained and unconstrained choices of management practices in rice production are different.

II. Training does not influence farmersôchoices of rice production practices.

III. There are no factors which influence farmersô adoption of GAP in rice production.

1.7 Scope of the Study

The study compares the differences between unconstrained choices made by famers when asked about GAP and farmersô actual (constrained) practices and attempts to identify the sources of the differences. The study also looks at differences in choices of farmersôpractices (both constrained and unconstrained) before and after training so as to determine the effect of training. Rice production practices during 2012 growing season have been compared between trained farmers and untrained farmers with a model fitted to explain adoption of GAP by farmers.

Chapter 2

Literature Review

2.1 Challenges Facing Rice Production in Tanzania

There are several challenges being experienced in each of the three main rice growing ecologies in Tanzania. The irrigated lowland system faces problems largely related to pests and diseases, floods and water logging in areas with broken down irrigation schemes. The most prevalent problems in the upland ecosystem are drought, weeds, pests, diseases, soil infertility and phosphorus deficiency (GoT-NRDS, 2009). Challenges faced in the rain fed lowland ecosystem include floods due to heavy rains, draught, pests, diseases, weeds, low soil fertility, competition between rice and other food crops such as maize for land and labor (GoT-NRDS, 2009). Another major challenge experienced in all the three ecologies is that there are hundreds of farmers who are still using traditional rice varieties. Most of these varieties have low yield potential, are late maturing and are susceptible to lodging when improved management practices such as fertilizer application are used (GoT-NRDS, 2009).

A rapid rural appraisal by Farming Systems Research Project in 1989 in the rain fed lowland ecology of Shinyanga region concluded that the main constraint mentioned by farmers was weed infestation. Farmers also stated that they were experiencing decreasing yields in their fields which led to the hypothesis that low yield was a result of low soil fertility (Meertens, *et al*., 2003). A study in Sukumaland also concluded that major constraints to rice production in the region included weed infestation, water shortage, stem borers, shortage of labor, high prices and poor availability of agricultural inputs, low soil fertility and damage from birds. Furthermore, solving these constraints had been difficult because it was not profitable for farmers to use inputs such as herbicides, pesticides and mineral fertilizer (Meertens, *et al*., 1999). These challenges call for efforts to be made so as to maximize utilization of the opportunities available so that rice yield can be improved.

2.2 The Concept of Good Agricultural Practices

Good Agricultural Practices in rice production should be understood as good agricultural farming practices which are suited for a particular environment aimed at helping farmers improve yield. Good Agricultural Practices should be seen as a basket containing several good agricultural farming practices from where farmers can choose the most appropriate practices that suite their environment. Good Agricultural Practices include, but are not limited to, improved cultivars, bunding, appropriate rice establishment method, appropriate weeding method, appropriate nutrient management method, appropriate measures of pest control, proper harvesting and post harvest practices.

The concept of GAP is not new in rice production. In Southeast Asia, farmers in Thailand and Vietnam are already exploring GAP for rice and research is being done to facilitate diffusion and adoption of these practices (IRRI, 2009). However, appropriate cultivation practices which are widely used in Asia are not commonly applied in SSA which is something that has been largely ignored (Balasubramanian, *et al*., 2007). Such practices in SSA include, farmersô use of broadcasting method in direct seeded rice planting which results in poor germination, farmersô failure to use straight-row planting when transplanting rice and farmersô failure to construct bunds (Kijima, *et al*., 2012).

2.3 Good Agricultural Practices and System of Rice Intensification

The concept of Good Agricultural Practices is very similar to the concept of System of Rice Intensification (SRI) which was initially developed in Madagascar through participatory on-farm experimentation in 1980ǿs and 1990ǿs (Dobermann, 2004). The System of Rice Intensification is an approach to increase rice production at affordable costs for small-scale farmers by changing farmersô agronomic practices towards more efficient use of natural resources without harming the environment (Noltze, *et al.*, 2012). It is based on the principle that poor farmers, lacking capital and access to credit, need methods with which they can improve yields and income without expensive inputs while sustaining the resource base on which they depend (Moser and Barrett, 2002). The System of Rice Intensification is now being promoted by different organizations in other countries most of which are in Asia (Noltze, *et al.*, 2012).

Good Agricultural Practices and System of Rice Intensification can be understood as system technologies defined as an integrated innovation to improve agricultural productivity and agro ecosystem resilience, involving different agronomic and management components with synergistic relationships (Noltze, *et al.*, 2012). However, most research and development projects or interventions deal with singular approaches, and do not assist in selecting from the broader basket of options (Giller, *et al.*, 2010). On the other hand, GAP and SRI take a different approach, in that they give farmers a broad range of practices from which they can choose.

The System of Rice Intensification is a strategy and a set of principles for enhancing plant growth performance and productivity than a standard technological package (Stoop, *et al.*, 2002). A study on SRI in Timor Leste considered intermittent irrigation, early transplanting, single seedlings and wide spacing as the core components of SRI (Noltze, *et al*., 2012). Similarly, in this study, the core components of GAP that were studied were cultivar selection, crop establishment method, bunding/ non-bunding, weeding method and nutrient management which have been suited to either irrigated ecology or rain-fed lowland ecology.

2.4 Good Agricultural Practices in Rice production in Tanzania

In Tanzania, there has been some work testing the impact of components of GAP in the lowland rain fed areas. One of the studies was carried out to assess the effects of soil bunds on the production of rain-fed lowland rice in South Eastern Tanzania (Raes, *et al*., 2007). In the study, rice was cultivated in bunded and nonbunded farmersô plots under the common agronomic practices in the region, for three successive seasons. Simulation of crop transpiration with the BUDGET soil water balance model was done by using observed weather data, soil and crop parameters. By using the soil water balance model, crop yields that can be expected in bunded and non-bunded fields were simulated. The results of the study showed that soil bunds can increase the production of rain-fed lowland rice in the region when the soil profile is slow drainage. With such soils, it was estimated that normal years are expected to have a minimum yield increase of 30 percent with use of bunds. On the other hand, wet years combined with soils that hardly drain, the increase in yield attributed to bunding was estimated to reach 60 percent, while in dry areas increase in yield was estimated to be mostly 10 percent. In addition, the study concluded that extension services have been making calls to promote on-farm rain water harvesting techniques one of which is construction of bunds to store excess water in rice fields in lowland rain fed area. This helps conserve water which the crop may use in times of water stress, resulting in higher yield. However, the practice is not yet adopted by most of the farmers because of lack of awareness of the importance of bunds in relatively flat areas, lack of specific guidelines for where to apply it and the labor intensity of the construction of bunds (Raes, et al., 2007).

A different approach was taken in a study on rice production in Sukumaland (Meertens, *et al*., 1999). In providing a detailed description of rice cultivation in the area, they discussed the several aspects of rice production some of which are crop establishment methods, cultivars grown in the area and constraints to rice production. The study concluded that most farmers from low population densities in Sukumaland used broadcasting method when sowing their rice while farmers from densely populated areas used transplanting method. Other farmers used a combination of broadcasting and transplanting by broadcasting large amounts of seed in upper slopes of their fields (which are the first to receive runoff water) so that excess seedlings can be transplanted to lower fields. It is further observed that very few farmers in this area used line sowing method (Meertens, *et al*., 1999). From this, it can be observed that farmers are using both GAP and no-GAP farmer practices which have an effect on yield. Hence the need to consider a study to find out which practices are economically viable for the farmers and to find out factors affecting farmersô adoption of GAP.

In terms of varieties, the study revealed that farmersô choice of varieties was mostly determined by water circumstances in their fields. The most prevalent rice varieties in the 1990ôs in Sukumaland were Super, Rangi mbili, Pishauli, Sindano, Faya, Kahogo, Tondogoso, Lugata; all of which are traditional varieties.

In the same study, it was found out that farmers in the region were able to get high yield of rice of up to 3-4 tons per ha despite farmers applying almost no fertilizer. This, at that time, indicated that most rice fields had satisfactory natural fertility. However, it was observed that in the future, farmers especially those with areas having sandy soils, would have to start applying nutrients to their rice fields for them to reach the yields of 3-4 tons per ha (Meertens, *et al*., 1999). This gives an indication of how soil fertility in the region was projected to decline overtime.

Following farmersô complaints about decreasing yields of rice in Sukumaland, another study was carried out on soil fertility research from 1990/1991 to 1995/1996 growing seasons in western Maswa district (Meertens, *et al*., 2003). The objective of the study was to test if the use of farmyard manure and mineral fertilizers could significantly, and profitably, increase rice yields. Results from the study showed that low dose of nitrogen of 30kg ha^{-1} in the form of urea, applied at maximum tillering, to flooded rice fields increased grain yield significantly with average increase in rice yield ranging between 463 kg ha^{-1} and 986 kg ha^{-1}. The study further showed that application of 30 Kg of nitrogen ha^{-1} to rice was more economically attractive to farmers with marginal rate of return of 125 percent than application of 60 Kg or 120 Kg of Nitrogen ha^{-1} which had marginal rate of returns of 15 percent and 8 percent respectively in Katunguru village of Sengerema district in Mwanza region (Meertens, et al., 2003).

From these studies, it can be argued that rice yield in Tanzania can be improved with farmersô adoption of, bunding, use of improved cultivars and use of fertilizer. However, there is need to test combinations of improved cultivars, nutrient, weed and bunding/ non-bunding technologies under GAP.

2.5 Economic Benefits of GAP to Farmers

For a GAP approach to succeed, it must meet the demands of agro ecological as well as socio-economic circumstances (Giller, *et al*., 2010). Use of GAP increases the chances that farmers have higher profits and healthier harvests (IRRI, 2010). Increase in productivity can be achieved by better agronomic management such as more timely planting and weeding which increase the efficiency with which available nutrients, water and labor are used (Giller, *et al*., 2010). Thus, through use of GAP, farmers can improve rice production which will eventually improve their income since they depend on such crops for consumption as well as income generation. For instance, gross margin (GM) analysis on three major crops: namely, rice, maize and cotton in Maswa district in Tanzania showed that rice had the highest economic benefits in terms of its contribution to the welfare of the poor households with financial returns sufficient to comfortably pay a minimum wage of TSH 55,000 for each month to each family member for over four months for an average family size of six (Ngailo, *et al*., 2007). Thus, GAP in rice production will help farmers, mostly those in rural areas tackle the problem of hunger and poverty.

Another economic benefit of adoption of GAP is that it can lead to the reduction of some production costs. Improved agricultural practices that reduce wastage or result in more efficient use of labor or other farm inputs can reduce average costs which are an economic incentive for farmers to adopt such practices (Hobbs, 2003). This is one aspect that GAP addresses by increasing the efficiency of the use of resources such as labor, water and fertilizer. For instance, by practicing direct seeding of rice (which is a component of GAP in rice production), farmers are able to save water, reduce labor cost involved with transplanting which is of greater benefit to women (IRRI, 2009). In this case, GAP can help rice farmers produce more with the limited resources. Thus, adoption of GAP in rice production is likely to help lift farmers and their communities from hunger and poverty.

2.6 Limitations to the Adoption of GAP by Farmers

Factors such as finance and time, influence farmers to try new technologies, especially if such considerations involve external inputs that are expensive or difficult to obtain (Glover, 2010). These factors may limit farmersô adoption of GAP. For instance, recent studies in Madagascar have shown slow adoption of SRI and high dis-adoption rates (40 percent), mainly because the method requires additional knowledge and is labor intensive (Moser and Barrett, 2003). In this regard therefore, it is important to ensure that the gains from the use of GAP outweigh the increases in costs so as to make GAP attractive to farmers.

2.7 Training on Farming Practices

Many new technologies considered effective have not been successful in alleviating the associated sustainability problems, because of poor adoption by targeted users (Subedi, *et al*., 2009). One of the possible reasons for this is usersô lack of understanding of the new technology. One requirement to be met for small scale farmersô implementation of GAP is that they need to be adequately informed about these practices (FAO, 2008) because farmersô awareness is the first key stage to adoption of new technology (Subedi, *et al*., 2009). Adoption decision is a process that extends over a certain period of time, from awareness about the technology to actual uptake which holds true in particular for knowledge-intensive system technologies (Noltze, *et al*., 2012). A study on economics of adoption and management of alley cropping in Haiti, showed that farmer training in soil conservation practices, favorably influenced adoption of those practices by the farmers (Bayard, et al., 2006).

Farmers need to have training to improve knowledge, attitudes and skills on better farming practices in order to increase productivity and alleviate poverty in rural areas (Kebede, 2010). A study on diffusion of biotechnology in Cotton in China showed that training helped farmers to change their cotton bollworm spraying practices (Lifeng, *et al.*, 2007). Also, after undergoing training in GAP and being exposed to demonstration fields, 335 farmers applied some or the entire GAP over an area of 609 hectares in 11 districts of An Giang, Vietnam in which 4 out of the 11 districts recorded profit increase of USD 208 per hectare of rice yield (IRRI, 2009). This clearly shows how important training can be in transferring knowledge about farming practices to farmers.

There are a number of ways of imparting knowledge on agricultural practices to farmers. These include, but are not limited to, farmer field schools (FFS) (Yang, *et al.*, 2008; David and Asamoah, 2011), lecture (Yang, *et al.*, 2008), television, radio, extension services and demonstration. For instance, a study in East Africa showed that FFSs had positive impact on crop production and income among women, low-literacy, and medium land size farmers with an estimated 61 percent increase in income attributed to farmersô participation in FFS (Davis, *et al.*, 2011). Whatever mode of knowledge transmission is used, it is necessary to make sure that farmers are actively involved. The intensity of participation during training increases the probability of farmersô adoption of new farming practices (Kijima, *et al.*, 2010; Noltze, *et al.*, 2012).

Thus, by being involved, farmers are likely to get a better understanding of the GAP, how to use GAP and the benefits of GAP adoption.

Compared to lecture method, FFS is more effective in training farmers. A study on effects of FFS and the classroom lectures training on acquisition of pest management knowledge and skills by small vegetable farmers in Yunnan province in China found that there were significant gains of knowledge about vegetable pests, natural enemies, insect and disease ecology and pest management among FFS farmers, but there were no significant improvements of knowledge among farmers trained using lecture method (Yang, *et al*., 2008). This could possibly be because of limited farmer involvement in lecture method which deprives them of the chance to test the new technology. However, considerable time and resources are needed for testing new technologies which justifies the usefulness of comparatively quick and less resource demanding options for awareness creation (Subedi, *et al*., 2009) which makes lecture method still an important method for imparting knowledge to farmers.

The need to find out if knowledge has been imparted to farmers cannot be overemphasized. Awareness and knowledge of a new technology is the first step in the process of adoption (Rogers, 1995). This is the case especially for interventions that are skill or knowledge based (David and Asamoah, 2011). Thus, farmersô knowledge of agricultural practices would be a reasonably good predictor of success in adoption of the practices and an indicator of the quality of training (David and Asamoah, 2011). For instance, a study in Greece found that lack of knowledge was one of the important reasons for not adopting tree planting (Kassioumis, *et al*., 2004). Also, a study to find out factors affecting farmersô adoption of improved technologies in Yunnan Province, China showed that awareness among farmers about the technology and their testing contributed positively to the adoption of the technology (Subedi, *et al*., 2009).

2.8 Factors Affecting Farmers' Adoption of Technology

It is rare that all farmers are able and willing to adopt new technologies due to constraints that they face (Mariano, et al., 2012). Understanding hindrances to technology adoption is a vital step in strategic dissemination of farm technologies (Mariano, et al., 2012). Farmersô adoption of new technology is affected by several factors. In broad terms, these factors include, but are not limited to, government policies, technological change, market forces, environmental concerns, demographic factors, institutional factors and delivery mechanisms (Wabbi, 2002).

Chapter 3

Materials and Methods

1.1 Study Design

The study followed a stratified design with two locations purposively selected. The two locations represented the two major rice growing ecologies; irrigated and lowland rain fed. Within the two locations, rice farmers were the subjects under consideration.

1.1.1 Study Sites

The study was conducted in Dakawa and Bagamoyo. Bagamoyo is located in Coast region. It is located at 6° 26N South and 38°54N East. It lies 70 km north of Dar-es-Salaam on the coast of the Indian Ocean, close to the island of Zanzibar. It represents the irrigated ecology. On the other hand, Dakawa is situated at 7° 26' 0" South and 37° 42' 0" East in Morogoro region. Morogoro region is one of the major rice producing regions in Tanzania. The site represents the lowland rain-fed ecology. Lowland rain fed rice is the most common production system in south eastern Tanzania (Raes, *et al.*, 2007). These sites are considered to have high potential for rice productivity growth (Kijima, *et al.*, 2012). Priority areas for rice production in Tanzania are irrigated lowland, rain-fed lowland and upland ecosystems, respectively (GoT-NRDS, 2009). Thus, these two study sites represent the two high priority areas for rice production in Tanzania.

1.1.2 Sample Size and Sampling Procedures

A survey was carried out in the two study sites for the 2012 production season. The survey involved 160 farmers in which 80 farmers (40 from each site) attended GAP training by AfricaRice and IRRI in 2011 and 80 farmers (40 from each area) did not attend training. A sample size of 160 was considered to ensure that the number of trained farmers was the same as that of untrained farmers. Selection of farmers who attended training in 2011 was done using purposive sampling frame followed by simple random sampling. Purposive sampling frame was used in identifying farmers involved in rice production. Having come up with the list of rice farmers, simple random sampling was used to select the 80 farmers using the random number generator in SPSS. A group of 40 farmers was chosen for each site because it was manageable enough to attend training in one room and resources available could not permit for more than 40 farmers. In addition, a group of 40 farmers would allow for statistical inferences to be made.

Apart from the trained farmers, eighty famers (forty from each site) were selected in 2012 to make up the control group. These farmers were selected using purposive sampling followed by simple random sampling in the same way as applied in selection of farmers who attended training. The only difference is that in selecting these farmers, names of trained farmers were excluded from the sampling frame. Farmers in the control group did not get the training that the other group received in 2011.

1.1.3 Data Collection

Survey data was collected using a structured questionnaire (Appendix 2). The questionnaire was adapted from AfricaRice GAP project questionnaire because data collected in this study will form part of that project. The questionnaire was pretested in Dakawa and Bagamoyo using farmers who were not part of the selected sample. The extension workers from the two sites were the enumerators. They received training for three days in which the first training took place before pretesting; second training during pretesting and final training was done after pretesting using the final version of the questionnaire.

To improve data quality, the questionnaire was split into two sessions so that each farmer was visited twice. The first round of the survey involved collection of data which was not time sensitive which included household structure, inventory of agricultural equipment, inventory of household livestock, financial transactions, agricultural training, knowledge and use of rice varieties, information on farmersô plots and rice productivity constraints. This was conducted while the rice growth season progressed so as later to allow the collection of time sensitive data like labor data yield which could not be collected when the first round was done. The second round of the survey involved collection of data on inputs used per plot, farmer contact with extension workers during the growing season, management practices at plot level, labor use, rice yield and marketing and agricultural production and use of other crops other than rice.

During the survey, data on actual farming practices for the 2012 production season (budget constrained choices) for trained farmers were collected. Untrained farmers were surveyed to find out treatment combinations that they would select from those that were in the experiment (unconstrained choice). Further to this, data on their actual farming practices (budget constrained choice) in 2012 were collected. This was done so that results could be compared with those obtained from trained farmers.

During data collection, there were several challenges faced which led to reduction of sample size from 160 to 137. At Bagamoyo, 2 untrained farmers who had been sampled had left the place by the time the survey was being done. It was difficult to find replacement because the list that had been obtained already included all farmers at the irrigation scheme limiting the number of untrained farmers at Bagamoyo to 39 instead of 40. As for trained farmers at Bagamoyo, 4 farmers had left the place by the time the survey was being conducted, 2 farmers had passed on and there was no other person who was cultivating their rice plots, 4 farmers did not grow rice in 2012 season. In addition, 1 farmer was interviewed in the first survey but had left the site by the time the second survey was being conducted. These factors reduced the number of trained farmers from 40 to 29.

The challenge experienced at Dakawa was that 11 trained farmers were not available. Some of the trained farmers originally came from distant areas and they had been cultivating rice at Dakawa. By the 2012 growing season, they had left Dakawa and gone back to their original homes. Additionally, some of those farmers initially came to Dakawa as casual laborers. Having spent some years there, they started cultivating their own rice fields too and got sampled during training in 2011 but they had left the site for other villages by 2012 growing season. Due to these factors, the total number of farmers interviewed at Dakawa reduced from the proposed 80 to 69 in which 29 were trained farmers and 40 were untrained. Thus, the combined total number of farmers interviewed was 137.

1.1.4 Experimental Treatments

Experiments were conducted in 2011 season, at the Bagamoyo site located in the Bagamoyo Irrigation Development Project (BIDP) and at Dakawa site located close to the Dakawa Research Centre (DRC). Crop establishment method, cultivars, nutrient and weed management were the five treatments tested at Bagamoyo with a factorial arrangement. Similarly, five treatment combinations of crop establishment, bunding/ non-bunding, weed management, nutrient management and cultivars were tested at Dakawa. The experiment included farmer-practices (FP) and GAP for each treatment as shown in Table 2.

Table 2. Treatments Tested in the Experiments at Bagamoyo and Dakawa

Treatment	Bagamoyo	Dakawa
Bunding/ Non-bunding	Not tested	1. Bunding (GAP) 2. Non-bunding (FP)
Establishment method	1. Direct seeding (FP) 2.Transplanting (GAP)	1. Broadcasting (FP) 2. Line sowing (GAP)
Nutrient management	1. 57.5N/ha of Urea per ha 15 days after planting (FP) 2 .120-60-40 (N-P-K 2 splits) (GAP) 3. 120-60-40 (N-P-K 3 splits) (GAP)	1. No fertilizer (FP) 2. 80-40-40(N-P-K 2 splits) (GAP) 3. 80-40-40 (N-P-K 3 splits) (GAP)
Weed management	1. Manual weeding (FP) after 30 days 2. Pre-emergence herbicide and weed after 30 Days (GAP)	1. Manual weeding after 30 days (FP) 2. Pre-emergence herbicide and weed after 30 Days (GAP)
Cultivars	1. Saro 5 (FP and GAP) 2. TXD 307 (GAP) 3. IR05N221 (GAP)	1. Saro 5 (FP and GAP) 2. IR05N221 (GAP)

1.1.5 Farmer Training

Apart from the experiment, there was farmer training at the two study sites in 2011 in which a total of 80 farmers were trained in GAP, 40 from each site. The training took the form of a lecture on GAP conducted over one day coupled with field visits to the experimental sites.

1.1.6 Criterion for Determining GAP Adoption

A farmer was considered to have adopted GAP if he or she had used at least two of the components of GAP presented in Table 2 in the 2012 growing season. A minimum of two components was chosen considering that farmers may be constrained and fail to adopt all components at once. Most farmers are unable to adopt the whole package of technology at once but rather they adopt some of the components of the technology in a step-wise manner (Mariano, *et al*., 2012). Due to possible constraints that may hinder farmersô adoption of all five components, a minimum of two components was considered with a view that after some years farmers will be able to adopt all the five components.

Factors that the study considered to influence GAP adoption included age of household head, gender of household head, education level of household head, household labor, farm size for rice, credit access, access to extension service, ownership of agricultural equipment, ownership of livestock, farmerös membership to farmer organizations and a composite variable for constraints experienced on the rice farm. The composite variable for constraints was a scoring based on constraints that farmers indicated that they face on their rice fields. These constraints were those that would directly influence farmersô decision to adopt GAP or not. Table 3 summarizes the explanatory variables which were considered in this study.

Table 3. Description of Explanatory Variables

Variable	Description	Variable Scale for dummies	Direction
Gender	Sex of the farmer	1= male; 0= female	(+)
Age	Age of the farmer in years	1= Ò35 years; 0= >35	(-)
Credit	Farmerôs access to credit for use in rice production	1= farmer has access to credit 0= farmer does not have access to credit	(+)
Labor	Number of persons in a household who are at least 15 years old	0= Ò3 household members 1= >3 household members	(+)
Farm	Land size for rice production in ha		(+)
Extension	Farmerôs access to extension services	1= farmer has contact with extension officers (at least 2 times in 2012 season) 0= farmer does not have contact with extension officers (less than 2 times)	(+)
Organization	Farmersô membership to farmer organization which is a dummy variable	1= farmer is a member of farmer organization 0= farmer is not member of farmer organization	(+)
Value	Total value of livestock and agricultural equipment owned by a household	0= ÒTSH 100,000 1= > TSH 100,000	(+)
Train	Farmerôs training in GAP	1=farmer got training in GAP 0= farmer did not get training in GAP	(+)
Constraint	A composite variable for constraints experienced on the rice farm.	0 = low constraint 1= high constraint	(-)
Education	Number of years of formal education	0= Ò4 years 1= >4 years	(+)

There are some variables whose effect on adoption was expected to be positive while others were expected to have a negative effect (Table 3). The choice of explanatory variables and expected regression signs was guided by intuition and by literature on other adoption studies. For instance, a study on farmersô adoption of certified seed technology in Philippines found that farm size, access to credit, farmersô attendance at on-farm demonstrations, farmersô access to extension services, farmersô attendance at training sessions and farmerõs formal education had a positive significant influence while biophysical constraints faced by farmers were impediments to farmersô adoption of the technology (Mariano, et al., 2012).

A study on the role of education and extension in the adoption of technology in Brazil found that farmersô education level had a positive impact on adoption of technology (Strauss, *et al.*, 1990). In a study on non-tillage technologies in cotton-wheat farming system in Pakistan, findings showed that among other factors, education level of the farmer and contact with extension agents were main factors that influenced farmersô uptake of the technology (Sheikh, *et al.*, 2003). The same study showed that farm size and contact with extension agents had a significant influence on farmersô uptake of non-tillage technologies in rice-wheat farming system.

A study on adoption of agroforestry in Malawi found that the probability of a farmer adopting agroforestry technology decreased by 6 percent as the household head grew older than 35 years (Thangata and Alavalapati, 2003). The same study found that the probability of adopting agroforestry increased by 2 percent with greater extension contact, and the probability of adopting agroforestry increased by 2 percent as the number of active people in the household increased by one person. Furthermore, other studies have found that the size of household labor influence adoption of agricultural technology (Feleke and Zegeye, 2006; He, *et al.*, 2007; Isgin, *et al.*, 2008; Mariano, *et al.*, 2012).

1.2 Analytical Procedure

Data analysis was done using SPSS and R 2.13.1 statistical packages. Microsoft Excel was used in generation of graphs. Statistical analysis involved use of McNemar test, Chi-square test and fitting of logistic regression.

1.2.1 McNemar Test

The McNemar test is a non-parametric method which is applied on nominal data. It is used to test the equality of binary response rates from two populations in which the data consist of paired, dependent responses (Mehta and Patel, 2010). It is used in a situation where there are repeated measurements in which responses from subjects are obtained twice, first response before treatment and second response after treatment. In this study, the treatment was training on GAP. Farmersô choices of GAP components before training and after training were subjected to McNemar test to determine equality of the two response rates.

Using the MacNemar test, the following comparisons were made:

I. Trained farmersô unconstrained choices before training with trained farmersô unconstrained choices after training. This was used so as to determine if there was an effect of training on the farmersô knowledge on GAP. In this comparison, significant difference in the choices before training and after training has been attributed to training.

II. Trained farmersô unconstrained choices after training in 2011 with trained farmersô unconstrained choices in 2012. This was used to determine if there were differences in farmersô choices with time.

III. Trained farmersô unconstrained choices after training with trained farmersô constrained choices in 2012 (actual practices). This was aimed at finding out if farmers were really practicing what they said they would do after training. This comparison also helped determine the degree to which farmers are constrained in their choices assuming the unconstrained choices are what they would like to do.

1.2.2 Pearson Chi-square Test

The Pearson Chi-square test is suitable for testing effect of one categorical explanatory variable on a dependent variable in which the observations made are independent of each other. In this study, the explanatory variable was farmer training (Trained or Untrained) and the dependent variable was farmersô choice of GAP. Thus, the Chi-square test tested the hypothesis that there is no association between training and choice of GAP. It was used to determine if there was equality in trained farmersô choices of GAP and untrained farmersô choices on the same. Differences in choices between the two groups were attributed to training that the other group received. The Chi-square test was used to compare trained farmersô constrained and unconstrained choices with those of untrained farmersô.

1.2.3 Logistic Regression

The Logistic regression is used to model response variables that have a binomial distribution. It describes the relationship between explanatory variables ($□_□$) and response variable (□) where

$$□ = \frac{□}{□} \text{é é é é é é é é é é é é é é é é} \quad (3.1)$$

in which p is probability of success, x is number of successes and n is number of independent trials.

Farmers' adoption of GAP followed a binomial distribution specified as:

$$Y_i = \begin{cases} 1 & \text{[illegible]} \\ 0 & \text{[illegible]} \end{cases}$$

The probability that a farmer i adopts GAP is $p = P(Y = 1)$ while the probability that a farmer i does not adopt GAP is $1 - p = P(Y = 0)$. We model the probability that a farmer adopts GAP as a function of predictor variables. The two models widely used in adoption studies are the Logit and Probit (Sheikh, *et al.*, 2003; Mariano, *et al.*, 2012). The advantage of using logistic model is that it enables meaningful interpretation of the results since probability is bound between 1 and 0. Having coded the response variable into 0's for non-adoption and 1's for adoption, a logistic regression model was fitted using R statistical software. Let Y be the decision to adopt GAP and let X be a vector of explanatory variables relating farmers' adoption of GAP. Then, farmers' decision to adopt GAP is specified by

$$Y = f(X, \varepsilon) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3.2)$$

where Y follows a binomial distribution and ε is an error term with logistic distribution. The logistic regression with binomial family takes the form:

$$\text{logit}(p) = \log_e(p/1 - p) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(3.3)$$

Where p is the probability that a farmer adopts GAP. $\text{logit}(p)$ is the link function that ensures that the predicted values will be between 0 and 1. The logits of the unknown binomial probabilities are then modeled as a linear function of the predictor variables as specified below

$$logit(p) = \ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots\ldots\ldots\ldots + \beta_n X_n \ldots\ldots\ldots\ldots\ldots\ldots (3.4)$$

For better interpretation of results, anti-logarithm of equation 3.4 is taken which gives equation 3.5.

$$\left(\frac{p}{1-p}\right) = \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots\ldots\ldots\ldots.. \beta_n X_n) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (3.5)$$

β_i are coefficients to be estimated

X_i are explanatory variables

$\left(\frac{p}{1-p}\right)$ is the odds of success. This is the chance of a farmer adopting GAP against farmer not adopting GAP.

The method of Maximum Likelihood is then used to estimate the unknown parameters (β_i).

Chapter 4

Results and Discussion

4.1 Household Characteristics

In Bagamoyo, there were more female respondents than males (Table 4 below). The situation was different in Dakawa

Table 4. Summary of Household Characteristics (%)

Characteristics	**Bagamoyo**			**Dakawa**		
	Male	Female	**Total**	Male	Female	**Total**
N	46	54	100	55	45	100
Age						
Ò35 Years	3	7	10	26	10	36
>35 Years	43	47	90	29	35	64
Education						
Ò4 Years	10	18	28	14	12	26
>4 Years	36	36	72	41	33	74
Labor						
Ò2	4	12	16	35	17	52
>2	42	42	84	20	28	48
Value						
Ò100,000	28	37	65	30	26	56
>100,000	18	17	35	25	19	44

where the proportion of males was higher than that of females. In terms of age, a larger proportion of respondents in both Bagamoyo and Dakawa were above the age of 35 years. A larger proportion of farmers in the two areas have at least 4 years of formal education. In Bagamoyo, a larger proportion of farmers have at least 3 household members who contribute to household labor with insignificant difference in proportions between male headed households and female headed households. In Dakawa, the proportion of farmers with at least 3 active household members was lower than that of farmers with less than 3 active members. Furthermore, the proportion of farmers with total value of livestock and agricultural equipment exceeding TSH100,000 was lower compared to that of farmers whose value was at most TSH100,000 in both Bagamoyo and Dakawa (See also Table 9).

4.2 Unconstrained Choices Before and After Training

Farmers were asked to make choices of selected farming practices that they would follow in rice production without regard to budget constraint. Farmersô choices before and after training were subjected to MacNemar test with results shown in Figure 1.

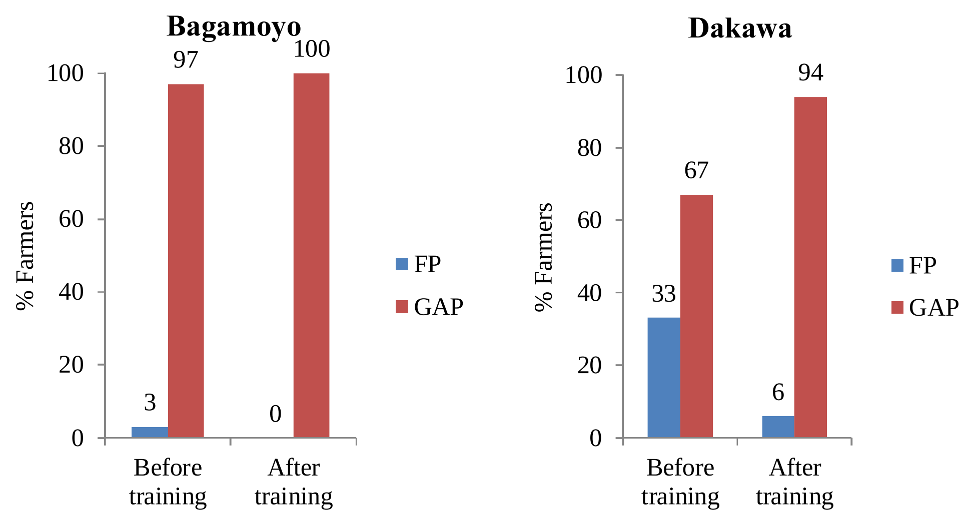

Figure 1. Farmersô Unconstrained Choices of Establishment Method before and after Training

At Bagamoyo, after training, all farmers indicated that they would plant their rice using the improved practice of transplanting method compared to 97 percent who chose the same before training (Figure 1). This result shows that farmers are already aware of use of improved practice in rice establishment in Bagamoyo. The insignificant change in farmersô choice of establishment method in Bagamoyo does not give a conclusive idea on the effect of training on farmersô unconstrained choice of establishment method because most farmers were already aware of the need for transplanting. The farmers in Bagamoyo indicated that they received training from various organizations like International Cooperation Agency (JICA) and government but this was not known *apriori.* In addition, most farmers might be aware of the improved practice because of continuous contact with extension workers at the irrigation scheme. Furthermore, farmers carry out their agricultural activities at the same time, thereby sharing ideas and learning from one another.

At Dakawa, shifts in farmersô unconstrained choices of establishment method from farmers practice to improved practice after training were significant (p-value <0.001). After training, 94 percent of farmers indicated that they would plant their rice using improved practice compared to 67 percent who chose the same before training (Figure 1). Thus, farmersô unconstrained choice of line sowing against broadcasting changed significantly after training. This implies that training had a significant influence on farmersô unconstrained choice of establishment method in Dakawa.

There were no significant differences in farmersô unconstrained choices of weed management before and after training at Bagamoyo (Figure 2). However, more than 60 percent of farmers chose the improved practice of combining pre-emergence herbicide and hand weeding before and after training.

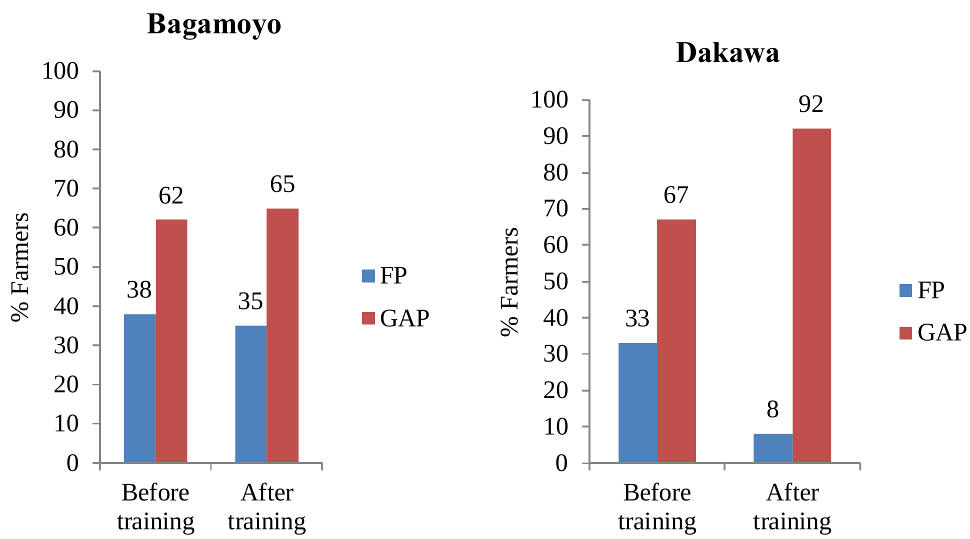

Figure 2. Farmersô Unconstrained Choices of Weed Management before and after Training

On the other hand, after training, 92 percent of farmers in Dakawa indicated that they would use pre-emergence herbicide compared to 67 percent who chose the same before training (p-value = 0.012). This implies that training influenced farmersô unconstrained choices towards the improved practice.

For nutrient management, GAP consisted of both the 2-split and 3-split fertilizer application methods. Figure 3 shows results of the MacNemar test for nutrient management in the two locations.

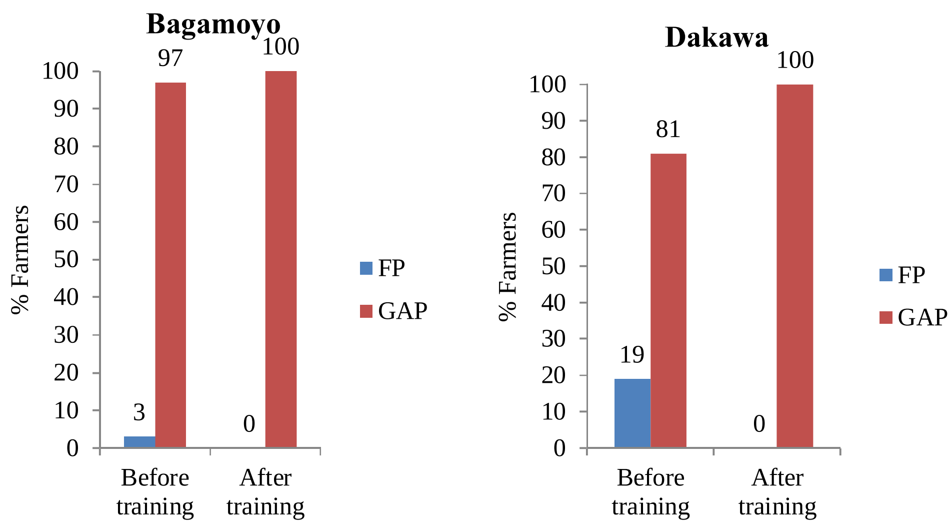

Figure 3. Farmersô Unconstrained Choices of Nutrient Management before and after Training

After training, all the farmers at Bagamoyo indicated that they would use the improved practice of nutrient management compared 97 percent who chose the same before training (Figure 3). This result gives an indication that farmers are already aware of the improved practice in Bagamoyo. The insignificant change in farmersô choice of nutrient management in Bagamoyo does not give a conclusive idea on the effect of training on farmersô unconstrained choice of nutrient management since most of them were already aware. Similar to the results on establishment method, this can be attributed to the fact that farmers in Bagamoyo had received training from other organizations before the experiment was conducted which was not known *apriori.*

In Dakawa, after training, all farmers indicated that they would use the improved practice compared to 81 percent who chose the same before training (p-value = 0.016). Thus, farmersô unconstrained choice of fertilizer application changed significantly after training. Farmers were more likely to choose the improved practice after training.

This result implies that there was a significant influence of training on farmersô unconstrained choice of nutrient management in Dakawa.

Farmers in Dakawa were asked to make unconstrained choice of bunding/ non-bunding method before and after training. Results of this comparison are given in Figure 4.

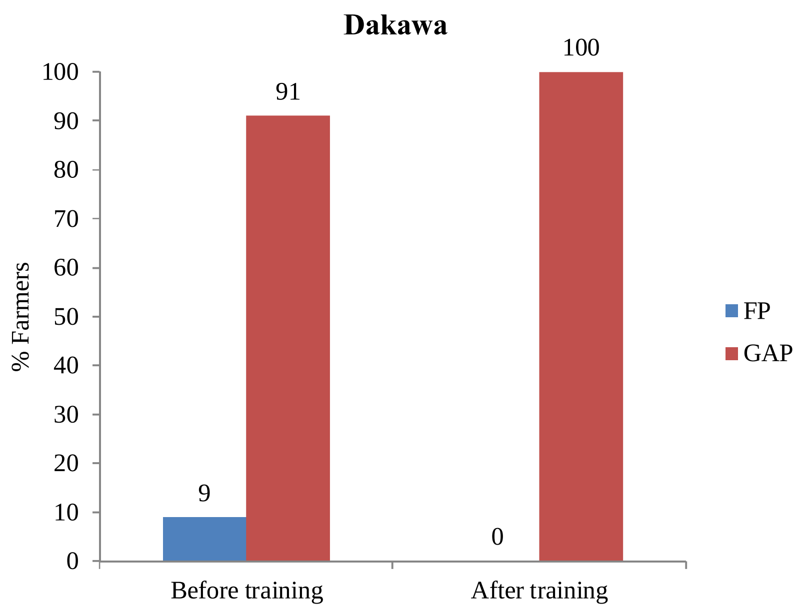

Figure 4. Farmersô Unconstrained Choices of Bunding/ Non-bunding Method before and after Training at Dakawa

At Dakawa, after training all farmers indicated that they would use improved practice of bunding method in their rice fields compared to 91 percent who chose the same before training (Figure 4). However the change in response rate was not significantly different. This implies that farmers in Dakawa are already aware of the improved practice of bunding.

4.3 Comparison of Trained Farmers' Unconstrained Choices after Training in 2011 and in 2012 Season

Trained farmersô unconstrained choices of agricultural practices after training in 2011 were compared with their unconstrained choices in 2012 season. Results of MacNemar test for this comparison are given in Table 5.

Table 5. Trained Farmersô Unconstrained Choices after Training and in 2012

Treatment	2011		2012		p-value	
	B	D	B	D	B	D
Establishment method	100	83	100	79	-	0.625^{ns}
Weed management	63	91	3	69	0.001**	0.453^{ns}
Nutrient management	100	100	100	86	-	0.701^{ns}
Bunding/ Non-bunding	Not tested	100		93		0.529^{ns}

B Bagamoyo, D Dakawa, ns not significant, ** significant at 0.01 Ð level,

There were no significant differences in trained farmersô unconstrained choices in establishment method and nutrient management in Bagamoyo (Table 5). An interesting result is observed in farmersô unconstrained choice of weed management method. After training in 2011, over 60 percent of the trained farmers in Bagamoyo indicated that they would use the improved practice of weed management. However, in 2012 only 3 percent of the trained farmers indicated that they would use the improved practice of weed management (p-value =0.001). This shows that there has been a significant change in farmersô unconstrained choices overtime. Further discussion regarding this inconsistency is discussed in subsequent comparisons. On the other, there were no significant differences in farmersô unconstrained choices of farming practices after training and in 2012 in Dakawa. This shows that farmers in Dakawa still remembered the improved practices which they were made aware during training.

4.4 Comparisons of Trained and Untrained Farmers' Unconstrained Choices

Trained farmersô unconstrained choices of farming practices were compared to those of untrained farmers using the Chi-square test. In this comparison, a random sample of 58 untrained farmers was chosen from the main sample so that the comparison was balanced since there were 58 trained farmers in 2012. Table 6 shows the results of this test.

Table 6. Trained and Untrained Farmersô Unconstrained Choices of GAP

Treatment	Trained		Untrained		Total		Chi-square		p-value	
	B	D	B	D	B	D	B	D	B	D
Establishment Method	100	79	100	73	100	76	-	0.756	-	0.279ns
Weed Management	3	69	0	51	2	60	2.09	2.482	0.421ns	0.092ns
Nutrient management	100	86	100	80	100	83	-	0.172	-	0.472ns
Bunding/ Non-bunding	Not tested	93		66		80		6.478		0.011*

B Bagamoyo, D Dakawa, ns not significant, * significant at 0.05 Ð level

At Bagamoyo, there were no significant differences between trained and untrained farmersô unconstrained choices of establishment method, nutrient management and weeding management (Table 6). All trained farmers and all untrained farmers indicated that they would use improved practices in establishment method and nutrient management. This implies that farmers in Bagamoyo are already aware of the improved practices for establishment method and nutrient management. This result is consistent with the earlier observations for the constrained and unconstrained choices of the farmers before and after training. The awareness could be attributed to training received from other organizations as mentioned earlier.

An interesting result is observed in terms of weed management in Bagamoyo. Only 3 percent of the trained farmers indicated herbicide use as the unconstrained choice with no untrained farmer choosing it. Thus, there is no difference between the unconstrained choices of trained and untrained farmers in 2012 regarding weed management in Bagamoyo. However, both before and after training in 2011, more than 60 percent of the farmers indicated that they would use the improved weed management practice. Observations regarding this will be made when unconstrained choices are compared to actual practices for 2012.

In Dakawa, significant differences (p-value = 0.011) in unconstrained choices between trained and untrained farmers were observed in bunding/ non-bunding only (Table 6). Ninety three percent of trained farmers and 66 percent of untrained farmers indicated that they would use bunding method. This implies that training had an influence on farmersô unconstrained choice of bunding/ non-bunding method with more trained farmers likely to choose the improved practice compared to untrained farmers. There were no significant differences in farmersô unconstrained choices of establishment method, weeding method and nutrient method in Dakawa. In terms of establishment method, 79 percent of trained farmers and 73 percent of untrained farmers chose line sowing.

In addition, 69 percent of trained farmers and 51 percent of untrained farmers indicated that they would use herbicide and manual weeding. Comparison of unconstrained choices of nutrient management showed that 86 percent of trained farmers and 80 percent of untrained farmers would use improved nutrient management method. Based on these percentages, it can be argued that a relatively large proportion of farmers in Dakawa are aware of use of improved nutrient management in their rice fields which is consistent with earlier results of unconstrained choices.

4.5 Trained Farmers' Unconstrained Choices and Actual Practices in 2012

Trained farmersô unconstrained choices in 2012 were compared to their actual agricultural practices in 2012 growing season. This was meant to determine if farmers were actually practicing what they said they would do in their rice fields. Results for this comparison are given in Table 7.

Table 7. Comparison of Unconstrained and Actual Practices for Trained Farmers in 2012

GAP component	Unconstrained choice		Actual practice		p-value	
	B	D	B	D	B	D
Establishment method	100	79	100	14	-	<0.001***
Weed management	3	69	0	41	-	0.077^{ns}
Nutrient management	100	86	100	38	-	0.001**
Bunding/Non-bunding	Not tested	93		64		0.021*

B Bagamoyo, D Dakawa, ns not significant, * significant at 0.05 Ð level, ** significant at 0.01 Ð level, *** significant at 0.001 Ð level

In Bagamoyo, there were no significant differences in farmersô unconstrained choices and actual practices in 2012 (Table 7). All trained farmers whose unconstrained choices were improved practices in establishment and nutrient management methods actually used the improved practices in 2012 growing season. Similarly, despite 3 percent of farmers in Bagamoyo indicating that they would use improved practice in weed management, no farmer actually used it in 2012 growing season. This result may explain the inconsistency observed earlier in farmersô unconstrained choices of weed management before and after training in 2011 and then in 2012. It would be expected that the unconstrained choices of farmers before training, would have similar proportions to those of untrained farmers in 2012.

It was observed that both before and after training, more than 60 percent of farmers chose improved practice of weed management. However, in 2012 only 3 percent of trained farmers indicated that they would use improved practice in weed management with no untrained farmer choosing it. It is worth noting that in 2012, both the trained and untrained farmers were informed that a survey collecting information about their actual practices would be performed. The data on actual practices shows that almost all the farmers in Bagamoyo used the farmer practice irrespective of training.

Thus, it is possible that, given the knowledge that the unconstrained choices in 2012 were collected after farmers were made aware of the fact that actual practices would be collected later, this may have influenced the unconstrained choices to be closer to the actual practices. It is therefore possible that the true reflection of unconstrained choices was before training in 2011. These results suggest that either farmers need training in weed management practices or there are constraints to the adoption of the improved weed management practice. Most likely, farmers are constrained because they indicated knowledge about the improved practice even before training.

On the other hand, in Dakawa, there were significant differences in farmersô unconstrained choices and actual practices in 2012 in terms of crop establishment method (p-value <0.001), nutrient management (p-value =0.001) and bunding/ non-bunding (0.021). Despite 79 percent of trained farmers who indicated that they would use line sowing, only 14 percent farmers actually used it in 2012 growing season (p-value <0.001). This suggests that farmers are constrained which leads to failure to adopt the improve practices.

Also, 86 percent of trained farmers indicated that they would use improved practice of nutrient management and only 38 percent actually used it in 2012 growing season (p-value = 0.001). This suggests that farmers are constrained such that they fail to adopt improved practice of nutrient management despite showing awareness.

In addition, 93 percent of trained farmers indicated that they would use improved practice of bunding but only 64 percent actually used the improved practice in 2012 season (p-value = 0.021). This suggests that despite the large proportion of farmers who are aware on use of improved practice of bunding, some farmers are constrained such that they are not able to adopt it.

In terms of weed management, there were no significant differences between trained farmersô unconstrained choices and their actual practices in 2012.

4.6 Farmers' Adoption of GAP

Farmersô overall adoption of improved practices was defined as discussed earlier in methodology section. A farmer was considered to have adopted GAP if he or she had used at least 2 of the improved practices in 2012. Using this criterion, the percentage of adopters was determined. Table 8 summarizes percentages of farmers who adopted improved practices for each component with overall adoption indicated in the last row.

Table 8. Summary of Farmersô Adoption of GAP by Location

GAP component	**Location**	
	Bagamoyo	**Dakawa**
Establishment Method	100	13
Nutrient management	100	29
Weed management	1	38
Bunding/ Non-bunding	Not tested	52
Overall GAP Adopters	100	43

There was no variability in overall adoption of GAP in Bagamoyo in which all farmers interviewed adopted it (Table 8). This gives an indication that GAP was not the suitable intervention in this ecology since farmers are already practicing GAP. On the other hand, in Dakawa, only 43 percent of the farmers adopted the improved practices. This difference in adoption of GAP between the two locations could be attributed to differences in awareness of the improved practices. It has been observed in Figures 1 and 3 that farmers in Bagamoyo were already aware of the improved practices even before training, compared to those in Dakawa.

Another explanation for the higher adoption of GAP in Bagamoyo compared to Dakawa could be because of training from other organizations such as JICA and ministry of agriculture that farmers at Bagamoyo received. It was found out that, unlike farmers in Dakawa, farmers in Bagamoyo had been getting training in rice production from other organizations. This is because farmers in Bagamoyo operate within the same irrigation scheme thereby making it easier to organize them for training. In addition, higher adoption of GAP in Bagamoyo than Dakawa could be attributed to continuous contact between farmers and extension workers who manage the irrigation scheme. Thus, there is always information on use of improved agricultural practices given to the farmers as they work on their farms within the irrigation scheme. The situation is different in Dakawa where sometimes extension workers have to walk long distances in order to reach out to most of the farmers. This might be a setback in terms of information about GAP that farmers in Dakawa receive.

Furthermore, less adoption of GAP in Dakawa could be attributed to farmersô dependence on other crops apart from rice. The study concluded that apart from rice, farmers in Dakawa also grow other crops unlike in Bagamoyo where farmers grow rice only. Figure 5 gives a summary of other crops grown by farmers in Dakawa.

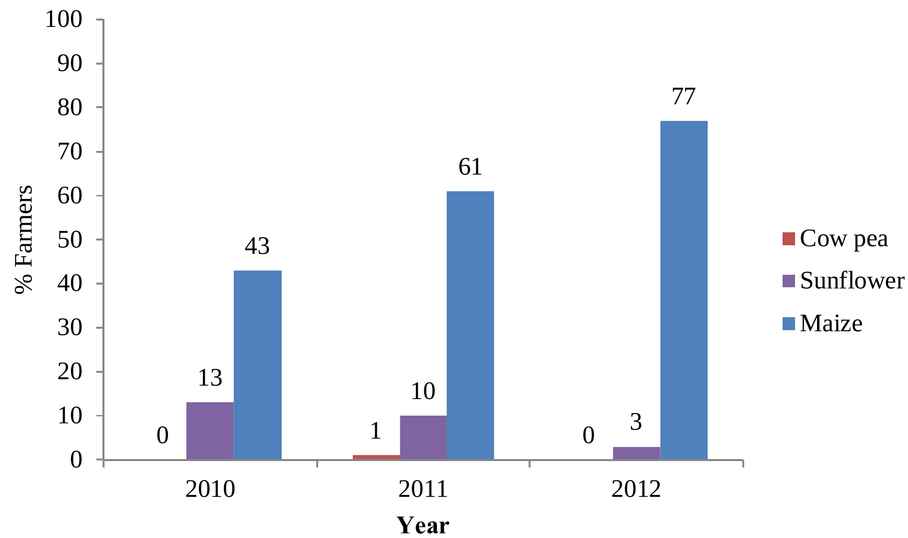

Figure 5. Percent of Farmers Growing other Crops apart from Rice in Dakawa

There has been an increase in percentage number of farmers growing maize in Dakawa (Figure 5). Since farmers in Dakawa have other crops to attend to in their fields, it is possible that there is less attention given to improved practices in rice production unlike in Bagamoyo where farmers have rice fields only to attend to. This is consistent with the findings that in lowland ecosystem, there is competition between rice and other food crops for land and labor (GoT-NRDS, 2009) thereby reducing adoption rate of the improved practices in rice production.

4.6.1 Logistic Model Fitting

Due to invariability in adoption of GAP in Bagamoyo, a regression model could not be fitted because the response was a constant. An alternative was to run a logistic regression for each GAP component for this site. However, establishment method and nutrient management had a constant dependent variable in which all farmers used improved practice. As such, a logistic model could not be fitted for these two components. Weed management had only a 1 percent success, thereby making it impossible to run a logistic regression because the number of adopters was very small for a logistic regression to be fitted. Due to these limitations, a regression model was not fitted for Bagamoyo.

In Dakawa, the highest percentage of adoption of improved practices was observed in bunding/ non-bunding with the least in establishment method. It must be pointed out that initially, the study was designed so that data from the two sites would be pooled together in running the regression analysis. However, with variability in GAP adoption observed in Dakawa only and not Bagamoyo, it clearly shows that the two sites are not homogeneous. Therefore, it was not possible to pool the data. A logistic regression was fitted for Dakawa only. A summary of GAP adopters at Dakawa is presented in Table 9.

Most adopters of improved practices were older than 35 years indicating that older farmers were more likely to adopt GAP than younger ones (Table 9). On the other hand, most of the adopters had more than four years of formal education suggesting that farmers who were more educated were more likely to adopt GAP than those who were less educated. Also, most adopters owned smaller land size for rice. In terms of total value of livestock and agricultural equipment, most adopters had their value greater than TSH100,000.

Table 9. Summary of GAP Adoption by Variable in Dakawa

Variable	**Adopters**	**Non-adopters**	**Total**
Age			
Ò35 years	10	15	25
>35 years	20	24	44
Education			
Ò4 years	5	13	18
>4years	25	26	51
Farm			
Ò1 ha	20	27	47
>1 ha	10	12	22
Value			
Ò100,000	13	39	52
>100,000	17	0	17
Labor			
Ò2	12	24	36
>2	18	15	33
Constraint			
High	21	26	47
Low	9	13	22
Train			
Trained	16	13	29
Untrained	14	26	40
Organization			
Yes	18	8	26
No	12	31	43
Gender			
Male	16	22	38
Female	14	17	31
Credit			
Yes	2	1	3
No	28	38	66
Extension			
Yes	4	7	11
No	26	32	58

In terms of household size, most adopters had more than two household members to assist with farm labor. Also, most of the adopters were trained farmers than those who were untrained. In addition, most of the adopters belonged to farmersô organizations which suggest that they were able to get information about GAP from such organizations. In terms of gender, most adopters were males. An interesting observation is made on farmersô contact with extension workers where most of the adopters did not have contact with extension workers, However, this observation could be explained by the total number of farmers who had contact with extension workers (11) and those who did not have contact with extension workers (58), Thus, already most of farmers did not have contact with extension workers.

To get a preliminary idea of the relationship between adoption and training, a Chi-square test was done on adoption against training. Results of this test are given in Table 10.

Table 10. Chi-square Test on GAP Adoption against Farmer Training at Dakawa

Adopters (%)		**Pearson Chi-square**	**p-value**
Trained	Untrained		
55	35	2.784	0.077[ns]

ns not significant

The Chi-square statistic was 2.784 with p-value of 0.077, suggesting that there is no evidence that training influenced farmersô adoption of GAP (Table 10). However, this is inconclusive in determining effect of training on adoption. Before fitting a logistic model, explanatory variables were tested for correlations and the results are given in Table 11.

Table 11. Test for Correlations of Explanatory Variables

	Age	Labor	Farm	Value	Organization	Train	Constraint	Extension	Credit	Gender	Education
Age	1										
Labor	**0.002****	1									
Farm	0.282	0.808	1								
Value	**0.005****	0.13	0.899	1							
Organization	0.188	0.483	0.71	0.97	1						
Train	0.212	0.166	0.246	0.38	0.3	1					
Constraint	0.988	0.791	0.58	0.25	0.88	0.521	1				
Extension	0.173	0.633	0.733	0.81	0.57	0.805	0.73	1			
Credit	0.916	0.066	0.957	0.38	0.88	0.135	0.19	0.448	1		
Gender	**0.033***	**0.044***	**0.044***	0.99	0.19	0.327	0.57	0.179	0.45	1	
Education	0.77	0.743	0.88	0.16	0.12	0.392	0.88	0.924	0.77	0.96	1

* Significant at 0.05 Ð level, ** significant at 0.01 Ð level

There were correlations between Age and Labor, Age and Value, Age and Gender, Gender and Labor, and Gender and Farm (Table 11). These were the least correlations observed having initially transformed some variables because at first, there were more correlations than the ones in Table 11.With these correlations in consideration, a logistic regression model was fitted without including two variables which are correlated. In this case, for instance, a model was being run with Farm without Gender, and then with Gender without Farm.

To avoid over-parameterization of the model, the maximum number of explanatory variables to be included in the model was set at 4. This is because the total number of successes for adoption was 30, thereby making it impossible to run a logistic regression with more than 4 explanatory variables. Different models were run using combinations of different explanatory variables with training included at each stage.

Results of different models were compared using AIC to identify the best fitting model. The best fitted model with the smallest AIC was one which had Organization, Labor, Value and Train with results given in Table 12.

Table 12. Results of Logistic Regression

	Df	Deviance	Resd. Df	Resd. Dev	P(>|Chi|)
Null			68	94.477	
Organization	1	11.462	67	83.015	0.001 ***
Labor	1	5.330	66	77.685	0.021 *
Value	1	4.191	65	73.495	0.041 *
Train	1	2.520	64	70.975	0.112^{ns}

ns not significant, * significant at 0.05 Ð level, *** significant at 0.001 Ð level

The Null deviance for the model was 94.477 on 68 degrees of freedom with Residual deviance of 70.975 on 64 degrees of freedom. The AIC was 80.975.

4.6.2 Factors Influencing Adoption of GAP

GAP adoption was significantly influenced by membership to farmer organization (p-value = 0.001), number of household members who contribute to household labor (p-value = 0.021) and value of livestock and agricultural equipment owned by a household (p-value = 0.041) (Table 12). There is no evidence supporting influence of training on GAP adoption. This is in agreement with results from Chi-square test above which suggested that there is no influence of farmer training on GAP adoption.

Despite insignificant influence of training on GAP adoption, earlier observations have shown that there is strong evidence pointing towards influence of training on farmersô awareness of GAP. Awareness of the technology is of great importance since it is the first step in the process of adoption (Rogers, 1995). Insignificant results relating training to GAP adoption may be attributed to the smaller sample size and/or the time taken from farmer training to the time that adoption has been studied. Since GAP adoption is more of a package, it could be argued that most farmers were unable to adopt the whole package of technology at once but rather they would adopt some of the components of the technology in a step-wise manner (Mariano, *et al.*, 2012).

In addition, considering the percentage of adopters, Table 10 has shown that a larger proportion of trained farmers adopted improved practices (55 percent) compared to that of untrained farmers (35 percent). Despite insignificant differences between these proportions, it is of interest from the perspective of further studies. A study on factors influencing farmersô adoption of modern rice technologies and good management practices in the Philippines showed that the probability of adopting the technology increased by 6 percent for farmers who attended training sessions (Mariano, *et al.*, 2012). In this case, it could be inconclusive to state that training does not influence farmersô adoption of GAP at Dakawa until a similar study is conducted after some years when farmers will have adopted most of the GAP components. Perhaps the influence of training can be observed after more than one season. On the other hand, even though training might influence adoption, there may be constraints to farmersô adoption of GAP

Due to insignificant influence of training on GAP adoption, a reduced model of Organization, Labor and Value was fitted. Results of this regression are given in Table 13.

Table 13. Results of Reduced Logistic Regression

	Df	**Deviance**	**Resd. Df**	**Resd. Dev**	**P(>|Chi|)**
Null			68	94.477	
Organization	1	11.462	67	83.015	0.001 ***
Labor	1	5.330	66	77.685	0.021 *
Value	1	4.191	65	73.495	0.041 *

ns not significant, * significant at 0.05 Ð level, *** significant at 0.001 Ð level

The Null deviance for the model was 94.477 on 68 degrees of freedom with Residual deviance of 73.495 on 65 degrees of freedom. The AIC was 81.495.

The reduced model accounted for 21.52 percent of total variation with AIC of 81.495 (Table 13). This percentage is relatively low suggesting that there is more variation which is unaccounted for. It may indicate that there are more variables influencing GAP adoption than just Organization, Labor and Value. A similar study on understanding the adoption of system technologies in smallholder agriculture found that household level characteristics alone were insufficient to explain observed adoption patterns. In the study, it was shown that several plot level variables such as availability of irrigation system, close proximity of a plot to a homestead, soil conductivity, loam content and slope had a significant effect on SRI adoption and the number of different SRI components used. The study suggested that relevance of plot level variables to explain adoption may also hold for other system technologies (Noltze *et al.*, 2012). Similarly, it could be argued that plot level characteristics could also influence farmersô adoption in Dakawa. Parameters for significant explanatory variables of the logistic regression were estimated with results given in Table 14.

Table 14. Parameter Estimates of the Reduced Logistic Regression

	Estimate	**Std error**	**z value**	**Pr(>|z|)**
Intercept	-2.197	0.614	-3.579	0.000 ***
Organization	2.194	0.645	3.400	0.001 ***
Labor	1.167	0.611	1.909	0.056 ^{ns}
Value	1.190	0.597	1.992	0.046 *

ns not significant, * significant at 0.05 Đ level, *** significant at 0.001 Đ level

Parameter estimates for Organization and Value were significant at 0.05Đ level while that for Labor was significant at 0.01Đ level despite analysis of deviance showing significance at 0.05 Đ level (Table 14). The model was tested by taking different samples of 60 cases out of the 69 to check if results were consistent with some of the results given in Appendix 1. Percentage predicted by the different models was consistent with the model above.

The anti-logarithms of each estimate from Table 14 were obtained to give the odds ratio. The odds ratio has been specified as $\left(\frac{p}{1-p}\right)$ where p is probability that a farmer adopts GAP and $1-p$ is probability that a farmer does not adopt GAP. The anti-logarithms of the parameter estimates and their respective 95 percent confidence intervals are given in Table 15.

Table 15. Anti-logarithms of Parameter Estimates of the Reduced Logistic Regression

	Estimate	**Anti-Log of estimate**	**2.5%**	**97.5%**
Intercept	-2.197	0.111	0.029	0.333
Organization	2.194	8.973	2.738	35.700
Labor	1.167	3.212	1.012	11.557
Value	1.190	3.288	1.051	11.266

Using the anti-log of parameter estimates, the final model fitted is:

$$\left(\frac{p}{1-p}\right) = e^{-2.197 + 2.194 * Organization + 1.167 * Labor + 1.190 * Value} \quad \ldots\ldots\ldots\ldots (4.1)$$

These findings imply that, holding labor and value constant, the odds of a farmer who belongs to a farmer organization adopting GAP increase by a factor of 8.97 against a farmer who does not belong to a farmer organization. A possible explanation to this is that farmers share information about rice farming in their organizations. In such a way, they learn on the need for using GAP in their rice farming.

As for labor, the Table shows that holding other variables constant, the odds of GAP adoption increase by a factor of 3.21 for farmers who have at least 3 household members who do farm work against farmers who have less than three active household members. This result could be explained by the fact that some of the components of GAP were labor intensive. For instance, line sowing is more labor intensive than broadcasting and most farmers use household labor for this. As such, farmers with more active household members are more likely to use line sowing than broadcasting.

A similar study on adoption of system technologies in smallholder agriculture under SRI in Timor Leste also showed that having one additional working age household member increases the SRI area by almost 0.05 ha (Noltze, *et al*., 2012). This is attributed to the higher labor requirement of the new SRI which is one example of GAP. Another study found that farmers with larger labor force were more likely to adopt improved maize varieties with each additional unit increase in the labor force increasing the odds of adoption by 33 percent (Feleke and Zegeye, 2006).

Similarly, a study on adoption of rainwater harvesting and supplementary irrigation technology by farmers in China found that for every 1 unit increase in household labor force there was 3.47 times increase in the probability of adoption of the technology (He, *et al*., 2007). A study on agroforestry adoption in Malawi found that an additional working member in a household increased the likelihood for adoption of the technology (Thangata and Alavalapati, 2003).

Lastly, holding other variables constant, the odds of GAP adoption increase by a factor of 3.29 for farmers whose value of livestock and agricultural equipment is at least TSH100,000 against farmers whose value is less than TSH100,000. Thus, the more the value, the more the chances of a farmer adopting GAP. The idea behind this is that value of livestock and agricultural equipment is a better proxy to measure how much income is disposable to agricultural activities by a farmer. This finding can be explained by the need for more money for labor and agricultural inputs due to some of the GAP components that were being tested. For instance, construction of bunds requires more labor that might need to be hired. In addition, farmers need money to buy fertilizer and pre-emergence herbicide. Compared to labor, purchase of herbicides and fertilizer are opportunity costs that farmers must use money. As such, chances are higher that farmers who have more value of livestock and agricultural equipment can afford to buy such inputs.

Chapter 5

Conclusions and Recommendations

This study was conducted in order to analyze the differences between unconstrained and constrained farmer choices of rice production practices and to assess whether training on GAP affects farmersô choices of rice production practices. In addition, the study examined factors influencing farmersô adoption of GAP in rice production.

Farmers at Bagamoyo were found to be already aware of improved practices regarding fertility management, establishment method and weed management. Using the criteria that a farmer who adopted two components of the practice under study was an adopter in Bagamoyo all farmers adopted GAP in rice production.. This awareness and 100 percent adoption rate could possibly be attributed to farmersô continuous contact with extension workers and training by other organizations. Despite awareness of improved practice of weed management, farmers in Bagamoyo did not use it in their rice fields suggesting that they may be constrained.

Despite awareness of improved practice of weed management, farmers in Bagamoyo did not use it in their rice fields suggesting that they are constrained. From these results, it can be concluded that GAP components which were tested in Bagamoyo are already what farmers are practicing. Possibly, consideration of as many GAP components such as pesticide use and post-harvest practices could be of greater benefit. The limited number of GAP components which were included in this study was determined by limited resources which were available for the project.

On the other hand, there was significant influence of training on farmersô unconstrained choices of nutrient management (p-value = 0.016) seed establishment method (p-value <0.001) and weed management method (p-value = 0.012) in Dakawa. Most farmers shifted from farmer practice to improved practices after the training in their unconstrained choices. These findings indicate the quality and effect of training on farmers (David and Asamoah, 2011). There were no significant differences in farmersô unconstrained choices of bunding. However, most farmers showed awareness of improved management practice of bunding both before and after training. Despite awareness of improved practices, most farmers did not use them in their rice fields in 2012 season. This is consistent with findings from a study that found that farmers in Kyela and Morogoro are aware of soil fertility depletion but they rarely use inorganic fertilizers because of poor fertilizer availability, high costs and low profits realized from their use (Kayeke *et al*., 2007). Another study in rain-fed lowland ecology in South Eastern Tanzania found that farmers were not using GAP of bunding because of labor force involved in the construction of the bunds (Raes, *et al*., 2007). Findings from other studies have also shown that appropriate GAP which are widely used in Asia are not commonly applied in SSA which is something that has been largely ignored (Balasubramanian, et al., 2007).

In Dakawa, 43 percent of farmers adopted GAP with 55 percent having been trained farmers and 35 percent untrained. Farmer organization (p=0.001), number of active household members (p= 0.021) and total value of livestock and agricultural equipment owned by a household (p=0.041) significantly influenced farmersô adoption of GAP. These results are consistent with findings from other adoption studies. For instance, number of household members who contribute to labor has been found to positively influence adoption of agricultural technology (Thangata and Alavalapati, 2003; Feleke and Zegeye, 2006; He, *et al*., 2007; Noltze, *et al*., 2012).

There was no influence of training on GAP adoption in Dakawa. This contradicts findings from other studies which have shown that training of farmers positively influences adoption of technologies (IRRI, 2009; Mariano, *et al*., 2012). However, the positive influence of training on farmersô awareness of GAP based on their unconstrained choices before and after training on GAP in Dakawa suggests that knowledge was imparted to farmers during training. It would be expected that with time, most trained farmers will be able to adopt GAP since awareness and knowledge of a new technology is the first step in the process of adoption (Rogers, 1995). In addition, farmers tend to adopt package-based technologies in a step wise manner (Mariano, *et al*., 2012). A similar study to find out factors affecting farmersô adoption of improved technologies in Yunnan Province, China showed that awareness among farmers about the technology and their testing both contributed positively to the adoption of the technology (Subedi, *et al*., 2009). Thus, farmersô awareness of GAP is a positive aspect which can help farmers adopt the improved practices.

Findings from this study suggest that farmer training is an important tool in disseminating information on GAP. This will help improve farmersô awareness of GAP and eventually improve GAP adoption. One of the implications for this is for research organizations and government to actively involve farmer organizations in disseminating information on GAP. More farmers have to be encouraged to join such farmer organizations and be actively involved. From the study, there is no evidence that training influenced farmersô adoption of GAP at Dakawa. However, the positive influence of training on farmersô awareness of GAP based on their unconstrained choices before and after training on GAP in Dakawa suggests that knowledge was imparted to farmers during training. If it was not for the considerations sited earlier, it would have been ideal to increase the sample sizes in order to minimize the challenges caused by dropouts.

Based on these findings, it is recommended that:

- ❖ Farmer training on GAP should emphasize on lowland rain-fed areas and irrigated areas where farmers are not trained in GAP. It would be important to have such farmer training for a couple of years while evaluating the groups after each growing season to check whether there is effect of training or not.
- ❖ More farmers be included in GAP trainings.
- ❖ Farmer organizations be encouraged and well structured
- ❖ Further studies specifically focused on determining factors influencing farmersô adoption of GAP in Tanzania be carried out. By carrying out such a study, it would help to get an insight into farmersô characteristics that improve chances of GAP adoption and those that reduce it. Consequently, corrective measures can be put in place if it is discovered that factors that improve GAP adoption are those that can be improved.
- ❖ More components of GAP, different from the ones considered in this study, to be tested in irrigated ecologies.

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Appendices

Appendix 1: Logistic regression Output

```
Call:

glm(formula = GAP1 ~ ORG + LBR + VAL + TRAIN, family =
binomial)

Deviance Residuals:

    Min       1Q   Median       3Q      Max

-2.0421  -0.6972  -0.3639   0.8811   1.8880

Coefficients:

                 Estimate Std.    Error      z value
Pr(>|z|)

(Intercept)       -1.7284         0.6713    -2.575
0.010030 *

ORG                2.1595         0.6539     3.302
0.000959 ***

LBR>=3             1.3909         0.6477     2.147
0.031756 *

VAL>100000         1.0835         0.6076     1.783
0.074555 .

TRAINUntrained    -0.9530         0.6097    -1.563
0.118031

---

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
' ' 1

(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 94.477  on 68  degrees of freedom

Residual deviance: 70.975  on 64  degrees of freedom

AIC: 80.975
```

```
Number of Fisher Scoring iterations: 4

> anova(rmod1,test="Chi")

Analysis of Deviance Table


Model: binomial, link: logit


Response: GAP1


Terms added sequentially (first to last)



          Df Deviance Resid. Df Resid. Dev P(>|Chi|)

NULL                         68     94.477

ORG        1  11.4622        67     83.015 0.0007102 ***

LBR        1   5.3296        66     77.685 0.0209658 *

VAL        1   4.1905        65     73.495 0.0406517 *

TRAIN      1   2.5202        64     70.975 0.1123985

---

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
' ' 1

> rmod2<-glm(GAP1~ORG+LBR+VAL+TRAIN,family=binomial)

> summary(rmod2)


Call:

glm(formula = GAP1 ~ ORG + LBR + VAL + TRAIN, family =
binomial)
```

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.0421  -0.6972  -0.3639   0.8811   1.8880

Coefficients:
                 Estimate Std. Error z value Pr(>|z|)
(Intercept)       -1.7284     0.6713  -2.575 0.010030 *
ORG               2.1595     0.6539   3.302 0.000959 ***
LBR               1.3909     0.6477   2.147 0.031756 *
VAL>100000        1.0835     0.6076   1.783 0.074555 .
TRAINUntrained    -0.9530     0.6097  -1.563 0.118031
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 94.477  on 68  degrees of freedom
Residual deviance: 70.975  on 64  degrees of freedom
AIC: 80.975
Number of Fisher Scoring iterations: 4
> rmod2<-glm(GAP1~ORG+LBR+VAL,family=binomial)
> summary(rmod1)

Call:
glm(formula = GAP1 ~ ORG + LBR + VAL, family = binomial)
```

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.2115  -0.7815  -0.4592   1.1100   1.6340
Coefficients:
                 Estimate Std. Error z value Pr(>|z|)
(Intercept)       -2.1967     0.6138  -3.579 0.000345 ***
ORG                2.1942     0.6454   3.400 0.000675 ***
LBR>=3             1.1671     0.6114   1.909 0.056284 .
VAL>100000         1.1902     0.5973   1.992 0.046317 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 94.477  on 68  degrees of freedom
Residual deviance: 73.495  on 65  degrees of freedom
AIC: 81.495

Number of Fisher Scoring iterations: 4

> anova(rmod2,test="Chi")
Analysis of Deviance Table

Model: binomial, link: logit
```

```
Response: GAP1

Terms added sequentially (first to last)


          Df Deviance Resid. Df Resid. Dev P(>|Chi|)
NULL                         68     94.477
ORG        1  11.4622        67     83.015 0.0007102 ***
LBR       1   5.3296        66     77.685 0.0209658 *
VAL       1   4.1905        65     73.495 0.0406517 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
' ' 1
>
```

Logistic regression with sample size of 60

```
Call:
glm(formula = GAP1 ~ ORG + LBR + VAL, family = binomial)


Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.3106  -0.7724  -0.4261   1.0746   1.6477
Coefficients:
                 Estimate Std. Error z value Pr(>|z|)
(Intercept)       -2.3534     0.7174  -3.280  0.00104 **
ORG               2.3509     0.7337   3.204  0.00135 **
LBR               1.2934     0.6743   1.918  0.05509 .
VAL>100000        1.3066     0.6506   2.008  0.04460 *
```

```
---

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
' ' 1

(Dispersion parameter for binomial family taken to be 1)


    Null deviance: 82.108  on 59  degrees of freedom

Residual deviance: 64.701  on 56  degrees of freedom

AIC: 72.701


Number of Fisher Scoring iterations: 4


> anova(rmod1,test="Chi")

Analysis of Deviance Table

Model: binomial, link: logit


Response: GAP1


Terms added sequentially (first to last)



          Df Deviance Resid. Df Resid. Dev P(>|Chi|)

NULL                         59     82.108

ORG       1   8.8585        58     73.249  0.002917 **

LBR       1   4.1602        57     69.089  0.041384 *

VAL       1   4.3883        56     64.701  0.036186 *

---
```

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
' ' 1

> exp(coef(rmod1))

     (Intercept)             ORG        LBR>=3 VAL>100000

      0.09504899      10.49494640       3.64511670
3.69374080

> exp(coef(rmod1))

     (Intercept)             ORG        LBR>=3 VAL>100000

      0.09504899      10.49494640       3.64511670
3.69374080
```

Appendix 2: Questionnaire

Survey Questionnaire for Economic Analysis of Good Agricultural Practices and farmer training on the joint AfricaRice-IRRI Activities in Dakawa and Bagamoyo

Name of districté é é é é é é é . Name of regioné é é é é é . Name of zoneé é é é é é é .. Name of countryé é é é é é é ...
Name of the Enumerator é .
Household code /__/__/__/__/__/__/__/__/__/__/__/__/
Interview date: ....é .../__/__/__/__/__/__/__/__/__/ (ddmmyyyy)
Name of the Controller:é .
Control date: ....é .../__/__/__/__/__/__/__/__/__/ (ddmmyyyy)
Name of the supervisor:é .
Supervision dateé .....//__/__/__/__/__/__/__/__/ (ddmmyyyy)

1. Household structure

Name and surname of the household head (HH)	Sex of the HH 1=male 0=female	Age of HH (years)	Education level of HH **(code1)**	Last class attended	Number of children			Number of adults >18 yrs
					<10 years	10≤age<15 years	15≤age< 18 years	
Code1: *Education level* 0=none ; 1=literate/coranic ; 2=primary, 3=junior high school, 4=senior high school, 5=tertiary, 6= other (specify)								

2. Inventory of agricultural equipment

Name of equipment	Number	Total cost purchase (in TSH)	How long does this equipment last (life cycle)
Cutlasses			
Plough			
Tiller			
Seeder			
Insecticide treatment device			
Herbicide treatment device			
Tractors			
Disc harrow/harrow			
Draught ox			
Hoes			
Knifes			
File			
Axe			
Sickle			
Rake			
Shovel			
Wheelbarrow			
Watering can			
Pickaxe			
Pair of secateurs			

3. Household livestock: Baseline inventory of household livestock (at the end of the past season)

NB: To estimate the total value of the livestock, ask how much he/she would gain if he/she sold everything

Type of animal	Number of heads	Total estimated value (in TSH)
Chickens		
Ducks		
Turkeys		
Pigeons		
Guinea fowls		
Goats		
Cattle		
Porcine		
Sheep		
Donkey		
Other (specify)		

4. Financial transactions

Do you have access to credit to use for rice production?

Year	Accessing **1=Yes, 0=No**	Credit source (**Code 1**)	Amount of credit (in TSH)	What was the money used for? **(code2)**
2012				
2011				
2010				

Code1=Credit source: 1=credit program, 2=bank, 3=projects, 4=NGO, 5=traders, 6=inhabitant of the village, 7=inhabitant of another village, 8=farmers' organization, 9= Village Community Bank, 10=other (specify)
Code2= What was the money used for : 1=input purchase, 2=agricultural activity, 3=commerce, 4=care, 5=food, 6=functions, 7=other expenses (specify)

5. Agricultural Training

a. Have you ever had any rice farming training? [ ] 1=Yes 0=No **(If No, go to question 5c)**

i. When did you get training (Year/s) ________________________

ii. Where did you get training _____________________

iii. Who organized the training? /__/ 1=AfricaRice/IRRI 2=Other (specify)__________

iv. What aspects of rice production were you trained in? (Circle appropriate)
Establishment methodé é é ..1
Cultivar selectioné é é é . é 2
Water managementé é é 3
Nutrient managementé é é é 4
Weed managementé é é .é é 5
All rice production practicesé ..6
Other____
____

v. Would you like to receive additional training in rice production? [ ] 1=**Yes =No**

vi. If yes, what aspects of rice production would you like to receive additional training? (Circle appropriate)
Establishment methodé é é ..1
Cultivar selectioné é é é . é 2
Water managementé é é 3
Nutrient managementé é é é 4
Weed managementé é é .é é 5
All rice production practicesé ..6
Other____
____

vii. If No, please explain why you feel you do not need additional training.
____
____
____
____
____

Question (b), for farmers who were trained in 2011

b. i. Did you receive the video on growing rice from AfricaRice? / / Yes=1 No=0 (**If No, go to 5v.**)

ii. If yes, were you able to watch it? / / Yes=1 No=0 (**If No, go to 5iv**)

iii. If yes, was it useful? / / Yes=1 No=0

iv. If No, why were you not able to watch it?

____

v. If No, would you like to receive the video on rice farming from AfricaRice? / / Yes=1 No=0

c. If o to 5(a), would you like to receive training in rice production? [ ] Yes=1 No = 0

1. If yes, what aspects of rice production would you like to receive training? (Circle appropriate)
   Establishment methodé é é ..1
   Cultivar selectioné é é é . é 2
   Water managementé é é 3
   Nutrient managementé é é é 4
   Weed managementé é é .é é 5
   All rice production practicesé ..6
   Other_______________________________________
   ____

2. If No to (bi) above, please explain why you feel you do not need training?
   ____
   ____

6. i. Are you a member of any famer organisation /__/ 1=Yes 0 = No

   ii. If yes, which organisation do you belong to (circle appropriate)

   1= Farmers Cooperative 2= Marketing scheme

   3= Credit Scheme 4= Other (Specify)_____________________________

7. During the current growing season, did the extension worker visit your farm to give you advice on rice growing? [ ] Yes=1 No = 0

ii. If yes, how many times (total) did the extension worker visit you to give rice growing advice during the current growing season?_________(Number)

iii. During the current growing season, did you visit the extension worker to seek advice about rice farming? [ ] Yes=1 No = 0

iv. If yes, how many times (total) did you visit the extension worker to seek rice growing advice during the current growing season?_____________(Number)

8. INFORMATION ON FARMERS' PLOTS

i. What is the **total** area of your land? [ ] acres

ii. What is the area under rice you grew over the past three years? (Indicate **total** for each year)
1) 2012 [ ] acres 2) 2011 [ ] acres 3) 2010 [ ] acres

9. Choice of farming practices

Based solely on your current knowledge of rice growing and without regard to budget constraints (ie without regard to whether you can financially afford the practice), which of the following farming practices would you choose to use in rice production? (Read the options by factor and circle the number corresponding to the choice made by the farmer)

Factor	Dakawa	Bagamoyo
Variety	1. Saro 5 2. IRO5N221 3. Does not know these varieties	1. Saro 5 2. IRO5N221 3. TXD 307 4. Does not know these varieties
Establishment Method	1. Broadcasting 2. Line Sowing	3. Direct Seeding 4. Transplanting (20-25 days old nursery)
Water Management	1. Unbunded 2. Bunded	3. N/A
Weed Management	1. Manual weeding 2. Pre-emergence herbicide followed by one hand weeding after 30 Days	3. Manual weeding 4. Pre-emergence herbicide and weed after 30 Days
Nutrient Management	1. No fertilizer 2. 80-40-40 (N:P:K) in Two splits i. 40-40-40 (basal: At time of sowing) ii. 40Kg N(at tillering starts: 20-25 days after sowing) 3. 80-40-40(N:P:K) in Three splits i. 40kg N-40Kg P-40Kg K (basal: At the time of sowing) ii. 20Kg N (At tillering: 20-25 days after sowing) iii. 20Kg N (At panicle initiation stage:60-65 days)	4. 57.5kg N/ha=1 bag and 7.5kg Urea per ha 15 days after planting 5. 120-60-40 (N:P;K) (Two splits) i. 60-60-40 (basal)at sowing or transplanting) ii. 60Kg N (At tillering: 20-25 days after sowing or transplanting) 6. 120-60-40 (Three splits) i. 60Kg N-60Kg P-40Kg K (basal: at sowing or transplanting) ii. 30Kg N (At tillering: 20-25 days after sowing or transplanting) iii. 30Kg N (At panicle initiation stage:60-65 days)

10. Knowledge and use of rice varieties by farmersHPRV1. Knowledge, Use, Access and Managemant of rice varieties (since 2009)

Name of variety **(varieties listed in the village)**	Code for type of variety **(code1)**	Knowledge of the variety ***1=Yes, 0=No***	Source of knowledge ***(see code 2)***	Year of knowledge	Grown at least once ***1=Yes, 0=No***	If yes first cropping year	Grown at least once since 2006 ***1=Yes, 0=No***	Cropping year ***1 = Yes ; 0 = No***			
								2012	2011	2010	2009

Code1 : Type of variety : *1= local/Traditional varieties, 2=Improved, AfricaRice NERICA, 3=Improved, AfricaRice non-NERICA, 4=Improved, IRAD, 5= other improved rice varieties*
Code2 : Code for knowledge source : *1= farmer from the village, 2= farmer from another village, 3=IER, 4=DRA, 5=CMDT; 6=OHVN, 7=SG2000, 8=IICEM, 9=CRS, 10= Farmers' Organization ; 11=Other facility (specify), 12= local market, 13=Seed fair, 14=Research Station, 15=Other (Specify)*

11. a) Inputs used in rice farming

Plot Number	Variety	Area (Acres)	Quantity of seed **(kg)**	**Total** Price of seed **(TSH)**	Quantity of insecticides used	Measurement unit of insecticide	**Total** cost of Insecticide (**TSH**)	Cost of insecticide sprayer (if hired) (**TSH)**	Quantity of herbicide used	Herbicide measure ment unit	**Total** cost of Herbicides (**TSH**)	Cost of herbicide sprayer (if hired) **TSH**	Cost of other products **(TSH)**	Yield	Unit
1															
2															
3															
4															
5															
6															

11 b) If the farmer has not harvested, when does s/he expect to harvest? ________________

12. Land preparation (Dakawa only)

What Bunding method do you often use? /__/ 0=No bunding, 1=Hands, 2=Animals, 3=Wheel tractors, 4= other _______

13. **General crop establishment methods**

i. What is the most common crop establishment method you use? /__/ 1=Direct seeding 2=Transplanting 3=Both
ii. If direct seeding, which techniques do you use? /__/ 1=Row sowing, 2=Hill sowing, 3=Broadcasting, 4=Other___________
iii. If transplanting, how did you transplant? /__/ 1=Random 2=Straight-row 3=Other (specify) _______________

14. General weed management methods

1. How many weedings do you usually do? ___________________
2. What kind of weeding do you do? / / 1=Manual only 2= Herbicide application only 3=Both manual and herbicide 4= Other_________________
3. Have you ever had any weed management training course? /__/ 1=Yes, 0=No

15. Weed management detail per plot (current growing season)

Plot Number	Variety	Weeding number	Number of days after planting	Duration (number of days)	Weeding methods **(Code 1)**	Equipment used	If herbicide use		
							Type **(Code 2)**	Name	Amount used
1		**1st**							
		2nd							
		3rd							
2		**1st**							
		2nd							
		3rd							
3		**1st**							
		2nd							
		3rd							
4		**1st**							
		2nd							
		3rd							
5		**1st**							
		2nd							
		3rd							
6		**1st**							
		2nd							
		3rd							

Code1: 1=Only Manual 2=Only herbicdes 3=Manual+herbicide 4=Other
Code 2: 1= Pre-emergnce herbicide 4= Post-emergence herbicide

NB: Plot number and varieties should be in the same order as in question 11.

16. Soil fertility management

General soil fertility management methods

i. Do you often use fertilizer in your fields? / / 1=No fertilizer, 2=Organic, 3=Chemical, 4=Both organic and chemical

ii. How many times do you apply fertilizer during growth stage? ________

iii. Soil fertility management details per plot (current growing season)

Plot Number	Variety	Fertilizer application number	Type of fertilizer (**Code1**)	If chemical fertilizer, name of the fertilizer (**Code 2**)	Timing:-Number of days after planting	Amount		Price (TSH)	Fertilizer Transport cost (TSH)
						Quantity	Unit		
1		1st							
		2nd							
		3rd							
2		1st							
		2nd							
		3rd							
3		1st							
		2nd							
		3rd							
4		1st							
		2nd							
		3rd							
5		1st							
		2nd							
		3rd							
6		1st							
		2nd							
		3rd							
Code 1 : 1= No fertilizer 2= Organic 3= Chemical				**Code 2: 1=Urea 2= NPK 3=DAP 4=TSP 5=Other**					

NB: Plot number and varieties should be in the same order as in question 11 and 15.

17. Use of household labor for rice farming

i. What is the average length of a working day for household labor____________________(hours)

NB: To know the time taken for an operation, please ask the respondent to give the number of days taken by household labor for each operation.

Plot Number	Variety	Cropping activity		Did you use family labor? Yes=1 No=0	Number of persons from the household who have really worked on the field and the time taken for each operation in days							
					Men (at least 15 years)		women (at least 15 years)		Children boys (less than 15 years)		Children girls (less than 15 years)	
					Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)
1		Mowing										
		Ploughing										
		Sowing/transplanting										
		Weeding	First									
			Second									
			Third									
		Fertilizer application	First									
			Second									
			Third									
		Pesticide application										
		Herbicide application										
		Bird scaring										
		Harvest	Cutting									
			Threshing									
			Winnowing									
		Other										
2		Mowing										
		Ploughing										
		Sowing/ transplanting										
		Weeding	First									
			Second									
			Third									
		Fertilizer application	First									
			Second									
			Third									
		Pesticide application										
		Herbicide application										
		Bird scaring										
		Harvest	Cutting									
			Threshing									
			Winnowing									
		Other										

NB: Plot number and varieties should be in the same order as in question 11, 15 and 16.

Plot Number	Variety	Cropping activity		Did you use family labor? Yes=1 No=0	Number of persons from the household who have really worked on the field and the time taken for each operation in days							
					Men (at least 15 years)		women (at least 15 years)		Children boys (less than 15 years)		Children girls (less than 15 years)	
					Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)
3		Mowing										
		Ploughing										
		Sowing/transplanting										
		Weeding	First									
			Second									
			Third									
		Fertilizer application	First									
			Second									
			Third									
		Pesticide application										
		Herbicide application										
		Bird scaring										
		Harvest	Cutting									
			Threshing									
			Winnowin									
		Other										
4		Mowing										
		Ploughing										
		Sowing/ transplanting										
		Weeding	First									
			Second									
			Third									
		Fertilizer application	First									
			Second									
			Third									
		Pesticide application										
		Herbicide application										
		Bird scaring										
		Harvest	Cutting									
			Threshing									
			Winnowing									
		Other										

NB: Plot number and varieties should be in the same order as in question 11, 15 and 16.

Plot Number	Variety	Cropping activity		Did you use family labor? Yes=1 No=0	Number of persons from the household who have really worked on the field and the time taken for each operation in days							
					Men (at least 15 years)		women (at least 15 years)		Children boys (less than 15 years)		Children girls (less than 15 years)	
					Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)
5		Mowing										
		Ploughing										
		Sowing/transplanting										
		Weeding	First									
			Second									
			Third									
		Fertilizer application	First									
			Second									
			Third									
		Pesticide application										
		Herbicide application										
		Bird scaring										
		Harvest	Cutting									
			Threshing									
			Winnowin									
		Other										
6		Mowing										
		Ploughing										
		Sowing/ transplanting										
		Weeding	First									
			Second									
			Third									
		Fertilizer application	First									
			Second									
			Third									
		Pesticide application										
		Herbicide application										
		Bird scaring										
		Harvest	Cutting									
			Threshing									
			Winnowing									
		Other										

NB: Plot number and varieties should be in the same order as in question 11, 15 and 16.

18. Use of external labor for agricultural activities on the rice field

i. Do you use external labor? [ ] 1=Yes, 0=No (If the answer is No move on to the next module)

ii. What is the average length of a working day for external labor______________________(hours)

NB: To know the time taken for operation, please ask the respondent to give the number of days taken by external labor for each operation?

Plot Number	Variety	Cropping activity		Did you use external labor? Yes=1 No=0	Number of persons (external labor) who have really worked on the field and the time taken for the operation in days								Type of intervention **1= help** **2= mutual aid** **3=employed**	Costs generated (TSH) including food
					Men (at least 15 years)		women (at least 15 years)		Children boys (less than 15 years)		Children girls (less than 15 years)			
					Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)		
		Mowing												
		Ploughing												
		Sowing/Transplanting												
		Weeding	First											
			Second											
1			Third											
		Fertilizer application	First											
			Second											
			Third											
		Pesticide application												
		Herbicide application												
		Bird scaring												
		Harvest	Cutting											
			Threshing											
			Winnowing											
		Other												

NB: Plot number and varieties should be in the same order as in question 11, 15, 16 and 17.

<table>
<tr><td rowspan="3">Plot Number</td><td rowspan="3">Variety</td><td rowspan="3" colspan="2">Cropping activity</td><td rowspan="3">Did you use external labor? Yes=1 No=0</td><td colspan="8">Number of persons (external labor) who have really worked on the field and the time taken for the operation in days</td><td rowspan="3">Type of intervention
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<tr><td rowspan="16">2</td><td rowspan="16"></td><td colspan="2">Mowing</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td rowspan="3">Weeding</td><td>First</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Second</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Second</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td colspan="2">Pesticide application</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Harvest</td><td>Cutting</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>Threshing</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>Winnowing</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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NB: Plot number and varieties should be in the same order as in question 11, 15, 16 and 17.

Plot Number	Variety	Cropping activity		Did you use external labor? Yes=1 No=0	Number of persons (external labor) who have really worked on the field and the time taken for the operation in days								Type of intervention **1= help** **2= mutual aid** **3=employed**	Costs generated (TSH) including food
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					Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)		
4		Mowing												
		Ploughing												
		Sowing/Transplanting												
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					Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)		
5		Mowing												
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		Sowing/Transplanting												
		Weeding	First											
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NB: Plot number and varieties should be in the same order as in question 11, 15, 16 and 17.

Plot Number	Variety	Cropping activity		Did you use external labor? Yes=1 No=0	Number of persons (external labor) who have really worked on the field and the time taken for the operation in days								Type of intervention **1= help** **2= mutual aid** **3=employed**	Costs generated (TSH) including food
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					Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)	Number	Time taken for operation (days)		
6		Mowing												
		Ploughing												
		Sowing/Transplanting												
		Weeding	First											
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		Bird scaring												
		Harvest	Cutting											
			Threshing											
			Winnowing											
		Other												

NB: Plot number and varieties should be in the same order as in question 11, 15, 16 and 17.

19. **Rice Marketing**

Please ask the farmer to provide information about (paddy) rice marketing for 2012 production

Variety name	Quantity sold (paddy)		Price (TSH)		Market	
	Amount	Unit	Amount	Unit	Name	Distance (Km)

20. How do you regard your access to markets of paddy?

    1= Easy
    2= Difficult

21. Agricultural production and use (Other crops)

Please ask the farmer to provide the following information about other crops other than rice
NB: productions are crops quantities directly harvested. In the case where the produce is not sold, please use the market price at the time when the produce is used

Code type of culture **(code1)**	**2012**					**2011**					**2010**				
	Area exploited (Acres)	Production		Market Price (TSH)		Area exploited (Acres)	Production		Market Price (TSH)		Area exploited (Acres)	Production		Market Price (TSH)	
		Amount	Unit	Amount	Unit		Amount	Unit	Amount	Unit		Amount	Unit	Amount	Unit

Code1 : Code type of crop : 2=maize, 3=millet, 4=sorghum, 5=cassava, 6=peanut, 7=fonio, 9=cowpea, 10=tomatoe, 11=sweet potatoe, 12=sesame, 13=Cotton, 14= eggplant, 15= pepper, 16=okro, 17=banana, 18=mango, 19=orange, 20=cashew nut, 21=Potatoe, 22=yam/bean, 23= voandzou, 24=pigeon peas, 25=sunflower, 26=other(specify

22. EVALUATION OF RICE PRODUCTIVITY CONSTRAINTS

i. List the three first major constraints that negatively affect your rice production.
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

Rank the following constraints as experienced in your rice field

List of constraints	**Ranking of the constraints (code 1)**
Weeds	
Insects	
Birds	
Diseases	
-African rice gall midge	
-Stem borers (dead heart & whitehead)	
-Bacterial leaf blights	
-Blast	
-Rice yellow mottle virus	
Nematodes	
Termites	
Soil related constraints	
-Poor soil quality(low fertility)	
-Zn deficiency	
-Salinity / Alkalinity	
-NPK deficiency	
-Iron (Fe) toxicity	
-Acidity	
-Soil erosion	
- Siltation	
Poor Water conservation measures	
Drought (inadequate water)	
Flooding	
Pre-harvest Physical grain loss	
Heat stress	
Cold temperature	
Land	
Small land size	
Poor property rights (ownership) on land	
Difficult to get land for renting	
Difficult to get land for buying	
Seed	
Poor quality of seed	
Seed not available	
Fertilizer	
High cost	
Not available throughout the year	
Available late in the season	
Long distance to the fertilizer market	

Code 1: 1=High; 2= Medium; 3= Low; 0= Not exist

List of constraints	Ranking of the constraints (code 1)
Labor	
Not enough labor	
Labor cost too high	
Equipment & Infrastructure	
Difficult to acquire rice production equipment	
Difficult to acquire rice harvesting and/ or processing equipment	
Difficult to Manage equipment	
Difficult to maintain equipment	
Poor access to the road	
Credit	
Non- availability of credit	
High interest rate charges on credit	
Delays in acquiring credit	
Difficult to repay credit	
Post harvest grain losses due to	
Threshing	
Winnowing	
Storage	
Transport	
Product market	
Long distance to market for rice	
Low prices for rice	
High transport cost	
Lack of market/demand for rice	
Extension services	
Unavailability of extension services	
Lack of effectiveness	
Long distance to the extension workers	
Others	
Limited economic use of rice straw	
Bagamoyo Only	
Water management at plot level	
Difficult to access water	
Difficult to manage water	
High cost of water fees	

Code 1: 1=High; 2= Medium; 3= Low; 0= Not exist