IMPLICATIONS OF SOCIO-ECONOMIC FACTORS ON ADOPTION OF PADDY PRODUCTION INNOVATIONS IN MVOMERO DISTRICT, TANZANIA

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A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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EXTENDED ABSTRACT

Adoption of innovations in paddy farming has a potential to impact productivity. The Government of Tanzania in partnership with non-Governmental organizations (NGOs) like Kilimo Trust (KT) have been promoting rice sector through implementation of agricultural programmes and strategies whereby among other initiatives farmers are encouraged to adopt innovations. However, the adoption of innovations by farmers is not sufficiently explored. The overall objective of the study was to assess the implications of socio-economic factors on adoption of paddy production innovations in the Mvomero District, Morogoro Region of Tanzania. Specifically the study sought to: i) establish the level of farmer participation in the innovations process in the study area, ii) determine the extent of adoption of the paddy innovations, iii) assess profitability for adoption of selected innovations, iv) analyze the factors affecting adoption of introduced innovations to paddy farmers, and v) assess the association between adoption of selected innovations and change in gender roles among paddy farmers in the study area. The study was conducted in Mvomero District. A cross-sectional research design was adopted in the study. Quantitative data were collected using a semi-structured questionnaire involving 299 paddy farmers. Qualitative data were collected through key informant interviews (KIs) and focus group discussions (FGDs). Quantitative data analysis employed development of participation index, ordinal probit regression, binary logistic regression, two-limit Tobit model, net farm income (NFI) and return on investment (ROI) as measures of profitability. IBM Statistical Package for Social Sciences (SPSS) was used to compute descriptive statistics including frequencies and percentages. Qualitative data were analyzed using content analysis. Results show that the overall participation level of paddy farmers in the innovation process is medium using a five-form typology of participation. Only 3.7% of the respondents adopted all 12 SRI practices (full adopters).

Binary logistic regression and Two-limit Tobit regression analysis indicated that farmers' knowledge of innovations, land ownership, access to credit facilities, labour and market availability, were the most important predictors of the adoption of system of rice intensification (SRI), power tillers (PTs), wooden threshers (WTs) and combine rice mills (CRMs) ($p < 0.05$). The profitability analysis shows that adopters of SRI, PTs and WTs secured more profit compared to non-adopters ($p < 0.01$). There was an association between the adoption of SRI, PTs and WTs and gender roles which are production, labour offering and financial management ($p < 0.05$). The study concludes that medium level of farmers' participation in the innovation process impairs active involvement of farmers into development of innovations, diffusion process as well as full adoption of paddy innovations. The selected innovations which were introduced in the study area are not fully adopted; this situation impacts paddy productivity and farmers' wellbeing. Adoption of introduced innovations is profitable compared to non-adoption in the study area. Adoption of introduced innovations have impact in changing gender roles particularly paddy production role, financial management role as well as offering labour to on- and off-farm activities role. Researchers and extension agents are advised to ensure that there is active participation of paddy farmers along the innovation process. The active participation of paddy farmers along the innovation process will be achieved through conducting farmer trainings. The provision of training to farmers will help to create and raise awareness on introduced innovations. The Ministry of Agriculture under farmers' training Division should design, implement, monitor and evaluate farmer training programmes on paddy innovations whenever introduced in Tanzania as it is responsible in the provision of various types of training to farmers. Rural development strategies that targeted to promote adoption of innovations in rural areas should be designed simple enough by development practitioners to be taken up by farmers and directed to promote profit to rural farmers. Extension agents should educate rural paddy farmers on

innovations especially non-adopters so as to adopt innovations once introduced in rural paddy farming. Extension agents and paddy related stakeholders need to address gender roles to paddy farmers in course of adoption of innovations since adoption empowers women in regards to paddy production.

DECLARATION

I, **SOLOMON SIMON MHANGO**, do hereby declare to the Senate of Sokoine University of Agriculture that this thesis is my own original work done within the period of registration and that it has neither been submitted nor concurrently being submitted to any other institution for a PhD or any other award.

__________________________ _____________________

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(PhD Candidate)

The above declaration is confirmed by;

__________________________ _____________________

Prof. John N. Jeckoniah Date

(Supervisor)

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AITFs	Agricultural Inputs Trust Funds
ASDS	Agricultural Sector Development Strategy
ASDS	Agricultural Sector Development Strategy
ATDC	Agro-technology Demonstration Center
BCR	Benefit-Cost Ratio
CRM	Combine Rice Mill
DMI	Decision-making index
DV	Dependent Variable
EAC	East African Community
ECORD	European Cooperative for Rural Development
EUCORD	European Cooperative for Rural Development
FAO	Food and Agriculture Organization (United Nations)
FAOSTAT	Food and Agriculture Organization of the United Nations Statistics
FC	Fixed Cost
FGDs	Focus Group Discussions
GDP	Gross Domestic Product
GM	Gross Margin
GoT	Government of Tanzania
Ha	Hectare
IBM	International Business Machines
IFAD	International Fund for Agricultural Development
IPM	Integrated Pest Management
IRR	Internal Rate of Return
KG	Kilogram
KIIs	Key informants’ interviews
KIs	Key Informants
KT	Kilimo Trust
LDCs	Least Developed Countries
MaA	Male Adult
MaC	Male Children
NBS	National Bureau of Statistics
NFI	Net Farm Income
NGOs	Non-Governmental organizations
NPS	National Panel Survey
NPV	Net Present Value
NRDS	National Rice Development Strategy
NSGRP	National Strategy for Growth and Reduction of Poverty
OCGSZ	Office of the Chief Government Statistician Zanzibar
OECD	Organization for Economic Cooperation and Development
PhD	Doctor of Philosophy
PT	Power Tiller
R&D	Research and Development
RDS	Rice Development Strategy
ROI	Return on Investment
RSDS	Rice Sector Development Strategy

SD	Standard Deviation
SDGs	Sustainable Development Goals
SE	Standard Error
SME	Small and Medium Enterprises
SPSS	Statistical Package for Social Sciences
SRI	System of Rice Intensification
SSA	Sub-Saharan Africa
STATA/SE	Statistics and Data Special Edition
SUA	Sokoine University of Agriculture
TC	Total Cost
TFC	Total Fixed Costs
TICD	Tengeru Institute of Community Development
TR	Total Revenue
TVC	Total Variable Cost
TXD	Tanzania Cross Dakawa
Tzs	Tanzanian Shilling
URT	United Republic of Tanzania
UWAWAKUDA	“Umoja wa Wakulima Wadogowadogo wa Kilimo cha Umwagiliaji Dakawa”
VC	Variable Cost
WB	World Bank
WT	Wooden Thresher

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Like many other smallholder paddy farmers in the world, paddy production remains the mainstay for the farmers in Mvomero District. Paddy productivity is achieved when farmers adopt innovations. Adoption of paddy innovations is among the attributes that promote paddy production and productivity. In this study paddy innovations are expressed in different forms including paddy varieties, paddy production practices, tools and machinery. But in this study paddy innovations are paddy production practices, tools and machinery. Adoption of innovations in agriculture has attracted considerable attention among development economists because the population of the least developed countries (LDCs) derive its livelihood from agricultural production (Feder *et al.,* 1985). Adoption of paddy innovations calls for participation of farmers in the innovation process in which in this study is referred to development, diffusion, implementation and confirmation of those innovations. Also, according to Garcia and Calantone (2002), innovation' process comprises of the technological development of an invention combined with the market introduction of that invention to end-users through adoption and diffusion.

Farmer participation in the innovation process is a crucial aspect towards paddy productivity for this case since farmers are the potential beneficiaries in agriculture. Low farmer participation in the innovation process occurs when interventionists do not take into account the role played by farmers at all levels of innovation process (World Bank *et al*., 2009). Often women farmers as potential stakeholders are not targeted by interventionists in respect to adoption of innovations with the assumptions that their husbands or fathers will share the knowledge with them, and often they are supplied with innovations that do not meet their needs (World Bank *et al*., 2009). For instance, because of performing triple role, women would love to adopt innovations which save labour, time and energy in respect to paddy production. Even when women have access to innovations, they face more constraints than men in accessing complementary resources for success (Morris and Doss, 1999; World Bank *et al*., 2009). Women face such constraints like limited decision making and lack of control over resources despite being the key players in paddy production.

All over the world, rural women have traditionally played, and continue to play multiple roles as agricultural producers, workers, mothers, and caregivers in paddy production and post-harvest activities but these roles are often not valued (FAO, 2004; Kabeer, 2009; World Bank *et al*., 2009). This is often attributed to by the fact that women's contribution are not put in statistics and do not appear in countries' gross domestic product (GDP). Multiple roles in this context are referred to roles performed by women as paddy farmers whilst undertaking domestic responsibilities as mothers, and caregivers for their families. Women comprise almost 50% of the agricultural labour force in sub-Saharan Africa and the averages in Africa range from just over 40% in Southern Africa to just over 50% in Eastern Africa. In Tanzania, women's share of total time-use is about 48%, while men contribute the rest (52%) of total time-use in agriculture (Raney *et al.*, 2011). However, it is believed that the design of some development interventions continue to assume wrongly that farmers and rural workers are mainly men (World Bank, 2008). Adoption of paddy innovations helps to reduce women's time and drudgery (Paris *et al.*, 2011). World Bank *et al*., 2009) argue that all tasks performed in relation to agricultural cycles, processing and domestic chores consume women's time and energy, leaving them overburdened.

The Government of Tanzania (GoT) in partnership with private sector have been taking measures to promote the agricultural sector including rice sector whereby farmers are assured access to and use of agricultural innovations. These measures include development and implementation of different policies, programmes and strategies whereby various paddy innovations are being introduced to farmers (URT, 2009). Policies include National Agriculture Policy of 2013; programmes are such as Agriculture Sector Development Programme (ASDP) I and II; and strategies like Rice Sector Development Strategy (RSDS) of 2009, Agriculture Sector Development Strategy of 2001 and National Strategy for Growth and Reduction of Poverty (NSGRP).

Private sector involves non-governmental organizations (NGOs) like Kilimo Trust-Tanzania (KT), and individual people who provide agricultural services like selling or hiring farm inputs and machineries. Participation of private sector is noted in rice milling, farm machineries, supply of agro-inputs (fertilizers, pesticides) and trading through Agricultural Inputs Trust Funds (AITF) and Input Subsidy Initiative of the Government. The private sector is facilitated to operate machinery hire services in or around the irrigation schemes to increase and expand farmers’ access to and utilization level of agricultural machinery. Nevertheless, the smallholder farmers who are women tend to experience difficulties in accessing key factors of production (URT, 2009; URT, 2013). This is due to the fact that women are marginalized group and thus are not given priority in accessing factors of production.

According to European Cooperative for Rural Development - EUCORD, (2012), rice has been gathered, consumed, and cultivated by women and men worldwide for more than 10 000 years-longer than any other crop. It is the highly important food crop for about half of the human race. As to 2012, rice represents 29% of the total output of grain crops worldwide. Over 90% of the world's total rice crop is produced in South and East Asia. In area and production, China is the leading country in the world. Africa accounts for three percent of global production. According to Food and Agriculture Organization of the United Nations Statistics - FAO (2017), world paddy production in 2016 was 751.9 million tonnes (499.2 million tonnes, milled basis). Moreover, rice production is a major source of employment, income generation and nutrition in many poor food-insecure countries in Sub-Saharan Africa (SSA). Less than three percent of global rice is produced in SSA, but at six percent p.a., its production has expanded faster than any other cereal over the past decade (OECD-FAO, 2016).

Favourable storage characteristics, ease of preparation and versatility in consumption make rice a popular choice among consumers and by 2025, SSA will produce more than 20 million tonnes. The five biggest producers (Nigeria, Madagascar, Mali, Tanzania and Guinea) account for almost 65% of production growth (OECD-FAO, 2016). In the East African Community (EAC), rice is the second ranked important staple food, behind maize (KT, 2014). Production is growing faster than demand but the increase comes from expanding the area under rice rather than from yield increases. Annual production is 1.25 million metric tonnes and is growing steadily. Local rice production is dominated by 1.5 million smallholder families who grow rice on farms of less than three Hectares, of these, about 1.1 million are in Tanzania (KT, 2014).

Morogoro is among the leading regions in rice production in Tanzania, others are Mwanza, Shinyanga, Tabora, Mbeya and Rukwa (URT, 2009). Major irrigation schemes in Morogoro region include irrigation Mkindo, Dakawa, Hembeti (Mvomero District), Kilombero and Mkula (Kilombero District). Paddy innovations in Tanzania can be categorized into paddy varieties, agronomic best practices, agro-inputs (fertilizers, pesticides), tools and machineries. Some of the paddy production innovations introduced in Morogoro region include new rice varieties (TXD 306), System of Rice Intensification (SRI), separation of unfilled grains from filled grains using salt water, raising seedlings in wet nursery bed, bunding, tillage, power tillers (PTs), powered leveling, Integrated Pest Management (IPM), cultural weed control methods, wooden threshers (WTs), timely harvesting and timely threshing, and combine rice mills (CRMs) (URT, 2011). The specific innovations introduced in Mvomero District include SRI (Katambara *et al.*, 2013). Others are power tillers (PTs), wooden threshers (WTs) and combined rice mills (CRMs) which aimed at relieving men and women from laborious and time consuming tasks. However, poor farmers especially women still experience drudgery in production despite adoption of such introduced innovations (URT, 2009; URT, 2013). Like in other places, women in the District play multiple roles as agricultural producers, workers, mothers and caregivers in paddy production. This study adapts the concept of gender from Huisinga *et al*. (2001) that refers gender as the social roles which men and women play and the power relations between them, which usually have a profound effect on the use and management of natural resources. Gender roles of women and men include different labour responsibilities, decision-making processes, and knowledge.

1.2 Problem Statement

Since independence the Government of Tanzania (GoT) has been taking various efforts to promote the agricultural sector by assuring famers of access to and utilization of innovations and other resources, but much efforts have been focusing on achieving quality livelihoods in terms of increased production and productivity (URT, 2009; URT, 2013). Despite the efforts to improve farmers' livelihoods, poor farmers, especially women, still experience excessive workload, are overburdened and indeed information regarding adoption and application of innovations by paddy farmers is insufficient (Paris *et al*., 2011; World Bank *et al*., 2009; URT, 2009).

Successful interventions are usually transformative, whether through creating opportunities or through changing the ways people do things (Beuchelt, 2016). Women, as compared to men, still struggle in farm operations using traditional technologies which are labour intensive, time and energy consuming (World Bank *et al*., 2009). Gender roles are dynamic and therefore it is difficult to predict what the adoption effects will be within households and communities. For example, in Africa including Tanzania after adopting innovation, women farmers face difficulties in maintaining profitable market niches and risk losing control over resources such as land, as men often take over production and marketing when it becomes financially lucrative (Beuchelt, 2016). Since various innovations have been introduced to smallholder paddy farmers in Mvomero District, one would expect the farmers in the area to have full adoption and eventually that adoption of innovations is associated to gender roles. However, scant information on the association between adoption of SRI, PTs, WTs and CRMs and gender roles was not documented elsewhere in regards to paddy farmers in the study area.

1.3 Justification of the Study

Some previous studies on the adoption of innovations and yield performance of introduced system of rice intensification (SRI) were conducted in the study area but did not show the extent of adoption of selected paddy innovations as well as association between adoption of these innovations with gender roles (Katambara *et al.,* 2013; Katambara *et al*., 2016). Therefore, this study was undertaken to determine the level of adoption of selected paddy innovations which were introduced in the study area and establish association between adoption of these introduced innovations with gender roles.

The study contribute information that will help in the attainment of Sustainable Development Goals (SDGs) of the Post-2015 Agenda at goal number Nine under target 9.5 which requires to "enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, particularly developing countries, including by 2030 encouraging innovation and increasing the number of research and development (R&D) workers per one million people by x% and public and private R&D spending" (Rippin *et al.*, 2015). The SDG goal number Nine under target 9.5 is also reflected in the National Rice Development Strategy (NRDS) which focuses on fostering adoption of rice innovations including modern agronomic practices and post-harvest management practices (URT, 2009). Also this study is in line with the Tanzania's Development Vision-2025, whereby in achieving "competence and competitiveness" goal under 3rd target which aimed at transforming the economy towards competitiveness by science and technology in realization of high productivity in agricultural production.

The study has generated empirical information on the extent of adoption of selected paddy innovations namely SRI, PTs, WTs and CRMs in the light of SDGs goal number Nine under target 9.5, NRDS-2009 and Tanzania's Development vision - 2025 to reflect the problem of farmers' adoption of paddy innovations. Moreover, this study generated empirical findings on participation of paddy farmers in the generation, diffusion and adoption of innovations, profitability for adoption of selected innovations among paddy farmers in Mkindo and Dakawa irrigation schemes. Also, the study generated information related to factors affecting adoption of introduced innovations to paddy farmers in the area of study and association of adoption of paddy production innovations on gender roles. The generated empirical information are useful to inform agricultural development practitioners including researchers and extension workers to devise ways on how to help the vulnerable and resource-poor, especially female farmers in Mvomero District whenever innovations are introduced in rural settings. Therefore, this study assessed the implications of socio-economic factors on adoption of paddy production innovations in Mkindo and Dakawa irrigation schemes.

1.4 Objectives

1.4.1 Overall objective

The overall objective of the study was to assess the implications of socio-economic factors on adoption of paddy production innovations in the Mvomero District, Morogoro Region of Tanzania.

1.4.2 Specific objectives

The specific objectives formulated to deliver the overall objective were:

i) To establish farmer participation levels in the paddy innovations process in the study area,

ii) To determine the extent of adoption of the selected innovations by paddy farmers in the area of study,

iii) To assess profitability for adoption of selected innovations among paddy farmers in the study area,

iv) To analyze the factors affecting adoption of introduced innovations to paddy farmers in the area of study, and

v) To assess the association between adoption of selected innovations and gender roles among paddy farmers in the study area.

1.5 Research Questions

i) How does introduction of paddy innovations in Mvomero District influence farmers' participation in the innovation process?

ii) To what level the selected innovations were adopted by paddy farmers in the study area?

iii) How the adoption of paddy innovations is economically profitable in the study area?

iv) What determines the adoption of introduced innovations in the study area?

v) How does adoption of introduced innovations influence change in gender role?

1.6 Hypotheses

The study assessed three Hypotheses;

i) There is no significant difference on profitability between non-adopters and adopters of selected paddy innovations.

ii) The odds of the farmers adopting selected paddy innovations are the same among the paddy farmers with different socio-economic and socio-demographic characteristics.

iii) There is no association between adoption of selected paddy innovations and change in gender roles.

1.7 Theoretical Framework

Different scholars look at the concept of innovation differently. Rogers (2003) defines innovation as something that involves both knowledge creation, diffusion of existing knowledge and application of such knowledge while Simmonds (1986) defined innovation as new ideas that consist of: new products and services, new use of existing products, new markets for existing products or new marketing methods. In this study an innovation is referred to as new paddy production practices, production and threshing tools as well as new paddy milling machines.

1.7.1 Rogers's theory of diffusion of innovation

Rogers (2003) defines innovation as something that involves knowledge creation, diffusion and application of such knowledge (innovation process). This theory identifies various factors for adoption of innovation. Factors can be grouped in innovation characteristics, adopter's characteristics and external factors. In innovation related characteristics, Rogers insists on five key qualities that determine the rate of an innovation adoption to be relative advantage, compatibility with existing values and practices, simplicity and ease of use, trialability, and observable results. Despite qualities related to innovation characteristics, Rogers (1995) further argued that the decision to adopt or reject an innovation is a mental process which takes place in an individual, thus in this case, for paddy farmers to accept or reject the paddy innovations, it depends on how paddy farmers perceive a given innovation in their own view on their felt needs and prior experiences (Meijer *et al*., 2015). Thus, it is argued that perceptions are determined by farmers' personal characteristics e.g. age, education, attitude, experience and extension services (Borges *et al*., 2015). External factors to the individual as important in behavior change, it is essentially "social," viewing communication as causing change, along with the individual's psychological make-up. The individual can learn a new behavior by observing another individual in person or via the mass media (especially the visual media like television or film). Social modelling can occur in interpersonal networks or by a public display by someone with whom one is unacquainted (Rogers, 1983).

1.7.2 The theory of change

On the other hand, the Theory of Change describes the process of social change by making explicitly the perceived current situation; its underlying causes, the long term change desired and the things that need adjustment for that change to happen (Adekunle and Fatumbi, 2014). The theory of change is relevant in this study as it helps to examine the association between adoption of system of rice intensification (SRI), power tillers (PTs), wooden threshers (WTs) and combine rice mills (CRMs) and change in gender roles in paddy production. Also this theory guides the assessment of the impact of adoption of selected paddy innovations in the study area on profitability. The Theory of Change helps to understand the process needed to achieve the desired change. These include changes within agricultural production and within farmers themselves. Changes within paddy production include farmers' realization of profitability resulting from adoption of such innovations and changes which occur within farmers themselves such as perception and decision making.

Farmers' perception towards certain paddy innovation lead to either accept or reject application of respective innovation and eventually impact on gender role of a farmer. It was expected that by adopting these innovations not only farmers would obtain; (1) more profit (2) save time, (3) reduce workload and (4) change traditional gender roles. Thus, basing on this theory the study answered the following empirical research questions which include i) How does introduction of paddy innovations in Mvomero District influence farmers' participation in the innovation process? ii) To what level selected innovations were adopted by paddy farmers in the study area? iii) How the adoptions of paddy innovations are economically profitable in the study area? iv) What determines the adoption of introduced innovations in the study area? and v) How does adoption of introduced innovations influence change in gender roles?

1.8 Conceptual Framework for the Study

Innovations in the society are a demand and supply driven phenomena. Once they are developed, they have to be marketed through diffusion process in order for adoption to take place (Sunding and Zilberman, 2000).

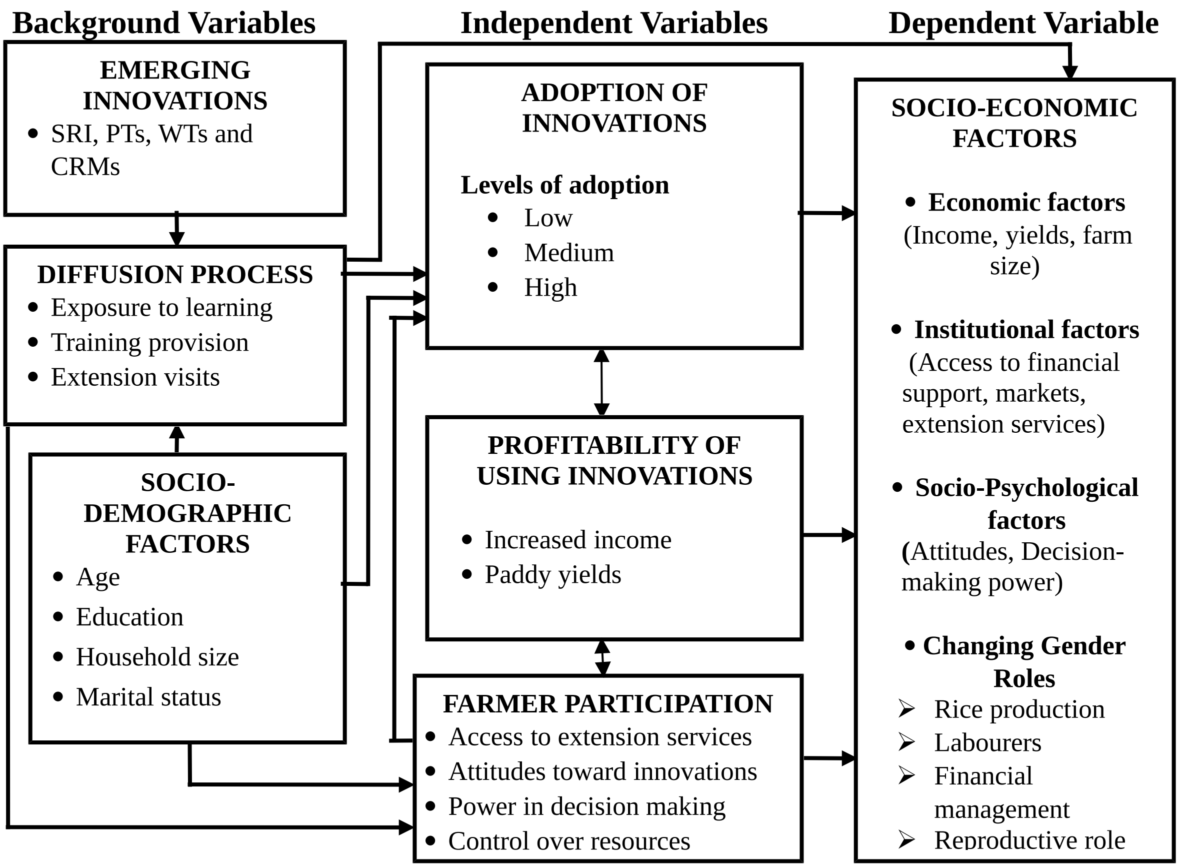

Figure 1.1: Conceptual framework

Source: Adapted from Sunding and Zilberman (2000), Leeuwis (2004) and Karugu (2006).

Diffusion of innovations as a learning process, enhances participation and strengthens their decisions on adoption of the new practices and affects gender roles directly or indirectly at farm level. Socio-demographic factors influence diffusion and adoption of innovations as well as the participation of farmers in innovation process. Change in gender roles among farmers is attributed to the adoption process and the benefits derived and costs incurred from applying the innovations.

The reverse relationship between adoption process and profitability is evidenced through choices made with regard to adoption of innovations. Profit resulted from adoption of innovations increase or decrease farmer involvement in learning process or decision-making at the farm level. Different levels of farmer participation in the use of innovation reflect who between men and women play specific role in relation to paddy production.

1.9 General Methodology

1.9.1 Description of the study area

The study was conducted in Mvomero District in Morogoro Region, Tanzania which involved two paddy irrigation schemes namely Mkindo and Dakawa. Mvomero District is one of the 6 districts of Morogoro Region. Others are Gairo, Kilosa, Morogoro, Kilombero, and Ulanga. The district is located in the Northern end of Morogoro Region (Fig. 1.2). The district borders with Morogoro District in the East, Gairo and Kilosa in the West, Tanga Region in the North and in the South it borders with Kilosa (partly) and Morogoro (partly). Geographically the District is located between latitude 6° 16’ and 6° 18’ South, and longitude 37° 32’ and 37° 36’ East and its altitude ranges between 345 and 365 m amsl. The map of Mvomero District shows Mkindo and Dakawa irrigation schemes as shown in Fig. 1.2.

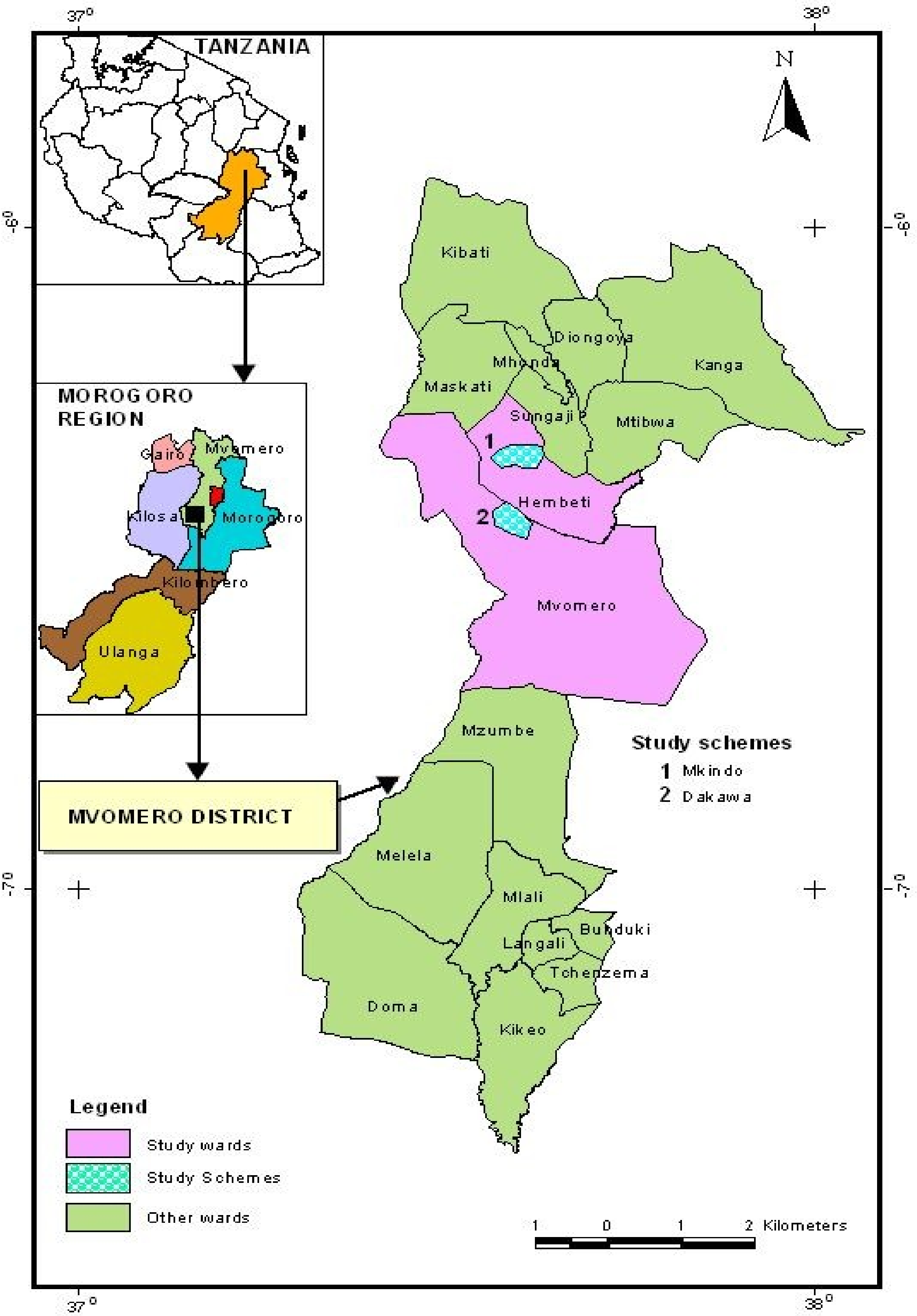

Figure 1.2: A Map of Mvomero District showing the Study Area

1.9.2 Research design

This study used cross-sectional research design for farmer survey which allows data to be collected at a single point in time and also it has a broad scope of incorporating numerous variables at once (Walliman, 2006). This approach was appropriate for this study because data collection was conducted during the production season where paddy farmers could be easily found in their farms for interview. Bailey (1998) documented that cross-sectional research design involves data gathering from the respondents which represents the existing situation at the time of the study.

1.9.3 Sampling procedure

1.9.3.1 Area sampling

The area of the study was Mkindo and Dakawa irrigation schemes which are found in Mvomero District in Morogoro Region. The two irrigation schemes involve smallholder paddy farmers who participate in paddy production where the selected innovations under this study were introduced. Tanzania. The criterion for selection of the study area was due to the fact that the selected innovations were introduced to smallholder paddy farmers (Temi, 2012; Katambara *et al.,* 2013; Kahimba *et al.,* 2014; Makundi, 2017). Therefore, it led to the purposive selection of Morogoro Region and Mvomero District.

A purposive sampling technique was employed for sampling Morogoro Region, Mvomero District, five Key Informants (KIs) as well as Mkindo and Dakawa irrigation schemes. Different population of farmers in Mkindo and Dakawa schemes (as explained in section 1.9.3.2) led to obtain different number of respondents in each irrigation scheme. Proportionate sampling technique was used to obtain 96 farmers from Mkindo irrigation scheme and 203 farmers from Dakawa irrigation scheme.

1.9.3.2 Respondents sampling

The study elicited data from the paddy farmers in the study area, whereby a formula by Yamane (1973) was adopted to obtain the desired sample size, assuming 95% confidence level and 0.05 as sampling error. The formula used is follows:

$$n = \frac{N}{1 + N(e^2)} \quad \ldots\ldots(1)$$

Where; *n* = sample size,

N = population size and

e = level of precision (sampling error).

According to established records from extension offices and irrigation schemes' leadership in Mkindo and Dakawa, the number of paddy farmers in the study area was 1192. In Mkindo scheme there were 350 farmers and Dakawa scheme had total of 842 farmers. Therefore, using the above formula, a total of 299 paddy farmers were sampled. Proportionate samples of 96 farmers from Mkindo scheme and 203 farmers from Dakawa scheme was estimated using a modified formula by Kothari (2004). Therefore, the formula used is shown hereunder;

$$n = \frac{N(one\_scheme) x n(all\_schemes)}{N(all\_schemes)} \quad \ldots\ldots(2)$$

Whereby;

n = the sample size in one scheme [Mkindo/Dakawa]

n (*all scheme*) = the sample size of the study [299]

N (*one sheme*) = Population of one scheme [Mkindo=350, Dakawa=842]

N (*all schemes*) = Study area population [1192]

Then, simple random sampling technique was employed to sample 299 farmers in two irrigation schemes whereby 96 farmers were obtained from Mkindo scheme and 203 farmers were sampled from Dakawa scheme. The names of all registered paddy farmers in each irrigation scheme were obtained from extension office and then the estimated number of farmers (96 and 203 farmers from Mkindo and Dakawa respectively) was randomly picked through table sampling. Then, with the help of extension officers, the farmers who constitute the sample size of the study were found in their fields for interview.

1.9.4 Methods for data collection

This study collected data from primary and secondary sources whereby primary data were collected through farmer surveys, key informants' interviews (KIs), focus group discussions (FGDs) and field observations. The study involved three FGDs and five KIIs, whereby one FGD was conducted in Mkindo scheme and the other two from Dakawa scheme. FGDs participants included paddy farmers who were registered in SRI groups, PTs groups and normal farmer groups. Moreover, KIIs involved PTs and CRMs operators, the Principal from Mkindo farmers' training centre and a researcher from Cholima Agri-research station who was involved in up-scaling of SRI. Selection of FGDs participants and key informants was done purposively to provide relevant and technical information on adoption of selected innovations. The primary data were collected by employing semi-structured questionnaire, checklist of questions, FDGs guide which covered data on socio-economic characteristics, farmer participation in innovation process, knowledge of selected innovations, paddy yields and sales, production costs and gender division of labour. Meanwhile, the secondary data from Mkindo farmers training center on different types of innovations introduced in the study area including SRI, PTs and WTs were collected.

1.9.5 Data analysis

1.9.5.1 Levels of farmer participation in the innovation process

Levels of participation were established using quantitative methods of data analysis through development of index. The statements representing conventional, consultative, collaborative, collegial and farmer experimentation forms of participation were graded on a five point Likert scales of 'strongly agree', 'agree', 'disagree', 'strongly disagree' and 'undecided' with 4, 3, 2, 1and 0 scores respectively. Then a participation index was developed in respect to each stage of participation as well as the overall participation by using the following formula; $PIndex = \frac{Tscore}{Maxscore} x100$. ……………..………..………

(3)

Where;

$PIndex$ =Participation index

$Tscore$ =Total score obtained

$Maxscore$ =Maximum possible score.

This approach was also used by Rao *et al*. (1992) and Fita and Trivedi (2012). Thereafter, participation levels were categorized from the index using mean and standard deviation (SD) into: Low = < (mean - SD), Medium = between (Mean ± SD) and High = > (Mean + SD).

1.9.5.2 Determinants of the farmers' participation levels in the innovation process

An ordinal probit regression model was used to analyze the determinants of the farmers' participation levels in innovation process. Ordinal dependent variable Y is presented in terms of levels participation of innovation process where 1=low participation, 2=medium participation and 3=high participation, of some underlying latent variable Y^*. We assume that $Y_i^* = X_i\beta + \mu_i$ ……………..…………………………………………………..…(4)

and that we observe the ordinal choice Y_i :

$$
\begin{cases}
0 & \text{If } Y_i^* \leq 0, \\
1 & \text{If } 0 < Y_i^* \leq \mu_1 \\
2 & \text{If } \mu_1 < Y_i^* \leq \mu_2 \\
3 & \text{If } \mu_2 < Y_i^*
\end{cases}
$$

Where;

Y^*= Latent variable.

β = Estimated coefficients of the respective explanatory variables

μ_i = Error terms, is normally distributed and is used to estimate β vector and the thresholds μ corresponding to the different levels of the variables.

X_1 = Age (years)

X_2 = Household size (number of people)

X_3 = Farming experience (years in farming)

X_4 = Farm size (Ha)

X_5 = Farm income (Tzs)

X_6 = Sex (Male 1, Female 0)

X_7 = Marital status (married 1, otherwise 0)

X_8 = Land ownership (Owned 1, otherwise 0)

X_9 = Extension advisory (Yes 1, otherwise 0)

X_{10} = Labour availability (Hired 1, otherwise 0)

1.9.5.3 Extent and factors influencing adoption of the SRI innovation

The extent and factors influencing adoption of SRI were analyzed using a two-limit tobit model. This regression model is used where dependent variable (DV) is metric and censored to the lower or upper limits (Fernando, 2011; Baum, 2013). Adoption of SRI as a DV involved 12 practices whereby a numerical score of 0 was assigned for non-adoption and 1 was assigned for adoption in each practice. In this study the dependent DV was set with the value of the adoption of SRI which ranged between 0 to 12 scores. The model was specified as follows:

$$Y\ast = \beta\chi_i + \varepsilon_i \quad \text{……………..………………………………………….………………} (5)$$

ε ~ Normal [0,σ2].

Denoting Y_i as the censored observed adoption of SRI practices,

$$Y_i = \begin{cases} 0 & \text{if } Y_i^* \leq 0 \\ Y_i^* = X_i\beta_i + \varepsilon_i & \text{if } 0 < Y_i^* < 12 \\ 12 & \text{if } Y_i^* \geq 12 \end{cases}$$

Where;

Y_i = the observed dependent variable, i.e. adoption of SRI, measured in scores upon adopted SRI practices by a farmer ranging from 0-12.

$Y_i \ast$ = the latent variable (unobserved for values smaller than 0 and greater than 12).

X_i = is a vector of independent variables (factors influencing adoption and intensity of adoption).

β_i = Vector of unknown parameters.

ε_i = error terms that are assumed to be independently and normally distributed with zero mean and a constant variance σ^2, and i=1, 2…n (n is the number of observations).

X_1 - X_{15} = are the predictor variables (x_1 = sex, x_2 =Age, x_3 = Marital status, x_4 = Education level, x_5 = household size, x_6 = labour availability, x_7 = land ownership, x_8 = farm size, x_9 = access to extension advisory, x_{10} = access to credit facilities, x_{11} = market availability, x_{12} = relative advantage of using SRI, x_{13} = total revenue per hectare per production season in 2015 (TZS), x_{14} = decision making (index score) and x_{15} = knowledge of SRI (score)).

The coefficients in Tobit model were farther disaggregated to estimate the expected value of Y_i (McDonald and Moffit, 1980; Sileshi *et al*., 2012) as follows:

The change in the probability of adopting SRI practices as an independent variable χ_i changes is:

$$\frac{\partial \Phi(\delta)}{\partial \chi_i} = \phi(\delta)\frac{\beta_i}{\sigma} \quad \text{..} (6)$$

The change in intensity of adoption of SRI practices with respect to a change in an explanatory variable among SRI adopters was specified as follows:

$$\frac{\partial E(Y_i / U \square Y_i^* \square L, X)}{\partial X_i} = \beta_i \left[1 + \frac{\delta_L \phi(\delta_L) - \delta_U \phi(\delta_U)}{\Phi(\delta_U) - \Phi(\delta_L)} - \left[\frac{\phi(\delta_L) - \phi(\delta_U)}{\Phi(\delta_U) - \Phi(\delta_L)} \right]^2 \right]$$

Where;

χ_i = explanatory variables,

$\Phi(\delta)$ =the cumulative normal distribution

$(\delta) = \frac{\beta_i \chi_i}{\sigma}$ = the Z-scores for the area under normal curve

β_i = Vector of Tobit maximum likelihood estimates

$\sigma =$ the standard error of the error term

$$\delta_L = \frac{L - \chi_i \beta}{\sigma}$$

$$\delta_U = \frac{U - \chi_i \beta}{\sigma}$$

L and U are threshold values (L =0 and U =12)

Φ and ϕ are probability density and cumulative density functions of the standard normal distribution, respectively.

Content analysis was applied to analyse qualitative data elicited through key informants interviews and focus group discussions.

1.9.5.4 Profitability for adoption of selected innovations among paddy farmers

The profitability of adoption of selected innovations was assessed using the two indicators namely net farm income (NFI) and return on investment (ROI).

***Net farm income* (NFI)** was computed:

$NFI = TR - TC$ …………….……………………………………………..………… (7)

Where;

NFI=Net Farm Income (Tzs); TR=Total Revenue (Tzs)

$TR = \sum Py.Y$

Where;

Py = Price per unit output (Tzs) i.e per kg of paddy

Y = Total quantity of output (Kg)

$TC = TVC + TFC$

Where;

TVC =Total variable cost (Tzs)

$TVC = \sum Px_i.x_i$

Where;

Px_i =Price per unit of input (Tzs)

x_i =Quantity of i[th] input used per unit input

TFC = Total fixed costs involved in paddy production (Tzs).

Return on Investment **(ROI)** was specified as follows:

$$ROI = \frac{Benefit}{InvestmentCost} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where;

ROI =Return on Investment in paddy production (Tzs)

$Benefit(Tzs)$ =Total Revenue (TR) – Investment Cost (TC)

TR =Total Revenue (Tzs)

$TC = TVC + TFC$

TVC =Total variable cost (Tzs)

TFC = Summation of fixed costs involved in paddy production (Tzs).

Content analysis was applied to analyse qualitative data elicited through key informants interviews and focus group discussions.

1.9.5.5 Factors affecting adoption of introduced innovations to paddy farmers

Factors influencing adoption of PTs, WTs and CRMs were analyzed using a binary logistic regression model in which dependent variables were dichotomous, that is, non-adoption (0) and adoption (1). So, three separate models were run for each innovation. The model was specified as follows:

$$\text{Logit}\left[p(x)\right] = Log\left[\frac{p(x)}{1-p(x)}\right] = \alpha + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \beta_n X_n + \varepsilon \text{ ....(9)}$$

The formula was adapted from Challa and Tilahun (2014) and Agresti (2002),

Where;

Logit (px) = ln (odds (event)), that is the natural log of the odds of adopting the innovations.

$p(x)$ = prob (event), that is the probability of adopting the innovations.

$1-p(x)$ = prob (nonevent), that is the probability of not adopting the innovations.

$Log\left[\frac{p(x)}{1-p(x)}\right]$ = is the logarithm of the ratio of probability of adopting the innovations p(x) to probability of not adopting them 1- p(x).

α = constant of the equation.

$\beta_1 - \beta_n$ = coefficients of the predictor variables.

ε = Error term.

n = number of independent variables.

$\chi_1 - \chi_n$ = predictor variables entered in the model (x_1 = sex, x_2 =Age, x_3 = Marital status, x_4 = Education level, x_5 = household size, x_6 = labour availability, x_7 = land ownership, x_8 = farm size, x_9 = access to extension advisory, x_{10} = access to credit facilities, x_{11} = market availability, x_{12} = relative advantage of using innovations, x_{13} = total revenue per hectare per production season in 2015 (Tzs), x_{14} = decision making (index score) and x_{15} = knowledge of innovations (score)).

Content analysis was applied to analyse qualitative data elicited through key informants interviews and focus group discussions.

1.10 Organization of the Thesis

This thesis is organised in publishable manuscript format. The whole thesis consists six chapters and starts with general introduction of the study in Chapter One. This sets up the overall theme of the study and methodology. While, Chapter Two presents the first paper on determinants of paddy farmer participation in innovation process in Mvomero District, Morogoro. Tanzania. Chapter Three presents second paper on adoption of selected paddy innovations among smallholder farmers in Mvomero District, Morogoro, Tanzania. Chapter Four presents third paper on comparative profit analysis of paddy farming by adopters and non-adopters of selected innovations in Mvomero District, Morogoro. Chapter Five presents fourth paper on association between adoption of selected innovations and gender roles among paddy farmers in Mkindo and Dakawa irrigation schemes. Finally, Chapter Six presents summary, conclusions and recommendation of the study with contribution of the study and suggestions for further research.

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CHAPTER TWO

2.0 Paper 1: Determinants and extent of Paddy Farmer Participation in Innovation Process in Mvomero District, Morogoro. Tanzania

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2.1 Abstract

Farmers' participation in paddy innovations is an important platform for economic growth. However, data on the farmers' participation level in the paddy innovation process in Tanzania is inadequate. Using a cross-sectional research design the study was conducted in Mvomero District, Morogoro, Tanzania to establish levels of farmers' participation in the paddy innovation process. The study involved 299 randomly selected farmers from different plots of each scheme who participated in the innovation process. Data related to farmers' participation and their socio-economic characteristics were collected from paddy farmers using semi-structured questionnaire. Data were analyzed using the IBM-SPSS program and STATA/SE software. The participation index was developed to measure participation levels and an ordinal probit regression model was used to determine factors influencing farmers' participation in the innovation process. Findings show that the overall level of farmers' participation by using a five-form participation typology was 61.9% which denoted a medium level. Ordinal probit regression results revealed that there were significant differences between the household size, farming experience, farm size, marital status, land ownership, access to extension advisory services and farmer participation in the innovation process. It is concluded that the participation of farmers in the innovation process was medium meaning that farmers decision making in the inception and adoption of innovations was low. Also it is concluded that farmer participation in Mvomero District is determined by farm size, household size, farmer experience, marital status, land ownership and access to extension advisory services. Extension workers should educate farmers on the benefits of the adoption of introduced innovations to advance farmers' participation in the innovation process. District land-use planners with collaboration with Dakawa and Mkindo village leadership are advised to monitor irrigation infrastructures to allow usability of marginal land proximity to irrigation schemes for farmers to expand their farm sizes since land is a key factor of paddy production.

Key words: *Innovation, adoption, participation, experimentation, stakeholders.*

2.2 Introduction

Rice is the staple food for most of the world's population and is increasingly becoming a strategic crop in many African countries, Tanzania being included due to its contribution to household income (Martey *et al.*, 2013). Potential paddy producing regions in Tanzania are Morogoro, Mwanza, Shinyanga, Tabora, Mbeya and Rukwa (URT, 2009). Paddy production in Tanzania is operated in different scale of production ranging from large, medium and small-scale farmers. The contribution of small-holder paddy production for food security and national economic growth should however not be overemphasized. In Tanzania small-scale paddy production is done through traditional and improved paddy irrigation schemes. This study focuses on paddy production in irrigation schemes and the small-holder "improved" paddy irrigation schemes in Tanzania include: Mbuyuni, Madabaga, and Mwamapuli in

Mbeya Region; Magozi, Mlenge, and Madibila in Iringa Region; and Mkula, Mkindo and Dakawa in Morogoro Region. Mkindo and Dakawa being amongst improved schemes are located in the Mvomero District of Morogoro Region. Introduction of innovations is important to paddy farmers as it is vital for increased paddy production and productivity.

Scholars (Rogers, 1995; Leeuwis, 2004) conceptualize innovation as an idea, practice, object or system that is perceived as new by individuals in a system In the agricultural sector, innovations create an array of new choices for producers, altering what is produced, where it is produced, and how it is produced (World Bank *et al*., 2009). Adoption and diffusion are the processes governing the utilization of innovations. Rogers (1995) asserts that the innovation-decision process is a process through which an individual (or any other decision-making unit) passes from first knowledge of innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and confirmation of this decision. According to Pisante *et al*. (2012) the process of innovation includes not only knowledge creation, but also the whole system of technological diffusion, adoption processes, interactions and market adjustments. In this study, an innovation process is referred to as a course of action whereby innovation is exposed to farmers by researchers or extension agents and its eventual utilization by farmers.

The participation of various actors in the innovation process is necessary for agricultural growth (Ghimire, 2009). Different scholars have looked into the concept of participation differently and their views have not focused on the differential degree of involvement of each actor in an intervention. According to Cornwall (2008), a ‘deep’ and ‘wide’ participatory process engages a range of participants at all stages of a particular activity from identification to decision-making. Leeuwis (2004) defines participation as a process through which stakeholders influence and share control over development initiatives and the decisions and resources which affect them. Cornwall (2008) looked at participation in the context of engagement of various actors with varying perceptions of the meaning of participation in the participatory process. Scholarly discourses on the concept of participation dwelt on elaboration that different actors take part in the implementation of development intervention but there is a need to emphasize the differential participation of each actor. According to Martey *et al.* (2013), participation is a necessary but not a sufficient condition for the adoption of an innovation.

In line with the concept of participation, one would expect to realize the innovation process to entail a 'full' or total commitment to inclusiveness from the development, inception and adoption of new ideas among the actors including end-users (farmers). The low participation of farmers in any agricultural development project could be due to the inability of the project to meet the production needs of those farmers. The idea of 'maximum participation' connects to a notion that there are different levels of participation (Leeuwis, 2004).

Literature show that there are different "forms" within each typology of farmers' participation in rural innovations (Johnson *et al*., 2003; Kumba, 2003; Leeuwis, 2004; Iqbal, 2007; Ghimire, 2009). But little is known on the level of farmers' participation in each form of particular participation typology. Sumberg *et al*. (2003) asserts that farmers are viewed as passive recipients of technology whereby all is needed is communication and information flow in a linear and unidirectional way from the researchers to the farmers, via the extension. In line with Sumberg *et al*. (2003) and Noltze *et al*. (2011) farmers participate in System of Rice Intensification (SRI) training at the level of receiving information where extension services announce SRI via local radio stations or demonstration sites. More integration of farmers in the innovation processes through greater participation is crucial and determining the effective ways of promoting farmer participation is required towards the innovation process.

This study adapts a five-form typology of farmer participation in the innovation process as used by Johnson *et al*. (2003) (Table 2.1). The adaptation customized into farmers participation rather than considering community participation in general. The five forms of participation in this typology are: conventional, consultative, collaborative, collegial and farmer experimentation.

Table 2.1: Typology of participation

Form	Characteristics in each form
Conventional (No farmer participation)	Scientists/researchers/extension agents make decision alone without organized communication with farmers. It entails the launching of an innovation to farmers. Scientists/researchers/extension agents are much less inclined to engage farmers in the introduction of innovations.
Consultative (Functional participation)	Scientists/researchers/extension agents make decisions alone, but with organized communication with farmers. Farmers participate by being consulted through forums/meetings where they express their views and opinions but they are not final decision-makers on the innovations.
Collaborative (Empowering participation)	Decision-making authority is shared between farmers and scientists/researchers/extension agents, and involves organized communication between them. Farmers are actively involved by taking control and influence the decision-making process. There is joint involvement of stakeholders.
Collegial (Empowering participation)	Farmers make decisions collectively in a group of people who are involved in organized communication with scientists/researchers/extension agents. Farmers take initiatives in promoting innovation and assume responsibility for carrying it successfully.
Farmer experimentation (No researcher participation)	Farmers make decisions collectively in a group without organized communication with scientists/ researchers/ extension agents. Farmers are responsible for customizing the technology to suit their farming conditions. Farmers do experiments and then use technology for their needs and circumstances.

Adapted from Johnson *et al*. (2003).

This typology is selected due to its precision and clearly defined forms of participation. Each form of participation within the typology clearly describes the position of farmers in decision making and organized communication between farmers and scientists/researchers/extension agents upon introduction and adoption of innovations (Table 2.1).

Since independence, the Government of Tanzania (GOT) has been making various efforts to promote the agricultural sector by assuring farmers' access to and utilization of innovations and other resources. Much effort has been focusing on achieving quality livelihoods in terms of increased production and productivity (URT, 2009; URT, 2013). These efforts have not paid much attention as to which extent farmers participate to the innovations process as innovations are constantly being introduced to their areas. Innovations which were introduced in Mvomero District where this study was conducted are: System of Rice Intensification (SRI), power tillers (PT), wooden threshers (WT) and Combined Rice Mills (CRM) (Katambara *et al*., 2013). Studies show that poor farmers, especially the rural ones, do not fully participate in the innovations process (URT, 2009; World Bank *et al.*, 2009; Paris *et al*., 2011). This study therefore established farmer participation level in the innovations process in Mvomero District, Morogoro Region of Tanzania. Specifically, the study aimed at determining the extent to which paddy farmers participate in a five-form typology of participation in the innovation process. In addition, the study analyzes factors influencing farmers' participation in the innovations process.

This paper is guided by Rogers's theory (1995) of diffusion of innovation. The theory identifies various factors for adoption of innovation. Factors can be grouped in innovation characteristics, adopter's characteristics and external factors. In innovation related characteristics, Rogers insists on five key qualities that determine the rate of an innovation adoption to be relative advantage, compatibility with existing values and practices, simplicity and ease of use, trialability, and observable results. Therefore these qualities dictate to which extent paddy farmers can participate in the introduced innovations to their setting. Despite qualities related to innovation characteristics, Rogers (1995) further argued that farmer's decision to adopt or reject an innovation is a mental process which takes place in an individual, thus in this case, for paddy farmers to accept or reject the paddy innovations, it depends on how paddy farmers perceive a given innovation in their own view on their felt needs and prior experiences (Meijer *et al*., 2014). Thus, it is argued that farmers' perceptions over innovation process are determined by personal characteristics such as age, education, attitude, experience and extension services (Rehman *et al*., 2007). Thus, basing on this theory the study answered the following empirical research questions which include i) How the selected innovations were adopted by paddy farmers in the study area? ii) How introduction of paddy innovations in Mvomero District does influence farmers' participation in the innovation process?

2.3 Methodology

The study was conducted in Mkindo and Dakawa paddy irrigation schemes in Mvomero District, Morogoro. Mkindo and Dakawa rice irrigation schemes were the first adopters of SRI among the smallholder paddy farmers in Tanzania and served as good sites for the study on the adoption of SRI. Given the study population of 1 192 farmers participating in two schemes, the sample size of 299 farmers was estimated by using Yamane (1973). Proportionate samples of 96 and 203 farmers from Mkindo and Dakawa respectively were obtained. The names of all registered paddy farmers in each irrigation scheme were obtained from extension office and then the estimated number of farmers (96 and 203 farmers from Mkindo and Dakawa respectively) was randomly picked through table sampling. Then, with the help of extension officers, the farmers who constitute the sample size of the study were found in their fields for interview. Data were collected only at once by using a semi-structured questionnaire to generate information related to farmers' participation and their socio-economic characteristics.

Levels of participation were established by using quantitative methods of data analysis. Statements representing conventional (9), consultative (4), collaborative (4), collegial (4) and farmer experimentation (4) forms of participation were graded on a five-point Likert scales of ‘strongly agree’, ‘agree’, ‘disagree’, ‘strongly disagree’ and ‘undecided’ with 4, 3, 2, 1and 0 scores respectively. The distribution of statements across stages varies depending the number of characteristics in each stage. Then a participation index was developed for each stage of participation as well as the overall participation. This means there were 6 participation indices, 5 for each stage and the sixth one for overall participation.

The following formula was used;

$$PIndex = \frac{Tscore}{Maxscore} x100 . \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where;

$PIndex$ =Participation index

$Tscore$ =Total score obtained

$Maxscore$ =Maximum possible score.

This approach was also used by Rao *et al*. (1992) as well as Fita and Trivedi (2012). Thereafter, in order to obtain cut points, the participation levels were categorized using mean and standard deviation (SD) into: Low = < (mean - SD), Medium = between (mean - SD) to (Mean + SD) and High = > (Mean + SD).

An ordinal probit regression model was used to analyze the determinants of the farmers’ participation levels in the innovation process. Ordinal dependent variable *Y* is representing levels of participation in innovation process where 1=low participation, 2=medium participation and 3=high participation, of some underlying latent variable *Y**. We assume that $Y_i^* = X_i\beta + \mu_i$ ....(2)

and that we observe the ordinal choice Y_i :

$$
\begin{cases}
0 & \text{If } Y_i^* \le 0, \\
1 & \text{If } 0 < Y_i^* \le \mu_1 \\
2 & \text{If } \mu_1 < Y_i^* \le \mu_2 \\
3 & \text{if } \mu_2 < Y_i^*
\end{cases}
$$

Where;

*Y**= latent variable.

β =Estimated coefficients of the respective explanatory variables

μ_i = Error terms, is normally distributed and is used to estimate β vector and the thresholds μ corresponding to the different levels of the variables.

X_1 = Age (years)

X_2 = Household size (number of people)

X_3 = Farming experience (years in farming)

X_4 = Farm size (Ha)

X_5 = Farm income (Tzs)

X_6 = Sex (Male 1, otherwise 0)

X_7 = Marital status (married 1, otherwise 0)

X_8 = Land ownership (Owned 1, otherwise 0)

X_9 = Extension advisory (Yes 1, otherwise 0)

X_{10} = Labour availability (Hired 1, otherwise 0)

The estimates for the parameters were obtained by using STATA/SE software version 12.0 through which data were transferred from IBM-SPSS program. The relative effect of each explanatory variable on the likelihood that a farmer participated in innovation process at either low, medium or high level is given by the marginal effect formula;

$$\frac{\partial P_i}{\partial \chi_{ij}} = \beta_{ij} * f(Z_i) \quad \text{.... ....(3)}$$

Where; $f(Z_i)$ is the inverse of the cumulative normal function and β_{ij} are the estimated parameters.

2.4 Description of Explanatory Variables

Age is expected to influence participation negatively. Younger farmers are more willing and dynamic than older ones to participate in the innovation process (Hartwich and Scheidegger, 2010). Sex of the farmer is expected to depict the difference in enthusiasm between male and female farmers to participate in the innovation process. According to Martey *et al*. (2013) females are normally confined with accomplishing domestic activities which deprive them of the opportunity to participate in the innovations compared to males. In another hand, married farmers are more likely to participate in the innovations as their spouses normally help them to carry out production activities and make a decision. Farmer experience is expected to influence participation in the innovations positively. Pedzisa (2016) established a positive relationship between farming experience and farmer participation. Experienced farmers normally use their experience gained over the years to assess the attributes of innovations. Farm size is expected to influence participation positively. A farmer with large farm size can spare proportion of the whole farm land to try an innovation availed to farm setting.

Household size is posited to positively influence head of the household to participate in the innovations. Availability of household members provides the head with the opportunity to share the responsibilities related to adoption of innovation. Scholars (Botlhoko and Oladele, 2013; Martey *et al*., 2013) have found a positive relationship between the household size and participation in the innovations. Extension advisory is expected to positively influence farmer to participate in the innovations. Extension advices help farmers to be aware on the potential benefits of using innovations (Howley *et al*., 2012). Land ownership status is expected to capture the difference in decision to participate in the innovations between the owners and non-owners of land used for paddy production. Farmers with full ownership to land are more willing to try and practice innovations than non-owners of land.

2.5 Results and Discussion

2.5.1 Socio-economic characteristics of the respondents

The household size serves for labour supply for farm and non-farm activities provided that age distribution favours labour force. In this study it was found that 65.2% of all respondents had household size ranging one to five members (Table 2.2). However, it is the fact that, commonly, rural farming communities tend to have large households due because rural people tend to live in extended family for farm labour provision. The findings revealed that 51.5% of farmers in the study area had farms size ranging between one to five hectares with an indication that farmers could spare part of their fields to practice the paddy innovations.

Table 2.2: Socio-economic variables (n=299)

Variable	Frequency	Percent
Household size (Number of persons)		
1-5	195	65.2
6-10	100	33.5
>10	4	1.3
Farm size (Hectares)		
< 1	140	46.8
1-5	154	51.5
6-10	5	1.7
Farming experience (years)		
<5	73	24.4
5-10	116	38.8
11-15	38	12.7
16-20	39	13
>20	33	11
Age (Years)		
<25	20	6.7
25 – 34	65	21.7
35 – 44	92	30.8
45 – 54	82	27.4
55- 64	30	10.0
>64	10	3.3
Sex		
Male	200	66.9
Female	99	33.1
Marital status		
Married	222	74.2
Not married	77	25.8
Land ownership		
Owned	89	29.8
Borrowed	166	55.5
Hired	44	14.7
Extension advisory		
Received	69	23.1
Not received	230	76.9
Farm labour availability		
Hired	182	39.1
Not hired	117	60.9

Findings further show that 58.2% of the respondents were in the energetic and economically active age category which is useful in undertaking paddy farm production and processing responsibilities like cultivation, weeding and carrying of heavy loads. In this study, there were 66.9% male respondents. Males are more dynamic and therefore can easily be exposed to new ideas compared to females. However, majority of respondents (74.2%) were married and being into partnership status, could enable them assist each other to accomplish family and farm activities. In relation to land tenure, this study shows that 55.5% of all respondents tend to borrow land from farmer association upon registration especially in Dakawa irrigation scheme and 60.9% of all respondents do not offer their labour for hire. Farmers who offer their labour for hire means they spend their entire time to off-farm activities which is a constraint for them to access opportunities attached to innovations and lowers their participation to extension services. However, 76.9% of respondents did not receive extension advisory which made it difficult to access and utilize the introduced paddy innovations.

2.5.2 Levels of farmer participation in the innovation process

High participation of farmers in the introduction and adoption of agricultural innovations is an important platform because farmers are the ultimate beneficiaries of innovations (Emond and Madukwe, 2010). This study revealed that participation of smallholder paddy farmers in the study area was below 45.1% for conventional, 49.0% for consultative, 48.4% for collaborative and 46.6% for collegial form, while it was slightly higher for farmer experimentation form (55.9%), whereas the overall farmer participation in innovation process was 52.0% (Table 2.3).

Table 2.3: Levels of Farmer Participation in the Innovation Process (n=299)

Forms of participation	Levels of participation	Frequency	%	Participation (%)
Conventional	Low (<28.6%)	35	11.7	45.1
	Medium (28.6- 72.1%)	189	63.2	
	High (>72.1%)	75	25.1	
Consultative	Low (<12.8%)	98	32.8	49.0
	Medium (12.8 - 67.4%)	135	45.2	
	High (>67.4%)	66	22.1	
Collaborative	Low (<13.4%)	85	28.4	48.4
	Medium (13.4 - 66.8%)	160	53.5	
	High (>66.8%)	54	18.1	
Collegial	Low (<12.3%)	77	25.8	46.6
	Medium (12.3 - 65.4%)	178	59.5	
	High (>65.4%)	44	14.7	
Farmer Experimentation	Low (<14.3%)	99	33.1	55.9
	Medium (14.3 - 69.9%)	161	53.8	
	High (>69.9%)	39	13.0	
Overall level of participation	Low (<18.8%)	81	27.1	52.0
	Medium (18.8- 65.8%)	185	61.9	

High (>65.8%)	33	11.0

The results indicate that farmers' participation in each of the five participation typology as well as the overall participation for five forms, was rated at medium level. This implies that farmers' involvement in decision-making in the innovation process was at the medium level and it has an impact on the final use of innovations. Kumba (2003) found that farmers' participation in agricultural programs was too low (below 30%).

Relatively lower participation of farmers at conventional compared to other forms of participation implies that the introduction of the innovations in the study area was vested to scientists and experimentation was mainly done by farmers themselves. The relatively higher participation at farmer experimentation means that it is a form of participation where innovation is tested in the inclusion of farmers and the attributes of such innovation are easily realized by farmers themselves. Findings from this study are similar to that by Johnson *et al.* (2003) who found no farmer participation at the conventional form and also no researcher participation at farmer experimentation form but there is a mixed interaction of farming stakeholders at other forms of participation. This difference implies that researchers and extension workers interacted with farmers through shared communication during the inception and utilization of respective innovations in the study area.

2.5.3 Determinants of farmers' participation in the innovations process

The signs of coefficients from ordinal probit regression analysis were used to discuss the direction of the relationship (positive/negative) between explanatory variables and the dependent variable. Based on the ordinal nature of the dependent variable, this study used marginal effects to discuss the magnitude of change of dependent variable with respect to change of explanatory variables.

Household members form the basis of family and farm labour. The result from this study shows that household size was statistically significant at $p<0.05$ level and positively influenced the participation of farmers in the innovation process (Table 2.4). Marginal effects results were found to be -.023, .011 and .012 for low, medium and high levels of participation respectively (Table 2.4). This indicates that an addition of one member in a household increases the likelihood of participation in the innovation process by 0.011 at medium level and by 0.012 at a high level but decreases the likelihood of participation at a low level by 0.23. This implies that large household size enabled members to share farm responsibilities and created an opportunity for a farmer to participate in the innovation process and it was vice versa for the households with relatively fewer members. In this study, an increased member of the households offered an opportunity to access and adopts innovations. The study finding coincides with Kefyalew (2013) who found that farmers who have access to more family labour are more likely to participate in agricultural production innovations, but Pedzisa (2016) found that household size negatively impacted the adoption of agricultural innovation.

Farming experience measured in years was statistically significant at $p<0.1$ level and had a negative relationship with farmer participation in the innovation process. This results show that marginal effects were 0.006, -0.003 and -0.003 for low, medium and high levels of participation respectively (Table 2.4). This indicates that increasing one year in farming experience increases the likelihood of a farmer to participate in the innovation process at low level by 0.006 while decreases the likelihood of a farmer participating in the innovation process by 0.003 at the medium as well as at high level (Table 2.4). The study findings imply that farmers with low farming experience had high participation in the innovation process but farmers who had high farming experience had low and medium participation to the innovation process.

Table 2.4: Results of the ordinal probit regression analysis

Variables	Coefficients	Z-statistic	Marginal effects for low participation	Marginal effects for medium participation	Marginal effects for high participation
Household size (number of persons)	.0725893**	1.98	-.0233965	.0110524	.0123441
Farming experience (years)	-.0191239*	-1.88	.0061639	-.0029118	-.0032521
Farm size (Ha)	.1680032***	3.34	-.0541497	.0255801	.0285697
Marital status (1=married)	-.3434029*	-1.84	.1042272	-.0391912	-.065036
Land ownership (1=Owned)	.3196402*	1.93	-.0983535	.0391958	.0591577
Extension advisory (1=Yes)	.2808704*	1.65	-.0857875	.0331292	.0526583
No of observation	299				
Log likelihood	-252.622				
LR chi2 (10)	29.420				
Prob > chi^2	0.001				
Pseudo R^2	0.055				

Key: ** ,*** and *: Significance at 1%, 5% and 10% respectively

This is based on the fact that farmers who spent fewer years in paddy production are more ambitious to learn on paddy innovations due to high expectations over respective innovations but they become more reluctant to accept innovations when they become more used to innovations. Ani *et al*. (2004) found similar results that farmers with high experience are usually older, uneducated and reluctant to change than new entrants.

The farm size of the respondents was statistically significant at $p < 0.01$ level and positively influenced farmer participation in the innovation process (Table 2.4). Marginal effects results were -.054, .026 and .0286 for low, medium and high levels of participation respectively (Table 2.4). This means an increase in a farm size by one hectare decreases the likelihood of a farmer to participate at a low level by 0.05 but increases the likelihood of farmer participating by 0.03 at medium level and by 0.03 at high level in the innovation process. This implies that a farmer with relatively bigger farms in size stands a good chance to practice paddy innovations and vice versa is true. Similar to this study's finding, other researchers have found a positive relationship between farm size and adoption of innovations (Noltze *et al*., 2011; Howley *et al.*, 2012; Singha *et al.*, 2012).

The finding shows that marital status was statistically significant at $p<0.1$ level and displayed a negative coefficient. Marginal effects results were found to be 0.104, -0.039 and -0.065 for low, medium and high levels of participation respectively (Table 2.4). This denotes that married farmers had 0.1 more likelihood to participate in the innovation process at low level, but less likelihood to participate in the innovation process at medium and high levels by 0.04 and 0.07 respectively (Table 2.4). The result implies that unmarried farmers have higher participation compared to married ones. Unmarried farmers are not more tied to family responsibilities than married farmers and therefore enhance their involvement in the innovation process. This study's finding conforms to that of Martey *et al*. (2013) who found that marital status had significant and negative influence on participation in rural development programmes and marital responsibilities being a reason to such relationship.

Land ownership status was statistically significant at $p < 0.1$ level and had a positive influence on farmer participation in the innovation process. Marginal effects results were -0.098, 0.039 and 0.059 for low, medium and high participation levels respectively (Table 2.4). Land ownership is associated with farmers being 0.10 less likely to be in low participation level, but 0.04 and 0.06 more likely to be in medium and high levels of participation respectively. The findings imply that farmers are more likely to participate in innovation process when they have ownership of land than those who hire or borrow land for paddy production. Findings suggest that farmers who own land had high participation status due to feeling more ownership and thus willing to try/and practice innovations. Finding of Soule *et al*. (2000) corresponds to this study finding, they found that renters are less likely than land owners to adopt agricultural innovations.

Extension service offered to farmers was statistically significant at $p < 0.1$ level and had positive relationship with farmer participation in the innovations process. Marginal effects were -0.086, 0.033 and 0.053 for low, medium and high participation respectively (Table 2.4). The study findings imply that participation increases with farmers who received extension services on introduced innovations in the study area. Increase in extension service delivery increases the likelihood of a farmer to participate in the innovation process at medium and high levels by 0.03 and 0.05 respectively, but decreases the likelihood of a farmer to participate in the innovation process at low level by 0.08. Farmers who do not get access to extension services are thus marginalized and denied with important knowledge on introduced innovations, therefore, they eventually experience low level of participation. But farmers who access extension services, are equipped with knowledge about introduced innovations and thus built willingness to try/and adopt such innovations among farmers. Howley *et al*. (2012) and Sjakir *et al*. (2015) found that extension advises positively influence farmer participation to innovations.

2.6 Conclusion and Recommendations

Participation of paddy farmers in the five-form participation typology was medium. Generally, the decision on the introduction and adoption of the innovations were vested to scientists and extension agents. Probit estimates revealed that important factors influencing participation of paddy farmers in the innovation process in Mvomero District are household size, farm size, farmer experience, marital status, land ownership and extension advisory. Land ownership is a potential incentive on the participation of farmers in the innovation process. Also extension services impart farmers with the knowledge and skills related to innovations.

To enhance participation of paddy farmers in the innovation process it is recommended that scientists and extension agents should work jointly with farmers to realize the benefits of adoption of innovations whenever introduced to their setting. This study, further, recommends that land-use planners at the District level in collaboration with Dakawa and Mkindo village leadership to make follow up on schemes to ensure the drainage system is not problematic to allow effective paddy production operations. This will aid in uncultivated land to be usable whereby farmers will increase their farm sizes and be able to try/and practice innovations. Also, it is recommended that the irrigation schemes' leadership through agricultural land use planning section in the Ministry of agriculture, livestock and fisheries should facilitate farmers' acquisition of legal ownership of agricultural land. Again, it is recommended that training division in the Ministry of Agriculture, livestock and fisheries should offer constant trainings to extension workers to keep them up-to-date to new ideas/practices, be competent and strengthen their service delivery.

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Conflict of interest

The authors declare that there is no conflict of interest during the review and publication of this manuscript.

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CHAPTER THREE

3.0 Paper 2: Adoption of Selected Paddy Innovations among Smallholder Farmers in Mvomero District, Morogoro, TANZANIA

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3.1 Abstract

Adoption of paddy innovations is important for production and productivity but there has been low or non-adoption at different places in Tanzania. This level of adoption of innovations has not been convincing. This research was conducted in Mvomero District, Morogoro, Tanzania to determine the extent of adoption of innovations in paddy production and analyzed factors influencing this adoption. A cross-sectional research design was adopted and 299 respondents were sampled using simple random technique. Data were collected using semi-structured questionnaire, key informant interviews, field observation and Focus Group Discussions (FGDs). The extent of adoption of innovations was analyzed with descriptive statistics namely, frequencies and percentage. Binary logistic regression analysis was used to estimate factors influencing adoption of innovations. A two-limit Tobit model was used to determine extent of adoption of System of Rice Intensification (SRI) and the factors influencing adoption of SRI. Qualitative data were analyzed using content analysis. The study found that only 3.7% of all respondents were the full adopters of SRI while 10% of all respondents did not adopt any practice among 12 SRI practices. It was difficult to adopt Power Tillers (PTs), Wooden Threshers (WTs) and Combine Rice Mills (CRMs) and their adoption levels were 47%, 5% and 18% respectively. Marital status, land ownership, availability of paddy markets, knowledge, age and education level had significant influence on adoption of SRI ($p < 0.05$). The study concludes that, it limits a smallholder paddy farmer to attain full adoption of an innovation package which composes several practices in it as it becomes complex to follow. Extension programmes including training on introduced innovations and regular visits are important for adoption of paddy innovations to rural farmers. Markets availability is an opportunity which motivates farmers to adopt paddy innovations. Therefore, farmers should be well-informed of the markets by the extension and marketing officers.

Key words: *SRI, adoption, innovation, paddy, smallholder farmer.*

3.2 Introduction

Adoption of paddy innovations is important to rural farmers. It is the decision by the farmers to accept and make use of paddy innovation which is perceived beneficial towards achieving a sustainable increase in farm productivity and leading to improved well-being of respective farmers (Roggers, 2003). Adoption in this case occurs when there is a continued use of paddy innovations by farmers. The concept of innovation includes an application of advanced idea, method, farm practices and inputs which replace the conventional ones. Scholars define innovation as an idea, farming practice, and or a system that is perceived new by individuals (Rogers, 1995; Leeuwis, 2004). In this paper, innovations refer to new paddy production practices, production tools, and threshing and processing tools. The paddy innovations in this paper are System of Rice

Intensification (SRI), Power Tillers (PTs), Wooden Thresher (WTs) and Combine Rice Mills (CRMs). These tools are considered innovations because they are new in paddy production and processing in the study area. Thus, this paper refers to adoption of SRI, PTs, WTs and CRMs in paddy production as the application of SRI techniques, the use of PTs in land preparation, threshing paddy using WTs and processing paddy using CRMs. In this context, SRI is defined as a set of paddy production practices which involve twelve practices namely; selection of seeds using floating-sink method, raising seedlings in nursery, transplanting seedlings of 8-15 days old, uprooting and transplanting within 15-30 minutes, keeping uprooted seedlings in moist conditions, single transplanting, transplanting at shallow depth, spacing at 25cm x 25cm, early and regular weeding, water control by alternate flooding and wetting, application of compost manure and disuse of herbicides. PT, WT and CRM are the single entity tools by themselves which are used for land preparation, threshing and processing of paddy respectively. Application of innovations in paddy production and processing has many advantages to rural farmers.

Adoption of innovations is an important aspect which is anticipated to deliver positive results to the rural paddy farming community. However, a few scholarly studies in Tanzania especially the study area have been conducted in this area. Literature show that, adoption of SRI to paddy growers have the following benefits; yields per hectare increases usually by 50% to 200% or more; water requirements are reduced by 25% - 50%; cost of production is reduced by eight percent to 20%; minimal capital costs make SRI methods more accessible to poor farmers, who do not need to borrow money; the rice plants under SRI have been noted to be more robust against extreme weather events, pests, and diseases due to plant vigour and strength (Dobermann, 2004; Gujja and Thiyagarajan, 2010; Katambara *et al*., 2013; Islam *et al*., 2014).

Adoption of PT and WT is anticipated to save time, increase yield, profit, income and employment, expand the area under cultivation, reduce workload and labour required in paddy production and threshing (Quayum and Ali, 2012; Miah and Haque, 2015; Sims and Kienzle, 2016). Combine Rice Mills (CRMs) are the processing machines which perform a number of operations that produce higher quality and higher yields of white rice from paddy or rough rice. CRMs range from single to multiple pass rice milling machines depending on the scale of operation. In other hand, CRMs add value to the processed rice which leads to fetching lucrative market and earn higher income to respective farmers. However, multiple operations through milling help to reduce human drudgery attached in processing of paddy. Deliberate effort of communicating innovations to farmers is required so as to influence famers' decisions.

Effort has been undertaken by the Government of Tanzania (GoT) to introduce and promote paddy innovations to rural farmers including Mvomero District aiming at improving production, productivity and farmers' wellbeing. Since 2005, GoT introduced paddy innovations to farmers including rice varieties – SARO 5 (TXD 306), IR05N 221 (named *Komboka*, be liberated) and IR03A 262 (named *Tai*, eagle); best agronomic practices - SRI, water-saving irrigation technologies, rice planting techniques, Integrated Pest Management (IPM), tools and implements-reapers, PTs, threshers, combine harvesters and processing machines (URT, 2009; URT, 2013). The SRI, PTs, WTs and CRM innovations have been in use in the study area between 1999 to 2006 years (Katambara *et al*., 2013). However, the practice shows that paddy farmers do not readily accept innovations immediately. Up to 2015, the GoT through Agricultural Sector Development Strategy (ASDP) phase one and two has been promoting better access and use of agricultural knowledge, technologies, and infrastructure to paddy farmers in 20 irrigation schemes including Mkindo and Dakawa. Similarly, extension agents have been advocating these innovations to ensure that smallholder paddy farmers take in full adoption. Despite the efforts done by the government and extension agents, the level of adoption of paddy innovations introduced in Mvomero District is not yet established. Therefore, this study intended to assess adoption of four selected paddy innovations among farmers. Specifically, it determined the extent of adoption of the selected innovations and analyzed the factors influencing adoption of these innovations in the area of study.

This study adapts a sociological model of adoption of innovation. The model considers adoption as a learning process and that every person goes through mental steps during that learning process about innovation (Rogers and Shoemaker, 1971; Semgalawe *et al*., 1998). The process involves four stages; awareness, evaluation, trial and adoption. In awareness stage, a farmer learns about the new idea; evaluation stage involves comparison of the expected benefits of the innovation with his/her conventional ones, while in trial stage a farmer decides to try an innovation in a small plot/quantity of paddy and then use it on a larger plot/ quantity of paddy. Adoption stage involves complete application (confirmation) or otherwise discards of the innovation. Therefore this study established levels of adoption of SRI, PTs, WTs and CRMs and analyzed factors influencing adoption of these selected innovations.

3.3 Methodology

This study was conducted in Mvomero District in Morogoro Region, within which Mkindo and Dakawa paddy irrigation schemes are found. Mvomero District is one of the 6 districts of Morogoro Region. Geographically the District is located between latitude 6° 16’ and 6° 18’ South, and longitude 37° 32’ and 37° 36’ East and its altitude ranges between 345 and 365 m amsl. The study used cross-sectional data to measure the extent of adoption of each innovation and analyse factors influencing adoption of the selected innovations among paddy farmers in Mvomero District in Morogoro Region. Two paddy irrigation schemes in the District namely Mkindo and Dakawa were selected. These are the smallholder irrigation schemes where SRI was introduced to Tanzania from Kenya. Cross-sectional research design was adopted whereby simple random technique was used to obtain 299 respondents from two schemes and estimated by Yamane's formula (Yamane, 1973). Proportionate sampling technique was used to obtain 96 and 203 respondents from Mkindo and Dakawa respectively. The study deployed a mixed methods approach which facilitated the deployment of both quantitative and qualitative methods in data collection. Primary data were gathered using semi-structured questionnaire, key informant's interviews (KIIs) and Focus Group Discussions (FGDs). Three FGDs with six to twelve participants and five KIIs were conducted using FGDs guide and checklist of questions respectively. In the field, observation was also used to watch PTs and CRMs under operations as well as some SRI practices against conventional practices. The extent of adoption of innovations was analyzed with fundamental statistics values, mainly, frequencies and percentages for adopters and non-adopters. This approach was also used by other scholars like Miller *et al*. (2008); Oman *et al*. (2010); Mackrell *et al*. (2009).

Factors influencing adoption of SRI were analyzed differently from those influencing PTs, WTs and CRMs innovations due to differences in their dependent variables (adoption). Adoption of SRI was limited between zero to 12 practices meaning (0) lower limit score and (12) upper limit score while adoption of PTs, WTs and CRMs was dichotomous, that is, non-adoption (0) and adoption (1). Therefore, the factors influencing adoption of SRI were analyzed using a Two-limit Tobit model. Adoption of SRI involved 12 practices whereby a numerical score of zero was assigned for non-adoption and 1 was assigned for adoption in each practice. The model used a limited dependent variable whereby the value of the adoption of SRI ranged between 0 and 12 scores. The model was specified as follows:

$$Y* = \beta \chi_i + \varepsilon_i ....$$

ε ~ Normal $[0, \sigma 2]$.

Denoting Y_i as the censored observed adoption of SRI practices,

$$Yi = \begin{cases} 0 & \text{if } Y_i^* \leq 0 \\ Y_i^* = X_i\beta_i + \varepsilon_i & \text{if } 0 < Y_i^* < 12 \\ 12 & \text{if } Y_i^* \geq 12 \end{cases} \quad ....(2)$$

Where;

Y_i = the observed dependent variable, i.e. adoption of SRI, measured in scores upon adopted SRI practices by a farmer ranging from 0-12.

$Y_i *$ = the latent variable (unobserved for values smaller than 0 and greater than 12).

X_i = is a vector of independent variables (factors influencing adoption and intensity of adoption) which are described in Table 3.1.

β_i = Vector of unknown parameters.

ε_i = error terms that are assumed to be independently and normally distributed with zero mean and a constant variance σ^2, and i=1, 2…n (n is the number of observations).

X_1 - X_{15} = are the predictor variables which are described in Table 1.

The coefficients in Tobit model were farther disaggregated to estimate the expected value of Y_i (Sileshi *et al*., 2012; Mc Donald and Moffit, 1980) as follows:

The change in the probability of adopting SRI practices as an independent variable χ_i changes is:

$d\Phi(\delta)/d\chi_i =$

$$\phi(\delta)\frac{\beta_i}{\sigma} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The change in intensity of adoption of SRI practices with respect to a change in an explanatory variable among SRI adopters is:

$$\frac{\partial E(Y_i / U \succ Y_i^* \succ L, X)}{\partial X_i} = \beta_i \left[1 + \frac{\delta_L \phi(\delta_L) - \delta_U \phi(\delta_U)}{\Phi(\delta_U) - \Phi(\delta_L)} - \left(\frac{\phi(\delta_L) - \phi(\delta_U)}{\Phi(\delta_U) - \Phi(\delta_L)} \right)^2 \right] \ldots\ldots\ldots\ldots\ldots (4)$$

Where;

χ_i = explanatory variables,

$\Phi(\delta)$ =the cumulative normal distribution

$(\delta) = \frac{\beta_i \chi_i}{\sigma} =$ the Z-scores for the area under normal curve

β_i = vector of Tobit maximum likelihood estimates

$\sigma =$ the standard error of the error term

$$\delta_L = \frac{L - \chi_i \beta}{\sigma}$$

$$\delta_U = \frac{U - \chi_i \beta}{\sigma}$$

L and U are threshold values (L =0 and U =12)

Φ and ϕ are probability density and cumulative density functions of the standard normal distribution, respectively.

Factors influencing adoption of PTs, WTs and CRMs were analyzed using a binary logistic regression model in which dependent variables were dichotomous, that is, non-adoption (0) and adoption (1). So, three separate models were run for each innovation. Binary logistic regression, as explained by Challa and Tilahun (2014) and Agresti (2002) was used to test the hypothesis that the odds of the farmers adopting selected paddy innovations are the same among the paddy farmers with different socio-economic and socio-demographic characteristics ($p < 0.05$). The model was specified as follows:

Logit

$$[p(x)] = Log\left[\frac{p(x)}{1 - p(x)}\right] = \alpha + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \beta_n X_n + \varepsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Where;

Logit (px) = ln (odds (event)), that is the natural log of the odds of adopting the innovations.

$p(x)$ = prob (event), that is the probability of adopting the innovations.

$1 - p(x)$ = prob (nonevent), that is the probability of not adopting the innovations.

$Log\left[\frac{p(x)}{1 - p(x)}\right]$ = is the logarithm of the ratio of probability of adopting the innovations p(x) to probability of not adopting them 1- p(x).

α = constant of the equation.

$\beta_1 - \beta_n$ = coefficients of the predictor variables.

$\chi_1 - \chi_n$ = predictor variables entered in the model, are described in Table 3.1.

ε = Error term.

n = number of independent variables.

Table 3.1: Variable definition, unit of measurement and assumed influence

Variable	Variables definition and unit of measurement	Expected sign
X_1	Sex of the paddy farmer (1 if Male, 0 if Female)	+
X^2	Age of the paddy farmer in years	+/-
X^3	Marital status of the paddy farmer (1 if married , 0 if otherwise)	+
X^4	Education of the paddy farmer in terms of years spent schooling	+/-
X^5	Household size in terms of number of people in the household	+
X^6	Labour availability (1 if available, 0 if Not)	+
X^7	Land ownership (1 if owned, 0 if otherwise)	+
X^8	Farm size for paddy production in hectares	+
X^9	Access to extension advisory (1 if yes received, 0 if not)	+
X^{10}	Access to credit facilities (1 if yes, 0 If Not)	+
X^{11}	Market availability (1 if yes, 0 if Not)	+
X_{12}*	Relative advantage (1 if yes, 0 if otherwise)	+
X_{13}	Total revenue per hectare per production season in 2015 in TZS	+
X_{14}	Decision making (index score in continuous from 0 to 1).	+
X_{15}*	Knowledge of a respective innovation (in scores; ranging from 0-13 scores for SRI; 0-7 scores for PT; 0-2 scores for WT; 0-4 scores for CRM).	+

Note: Innovation attribute (χ_{12}^*) and Knowledge (χ_{15}^*) apply to four separate innovations i.e SRI, PT, WT and CRM.

Decision-making (DM) and Knowledge were the composite variables that involved procedure in measurement. DM fitted in a two-limit Tobit and binary logistic regression models was determined using scores whereby Three statements representing DM were assigned scores i.e. 1 =yes and 0=otherwise and decision-making index (DMI) was developed in a range of 0 to 1 for each innovation. The formula was adapted from Meena *et al.* (2012);

$$DMIndex = \frac{TscoreObt}{Maxscore} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where;

$TscoreObt$ =Total scores obtained

$Maxscore$ = Maximum expected score

Knowledge as a variable in this research involved farmers' awareness and technical know-how to utilize each innovation (i.e SRI, PT, WT or CRM separately).

It was determined using scores whereby statements were made to represent knowledge for each innovation and assigned scores i.e. 1 =yes and 0=otherwise. There were 13 statements representing knowledge for SRI, while Seven statements for PT, Two statements for WT and Four statements represented knowledge for CRM.

However, qualitative data were analyzed through content analysis, in which pieces of information from the FGDs and KIIs were condensed, coded and organized into different themes and compared based on study objectives.

3.4 Results and Discussion

This section gives the findings and results of the research and discussions. The results on extent of adoption of SRI, PTs, WTs and CRMs (section 3.4.1) as well as factors that influence adoption of each innovation (section 3.4.2) are presented and discussed below.

3.4.1 Extent of adoption of SRI, PTs, WTs and CRMs

The extent of adoption of the four innovations is presented in terms of frequency and percentage in which each innovation was adopted as well as qualitative data as obtained from Key informant interviews and Focus Group Discussion. However, the adoption differs from one another based on the percentage of farmers who adopted each innovation. The findings are presented and discussed below based on extent of adoption of SRI, PTs, WTs and CRMs.

3.4.1.1 Extent of adoption of SRI

Taking into account that System of Rice Intensification (SRI) is composed of twelve practices, this study presents and discusses the extent of adoption in terms of the number of practices adopted by farmers. The findings on the extent of adoption of SRI indicated that 10 percent of famers did not adopt any practice, 4percent adopted one practice e 6percent adopted two practices 15.4percent, adopted three practices 15.1percent, four practices 13.1 percent, five practices and 11percent six practices. other results indicate that 10.4 percent adopted seven practices, 3.7 percent eight practices 2 percent nine practices; 3.7 percent ten practices, 1.3percent eleven and the respondents who adopted twelve practices (full adoption) were 3.7% (Table 3.2).

Table 3.2: Extent of adoption of SRI

Adoption status of SRI (practices)	Frequency	%
00 practice (Non-adoption of SRI)	30	10.0
1 practice	12	4.0
2 Practices	18	6.0
3 Practices	46	15.4
4 Practices	45	15.1
5 Practices	41	13.7
6 Practices	33	11.0
7 Practices	31	10.4
8 Practices	11	3.7
9 Practices	6	2.0
10 Practices	11	3.7
11 Practices	4	1.3
12 Practices (full adoption of SRI)	11	3.7
Total	**299**	**100.0**

The findings show that 10 percent of all the respondents did not adopt any of 12 SRI practices (Table 3.2). This means that 90percent of all the respondents adopted SRI practices ranging from one practice to a varying combination of two to twelve SRI practices. However, the results indicate that the distribution of the adoption of SRI is concentrated around 3 to 7 practices, with a limited percentage of respondents adopting 1 to 2 and 8 to 12 SRI practices. This implies that when a package of paddy innovation is blended with several practices, there is a possibility that some practices are more complex to understand than others thereby making them difficult for farmers to follow all of them at once. This eventually slows the rate of adoption.

3.4.1.2 Extent of Adoption of Power Tillers (PTs)

The finding demonstrates that PTs were the frequently adopted innovation compared to WTs and CRMs accounting for 47percent of the farmers (Table 3.3). It is clear from the findings that more than half of all the respondents did not adopt this innovations. This implies that the PTs were difficult to be adopted in the study area. A similar observation is reported by Ngegba (2016) in rice farming community from six different villages of Northern Sierra Leone. The study found that less than 15percent of the farmers had adopted power tillers because of difficulties in operating the said innovation.

Table 3.3: Extent of adoption of Power tillers, Wooden threshers and Combine Rice Mills (n=299)

Innovation	Adopters		Non-adopters	
	Frequency	%	Frequency	%
Power tillers	140	46.8	159	53.2
Wooden threshers	16	5.4	283	94.6
Combine Rice Mills	53	17.7	246	82.3

In addition, information from Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) supports the conclusion that low rate adoption of PTs was its difficultness to operate by farmers. For instance, a KI from Chollima Agro-Scientific research centre argues that:

> *"...power tillers are environmental-specific innovations whose operations are difficult in Dakawa Irrigation Scheme because of heavy soil whose texture is clay in nature. Furthermore, majority of farmers possess large plots"* (KII three, 24th May 2016).

This quotation suggests that power tillers work best on sandy soil and work efficiently in small farms compared to large farms as compared to large tractors. Heavy soil retards

PT's speed and the PTs work longer than expected on large farms, thus, influence farmers' decision on adoption.

3.4.1.3 Extent of Adoption of Wooden Threshers (WTs)

According to the findings, only 5.4 percent of all the respondents adopted WTs (Table 3.3). The findings show that more than half of all the respondents did not adopt WTs. This implies that WTs are difficult to adopt in the study area. Similarly, a study conducted in Northern Sierra Leone by Ngegba (2016) found that less than 15percent of the farmers adopted paddy threshers and the majority did not adopt due to complications in operating them.

In addition, operation costs are another aspect that militates against the adoption of WTs. The results obtained from KIIs indicate that it was difficult to adopt WTs in the study area due to high costs involved, as key informant says,

> *"...it is costly to operate WT in the field because it requires purchasing big canvas, timbers and transporting these to and from the field during threshing period"* (KII one, 19th March 2016).

This result implies that high costs attached to the adoption of innovation can act as a constraint against farmers' application of such an innovation, since adds to the costs of operation and the reduction of profit to be realized.

3.4.1.4 Extent of adoption of CRMs

The findings indicate that 17.7percent of all the respondents adopted CRMs (Table 3.3). In other words, the majority of paddy farmers did not adopt CRMs. This implies that majority of farmers do not process their paddy using CRMs. The processing of paddy using this innovation requires paddy to be dried well enough to reduce breakage of milled kernels; in contrast, majority of rural farmers dry their paddy locally. Therefore, the local paddy drying system sustains high breakage during milling thereby producing little whole white rice kernels.

In addition, qualitative data shows that the processing of paddy using CRMs requires a large quantities of paddy at one time. One Key informant (KI), this to say about the adoption of CRM:

> *"...small-holder paddy farmers prefer convention mills than CRM because processing paddy with CRM requires large quantity of paddy (one 100kg bag) in order to operate the machine"* (KII two, 22nd March, 2016).

The costs involved in the adoption of an innovation, which in turn add to operation costs, minimise profit a farmer anticipates to realize from paddy production.

3.4.2 Factors influencing adoption of SRI, PTs, WTs and CRMs

Each innovation has different factors that determine its adoption. The overall results of the two-limit tobit regression indicate that adoption of SRI was influenced by marital status, land ownership, market availability, age of the respondents ($p < 0.05$), education level and knowledge of SRI ($p < 0.01$) (Table 3.4). Factors influencing adoption of PTs were: knowledge, relative advantage of using PTs ($p < 0.01$), labour availability, land size, access to extension advisory, market availability, access to credit facilities, and decision making power ($p < 0.05$) (Table 3.4). While, marital status, access to credit facilities ($p < 0.05$) and knowledge ($p < 0.01$) influenced adoption of WTs and land ownership and knowledge on CRMs were found to influence adoption of CRMs ($p < 0.01$) (Table 3.4).

3.4.2.1 Factors influencing adoption of SRI

The results show that farmers' knowledge was significantly associated with adoption of SRI practices at $p < 0.01$ significance level (Table 3.4). The probability of adoption of

SRI increased for farmers who had knowledge of SRI as compared to un knowledgeable farmers. Moreover, it was found that knowledge of SRI increased probability of adopting SRI practices by 1.19 percent and increased the rate of adoption on average by 56.67 percent (Table 3.4). This means that the probability for a farmer who was informed of SRI practices had greater chance to adopt SRI than for unknowledgeable farmer. This finding concurs to that of Fita *et al*. (2012); Sarada and Kumar (2013); Ngwira *et al*. (2014) who found that there is a significance and positive influence between farmers' knowledge and adoption of innovations.

The results indicate significant association between marital status and adoption of SRI practices at $p < 0.05$ significance level (Table 3.4). The chance of adoption of SRI increased for married farmers as compared to unmarried farmers. Further, it was found out that a probability for the marital status is 2.21 and unconditional expected value is 84.38 (Table 3.4). This means that the probability a married farmer being an adopter of SRI is greater than for unmarried farmer by 2.21 percent and adoption rate increased by 84.38 percent for all respondents. These results imply that married farmers are better positioned to assist each other compared to unmarried farmers. Given the fact that smallholder farmers in rural areas do not rely on hired labour, spouses help each other in production and domestic activities hence facilitate easy practice of the SRI techniques. This is in agreement with Johnson and Vijayaragavan (2011) observation that adoption of SRI practices requires high labour in case of accomplishing activities related to adoption of SRI practices.

The study also found that the association between adoption of SRI practices and farmers' land ownership was significant ($p < 0.05$) (Table 3.4). The model results similarly indicate that land ownership increased farmers' probability to adopt SRI by 1.48 percent and it increased the rate of adoption of SRI practices by 79.90 percent. This result suggests that farmers with land ownership had higher adoption of SRI than those without ownership by the factor of 1.48 and adoption rate of SRI practices by increased by 79.90 percent. Thus, since land ownership acts as a security which increases farmers' incentives to adopt, it is obvious that land ownership influences adoption decision whereby farmers with land ownership are more likely to adopt SRI practices than those without ownership. In the same manner, Ogutu *et al*. (2015) confirmed that land ownership significantly affects adoption decision of Sustainable Agricultural Intensification technologies (SAI) in multiple ways in Kenya.

Table 3.4: Two-limit Tobit model estimates of level of adoption of SRI and factors influencing adoption of SRI (n=299)

Variable	ß	SE	t-value	Sig.	Probability	Unconditional expected value
Sex (X_1)	.100	.3170	0.31	0.753	.0021	.0977
Age (X_2)	-.022*	.0134	-1.66	0.099	-.0005	-.0217
Marital status (X_3)	.866**	.3740	2.32	0.021	.0221	.8438
Education level (X4)	-.179***	.0579	-3.10	0.002	-.0037	-.1758
Household size (X_5)	-.044	.0716	-0.61	0.542	-.0009	-.0428
Labour availability (X_6)	-.189	.3126	-0.61	0.546	-.0038	-.1854
Land ownership (X_7)	.814**	.3329	2.45	0.015	.0148	.7990
Land size (X_8)	-.075	.1016	-0.74	0.462	-.0015	-.0733
Access to extension advisory (X_9)	-.429	.3495	-1.23	0.221	-.0099	-.4185
Access to credit facilities (X_{10})	.014	.2907	0.05	0.962	.0003	.0136
Market availability (X_{11})	.791 **	.3251	2.43	0.016	.0199	.7705
Perceived relative advantage of SRI (X_{12})	-.004	.3510	-0.01	0.992	-.0001	-.0036
Total revenue per hectare per production season in 2015 (X_{13})	-1.350e-08	8.61e-08	-0.16	0.876	-2.76e-10	-1.32e-08
Decision making power index (X_{14})	-.384	.5923	-0.65	0.517	-.0079	-.3763
Knowledge of SRI (X15)	.579***	.0434	13.34	0.000	.0119	.5667
_cons	2.798	1.0581	2.64	0.009		
Number of obs	299					
LR chi^2 (15)	222.37					
Prob> chi^2	0.000					
Pseudo R^2	0.152					
Log likelihood	-620.966					

Note: *, ** and *** indicate statistical significance at 10%, 5% and 1% significance levels respectively.
β = Coefficient; SE= Standard error

Availability of paddy markets is found to be a significant determining factor in the adoption of SRI practices at $p < 0.05$ significant level (Table 3.4) in the study area as expected. Equally, availability of paddy markets increased probability of adopting SRI practices by 1.99 percent and increased the rate of adoption on average by 77.05 percent (Table 3.4). This result implies that the availability of paddy markets increased the likelihood of farmers to adopt SRI practices. The reason for increased likelihood of farmers to adopt SRI in light with markets availability is the fact that commercial paddy farmers would like to have high production so as to realize profit. Katambara *et al*. (2013) documented that adoption of SRI practices in Mkindo area produces 6.3 tons/ha compared to 3.83 tons/ha when conventional practices are used.

Moreover, farmers' knowledge has an influence on the adoption of SRI practices. It was found that farmers' knowledge on SRI was significant and positively associated with adoption of SRI practices at $p < 0.01$ significant level (Table 3.4). The results show that for a unit increase in knowledge of SRI, a probability of adopting SRI increased by 1.19 percent and the rate of adoption increased by 56.67 percent for all respondents. This implies that farmers who were aware and knew how SRI techniques are applied had higher chance to adopt this package of innovations compared to farmers who were not knowledgeable on SRI practices. Similar result on the significant and positive relationship between knowledge and adoption of innovations has been reported by other scholars (Fita *et al*., 2012; Sarada and Kumar, 2013; Ngwira *et al*., 2014). For instance, Sarada and Kumar (2013) observe that as farmers' knowledge increases, the adoption levels of farmers on recommended production practices also increases.

Age was significantly associated with adoption of SRI practices ($p < 0.1$) (Table 3.4). Two-limit Tobit regression results also indicate that for a unit increase in age, a probability of adoption of SRI practices decreased by 0.05 percent and on average decreased the rate of adoption by 2.17 percent for all respondents. In addition, the FGD as conducted on 13thJune, 2016 at Dakawa village revealed that age of a farmer has an influence on adoption of SRI practices. The data from that focus group discussions reflected that some practices like transplanting seedlings within 15-30 minutes, keeping uprooted seedlings in moist conditions, single transplanting, careful transplanting at shallow depth and transplanting at spacing of 25cm x 25cm are technical and laborious.

This means that as age of a farmer increases, the adoption of SRI practices decreases. Thus, the likelihood of a younger farmer to adopt SRI practices is higher than an older farmer. This could be due to the fact some practices within SRI practices are technical which require measurements, timing and intensive care such that they become hectic and cumbersome for elderly farmers to accomplish. The older farmers, unlike younger farmers who have more propensities in learning and adopting innovations, become unable and unwilling to apply SRI techniques. Similarly, Howley *et al*. (2012); Martey *et al*. (2013); Akinbode and Bamire (2015); Nayak *et al*. (2016) reported that age was negatively associated with the adoption of innovations.

Education level of the respondents is an important aspect in the adoption of an innovation. The evidence from the regression analysis shows that education level was significantly associated with the adoption of the SRI practices at $p < 0.01$ significant level (Table 3.4). The negative sign of the coefficient shows that as the education level increases, the probability of adopting SRI practices decreases. The two-limit tobit model results also indicate that probability of adoption was 0.0037 and unconditional expected value was 0.1758 (Table 3.4), meaning that an increase in education level decreased farmers' probability to adopt SRI practices by 0.37 percent and adoption rate declined by 17.58

percent for all respondents. This means, farmers with low level of education were more willing to adopt SRI practices than the farmers with high level of education. Farmers with high level of education tend to have off-farm (professional or entrepreneurial) activities and therefore would prefer less tedious and time saving farm techniques. The same is true for Martey *et al*. (2013) and Shah *et al.* (2014) who asserted a negative relationship between education level and adoption of rice innovations in Northern Ghana and Bangladesh respectively. These researchers pointed out that educated farmers deflect their skills to off-farm employment opportunities and are unwilling to adopt farm innovations.

This suggestion is supported by the field observation and KII made during the data collection. A paddy farm of one farmer, a Masters Degree holder, and a researcher at Cholima Agro-Scientific Research Centre was planted paddy using broadcasting system instead of adopting SRI practices. He gave the following reason for not using SRI practices;

> "*…the SRI practices like transplanting at spacing of 25cm x 25cm and transplanting single seedling per hole is laborious and costly to hire labourers for large plots like mine*" (KII three, 24th May, 2016).

This finding indicates that though a farmer had relatively higher education, he opted for conventional practices rather than adopting SRI practices. The laborious nature of innovation consumes a lot of time that a farmer could spend for other off-farm activities. Nirmala and Vasantha (2013) had similar observation. They described that non-adoption of SRI practices such as seed treatment, preparation of raised seed bed, application of organic manure, planting single seedling at 25 cm x 25 cm spacing at shallow depth was due to laborious nature of practices.

3.4.2.2 Factors influencing adoption of PTs

A relationship existed between adoption of power tillers and availability of labour in the area of study. The results indicate that labour availability was statistically significant (ß=0.668; p=0.065) related with adoption of PTs (Table 3.5). This means that farmers who had available labour (hired and not hired) had higher chance to adopt PTs than farmers who had no labour. The odds ratio for labour availability is 1.950; meaning that farmers who had access to labour 1.950 more likely to adopt power tillers compared to farmers with no access to labour. Thus, it can be inferred that those farmers who had access to labour (that means labour who were sourced from households or hired) for paddy production operations were motivated to adopt PTs. Power tillers are applied for land preparation, so labour is highly important to fulfill immediate post-land preparation activities such as perfect leveling and irrigation which are followed by timely transplanting. Scholars hold that availability of labours encourages farmers' adoption of technology (Nirmala and Vasantha, 2013).

Availability of markets was significantly associated with adoption of PTs (ß=0.986; P=0.011). This result indicates that farmers who were informed on availability of markets had higher chance to adopt PTs compared to farmers who were not informed on availability of markets. Paddy was sold at farm gate to middlemen, warehouses owners and rice millers. During the interview in focus group discussion, it was revealed that farmers get data about paddy markets from extension officers and fellow farmers. The results from binary logistic regression analysis also show that, the odds of adoption is estimated to increase by a factor of 2.680, meaning that farmers who were accessible to information on paddy markets had 2.7 times more likely to adopt PTs than those who had no accessibility. This implies that the rational decision made by farmers to adopt PTs resulted from the availability of market that assures the farmer to sell his/her paddy/and rice.

Adoption of PTs was also influenced by perceived relative advantage of using PTs. The results revealed a significant relationship between perceived relative advantage of using PTs and adoption of PTs (ß=1.755; p=0.000) (Table 3.5). The odds ratio for relative advantages of using PTs was 5.786; this shows that farmers who perceived power tillers being relatively advantageous to conventional ones had around 5.8 times likely to adopt PTs than farmers who felt the use of PTs had no benefits. The result confirms that farmers who perceived PTs being advantageous in land preparation over conventional tools had greater chance of adoption than farmers who perceived PTs otherwise. Similar to this result, Akudugu *et al*. (2012); Howley *et al*. (2012) noted that farmers who are more likely to receive benefits from the use of an innovation are more likely to adopt such innovation.

Table 3.5: Binary logistic regression model estimates of factors influencing adoption of PT, WT and CRM separately

Variable	Power Tillers					Wooden Threshers					Combine Rice Mills				
	ß	SE	Wald	Sig.	Exp(B)	ß	SE	Wald	Sig.	Exp(B)	ß	SE	Wald	Sig.	Exp(
Sex (X_1)	.293	.370	.628	.428	1.341	.562	.829	.459	.498	1.754	.229	.543	.177	.674	1.2
age (X_2)	-.019	.015	1.601	.206	.981	-.022	.033	.460	.498	.978	-.025	.027	.898	.343	.9
Marital status (X_3)	.379	.442	.737	.391	1.461	-1.934**	.918	4.434	.035	.145	.243	.654	.138	.711	1.2
Education level (X_4)	-.031	.068	.203	.652	.970	.011	.128	.008	.929	1.012	-.031	.098	.098	.754	.9
Household size (X_5)	-.012	.091	.018	.894	.988	.223	.176	1.610	.204	1.250	-.018	.115	.023	.879	.9
Labour availability (X_6)	.668*	.362	3.405	.065	1.950	.234	.695	.114	.736	1.264	.514	.585	.773	.379	1.6
Land ownership (X_7)	.469	.400	1.377	.241	1.598	.601	.823	.533	.465	1.823	1.904***	.585	10.571	.001	6.7
Land size (X_8)	-.337**	.140	5.827	.016	.714	.167	.240	.484	.486	1.182	-.004	.183	.000	.984	.9
Access to extension advisory (X_9)	-.924**	.409	5.110	.024	.397	-.606	.912	.442	.506	.545	-.682	.617	1.225	.268	.5
Access to credit facilities (X_{10})	-.583*	.352	2.746	.098	.558	1.453**	.693	4.394	.036	4.274	.389	.500	.605	.437	1.4
Rice markets availability (X_{11})	.986**	.390	6.404	.011	2.680	2.0x10^{1}	3.8x10^{3}	.000	.996	4.8x10^{8}	.736	.556	1.751	.186	2.0
Perceived relative advantage (X_{12}^{*})	1.755***	.371	2.2x10^{1}	.000	5.786	.558	.842	.439	.508	1.747	.936	.672	1.938	.164	2.5
Total revenue per hectare per production season in 2015 (X_{13})	.000	.000	.036	.849	1.000	.000	.000	.189	.664	1.000	.000	.000	1.377	.241	1.0
Decision making power index (X_{14})	1.292*	.748	2.985	.084	3.642	1.816	2.895	.393	.530	6.147	.175	1.193	.022	.883	1.1
Knowledge of SRI (X_{15}^{*})	.592***	.103	3.3x10^{1}	.000	1.807	3.117***	.929	1.1x10^{1}	.001	2.3x10^{1}	1.379***	.187	5.4x10^{1}	.000	3.9
_cons	-3.391	1.279	7.029	.008	.034	-2.6x10^{1}	3.8x10^{3}	.000	.994	.000	-6.120	2.051	8.900	.003	.0
Nagelkerke's R^2 0.549						0.445					0.631				
Cox and Snell R^2 0.404						0.152					0.383				
Hosmer and Lemeshow Test (chi^2 = 11.976; Sig. = 0.152)						(chi^2 = 3.823; Sig. = 0.873)					(chi^2 = 4.525; Sig. = 0.807)				
Omnibus Tests of Model Coef (chi^2= 154.698; Sig. = 0.000)						(chi^2= 49.202; Sig. = .000)					(chi^2=144.438; Sig.= 0.000)				
- 2 Log likelihood 258.596						75.618					134.953				

Note: β = Coefficient; SE = Standard error; Exp (B) = Odds ratio; *, ** and *** indicates statistical significance at 10, 5% and 1% significance levels respectively; χ_{12}^{*} = Relative advantage of PT, WT and CRM separately; χ_{15}^{*} = knowledge on PT, WT and CRM separately.

Decision making power makes contribution to farmers' choices in adopting PTs. The decision making power attributes; use of farm resources, use of innovations and choice of market were statistically significant related with adoption of PTs (ß=1.292; p=0.084) (Table 3.5). The odds ratio confirms that an increase in decision making power by 0.1 index score increases the adoption of PTs by a factor of 3.642 (Table 3.5). This implies that adoption of PTs is subject to the farmers' decision on utilization of land, water, harvests and relative ability to decide market to sell produce. Thus, farmers with higher decision making power increased adoption of PTs than those with low decision making power. Water saturation on paddy fields is a necessary condition for a farmer to operate a PT, therefore a farmer who is denied access to irrigated water will not use a PT. Baird *et al*. (2004) found the similar result that decision usefulness was statistically significant related with adoption of innovations.

Farm size influenced the adoption decision of the farm households significantly. Farm size was correlated with the adoption of PTs at 0.05 level of significance (ß= -0.337; p-value = 0.016) (Table 3.5). The negative sign of the coefficient reflects that as land size increases, the adoption of PTs decreases. This is due to the fact that as the farm size increases, the applicability of the PTs for land preparation and transplanting decreases. PTs become more usable and desirable where a farm is small. In other hand, PTs are ineffective where farm size is large. The odds ratio depicts that an increase in farm size by one hectare decreases the adoption of PTs by a factor of 0.714. Similar to the finding of this study, Howley *et al*. (2012); Umeh and Chukwu (2013); Ngwira *et al*. (2014) reported that farm size was statistically significant and negatively correlated with adoption of innovations.

Farmers' access to extension services is an important component in the adoption of innovations. The finding in Table 3.5 revealed that an access to extension advisory significantly (ß= -0.924; p=0.024) associated with adoption of PTs. This result connotes those farmers who received extension advices were less likely to adopt PTs compared to those who received no advices. The results also indicate the odds ratio of 0.397; that means farmers with access to extension services were 0.4 times less likely to adopt power tillers compared to those with no access to extension services. In this regard, it is clear extension service packages were not context specific. For instance, the introduction of PTs in the study area did not take into consideration the paddy farming situation such as appropriate soil. This study result is consistent with other findings like Fita *et al.* (2012); Akinbode and Bamire's (2015) who found negative relationship between extension services with the adoption of innovations.

There is an association between farmers' access to credit facilities and adoption of PTs. It was found that access to credit facilities significantly associated with adoption of PTs (ß= -0.583; p=0.098) (Table 3.5). This suggests that farmers who had access to credit had low chance to adopt PTs than those with no access to credits. The odds of adopting PTs are estimated to decrease by a factor of 0.558, meaning that farmers who had access to credit facilities were around 0.6 times less likely to adopt power tillers compared to those with no access credit facilities. Therefore, access to credit facilities was not applicable in the adoption of PTs. In other words, application of power tillers was not a preference to farmers who had access to credit but it was mentioned during the interview that the beneficiaries of loan tend to purchase fertilizers and pesticides.

Knowledge about innovation is a pre-disposing factor for adoption of an innovation. The result show that farmers' knowledge on PTs was statistically significant related to adoption of PTs ($p < 0.01$) (Table 3.5). The odds ratios for knowledge of respective innovation were 1.807 for adoption of PTs. This means that farmers who were informed of PTs in terms of awareness, knew how to operate and repair PTS had around 2.0 times more likely to adopt PTs, compared to those who were not knowledgeable of PTs. Farmers who have appropriate knowledge on PTs are able to compare the advantages of using PTs against conventional tools for land preparation. So, the benefits from using power tillers like time saving, reducing laboriousness, easy paddling and simplifying land leveling motivate the paddy farmers to adopt PTs in expense to other traditional tools for land preparation. Fita *et al*. (2012); Sarada and Kumar, (2013); Ngwira *et al*. (2014) also found similar results about significance and positive influence between farmers' knowledge and adoption of paddy innovations.

3.4.2.3 Factors influencing adoption of WTs

Marital status of the respondents influenced adoption of WTs. The results show that marital status was statistically significant associated with adoption of wooden threshers (ß= -1.934; p=0.035) (Table 3.5). The result shows that unmarried respondents had higher likelihood to adopt WTs than married couple. Also model results indicate that, the odds ratio for marital status was 0.145; so, married farmers were 0.145 times less likely to adopt WTs compared to unmarried ones. This might be due to the fact that married farmers, unlike unmarried, have family responsibilities and thus, the costs related to taking care of a large family diminish commitment to adopt WTs at the expense of traditional method of paddy threshing. In the same line, FGDs which were held at Mkindo village on 04thMay, 2016 revealed that adoption of WTs had cost implication compared to conventional way of paddy threshing. The participants in a FGD at Mkindo village showed that adoption of a WT requires incurring costs of purchasing large canvases and a wooden stand and the married farmers find it difficult to adopt in line to costs required to take care of their families. Therefore, it can be concluded that the cost related to family obligations among married farmers hinder farmers' adoption of a WT which also requires substantial investment.

The results indicate that farmers' knowledge on WTs was a key factor in the adoption of such innovation. It was found that knowledge of farmers on WTs was significantly associated to adoption of WTs ($p < 0.01$) (Table 3.5). The odds ratio for knowledge of WTs was 23.00 for adoption of WTs. This suggests that farmers who were knowledgeable on the WTs innovations are around 23.0 times more likely to adopt WTs, compared those who had no knowledge of using WTs. Farmers who have appropriate knowledge on WTs can easily evaluate the profitability of using such an innovation. So, the possibilities of realizing profit from using such innovation made the farmers to decide to adopt WTs in expense of conventional methods of threshing paddy. This finding is in line with other researchers who reported significance and positive influence between farmers' knowledge and adoption of innovations (Sarada and Kumar, 2013).

Farmers' access to credit facilities is related to adoption of WTs. The results show that there is a significant relationship between farmers' access to credit facilities with adoption of WTs (ß=1.453; p=0.036) (Table 3.5). This means that farmers with access to credit facilities had higher likelihood to adopt WTs than farmers who lack access to credit facilities. This is also revealed in regression analysis results where the odds of adopting WTs are predicted to increase by a factor of 4.274, meaning that farmers who had access to credit facilities were 4.3 times more likely to adopt WTs compared to those with no access to credit facilities. This implies that accessibility to credit facilities is capital that facilitates farmers to secure loans which in turn will enable them to meet the expenses of applying WTs. Adoption of WTs require purchase of materials like canvases and wooden stand and transportation to and from the fields. This research revealed similar findings to those of Mmbando and Baiyegunhi (2016) who reported positive relationship between access to credit and adoption of innovations.

3.4.2.4 Factors influencing adoption of CRMs

Land ownership showed a highly significant relationship with adoption of CRMs. A binary regression analysis indicate that there was significant (ß =1.904; p=0.001) relationship between land ownership and adoption of CRMs (Table 3.5). Also, model analysis found that the odds ratio for land ownership status was 6.710; meaning that farmers with ownership to land were 6.7 times more likely to process paddy using CRMs compared to those with no ownership. This indicates that farmers with land ownership have higher chance to adopt CRMs than those with no land ownership. As it was observed by Ogutu *et al*. (2015) that land ownership security increases farmers' incentives to adopt agricultural innovations, this result implies that land ownership as a security encourages farmers to engage into paddy production and thus are able to harvest enough paddy which enable them to process using CRMs instead of simple mills.

Knowledge about innovation is an important variable for adoption of CRMs. The results indicate that farmers' knowledge on CRMs was significantly related to adoption of CRMs ($p < 0.01$) (Table 3.5). The odds ratio for knowledge of respective innovation was 3.97 for adoption of CRMs. This suggests that farmers who were knowledgeable on CRMs had around 4.0 times more likely to adopt CRMs, compared those who were not knowledgeable. Farmers who have appropriate knowledge on an innovation can assess the advantages and the opportunities of using CRM. So, the possibilities of making profit via such innovation made the farmers to take positive decisions to CRMs. This finding is in line with other researchers who reported significance and positive influence between farmers' knowledge and adoption of innovations (Fita *et al*., 2012).

3.5 Conclusion and Recommendations

This study indicates that farmers' knowledge is an important variable in adoption of each innovation. Therefore, it is not necessary for the variables which influence adoption of one innovation to have an influence on other innovations. Distribution pattern of SRI adoption was noted to be concentrated into three to seven practices, with limited adoption of one to two as well as combination of eight to 11 SRI practices. It was also shown that PTs, WTs and CRMs were inappropriate to farmers' situation making them difficult to be adopted in the study area. The land ownership gives a farmer the right and security which is a motivation to adopt innovations. It further revealed that although extension services are crucial in promoting paddy farming, if not well programmed to promote innovations, there is a possibility to constrain adoption of such innovations. Available paddy markets at farm level are an opportunity that motivates farmers to adopt innovations and eventually raise their production and productivity.

Since knowledge was an important aspect in the adoption of innovations, therefore extension officers are advised to educate and train farmers to clearly understand and eventually practice the innovations. The knowledgeable farmers in turn are anticipated to practice innovations thereby advance their rate of adoption. Paddy farmers should be assisted to secure land title deeds by the village government in collaboration with District land planners. In order to avoid negative influence of extension services, extension officers and agricultural interventionists should design farm-level innovations that reflect the paddy production and processing attributes of the potential recipients in the rural farmers' communities. Such innovations should be simplified to fit into the existing paddy farming of the potential users. Active participation of paddy farmers in agricultural empowerment interventions is needed because their willingness is important in adoption of innovations. Extension officers are advised to raise awareness to paddy farmers on available markets at their setting as an opportunity for their economic growth.

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CHAPTER FOUR

4.0 Paper 3: Comparative Profit Analysis of Paddy Farming by Adopters and Non-adopters of Selected Innovations in Mvomero District, Morogoro.

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4.1 Abstract

Level of profit generated from adoption of paddy innovations can influence famers' decision to adopt such innovations; however it is imperative to know whether there are profit differences between adopters and non-adopters of innovations. This study was conducted in Mvomero District, Tanzania. The main objective was to compare profitability among adopters and non-adopters of selected innovations. Cross-sectional research design was employed and simple random sampling technique was employed to select 299 who were interviewed using a semi-structured questionnaire. Net farm income (NFI) and Return on investment (ROI) were used to analyze the profitability for selected innovations. Content analysis was used to analyze qualitative data. The study revealed that adoption of SRI, PTs and WTs was more profitable compared to non-adoption of the same innovations ($p < 0.01$). Adoption of SRI, PTs and WTs to farmers in the study area is a profitable venture ($p < 0.01$) and serves as a stimulus for other farmers to apply the

innovations in paddy production. Extension officers and rural development agents should educate farmers especially those who did not adopt innovations on the advantages of adoption of paddy innovations so as to improve their wellbeing.

Key words: *Profitability, adoption, innovation, Return on Investment, Net Farm Income.*

4.2 Introduction

Agriculture is an important economic sector of the Tanzanian economy and contributes about 29.1% of Gross Domestic Product (GDP) (URT, 2017). The important cereal crops produced in Tanzania are maize, paddy, sorghum, finger millet, bulrush millet, and wheat. Paddy is among the important cereal crops grown in different parts of Tanzania as food crop and source of income. In the 2016/17 season, paddy was ranked the second produced cereal crop after maize with a harvest of 1 382 794 tons (17.8 %) compared to 1.4 million metric tons in National Panel Survey (NPS) 2014/15. Morogoro Region recorded the highest paddy production in Mainland Tanzania with 332 280 tons (24.0 %) and crop yield of 4.0 tons/ha, followed by Mbeya Region with 246 649 tons (17.8 %) (URT, 2017; NBS, 2017). Morogoro is among the three potential paddy producer regions in the Central Corridor, others are Tabora and Shinyanga. The regions have larger areas under paddy which together constitute 48.4 % of the total area under paddy cultivation in Tanzania (Rice Sector Assessment Report, 2009).

In Morogoro, paddy is produced by large scale as well as smallholder farmers. Mkindo and Dakawa paddy irrigation schemes, located in Mvomero District in Morogoro region, are among Tanzania’s major areas of paddy production. The study area is strategically positioned which attracted different stakeholders to diffuse paddy innovations. The study area is located close to Morogoro to Dodoma main road and therefore makes it possible for paddy stakeholders to accessible the two irrigation schemes and so to introduce innovations. Also, the area is strategically positioned in the sense that, the two irrigation schemes are located besides the Dakawa – Turiani main road whereby farmers, traders and millers could use that opportunity to access paddy and rice markets like Morogoro and Dar es Salaam. The stakeholders include Mkindo Farmers Training Center, Chinese Agro-technology Demonstration Center - ATDC, NAFAKA project under Feed the Future program, Ministry of agriculture, researchers from Sokoine University of Agriculture (SUA) and Cholima research station (Dakawa Agri-research centre). Paddy innovations have been introduced in the study area by the Government of Tanzania and related stakeholders to enable farmers to adopt and enhance their productivity as well as profitability (Katambara *et al.*, 2013 and Makundi, 2017). Katambara *et al.* (2013) reported that SRI in Mkindo area produced 9.90 tons/ha paddy yield compared to 3.83 tons/ha in conventional practice, which is 158% more.

Among the motivating factors of adoption of paddy production innovations is the level of profit generated. There are various measures of profitability; including the Return on Investment (ROI), Net Farm Income (NFI), Gross Margin (GM), Net Present Value (NPV), Internal Rate of Return (IRR) and the Benefit-Cost Ratio (BCR or B/C). The measures differ from one another on how profit generated is expressed and simplicity on financial profitability analysis of a given project. Benefit-Cost Ratio (BCR or B/C) and Internal Rate of Return (IRR) are useful in expressing project viability for a number of years (year t). According to Terauchi *et al.* (2014) the NPV is the profitability of an investment in monetary terms, and this takes into account the risk of future profits. If the NPV is greater than zero, the investment for a project is profitable. IRR is the discount rate at which the NPV of the costs of the investment equals the NPV of the benefits of the investment. If the B/C ratio is greater than 1, the benefit of the investment exceeds the cost of the investment. GM is an important measure of resource efficiency in Small and Medium Enterprises (SME). GM is the gross return minus the total variable expenses, can be expressed in normal value (Tzs), ratios or percentage of return. The GM does not take into account total fixed costs involved during production and not necessarily reflect genuine production performance of the farms (Tugeineyo and Hella, 2011). ROI and NFI take into account of the variable costs and fixed costs in measuring profit.

NPV, IRR and BCR seem to be complex compared to GM, ROI and NFI as indicators of profit especially for smallholder paddy farmers like that of Mvomero District. Time factor is ignored when using ROI but it is not a problem to present study since profitability analysis of selected innovations considers only 2015/16 production season. However, this study is in favour of Return on Investment (ROI) and Net Farm Income (NFI) because they are widely used by different scholars, simple and yet the effective techniques in evaluating financial performance of a given business (Antwi and Aborisade, 2017; Ngabitsinze, 2014). ROI and NFI are used to evaluate the performance of small and medium projects/investment and businesses. The two profitability measures were applied in the study area because smallholder paddy production is seasonal and respective farmers would be interested to increase income and reduce poverty. Smallholder paddy farmers would like to know profit (that is NFI) in terms of exact income (TZS) generated after they have incurred production costs which involve variable costs and fixed costs. Also, ROI is useful for farmers who get loan and invest in production process so as to measure the returns. Since nowadays smallholder rural farmers tend to acquire loans from credit facilities, it could be imperative to know the ratio of the profit made on paddy farming to the cost of the paddy production in terms of how much money in TZS produced for every single TZS invested in production.

Paddy farming in Tanzania is characterized by poor technologies and a limited application of improved technologies (Makundi, 2017). The unique innovations that were introduced to smallholder farmers in Mvomero District include the System of Rice Intensification (SRI), Power Tillers (PTs), Wooden Threshers (WTs) and Combine Rice Mills (CRMs). Enhancing adoption of paddy innovations in the study area is subject to its economic feasibility. However, profitability of adoption of introduced innovations for the 2015/16 production season from which this study was conducted in Mvomero District was not evaluated by other scholars. Despite technical superiority of SRI, PTs, WTs and CRMs, there is limited information on the profitability of these innovations. To develop effective policies to enhance adoption of introduced innovations specifically the SRI, PTs, WTs and CRMs, policy makers need information on the profitability of the innovations that can be targeted to improve farmers' well-being and reduce poverty. The overall objective of this paper was to assess profitability for adoption of selected innovations among paddy farmers in Mvomero District. Specifically the paper aimed at comparing profitability between adopters and non-adopters of SRI, PTs, WTs as well as CRMs in the study area.

4.3 Theoretical Framework

This study is guided by the theory of the firm. The theory of the firm considers a firm in profit making perspective. Behavior of a firm in pursuit of profit maximization is analyzed in terms of (1) what are its inputs, (2) what production techniques are employed, (3) what is the quantity produced and (4) what prices it charges. The theory suggests that firms generate goods to a point where marginal cost equals marginal revenue and use factors of production to the point where their marginal revenue product is equal to the costs incurred in employing the factors. Theory of the firm assumes firms maximize profit. This means that a firm achieves a maximum profit with low operating expenses. The theory also considers perfectly competitive markets whereby the firms (and consumers) are price-takers and quantity is firms' only choice variable. Smallholder paddy farmers in Mvomero District are not different from other smallholder farmers in the developing countries who produce under perfect competition characteristics (Makindara *et al.*, 2009). These are: (1) a large number of small farms, (2) identical products sold by farmers, (3) perfect resource mobility or freedom of entry into and exit out of the production. In this study a firm is considered as an individual paddy farmer, while factors of production involve land, labour, money and resources used in paddy production. Production techniques are the methods and tools used to create and process paddy yield. The production techniques are SRI, PTs, WTs and CRMs.

4.4 Conceptual Framework

Paddy production is an economic activity that is practiced by farming community in course of their survival. In this activity both prices and quantities produces are sometimes uncertain (Makindara *et al.*, 2009), such that many smallholder rural farmers find it difficult to estimate profit. Profitability analysis is a way to help a project to make decision whether the investment is profit-making potential or not. Profit is estimated by considering income accrued from sales of paddy output, variable cost incurred and fixed cost involved in paddy production. Profit is generated where there is excess of revenue and a loss is obtained where there is excess of costs. The revenue is derived from the sale of the paddy output and costs could be from the farm inputs such as fertilizers, pesticides, seeds and labour and other cost can be transportation of materials and farmer registration into a farmer group. Cost can be categorized into variable cost (VC) and fixed cost (FC).

4.5 Methodology

Data for the study were collected from Mkindo and Dakawa paddy irrigation schemes in Mvomero District. The two irrigation schemes were selected because they are the areas where SRI was introduced among the smallholder paddy irrigation schemes in Tanzania.

Cross-sectional research design was adopted whereby 299 farmers who are members in two schemes were estimated using Yamane (1973) and farmers were sampled using simple random technique. The formula assumed 95% confidence level and precision of 0.05; $n = N/[1+Ne^2]$ where: *n* is the sample size, *N* is the population size and *e* is the level of precision, whereby farmers constituted the population for the study. Proportionate samples of 96 and 203 farmers were obtained from Mkindo and Dakawa respectively for good representation in each scheme. Semi-structured questionnaire was used to gather quantitative data related to quantity of paddy harvested by farmers, selling price, costs related to inputs used and costs incurred in different paddy production activities. Two key informants (KIs) were purposively selected and interviewed using checklist of questions and one Focus Group Discussion (FGD) was involved to generate qualitative data using FGD guide. Interviews were conducted in Kiswahili language and translated to English during data processing and analysis but the tools were designed in English. The data were entered, processed and analysed using Statistical Package for Social Sciences (SPSS) and Microsoft Excel Programme to calculate profitability in terms of Net Farm Income (NFI) and Return on Investment (ROI). Then, profitability analysis was conducted using NFI and ROI.

Net farm income (NFI) analysis:

The net farm income analysis was used to determine the profitability of paddy production upon adoption of SRI, PTs, WTs and CRMs innovations in the study area. A unit of calculation for paddy crop was a hectare. The net farm income analysis is given by the following mathematical expression:

$$NFI = TR - TC \ldots\ldots\ldots\ldots\ldots\ldots$$

Where;

NFI=Net Farm Income (TZS); TR=Total Revenue (TZS)

$$TR = \sum Py.Y ....$$

Where;

Py = Price per unit output (TZS) i.e per kg of paddy

Y = Total quantity of output (Kg)

$TC = TVC + TFC$

Where;

TVC =Total variable cost (TZS)

$$TVC = \sum Px_i .x_i ....$$

Where;

Px_i =Price per unit of input (TZS)

x_i =Quantity of i[th] input used per unit input

TFC = Total fixed costs involved in paddy production (TZS).

Return on Investment (ROI) analysis:

Return on Investment was estimated using the following mathematical expression:

$$ROI = \frac{Benefit}{Investment Cost} ....$$

Where;

ROI =Return on Investment in paddy production (TZS)

$Benefit(TZS)$ =Total Revenue (TR) – Investment Cost (TC)

TR =Total Revenue (TZS) (equation 2)

$TC = TVC + TFC$

TVC = Total variable cost (TZS) (equation 3)

TFC = Summation of fixed costs involved in paddy production (TZS).

Variable costs in this study included extension services, bunds maintenance, land renting, land preparation, nursery bed preparation, seeds preparation, raising seeds in nursery, uprooting seedlings and transplanting, irrigation, water fee, fertilization, weeding, birds scaring, farm security, harvesting, threshing, winnowing, inputs purchase, seeds purchase, chemical spraying, storage, milling and transportation during 2015/16 production season while fixed cost involved membership admission fee.

The Mann-Whitney U test was conducted to determine if there are statistically significant differences in ROI and NFI between adopters and non-adopters for each innovation. The test was ideal because it is appropriate to test for differences between two independent groups (Pallant, 2007). The test was carried out because the dependent variable, profit (Tzs), was not normally distributed. Also the test is the alternative of the t-test for independent samples and also it analyses differences in the positions of dependent variables in two independent groups (Nachar, 2008).

Calculation of the Mann-Whitney U used the following illustration:

$$U = n_1 n_2 + \frac{n_2(n_2+1)}{2} - \sum_{i=n_1+1}^{n_2} R_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where;

U=Mann-Whitney U test

n_1 = sample size one (adopters of innovations/male adopters of innovations)

n_2 = Sample size two (non-adopters of innovations/female adopters of innovations)

R_i = Rank of the sample size

Qualitative data was analyzed using content analysis whereby pieces of information collected from FGDs and KIIs were summarized, coded, grouped into themes and compared to reflect profitability among farmers.

4.6 Results and Discussion

The results in Table 4.1 present profitability among adopters and non-adopters of SRI, PTs, WTs and CRMs. The aim of this analysis is to find out if adoption of the respective innovation is profitable. This was done through camparison of the profitability between non-adopters and adopters of the selected innovations.

4.7 Profitability among Adopters and Non-adopters for SRI, PTs, WTs and CRMs

Results of the analysis of profitability for paddy farmers in Mvomero District show that, there were significant differences ($p<0.01$) in mean ranks for Return on Investment (ROI) and Net Farm Income (NFI) between the adopters and non-adopters of SRI, PTs and WTs (Table 4.1). Thus the hypothesis that profitability in terms of ROI and NFI is likely to differ between adopters and non-adopters of SRI, PTs and WTs is confirmed. The ROI medians and NFI medians for adopters of SRI, PTs and WTs were higher compared to that of non-adopters of the same innovations meaning that adopters of SRI, PTs and WTs performed better in profit compared to non-adopters of the same innovations (Table 4.1).

According to the results in Table 4.1, adopters of SRI, PTs and WTs accrued more profit compared to non-adopters of the same innovations. This means that the use of SRI, PTs and WTs in paddy production result into high yield while the cost of production was minimized. Also, PTs reduce cost related to labour demand in puddling operation and the mode of construction as well as operation with WTs maximize paddy yields through reduced grain loss. WTs are wooden stand made with crossing timbers and during threshing the paddy kernels are detached from the panicles by impact through beating in which a canvas is camped to surround the threshing area and another canvas is spread in ground. This finding implies that realization of profitability for adopters of SRI, PTs and WTs in course of paddy production will act as a trigger for non-adopters to adopt such innovations.

Table 4.1: Results for ROI and NFI between adopters and non-adopters of SRI, PT, WT and CRM innovations

Innovation	Adoption category	ROI median	ROI $\overline{X}$ rank	p-value	NFI median	NFI $\overline{X}$ rank	p-value
SRI	Adopters (n=148)	2.59	216.63	.000	829 950.80	223.66	.000
	Non-adopters (n=151)	.12	84.70		40 307.60	77.81	
PT	Adopters (n=140)	2.39	215.84	.000	750 633.55	224.59	.000
	Non-adopters (n=159)	.10	92.03		29 048.90	84.33	
WT	Adopters (n=16)	3.50	236.94	.000	344 094.10	260.50	.000
	Non-adopters (n=283)	1.04	145.08		344 094.10	143.75	
CRM	Adopters (n=53)	1.04	148.09	.860	331 735.80	146.32	.733
	Non-adopters (n=246)	1.04	150.41		341 120.20	150.79	

Key: $\overline{X}$ =mean

The result on profitability of SRI is supported by the information from Key Informant Interview (KII) who was a researcher in Dakawa Agri-research station known as CHOLIMA. A Key Informant gave the following statement:

> *"...adoption of SRI practices is more profitable since input costs are reduced, high yield is achieved and minimum water is needed and therefore it solves water problems compared to traditional practices"* (KI three (Dakawa) interview, 24th May, 2016).

This information from Key Informant implies that farmers who adopted SRI practices got higher profit compared to non-adopters because SRI practices lead to increased yield and minimize cost of production. This means that adoption of some of SRI practices like minimum water application of 2cm depth reduces demand for labour in water management; use of single transplants per hole encourages high tillering and grain yields due to plants being well aerated; wide plant spacing of 25x25 cm discourages pests therefore reduces cost attached with pest control. Therefore if operation costs are reduced and higher paddy output are achieved, that means the return and net income are anticipated to increase.

However, there were no statistically significant in profit between adopters and non-adopters for CRMs. This means that adopters of CRMs in fact tend to face high amount of cracked and broken kernels during de-husking or de-hulling due to poor drying of paddy which end up obtaining low amount of quality rice. This is attributed to by the fact that rural farmers tend to perform paddy drying locally.

Similar to this study's findings, Nayak *et al*. (2016) reported that SRI farmers received higher net income per acre than traditional farmers in Kendrapara District of Odisha in India. Also, Dagar *et al.* (2015) found that the adoption of SRI by farmers was profitable through increased yield of rice as compared to the conventional method of rice cultivation in Haryana, India. Similar suggestion was given by Katambara *et al.* (2013) who conducted a study in Mkindo scheme, that SRI produced as high yield as 158% more than conventional practices. Katambara *et al.* (2016) as well provided similar argument that, rice yields under SRI practices yield more than 16ton/ha against less than 8ton/ha for conventional rice growing practices. In their study conducted in Sri Lanka on adoption of SRI, Namara *et al.* (2003) found that among other advantages, adoption of SRI is profitable since farm operational costs are reduced. Miah and Haque (2015) reported that power tillers' operation services for land preparation, sowing and transplanting seeds/seedlings of different crops at farm level was highly profitable. Again, similar argument to this study was provided by Kwatra *et al.* (2010) that, the use of paddy thresher was profitable and cost of work was reduced by 60.28 %. Moreover, Prasanna *et al.* (2004) found that, farmers who adopted paddy threshers increased profit against reduced labour cost.

4.8 Conclusions and Recommendations

This study shows that paddy production in Mvomero District is profitable for farmers with SRI, PTs and WTs compared to farmers without SRI, PTs and WTs as estimated using both Net Farm Income (NFI) and Return on Investment (ROI).

Extension officers and rural development actors should educate paddy farmers on the significance of adoption of innovations especially SRI, PTs and WTs because it is proved to be worthwhile investment for paddy farming communities. Policy-makers should design agricultural policies that ensure adequate supply of agricultural inputs at subsidized rates so as to help paddy farmers to minimize cost of production.

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CHAPTER FIVE

5.0 Paper 4: Association between adoption of selected innovations and gender roles among paddy farmers in Mkindo and Dakawa Irrigation schemes

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5.1 Abstract

Adoption of innovations has potential to change gender roles of farmers in paddy production as well as in processing. This paper assessed the association between adoption of selected innovations and change in gender roles among paddy farmers in Mkindo and Dakawa irrigation schemes in Mvomero District. Specifically, it examined gender division of labour in paddy production and determined gender roles among non-adopters and adopters of innovations. The study involved 299 farmers who were selected using a simple random sampling technique. Quantitative data were collected using a semi-structured questionnaire. Qualitative data related to gender roles were collected through key informant interviews and focus group discussions. Quantitative data were analyzed using the IBM Statistical Package for Social Sciences (SPSS) version 20 software by computing descriptive statistics including frequencies and percentages. Chi-square test was conducted to test the associations between adoption of each innovation and gender roles. Qualitative data were analyzed using content analysis. Gender division of labour indicated that male adults (MaA), female adults (FeA), male children (MaC) and female children (FeC) perform different activities in paddy production. There is an association between adoption of innovations and gender roles of paddy farmers ($p < 0.001$). The study found that female farmers performed burdened, tiresome activities including transplanting, harvesting and winnowing which are normally performed in a bowing approach. Adoption of innovations shifted paddy production role, labour provision role and financial management role from being male dominated to being shared roles by both men and women. Extension officers and other agricultural development practitioners need to create and raise awareness on gender division of labour to paddy farming community. It is recommended that extension agents should stress more on adoption of innovations in the area of study because it empowers women in paddy farming.

Key words: *Adoption, innovation, paddy, gender roles, farmer.*

5.2 Introduction

Adoption of agricultural innovation is the situation whereby an individual accepts, practices and continues using a new idea, agricultural practice or tool in production. In this study, non-adoption of innovations means that farmers apply conventional practices, tools and machines in paddy production and processing. Gender constructed innovations can enhance its efficiency and performance in paddy farming; otherwise it can lead to non-adoption. According to Roggers (2003), there are five attributes of innovations for successful adoption which are relative advantage, compatibility, complexity, trialability, and observability. Adoption of innovations depends on the availability of required resources, how local men and women view the perceived benefits, the way data is shared and other socio-cultural constraints.

Adoption of innovations has potential to contribute to the livelihood of rural poor farmers in Tanzania. Even when women have access to innovations, they face more constraints than men in accessing complementary resources for success (Morris and Doss, 1999; World Bank *et al*., 2009). Adoption process involves first knowledge of an innovation, forming an attitude, decision to adopt or reject, implementation, and confirmation of the decision. If male and female farmers are not adopting innovations, or are adopting them at lower rates, then it is important to determine how best participatory development and dissemination of innovations can be done so as to benefit both males and females (Morris and Doss, 1999). Adoption of paddy innovations has the potential to reduce inefficiencies in paddy production and processing. In doing so, they can change how production and processing activities are conducted and by whom. Therefore, adoption of paddy innovations affects men and women differently whereby work burden, time and energy is reduced or vice versa. The differential impact of adoption of innovation result into men and women performing different roles in paddy production.

Gender division of labour is crucial because it helps to understand men's and women's socio-economic opportunities, constraints and incentives. Lack of gender awareness at different levels of society constructs and reinforces traditional divisions of labour based on gender, and neglects the fact that men and women have different needs. Paddy is grown in many districts including Mvomero District by smallholder male and female farmers as a food and cash crop. Socio-economic and socio-cultural aspects, especially lack of access to and control over resources, limit women to exercise their potentials in paddy farming. For instance, in rural areas, women often have access, but not ownership, to productive resources such as land and innovations due to high costs attached to these resources. So, women are compelled to use conventional techniques due to limited control over innovations. This situation limits women's productivity potentials in paddy farming.

Women play significant roles in paddy farming because they perform most of activities. Women's labour contributions in paddy farming vary from region to region, and even within regions where they offer their labour to other farms or non-farm activities for wages or hire. Yet, women face several constraints in performing these roles in paddy farming because they lack access to technical knowledge and innovations which can reduce their drudgery and provide additional income. World Bank *et al*. (2009) argue that all tasks performed in relation to agricultural cycles, processing and domestic chores consume most of women's time and energy, leaving them overburdened. Therefore, adoption of innovations can help to reduce women's time and drudgery (Paris *et al.*, 2011).

Paddy innovations have the potential to affect paddy farmers' socio-economic standpoint. Adoption of paddy innovations results into such changes as increased production and productivity, farmers' income, participation in particular activities including paid labour, or participation in a particular work sectors and knowledge attainment. Adoption of paddy innovations would also bring about social changes including institutional labour arrangement whereby more or less labour, increased or reduced labour is demanded. This labour requirement result into females or males displacement in performing certain paddy production and processing operations. Each innovation affects gender roles according to its mode of development. An innovation which affects the demand for labour will automatically impact men and women differently.

Adoption of innovations in paddy production and processing has been valuable to respective farmers worldwide. For instance in Ndop, Cameroon adoption of new production practices provided both social and economic benefits that went beyond the purview of women's empowerment (Fonjong and Athanasia, 2007). Adoption of power tillers and rice threshers in Bangladesh enhanced the labour productivity of smallholder paddy farmers (Mottaleb *et al*., 2016). In Phillipines, adoption of commercial rice mills reduced drudgery and labour to female farmers, which displaced women's work because processing operation were females' work (Paris, 1998). The study on which this paper is based adds to the body of knowledge on "who does what" between male adults (MaA), female adults (FeA), male children (MaC) and female children (FeC) with regards to paddy farming in the study area. Also, the study generated empirical evidence about the association of adoption of innovations and the gender roles within paddy farming community in Mvomero District. The specific gender roles considered in this study are production role, labour offering to on- and/off-farm activities, financial management and reproductive role. Moreover, the study findings will inform policy makers on how introduced paddy innovations have association with gender roles distribution.

The Government of Tanzania (GoT) and private sector have been taking measures to promote the rice sector by assuring farmers' access to and use of innovations. This is achieved through development and implementation of different policies, programmes and strategies (Rice Sector Strategy, 2009). Despite the efforts to improve farmers' livelihoods, poor farmers, especially women, still experience excessive workload, and they are hence overburdened (Rice Sector Strategy, 2009; World Bank *et al*., 2009; Paris *et al*., 2011). More women, as compared to men, still struggle in farm operations using traditional technologies which are labour intensive and time and energy consuming (World Bank *et al*., 2009). Studies on adoption of innovations in Mvomero District show that different paddy innovations were introduced (Makundi, 2017; Katambara *et al.*, 2013). However, little data is readily available on the association between paddy farmers' adoption of different innovations and gender roles associated with System of Rice Intensification (SRI), Power Tillers (PTs), Wooden Threshers (WTs) and Combine Rice Mills (CRMs) innovations in the study area. Selection of the SRI, PTs, WTs and CRMs was made due to the fact that little information is available about these innovations especially in relation to the topic under study. PTs and WTs are tools while CRMs are machines.

Adoption of the introduced innovations in the study area means the owners and those who hire using them in paddy operations. It is anticipated that adoption of paddy innovations in the study area will gradually transform farmers' gender roles to benefit men and women equitably in the context of reducing their workload, saving time and energy. Therefore, the study assessed the association between adoption of selected innovations and gender roles among paddy farmers in the study area. Specifically, it examined gender division of labour in paddy production and determined gender roles among adopters and non-adopters of SRI, PTs, WTs and CRMs in the area of study. It was hypothesized that there is no association between adoption of innovations and change in gender roles.

This study is guide by the Gender Role Theory (GRT) which stipulates that individuals socially identified as males and females tend to occupy different ascribed roles within social structures and tend to be judged against divergent expectations for how they ought to behave (Shimanoff, 1980). The theory offers theoretical analysis of gender roles based on perceived expectations of male and female farmers on the use of innovations. Individuals learn to use the content around them related to gender to evaluate people and situation in order to assimilate new information (Bem, 1981). According to Alesina *et al*. (2013) the use of innovations relative to conventional methods causes less females' participation than males in market activities. Therefore this study adopts the theories in the attempt to examine the effects of learning process and adoption behaviour over new ideas and farm practices on different roles assigned to males and females rice farmers.

5.3 Methodology

The study was conducted in Morogoro Region in Mvomero District from two paddy irrigation schemes known as Mkindo and Dakawa. Mvomero District is one of the 6 districts of Morogoro Region. Others are Gairo, Kilosa, Morogoro, Kilombero, and Ulanga. The district is located in the Northern end of Morogoro Region (Fig. 1.2). The district borders with Morogoro District in the East, Gairo and Kilosa in the West, Tanga Region in the North and in the South it borders with Kilosa (partly) and Morogoro (partly). Geographically the District is located between latitude 6° 16' and 6° 18' South, and longitude 37° 32' and 37° 36' East and its altitude ranges between 345 and 365 m amsl.

The selection of the schemes was based on the fact that it is an area where SRI, PTs, WTs and CRMs were introduced among smallholder paddy irrigation schemes in Tanzania. Cross-sectional research design was adopted. Sample size of 299 farmers participating in two schemes was estimated using Yamane formula (Yamane, 1973). This formula assumed 95% confidence level and precision of 0.05; $n = N/[1+Ne^2]$ where: n is the sample size, N is the population size and e is the level of precision, whereby farmers constituted the population for the study. Farmers were sampled using simple random sampling technique. Proportionate samples of 96 and 203 farmers were obtained from Mkindo and Dakawa respectively for fair representation of farmers in each scheme to constitute the study sample.

A semi-structured questionnaire was administered to 299 farmers to gather quantitative data related to gender division of labour and gender roles. Data on "who does what" for every production and post-harvest activity was designed in multiple responses format whereby these activities included bands construction/repair, land preparation, nursery bed preparation, seeds preparation, raising seeds in nursery, uprooting of seedlings, transplanting seedlings, irrigation, fertilization, weeding, birds scaring, farm security, harvesting, threshing, winnowing, spraying chemicals, storage, transporting to millers, packaging and transporting to market places. Division of labour in paddy farming involved male adults, female adults, male children and female children. With regards to collection of data on gender roles, each respondent had to choose whether male, female or both perform the identified gender role. For this paper, one key informant (KI) who is the Principal of Mkindo farmers training centre generated qualitative data. This KI was purposively selected and interviewed using a checklist of questions. Moreover, this study involved a total of three Focus Group Discussions (FGDs) with the size of six to twelve farmers. The number (six to twelve) is the one advised by Bryman (2004) and Barbour (2011) for the reasons that too few participants may not have enough knowledge to discuss difficult topics effectively, and that if the participants are too many some of them may just remain silent. FGDs were held to generate qualitative data on gender-based division of labour and gender roles among paddy farmers. FGD guide was used to gather data during FGDs.

Gender division of labour was analyzed descriptively using frequencies and percentages. Descriptive and inferential statistics were involved to determine gender roles among adopters and non-adopters for each innovation through crosstabulation using SPSS version 20. Chi-square test was conducted to determine the associations between gender roles and adoption of selected innovations in the study area. Qualitative data were analyzed using content analysis.

5.4 Results and Discussion

5.4.1 Gender division of labour

Division of labour varies with crop type and so for paddy production. Men and women are engaged in various paddy production activities. The results indicated that female adults (FeA) were responsible in performing activities which mainly take longer time in the field and usually they perform these activities while bending instead of standing leading to drudgery. The activities include uprooting immature seedlings ready for transplanting (76.5%) and transplanting seedlings (91.5%), weeding (82.6%), birds scaring (80.8%), harvesting (93.9%), threshing (89.0%) and winnowing (97.6%) (Table 5.1).

Table 5.1: Multiple responses results on gender division of labour in paddy farming (n=299)

Production/post-harvest activity	Responses (n)	Gender of the farmer							
		Male Adults		Female Adults		Male children		Female children	
		n	%	n	%	n	%	n	%
Bands construction/repair	202	183	90.6	37	18.3	8	4.0	6	3.0
Land preparation	167	149	89.2	39	23.4	5	3.0	0	0.0
Nursery bed preparation	248	206	83.1	116	46.8	8	3.2	10	4.0
Seeds preparation	262	185	70.6	154	58.8	3	1.1	9	3.4
Raising seeds in nursery	259	194	74.9	143	55.2	7	2.7	9	3.5
Uprooting of seedlings	200	109	54.5	153	76.5	3	1.5	7	3.5
Transplanting	294	119	40.5	269	91.5	43	14.6	45	15.3
Irrigation	222	177	79.7	72	32.4	7	3.2	7	3.2
Fertilizer application	207	167	80.7	94	45.4	5	2.4	5	2.4
Weeding	207	122	58.9	171	82.6	11	5.3	17	8.2
Birds scaring	297	136	45.8	240	80.8	192	64.6	86	29.0
Farm security	299	255	85.3	61	20.4	204	68.2	53	17.7
Harvesting	297	225	75.8	279	93.9	75	25.3	71	23.9
Threshing	299	130	43.5	266	89.0	140	46.8	253	84.6
Winnowing	295	86	29.2	288	97.6	2	0.7	93	31.5
Spraying chemicals	298	295	99.0	16	5.4	5	1.7	0	0.0
Storage	299	299	100.0	53	17.7	3	1.0	2	0.7
Transporting to millers	299	299	100.0	34	11.4	4	1.3	3	1.0
Packaging	108	88	81.5	32	29.6	4	3.7	4	3.7
Transporting to market places	114	93	81.6	31	27.2	2	1.8	1	0.9

On the other hand, the respondents showed that male adults (MaA) performed rest of paddy production activities not performed by FeA. Male children (MaC) were involved in birds scaring, farm security and threshing while the main tasks performed by female children (FeC) were transplanting, birds scaring, farm security, harvesting, threshing and winnowing. It was also found that seeds preparation, raising seeds in the nurseries and harvesting were done jointly by male adults and female adults. However, farm security was exclusively carried out by male adults assisted by MaC, and threshing of paddy was performed by female adults assisted by FeC (Table 5.1). This means that every gender category (FeA, MaA, MaC and FeC) plays an important part in paddy production but differs in their activities. The fact that, female farmers performed tedious activities, this situation tends to lead to drudgery. These activities take longer time to perform without resting, attached with petty tasks within a piece of activity, involve moving of materials as well as products from one point to another and are usually performed in bending way. This implies that the nature of the activities which are performed by women impairs paddy productivity. This is because women differ energetically with men leading to reduced effectiveness and efficiency in performance along with low final output due to the fact that they are poor farmers.

The environment in which women work in paddy production involves muddy (transplanting), no use of protective gears (Uprooting of seedlings, harvesting), sunny (birds scaring, harvesting, threshing and winnowing) and bending throughout the respective operation (Uprooting of seedlings transplanting weeding, harvesting, threshing and winnowing). Also, MaC and FeC accomplish activities to assist women with the implication that children do non-technical production and post-harvest activities. Iwuchukwu and Udegbunam (2017) reported a similar finding in their study about productivity and gender/intra-household roles in rice production in Awka North Local Government Area, Anambra State, Nigeria. They stated that females play majority of activities related to paddy production. In Africa, women undertake much of the work in rice production systems including sowing, transplanting, weeding, and crop processing which are normally tedious (Chowdhury, 2014).

5.4.2 Gender roles among adopters and non-adopters of the selected innovations

5.4.2.1 Gender Roles among Adopters and Non-adopters of System of Rice Intensification (SRI)

Changing in gender roles is associated with many factors and change over time. Adoption of innovations is among such factors. The findings from this study as presented in Table 5.2 reveal that the associations between adoption of SRI and paddy production role were statistically significant ($\chi^2 = 18.47$, df = 2, $p < 0.001$). Therefore, this result confirms that there was an association between adoption of SRI practices and gendered paddy production. The significance association between the two variables means that adoption of SRI practices influences participation of male and female farmers in paddy production. For instance, the technical requirement in SRI transplanting operation (that is 8-15 day transplants and 25x25 spacing) makes it more likelihood for men’s involvement as compared to women.

Table 5.2: Gender roles among adopters and non-adopters of each innovation

Innovation	Gender roles	Adoption category of farmers												χ^2 value	p-values
SRI		**Non-adopters (n=151)**						**Adopters (n=148)**							
		Males		**Females**		**Both**		**Males**		**Female s**		**Both**			
		n	**%**	**n**	**%**	**N**	**%**	**n**	**%**	**n**	**%**	**n**	**%**		
	Paddy production	76	50.3	35	23.2	40	26.5	50	33.8	23	15.5	75	50.7	18.472***	.000
	Working as labourers	122	80.8	12	7.9	17	11.3	89	60.1	23	15.5	36	24.3	15.401***	.000
	Financial management	89	58.9	35	23.2	27	17.9	69	46.6	25	16.9	54	36.5	13.140**	.001
	Reproductive role (social)^ns	8	5.3	136	90.1	7	4.6	3	2.0	131	88.5	14	9.5	4.670	.097
PT		**Non-adopters (n=159)**						**Adopters (n=140)**							
	Paddy production	80	50.3	35	22.0	44	27.7	46	32.9	23	16.4	71	50.7	16.857***	.000
	Working as labourers	125	78.6	12	7.5	22	13.8	86	61.4	23	16.4	31	22.1	11.031**	.004
	Financial management ^ns	85	53.5	35	22.0	39	24.5	73	52.1	25	17.9	42	30.0	1.488	.475
	Reproductive role (social)^ns	3	1.9	148	93.1	8	5.0	8	5.7	119	85.0	13	9.3	5.428	.066
WT		**Non-adopters (n=283)**						**Adopters (n=16)**							
	Paddy production^ns	119	42.0	53	18.7	111	39.2	7	43.8	5	31.2	4	25.0	2.031	.362
	Working as labourers	203	71.7	30	10.6	50	17.7	8	50.0	5	31.2	3	18.8	6.540*	.038
	Financial management ^ns	150	53.0	56	19.8	77	27.2	8	50.0	4	25.0	4	25.0	.258	.879
	Reproductive role (social)^ns	11	3.9	252	89.0	20	7.1	0	0.0	15	93.8	1	6.2	.674	.714
CRM		**Non-adopters (n=246)**						**Adopters (n=53)**							
	Paddy production^ns	104	42.3	48	19.5	94	38.2	22	41.5	10	18.9	21	39.6	.038	.981
	Working as labourers ^ns	174	70.7	27	11.0	45	18.3	37	69.8	8	15.1	8	15.1	.889	.641
	Financial management ^ns	126	51.2	48	19.5	72	29.3	32	60.4	12	22.6	9	17.0	3.335	.189
	Reproductive role (social)^ns	9	3.7	221	89.8	16	6.5	2	3.8	46	86.8	5	9.4	.580	.748

Note: *** significant at $P < 0.001$, ** significant at $P < 0.01$, *significant at $P < 0.05$, ns non-significant

SRI=System of rice intensification, PT=Power tiller, WT=Wooden thresher, CRM=Combine rice mill

This study's findings further showed that the role of paddy production for non-adopters of SRI was mainly performed by male farmers whereas, for adopters, the role was generally performed by both men and women (Table 5.2). This means that women are increasingly taking up the paddy production role upon adoption of this innovation in the area of study. This implies that the relative advantage of adoption of SRI to conventional practices attracted more women to be engaged in paddy production. Female farmers in the study area, like any other rural poor farmers who would like to get out of poverty, were attracted to engage in rewarding adoption of SRI practices in paddy farming. Fonjong and Athanasia (2007) who researched on rice innovations and their implications for gender roles in Ndop, Cameroon found similar results that introduction of modern rice cultivation benefited women and hence more were involved in rice production.

During Focus Group Discussions (FGDs), at Mkindo village conducted on 04th May, 2016, it was revealed that there was a gradual increase of women's engagement in paddy production as a result of adoption of SRI. The discussion indicated that adoption of SRI practices has encouraged women's participation due to its superiority in generating income, and much of practices are carried out by women.

This finding from FGDs implies that previously paddy production was recognized as men's role though women are always involved in paddy production and processing alongside with men, but that due to benefits derived from applying SRI practices, more women were involved in paddy production.

Financial management role that was explored in this study included financial planning, acquisition and proper allocation of funds, and promoting and mobilizing savings. The findings in Table 5.2 show that there was a significant association between adoption of SRI practices and financial management role ($\chi^2 = 13.17$, df = 2, $p < 0.01$).

This suggests that farmers's participation in adoption of innovations helps them to be aware of their rights and potentials in paddy production including financial management at different levels. Moreover, the findings in Table 5.2 show that 17.9% of all the responses for the case of non-adopters indicated that financial management was a joint role between men and women while for adopters of SRI 36.5% of all the responses reflected this role to be performed jointly by men and women. This means that there was an increase of responses from non-adopters to adopters of SRI that the "financial management role" was shared by both men and women. This suggests that adoption of SRI builds joint financial management as a way of life between men and women through displacing men from being the only players of the said gender role.

Precisely, women's involvement in paddy production as a result of adoption of SRI means that they form part in decision-making and control of paddy production resources including accrued farm income. Increased involvement of women in paddy production enhances ownership of production resources and decision-making power concerning management of earned income. Therefore, women constitute part in paddy production and consequently recognized as producers, decision-makers and beneficiaries of farm resources equal to men. This situation triggers women financial management after adoption of SRI. Similar to this study finding about financial management, Johnson (2014) found that there was a continuum of strategies which ranged from separate to shared management of income. But a similar argument was provided by Jeckoniah *et al*. (2012) that, participation of women in agricultural production increases their ability to take control over material assets including control of income.

In addition, during an interview with a key informant (KI) in Mkindo village, it was found that adoption of SRI improved women's financial status due to additional income obtained from selling of paddy and/rice. The key informant gave the following statement:

"...adoption of SRI practices has attracted more women to engage in paddy farming in Mkindo village. Adoption of SRI increased women's power financially" (KII at Mkindo village, 19thMarch, 2016).

Increased involvement of women in paddy production implies that they realized relative benefits as a result of adoption of SRI practices. The benefits include high yields in paddy and improved income. This in turn improved their economic and social positions in terms of increased purchasing power, self-esteem and decision-making in their society. Other researchers like Fonjong and Athanasia (2007) have reported similar finding that adoption of new cultivation practices in rice enhanced women's participation in the production and hence acquired more income.

5.4.2.2 Gender roles among adopters and non-adopters of Power Tillers (PTs)

Adoption of PTs has an implication to the roles played by men as well as women in paddy production. This study found that male farmers dominated (50.3%) the role of paddy production for non-adopters of PTs but for the adopters of the same innovation, paddy production is a shared venture between males and females (50.7%). The association between adoption of PTs and production role was significant ($\chi^2 = 16.86$, df = 2, $p < 0.001$) (Table 5.2). This association means that the adoption of PTs motivated more females to be involved in paddy production due to its ability to simplify land preparation. This result implies that adoption of PTs eliminates the traditional notion that men are the only paddy producers but rather it can be performed by both male and female farmers. Due to efficiency of PTs in performing land preparation operations, adoption of PTs for women is imperative to solve the challenges of high workload as women perform triple role they play especially time constraint.

During a Focus Group Discussions (FGDs) which were conducted at Dakawa village, 13thJune on 2016 revealed that adoption of PTs simplifies land preparation. The consensus from the participants' discussion reflected that land preparation using a PT reduces labour requirement and saves time compared when it is done by human beings. So for women who adopt PTs are granted opportunity to fulfil other roles such as the reproductive one.

This finding from FGD implies that adoption of PTs reduced work burden, saved time and labour hence allowed female farmers to participate in other activities such as entrepreneurship and on domestic sphere. Women who adopt PTs accomplish land preparation within a short time in a day; yet they are not tired and are more likely to participate in other income generating activities, community roles and in the reproductive role which is crucial in their welfare. This study's argument is similar to Manfre *et al*. (2017) who documented that physical technologies like tractors and Mini-tillers allow farmers to use less labour to prepare land thereby reducing work load.

5.4.2.3 Offering labour between adopters and non-adopters of SRI, PTs and Wooden Threshers (WTs)

Like men counterparts, women also tend to offer their labour for the sake of making money. This study's findings showed that there was an increase in responses from 7.9%, 7.5% and 10.6% for non-adopters of SRI, PTs and WTs respectively to 15.5%, 16.4% and 31.2% for adopters of SRI, PTs and WTs respectively based on the information that "women offer labour to on- and/or off-farm activities (Table 5.2). However, there was a decrease in responses that "male offer labour to other activities" for adopters compared to non-adopters of the said innovations (Table 5.2). The associations between offering labour as a gender role and adoption of SRI, PTs and WTs were statistically significant ($\chi^2 = 15.40$, df = 2, $p < 0.001$), ($\chi^2 = 11.03$, df = 2, $p < 0.01$) and ($\chi^2 = 6.54$, df = 2, $p < 0.05$)

respectively. This suggests that female farmers are increasingly offering their labour to on- and/or off-farm activities seeking for additional income in order to afford production costs in own operated farms as well as their livelihood in general. This is due to the fact that adoption of PTs and WTs reduces the amount of time women use on land preparation and threshing tasks, potentially allowing them to shift to other on- and off-farm activities.

Additionally, SRI requires more labour to accomplish its practices, therefore, rural female farmers who adopt it are obliged to offer their labour to other farms or off-farm activities to seek money to afford costs of production. Similarly, Fonjong and Athanasia (2007) argued that introduction of modern rice cultivation helped women to participate in the cultivation of cash crops as well as other income generating activities, through which some of them became major breadwinners. Also, a similar finding has been reported by Jeckoniah *et al*. (2013) in their study about mapping of gender roles and relations along onion value chain in Northern Tanzania who reported that a shift in gender roles and participation to some activities is caused by less support from male partners and inability to afford high labour costs related to production activities.

5.5 Conclusion and Recommendations

With reference to gender division of labour, female farmers accomplish non-technical, long lasting as well as tedious production and post-harvest activities. These activities are usually performed in a bending manner instead of standing leading to tiresome. This situation makes women overburdened and tired, which reduces their productivity. Non-adopters female are unlikely to offer labour, engage into paddy production and financial management but upon adoption of innovations the respective roles are being performed jointly by both male and female farmers. Hence, adoption of innovation in the area of the study ignored the traditional notion that, females are not producers rather both male and female are potential paddy producers. Adoption of innovations in the area of study has brought a new status to women of being valued as producers in paddy farming. Therefore, this circumstance improved women's position, economically and socially in paddy farming communities.

Agricultural development practitioners especially in relation to paddy production and processing should create and raise awareness on gender division of labour to paddy farming communities. It is recommended that extension agents should stress more adoption of innovations in the study area because it empowers women in paddy farming. This can be achieved through delivering different trainings on paddy production and processing whenever innovations are introduced to their areas.

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CHAPTER SIX

6.0 Conclusions and Recommendations

6.1 Conclusions

6.1.1 Determinants of paddy farmer participation in innovation process

Determinants of paddy farmer participation in innovation process are discussed in Chapter Two to address the first objective of this study. The chapter established levels of participation of paddy farmers in the innovation process and determined factors influencing participation of farmers in the innovation process.

The study concludes that the overall level of participation of farmers in the innovation process was generally medium reflecting that the interaction between paddy farmers, researchers and extension workers in development, diffusion and adoption of innovations was not active. The key decisions within the innovation process were mostly made by researchers with little involvement farmers. Farmers get extensively involved during diffusion, implementation and confirmation of the innovations with extension officers in the field through demonstration plots and eventually final use in their farms. Moreover, farm size, land ownership and access to extension advisory are the key predictors for participation of farmers in the innovation process.

6.1.2 Factors influencing adoption of selected paddy innovations among smallholder farmers

Chapter Three determined the extent of adoption of the paddy innovations and analyzed the factors affecting adoption of introduced innovations to paddy farmers which are the second and fourth objectives of this study.

The study concludes that, the combination of many practices for System of Rice Intensification (SRI), made it difficult for rural farmers to apply all practices concurrently. This is why the adoption pattern was concentrated into 3 to 7 SRI practices with limited adoption in a combination of 8 to 11 SRI practices. The adoption of PT, WT, and CRM was difficult in the study area because the innovations were inappropriate to farmers' situation.

It is concluded that farmers' knowledge of innovations is the main driver of adoption of introduced innovations in the area of study. Moreover, the land ownership and market availability of paddy/and rice had greatly affected the farmers decision making to adoption of SRI. Labour and market availability are the important factors in the adoption of PTs, while access to credit facilities is crucial for farmers to adopt PTs because the money secured tend to help them in purchase of materials necessary in construction of wooden threshers like canvases and wooden. For the case of CRMs, the results show that land ownership is the main driver in the adoption of such modern milling machine.

6.1.3 Comparing profitability among adopters and non-adopters of selected Innovations in the study area

Third paper aimed at assessing profitability for adoption of selected innovations among paddy farmers in Mvomero District. Specifically, the paper compared profitability among adopters and non-adopters of selected Innovations and is discussed in chapter four. A profitability analysis was employed to evaluate the economic viability of the adoption of innovations whereby NFI and ROI indicators were used. The Mann-Whitney U test was applied to establish whether there are statistically significant differences in profitability between adopters and non-adopters for each innovation. Alongside this test, content analysis analysed opinion of paddy farmers on issues linked to profitability of adoption of innovations. This analysis was of particular relevance to enrich quantitative data.

It is concluded that profitability analysis indicated that adoption of SRI, PTs and WTs was more worthwhile as compared to non adoption of these innovations. Application of these innovations in paddy production helps to generate a significant profit which is important factor towards sustainable production of paddy and farmers' livelihood.

6.1.4 Association between adoption of selected innovations and gender roles among paddy farmers

Association between adoption of selected innovations and gender roles among paddy farmers is discussed in paper four which is presented in chapter five to address the fourth specific objective of this study. Paper four assessed the association between adoption of selected innovations and gender roles among paddy farmers in Mkindo and Dakawa irrigation schemes in Mvomero District. Specifically, it examined gender division of labour in paddy production and determined gender roles among non-adopters and adopters of innovations. On gender division of labour in paddy production, it was found that males perform production activities different from those performed by females. For adoption of selected innovations and gender roles; it was found that there was an association between adoption of selected innovations and gender roles among paddy farmers.

The study concludes that males accomplish those energetic related activities while females' activities take longer time and require them to perform while they bend throughout leading to drudgery. There is an association between adoption of SRI practices

PTs and WTs and change in gender roles such as paddy production role and offer their labour to on-farm as well as off-farm activities for the sake of securing money.

6.2 Recommendations

6.2.1 Determinants of paddy farmer participation in innovation process

In order to attain active participation of the farmers in the innovation process it is recommended that researchers and extension agents to train farmers on innovations once are introduced to farmers' setting to create and raise awareness on such innovations. This can be achieved through collaboration between the Ministry of Agriculture under training division and extension agents. Training programmes at the training division of the Ministry must be informed to the extension officers for implementation to paddy farmers such that whenever innovations are introduced, then they can be mainstreamed to those programmes.

6.2.2 Factors influencing adoption of selected paddy innovations among smallholder farmers

Extension officers are advised to emphasize on innovation education whenever innovations are introduced to framers' setting. Education provision will create and raise awareness about innovations on matters like markets and general knowledge for the sake of affecting farmers' wellbeing.

6.2.3 Comparing profitability among adopters and non-adopters of selected Innovations in the study area

Tanzania rural targeting strategy need to be revised to accommodate issues related to adoption of introduced innovations and their benefits to inform development actors and extension workers about innovations and profitability. The realization of adoption of innovations and profitability in rural strategies will promote more farmers to adopt innovations. In doing so, farmers are anticipated to improve productivity and eventually their well-being.

6.2.4 Association between adoption of selected innovations and gender roles among paddy farmers

As it was found that adoption of SRI, PTs and WTs had association with males' and females' role in paddy production, offering labour and power in decision-making related to financial management. Extension agents should promote more adoption of innovations to rural farmers since it has evident to empower women's status as compared to their status quo.

6.3 Contribution of the Study/Research to Knowledge

This study contributes in the existing literature that farmer participation in the innovation process in Mvomero District is established to be in medium level since it was not established before this study. Moreover, this study contributes to the existing literature that farmers' socio-economic and socio-demographic characteristics proved to have an influence on adoption of selected innovations. In addition, the contribution of the study to the body of knowledge lies on the fact that it provides empirical data on the adoption of selected innovations in relation to profitability realization. Lastly, the study ascertained that adoption of innovations has association with gender aspect in paddy farming. This confirms that, adoption of innovations in paddy farming contains gender dimension such that gender division of labour and gender roles are not static rather context specific.

6.4 Areas for Further Research

(i) It was found in this study that the farmers' knowledge of innovations was important variable in the adoption of innovations. The aspects of knowledge include awareness and technical know-how to utilize each innovation. Therefore, it is suggested that further research should be conducted to assess the level of knowledge of the farmers on each innovation.

(ii) Another key limitation was based on profitability of innovations being promoted to paddy farmers in the study area, analysis of profitability of adoption of innovations was based on cross-sectional data. These data have their own limitations such that could not tell profitability for the same farmer under the same farmer's characteristics before and after adoption of respective innovation(s). Therefore, the use of panel data from before and after adoption of innovation(s) would have allowed analyzing impact of adoption of the introduced innovations on profitability. However, due to the fact that no data based on before adoption of innovations for the same farmers was available for this study, this limitation was avoided by considering adopter and non-adopters of innovations. Hence, there is a need for a follow up study to be conducted. Such a study should take into account of the availability of time series and panel data so as to come out with the robust results which would give data of the same farmers under study.

APPENDICES

Appendix 1: Smallholder Paddy Farmers' Questionnaire on: "Implications of Paddy Production Innovations to Gender Roles in Mvomero District, Tanzania"

Introduction

Dear respondent,

Good morning/afternoon, I am **Solomon Mhango** conducting a study on "**Implications of paddy production innovations to gender roles in Mvomero District, Tanzania**". This study considers you as an important person among many other rice farmers in the district. With your permission, I would like to ask you few questions related to rice farming and adoption of innovations. Your answers are valuable and mind you that, there are no wrong answers therefore give the answers that best reflect your situation. The interview will take about 40 – 45 minutes. Your responses will be treated with high confidentiality since will not be used for any other purposes than presentation of this PhD Thesis.

A. Background Information

Questionnaire number…………………Name of interviewer……………………………

Date of interview……………………...Name of District…………………………………

Ward.................1= Mkindo [ ] 2 = Dakawa [ ]
Village...............1= Mkindo [ ] 2 = Dakawa [ ]
Name of Irrigation scheme 1= Mkindo [ ] 2 = Dakawa [ ]

B: Farmer and Farming Characteristics

Circle the right option, and fill in the appropriate answer(s) in blank spaces.

B1. Sex of respondent 1=Male…… 2=Female……

B2. Age………………………Years old

B3. Marital status of farm owner

1= Single 2= Married 3= Living together

4= Separated 5= Widowed 6= Divorced

B4. Level of Education of rice farmer

1= None 2= Adult education 3= Primary 4= Secondary

5= Certificate 6= Diploma 7= First degree 8= Postgraduate degree 9= Others (Specify)………

B5. Household size

1= Household male adults 2= Household female adults
3= Household children between 12 – 18 years 4= Household children below 12 years

B6. Labour availability for rice production 1= Available 2= Not available

B7. Rice farming experience ……………years

B8. What is the source of labor for the rice farm activities?

1= Family 2= Exchange 3= hired labour 4= Both family and hired

B9. Land tenure:

1= Owned 2= Borrowed 3= Hired

B10. Ownership of land used for rice farming:

1= Husband 2= Wife 3= Husband and wife 4= Children

5= Family

B11. What is the total size of land used for rice production………….. (acres)

C: Farmer Participation in Innovation Process

C1. Are you aware of the following innovation (s)? Circle the appropriate:

SRI: 1= Yes 2= No   PT: 1= Yes 2= No   WT: 1= Yes 2= No   CRM: 1= Yes 2= No.

C2. If Yes, from whom did you get?

	SRI	**PT**	**WT**	**CRM**
	1=Extension unit	1= Extension unit	1= Extension unit	1= Extension unit
	2= Farmers	2= Farmers	2= Farmers	2= Farmers
	3= Researchers	3= Researchers	3= Researchers	3= Researchers
4=	4= Traders	4= Traders	4= Traders	4= Traders
5=	5= Farmer cooperative	5= Farmer cooperative	5= Farmer cooperative	5= Farmer cooperative
	6= Agriculture officers from Ministry of Agriculture	6= Agriculture officers from Ministry of Agriculture	6= Agriculture officers from Ministry of Agriculture	6= Agriculture officers from Ministry of Agriculture

C3. Have you applied the following innovation(s)? Circle the appropriate:

SRI: 1= Yes 2= No   PT: 1= Yes 2= No   WT: 1= Yes 2= No   CRM: 1= Yes 2= No.

C4. What is the size of land allocated for SRI……………….………………….. (acres)

C5. Levels of farmer participation in the innovations process. Where; Undecided= (0), Strongly disagree= (1) Disagree= (2) Agree= (3) Strongly agree= (4) [Tick the appropriate score against each statement].

Conventional level	**(0)**	**(1)**	**(2)**	**(3)**	**(4)**

	(0)	(1)	(2)	(3)	(4)
1. Decision on the generation of innovation is done by scientists only					
2. Farmers are not consulted on the development of innovation					
3. Researchers have no relations with farmers					
4. Researchers do not value famers' knowledge					
5. Researchers do not value famers' experience					
6. Farmers are not encouraged to choose innovations to their own environment					
7. Farmers' views are not taken during generation of innovations					
8. Innovations are developed without taking into account the needs of male and female farmers					
9. Innovations are developed without consideration of male and female responsibilities					
Overall conventional (Total)					
Consultative level	**(0)**	**(1)**	**(2)**	**(3)**	**(4)**
1. Decisions about development of innovations are vested to scientists alone					
2. There is doctor-patient relationship between scientists and farmers					
3. Scientists develop innovation after consulting and diagnosing farmers' problems in order to solve them					
4. Scientists explore farmers' and problems so as to develop innovations					
Overall consultative (Total)					
Collaborative level	**(0)**	**(1)**	**(2)**	**(3)**	**(4)**
1. There is joint decision on the development of innovations between scientists and farmers					
2. There is two-way communication between researchers and farmers					
3. Scientists know priorities of farmers					
4. Farmers know priorities of scientists					
Collegial level	**(0)**	**(1)**	**(2)**	**(3)**	**(4)**
1. Researchers actively encourage research and development (R&D)					
2. Farmers make final decision on the development of innovation					
3. Researchers diagnose farmers' problems					
4. Farmers know about scientists priorities through organized communication with them					
Overall collegial (Total)					
Farmer experimentation level	**(0)**	**(1)**	**(2)**	**(3)**	**(4)**
1. Innovation emerged from the efforts of farmers					
2. Scientists were not communicated upon emergence of innovation					
3. Farmers' knowledge matters					
4. Farmers' experience contributed in the emergence of the innovations					
Overall farmer experimentation (Total)					

D: Labour Force Participation in Rice Production
D1. Number of people participation in rice production

Age group (years)	Number of Males	Number of Females
Below 18		
18 – 60		
Above 60		

D2. Labour force participation in relation to time of participation in rice production (put the number representing gender group)

Age group (years)	**Full time** 1= Males 2= Females 3= Both males and females 4=Neither males nor females	**Part time** 1= Males 2= Females 3= Both males and females 4=Neither males nor females

Below 18		
18 – 60		
Above 60		

E: Diffusion of Innovations

Innovation	E1. What is the source of information for respective innovation? 1=Fellow farmer 2=Extension workers 3=Researchers 4=Traders 5=Farmer cooperative 6=Demonstration sites 7=Exchange visits	E2. Time to hear (year/season)	E3. Did you use the following innovations? 1= Yes 2= No	E4. If Yes, when did you start using innovation (Year/season)
SRI				
PT				
WT				
CRM				

E5. Do you know whether there are extension agents who work in your location?

1=Yes. 2=No

E6. If Yes, How many times does extension worker visits you per month?..........................

E7. Has the extension agent ever advised you on farming matters?

1= Yes 2= No

E8. Where do you collect extension information?

1= Extension workers 2= Fellow farmer 3= Demonstration sites

4= Mass media 5= Traders 6= Seminars 7= Exchange visits

E9. Some people think the extension agent is helpful. Some do not. What do you think? ....

E10. Do you incur any monetary costs in accessing extension information?

1= Yes 2= No

E11. If yes, how much does it cost you? (_______ TZS)

E12. Do you have problems in getting extension information? 1=Yes (__) 2=No (__)

E13. If YES, mention the problems and strategies to have information on time

	Problems	Strategies used to solve the problem
1		
2		
3		

F: Extent of Adoption of Innovations

F1. Which extent of using the innovations?

Innovation	Practice/principle	Expected scores 1=Adopted 0 = Not adopted
SRI	1. Sorting out of the seeds using floating-sink method	
	2. Raising seedlings in nursery	
	3. Transplanting seedlings of 8-15 days old	
	4. Uprooting and transplanting within 15-30 minutes	
	5. Uprooted seedlings be kept in moist conditions	
	6. Single transplants	
	7. Careful transplanting at shallow depth	
	8. Widely spaced transplants at 25cmx25cm	
	9. Early and regular weeding	
	10. Controlled water management by alternate flooding and wetting	
	11. Application of compost	
	12. No use of herbicides	
Power Tiller	1. Land preparation	
	2. Transplanting	
	3. Transportation	
Total Scores for PT		
Wooden Thresher	1. Threshing	
Total Scores for WT		
Combined Rice Mills	1. Rice milling by using CRM	
	2. Grading by using CRM	
	3. Packaging in CRM	
Total Scores for CRM		
Overall Scores for all Innovations		

G: Factors Influencing Adoption of Innovations

G1.0 Farmer attitude to socio-economic benefits of rice innovations

Innovation	**Farmer attitude**	**Expected scores** 1=Strongly disagree, 2=Disagree, 3= undecided 4=Agree, 5=Strongly disagree
SRI	1. Provide higher income	
	2. Easy to operate	
	3. Reduce workload	
	4. Save time	
	5. Save energy	
	6. Improve women's self-esteem	
	7. Increase women's decision-making power	
	8. Create social network among farmers	
	9. Require higher cost of investment	
	10. Stimulates growing of weeds	
	11. Results into high production	
	12. Easy weeding	
	13. Leads to high productivity	
	14. Costly to implement	
	15. Quality rice produce	
	16. Facilitate easy access to knowledge	
Total scores		
Power Tiller	1. Provide higher income	
	2. Easy to operate	
	3. Reduce workload	
	4. Save time	
	5. Save energy	
	6. Improve women's self-esteem	
	7. Increase women's decision-making power	
	8. Create social network among farmers	
	9. Require higher cost of investment	
	10. It compacts/compresses soil	
	11. Stimulates growing of weeds	
	12. Results into high production	
	13. Leads to high productivity	
	14. Costly to implement	
	15. Quality rice produce	
	16. Facilitate easy access to knowledge	
Total scores		
Wooden Thresher	1. Provide higher income	
	2. Easy to operate	
	3. Reduce workload	
	4. Save time	
	5. Save energy	
	6. Improve women's self-esteem	
	7. Increase women's decision-making power	
	8. Create social network among farmers	
	9. Require higher cost of investment	
	10. Results into high production	
	11. Leads to high productivity	
	12. Costly to implement	
Total scores		

Combined Rice Mills	1. Provide higher income	
	2. Easy to operate	
	3. Reduce workload	
	4. Save time	
	5. Save energy	
	6. Improve women's self-esteem	
	7. Increase women's decision-making power	
	8. Create social network among farmers	
	9. Require higher cost of investment	
	10. Costly to implement	
	11. Quality rice produce	
	12. Facilitate easy access to knowledge	
Total scores		
Overall farmer attitude (Total)		

G2.0 Knowledge on rice innovations

Innovation	**Knowledge about introduced innovations**	**1=YES, 0=Otherwise**
SRI	Have you ever heard about SRI	
	Sorting out of the seeds using floating-sink method	
	Raising seedlings in nursery	
	Transplanting seedlings of 8-15 days old	
	Uprooting and transplanting within 15-30 minutes	
	Uprooted seedlings kept in moist conditions before transplanting	
	Single transplants in the field	
	Careful transplanting at shallow depth	
	Widely spaced transplanting at 25cmx25cm	
	Early and regular weeding	
	Water management by alternating flooding and wetting	
	Application of compost	
	No use of herbicides	
Power Tiller	Have you ever heard about power tiller	
	Do you use power tiller in rice production activities	
	Do you know how to operate it	
	Do you do maintenance on yourself	
	Do you apply it in land preparation	
	Do you apply it for Transplanting	
	Do you use it for Transportation	
Wooden Thresher	Have you ever heard about wooden thresher	
	Threshing by using wooden thresher	
Combined Rice Mills (CRM)	Have you ever heard about CRM	
	Do you process your produce by using Combined rice mill	
	Do you use CRM in grading processed rice	
	Does packaging done in CRM	
Total scores		

G3.0 Access to financial support

G3.1 Do you have access to credit facilities (1=Yes, 0=Otherwise)

G3.2 Do you use loan to implement introduced innovations (1=Yes, 0=Otherwise)

G4.0 Access to markets

G4.1 Do you have any information about rice markets (1=Yes, 0=Otherwise)

G4.2 Are markets available for selling produce? (1=Yes, 0=Otherwise)

G4.3 Do you participate to identify markets (1=Yes, 0=Otherwise)

G4.4 Are rice markets accessible in terms of distance? (1=Yes, 0=Otherwise)

G4.5 Do you go to market to sell produce? (1=Yes, 0=Otherwise)

G5.0 Innovation attributes

G5.1 What characteristics of innovations that make you to adopt SRI?

(1=relative advantage, 0=otherwise)

G5.2 What characteristics of innovations that make you to adopt PT?

(1=relative advantage, 0=otherwise)

G5.3 What characteristics of innovations that make you to adopt WT?

(1=relative advantage, 0=otherwise)

G5.4 What characteristics of innovations that make you to adopt CRM?

(1=relative advantage, 0=otherwise)

G6.0 Decision making power

G6.1 Are you involved in making decision on the use of [1]resources (1=Yes, 0=Otherwise)

G6.2 Do you have decision making on which markets to sell (1=Yes, 0=Otherwise)

G6.3 Do you have decision-making power generally over the use of introduced SRI, PT, WT and CRM? (1=Yes, 0=Otherwise)

N.B: [1]Resources= Land, rice field, harvest, income, water, farm inputs and machinery

H: Costs of Using Innovations

H1.0. Direct cost and Family labour inputs for 2015 season:

Family labour = people (A.E)*Effective days *Effective hours A.E = Adult Equivalent (1=A person of 15 and above years of age; A child of 10-14 years of age will be equated to 0.5 of an adult equivalent

Activity	**Family labour**						**Hired labour used**	**Total cost**
	Number of people				**No of days per week**	**No of hours per day**	1= Yes 2= No	
	MA	FA	MC	FC				
Bands construction								
Land renting								
Land preparation								
Nursery bed preparation								
Seeds preparation								
Raising seeds in nursery								
Uprooting of seedlings								
Transplanting								
Irrigation								
Water fees								
Fertilization								
Weeding								
Birds scaring								
Field farm security								
Harvesting								
Threshing								
Winnowing								
Purchasing farm inputs								
Purchasing Seeds								
Spraying chemicals								
Storage								
Milling								
Transport to market[1]								
Market place[1] 1=Farm gate, 2=Village, 3=Neighbourhood village/road side/road junction, 4=Town, 5=Outskirts of the town, 6=Regional market, 7=Others								

H1.1. Who usually incurs the cost of production?1= Husband ( ) 2=Wife ( ) 3= Husband and Wife ( ) 4.children ( ) 5.family ( )

I: Benefits of Adoption of Innovations

I1.0 What income – related benefits do you get from adopting introduced innovations? (Put the number of correct answer (s) to the appropriate innovation (s))

Income – related benefit	**SRI**	**PT**	**WT**	**CRM**
1. Increased productivity				
2. Increased volume of sales				
3. Markets availability				
4. Easy access to markets				
5. Improved quality of produce				
6. Easy land preparation				

I1.1Financial benefits accrued from adoption of innovations in 2015

Harvested rice	**Rain growing season 2015**				**Dry growing season 2015**			
	Quantity	**Unit price**	**Total cost**	**Month**	**Quantity**	**Unit price**	**Total cost**	**Month**
Quantity harvested (based in 80kgbag)								
Quantity in store (based in 80kgbag)								
Quantity sold (based in 80kgbag)								
Quantity consumed (kg)								

I1.2. Has your agricultural income 1= Increased ( ) 2= Remained the same ( ) 3= Declined ( ) upon adoption of introduced innovations?

I1.3. What time (hrs) do you save upon adoption of introduced innovations?

Activities related to innovations	**Time used by adopters of innovations (hrs)**				**Time used by non-adopters of innovations (hrs)**				**Saved time(hrs)**
	Number of hours/day	**Number of days/wk**	**Number of months/ production season**	**Number of hours/production season**	**Number of hours/day**	**Number of days/wk**	**Number of months/ production season**	**Number of hours/production season**	
Bands construction									
Land preparation									
Nursery bed preparation									
Seeds preparation									
Raising seeds in nursery									
Uprooting of seedlings									
Transplanting									
Irrigation									
Fertilization									
Weeding									
Birds scaring									
Harvesting									
Threshing									
Winnowing									
Spraying chemicals									
Storage									
Milling									
Grading									
Packaging									
Transporting to market									
Adopters total time (hrs) per season					**Non-adopters total time (hrs) per season**				
									Total time saved

J: Social-Benefits of Using Innovations

J1.0. What are the perceived non-financial benefits of using introduced innovations? (Put the number of the correct answer (s) to the appropriate innovation (s))

Non income – related benefit	SRI	PT	WT	CRM
1. Reduced workloads				
2. Equal distribution of labour				
3. Improved decision-making				
4. Equal control over assets				
5. Easy production operations				
6. Building networks				
7. Improved self confidence to women				
8. Positive perception over women				

Innovation	**J1.1 Who have access to;** 1= MA only, 2= MA majority, 3= MA and FA equal, 4= FA only, 5= FA majority, 6= MC only, 7= MC majority, 8= MC and FC equal, 9= FC only, 10= FC majority (Put the number of correct answer (s) to the appropriate innovation (s))	**J1.2. Who have control over;** 1= MA only, 2= MA majority, 3= MA and FA equal, 4= FA only, 5= FA majority, 6= MC only, 7= MC majority, 8= MC and FC equal, 9= FC only, 10= FC majority (Put the number of correct answer (s) to the appropriate innovation (s))	**J1.3. Who have decision making power;** 1= MA only, 2= MA majority, 3= MA and FA equal, 4= FA only, 5= FA majority, 6= MC only, 7= MC majority, 8= MC and FC equal, 9= FC only, 10= FC majority (Put the number of correct answer (s) to the appropriate innovation (s))
Bands construction			
[b]Land preparation[a]			
Nursery bed preparation[a]			
Seeds preparation[a]			
Raising seeds in nursery[a]			
Uprooting of seedlings[a]			
[b]Transplanting[a]			
Irrigation[a]			
Fertilization[a]			
Weeding[a]			
Birds scaring			
Harvesting			
Threshing[c]			
Winnowing			
Purchasing inputs			
Purchasing Seeds			
Spraying chemicals			
Storage			
Milling[d]			
Grading[d]			
Packaging[d]			
[b]Transporting to market			

[a] =SRI, [b] =Power tiller, [c] =Wooden thresher and [d] =CRM,

Innovation	Practice/principle	J1.4. Who benefit from innovations	J1.5. Who is valued from accomplishing innovations
		1= MA only, 2= MA majority, 3= MA and FA equal, 4= FA only, 5= FA majority, 6= MC only, 7= MC majority, 8= MC and FC equal, 9= FC only, 10= FC majority	1= MA only, 2= MA majority, 3= MA and FA equal, 4= FA only, 5= FA majority, 6= MC only, 7= MC majority, 8= MC and FC equal, 9= FC only, 10= FC majority
SRI	1. Sorting out of the seeds using floating-sink method		
	2. Raising seedlings in nursery		
	3. Transplanting seedlings of 8-15 days old		
	4. Uprooting and transplanting within 15-30 minutes		
	5. Uprooted seedlings be kept in moist conditions		
	6. Single transplanting		
	7. Careful transplanting at shallow depth		
	8. Widely spaced transplants at 25cmx25cm		
	9. Early and regular weeding		
	10. Controlled water management by alternate flooding and wetting		
	11. Application of compost		
	12. Not applying herbicides		
Power Tiller	1. Land preparation		
	2. Transplanting		
	3. Transportation		
Wooden Thresher	1. Threshing		
Combined Rice Mills	1. Rice milling		
	2. Grading		
	3. Packaging		

K: Gender Perspective in Paddy Production and Post-Harvest Operation

K1.0. Who does paddy farming operations? (Put 1=Yes 0=Otherwise)

Activity	**Responsible person**			
	Male Adult	Female Adult	Male Children	Female Children
Bands construction/repair				
Land preparation				
Nursery bed preparation				
Seeds preparation				
Raising seeds in nursery				
Uprooting of seedlings				
Transplanting				
Irrigation				
Fertilization				
Weeding				
Birds scaring				
Farm security				
Harvesting				
Threshing				
Winnowing				
Spraying chemicals				
Storage				
Transporting to milling				
Packaging				
Transporting to market				

K2.0. Gender roles for farmers with innovations

Tasks in the rice production	No of people performing tasks				Time (hrs) for accomplishing gender roles			
	MA	FA	MC	FC	No of days/week	Average No of hrs/day	Average No of months/season	Total time spend (hrs) in 2015
Bands construction								
Land preparation								
Nursery bed preparation								
Seeds preparation								
Raising seeds in nursery								
Uprooting of seedlings								
Transplanting								
Irrigation								
Fertilization								
Weeding								
Birds scaring								
Harvesting								
Threshing								
Winnowing								
Purchasing farm inputs								
Purchasing Seeds								
Spraying chemicals in the field								
Storage								
Storage pesticide application								
Milling								
Grading								
Packaging								
Going to town to identify markets								
Decision on which markets to sell								
Going to markets to sell								
Keeping the money after sales								
Decision on the use of money								
Off-farm activities								
Wage labourer								
Domestic chores								
MA=Male adult, FA=Female adult, MC=Male child, FC=Female child								

K3.0. Gender roles for farmers without innovations

Tasks in the rice production	No of people performing tasks				Time (hrs) for accomplishing gender roles			
	MA	FA	MC	FC	No of days/week	Average No of hrs/day	Average No of months/season	Total time spend (hrs) in 2015
Bands construction								
Land preparation								
Nursery bed preparation								
Seeds preparation								
Raising seeds in nursery								
Uprooting of seedlings								
Transplanting								
Irrigation								
Fertilization								
Weeding								
Birds scaring								
Harvesting								
Threshing								
Winnowing								
Purchasing Fertilizers/FYM/Compost								
Purchasing Seeds								
Purchasing Pesticides								
Spraying chemicals in the field								
Storage								
Storage pesticide application								
Milling								
Grading								
Packaging								
Going to town to identify markets								
Decision on which markets to sell								
Going to markets to sell								
Keeping the money after sales								
Decision on the use of money								
Performing Off-farm activities								
Wage labourer								
Domestic chores								
MA=Male adult, FA=Female adult, MC=Male child, FC=Female child								

K3.0 Who performs the following gender roles (put the number of the appropriate option: 1=Male 2=Female 3=Both)

1. Paddy production…………………………………………
2. Offering labour…………………………………………….
3. Financial management…………………………………..
4. Reproductive role (social)………………………………

Appendix 2: Checklist of Questions for Key Informant Interviews on: "Implications of paddy production innovations to gender roles in Mvomero District, Tanzania"

1. Name of Village…....……………………………………
2. Name of Irrigation scheme………………………………..
3. Invention of paddy production innovation in Mvomero District
4. Procedures undertaken by researchers in the development of innovations
5. Adoption of introduced innovations in the study area
6. Gender context and ways taken by researchers to reach farmers
7. Gender perspective and extension service provision (dissemination of information and involvement of farmers)
8. Gender relations among farmers (Access to and control of resources between male and female farmers)
9. Perceived profit to farmers in regards to the use of introduced innovation.
10. Factors influencing adoption of innovations (famers' perspective and external drivers)
11. Gender roles transformation among male and female farmers upon adoption of innovation
12. Role of Government towards promotion of men and women farmers

Appendix 3: Discussion Guide for Focus Group Discussions on: "Implications of paddy production innovations to gender roles in Mvomero District, Tanzania"

1. Name of Village…....…………………………………….
2. Name of Irrigation scheme………………………………..
3. Adoption of introduced innovations in the study area
4. Attitudes of farmers on the introduced paddy innovations.

1. Factors influencing adoption of innovations (famers' perspective and external drivers)
2. Gender perspective and extension service provision (dissemination of information and involvement of farmers).
3. Gender division of labour and gender roles in relation to paddy production and post-harvest.
4. Profitability to farmers in regards to the use of introduced innovation