

**COMPARATIVE ANALYSIS OF FARM POWER TECHNOLOGIES IN RICE
PRODUCTION FOR SMALLHOLDER FARMERS IN MBARALI DISTRICT,
TANZANIA**

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
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ABSTRACT

This study aimed at undertaking a comparative analysis of farm power technologies; manual, oxen, 2WT and 4WT in Rice Production for Smallholder Farmers in Mbarali District, Tanzania. The study had three objectives namely: (i) identification of different farm operations by power sources used by smallholder farmers in paddy production, (ii) analysing costs and returns per unit area of using the mentioned sources of farm power and (iii) examining factors influencing smallholder farmers' choice of farm power technologies for use in selected farm operation. Purposive and random sampling techniques were employed in selecting 240 smallholder rice farmers. Descriptive statistics, partial budget approach and binary logistic regression model were used in data analysis. Results show that different types of farm power were used to suit specific farm operations. In most cases operations like land clearing, transplanting, weeding, and fertilizer applications were normally done manually. On the other hand, tilling and puddling operations were done by manual, draught animal, 2WT or 4WT power with the exception of 2WT being used mostly compared to other farm power . Considering tilling and puddling using manual power or 4WT as current practices, partial budget results indicated a positive net change implying that a farmer will be better off when choosing to use 2WT technology. Considering tilling and puddling using oxen as current practices, partial budget results indicated a negative net change implying that a farmer will be better off continuing with the use of oxen than the proposed change of using 2WT. The binary logistic results to establish factors affecting choice of technologies show that, the highly statistically significant variables at 1% ($P < 0.01$) and 5% ($P < 0.05$) level are time, availability of technology and age of household head. These findings suggest that an adjustment in each one of the significant variables can significantly influence the

probability of using the farm power technologies. Based on the findings of the study the following recommendations were made; (a) farm power technology especially machines should be made available and affordable at the proper time for use, (b) supply of quality and durable farm power with more attachments to enable carrying out multi-operations, and (c) conducting thorough research on the needs of farmers in a targeted area priori to supplying of farm machinery.

DECLARATION

I, Zena Babu, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other Institution.

Zena Babu
(MSc. Candidate)

Date

The above declaration is confirmed by;

Prof. Joseph .P. Hella,
(Supervisor)

Date

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DEDICATION

This work is dedicated to my beloved mother Anna Mosha who contributed much in my education. This work is also dedicated to my loving husband Emmanuel and my sons Prince and Grant for their courage, inspiration, compassion and love they have shown me during the whole period of study hence this success.

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LIST OF ABBREVIATIONS AND ACRONYMS

2WT	Two Wheel Tractor
4WT	Four Wheel Tractor
BEP	Break Even Point
CIMMYT	International Maize and Wheat Improvement Center
DASIP	District Agricultural Sector Investment Program
FACASI	Farm Mechanization and Conservation Agriculture for Sustainable Intensification
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
ha	Hectare
HIV/AIDS	Human Immunodeficiency Virus /Acquired Immune Deficiency Syndrome
IAAE	International Association of Agricultural Economists
IAGRI	Innovative Agricultural Research Initiative
IDRC	International Development Research Centre
IISD	International Institute for Sustainable Development
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
ITCZ	Inter-Tropical Convergence Zone
MAFC	Ministry of Agriculture Food Security and Cooperatives
NFRA	National Food Regulatory Authority
NPV	Net Present value
PASS	Private Agricultural Sector Support

PB	Partial Budget
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SNAL	Sokoine National Agriculture Library
SSA	Sub Saharan Africa
URT	United Republic of Tanzania
VEO	Village Executive Officer
WWF	World Wildlife Fund for nature

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Tanzania has an area of about 945 km² (94 million ha), of which 44 million ha are classified as suitable for agriculture and about 10.1 million ha (23%) are under cultivation. Agriculture is the mainstay of the Tanzanian economy contributing to about 24.1% of GDP, 30% of export earnings and it employs about 75% of the total labour force (MAFC, 2013). Over the past decade the agricultural sector Gross Domestic Product grew at a rate of 4.4%, which is higher than the average annual population growth rate of 2.6% implying growth in incomes (MAFC, 2013). However, this average growth is insufficient to lead to significant wealth creation and alleviation of poverty, given the low level of agricultural development. Attaining poverty alleviation in Tanzania requires annual agricultural growth rate of from 6 to 8% (MAFC, 2013).

According to World Bank (2012), agriculture in Tanzania is hampered by widespread underinvestment despite its significance to livelihoods and to the overall macro economy. As a result it continues to operate largely at subsistence levels and its potential to bring commercialization to scale remains for the most part unrealized. Smallholder farming, which is dominant in the country, is characterised by a low level of technology, highly uneven and irregular rainfall, unstable commodity prices and low adoption of improved crop production techniques, including mechanization, leading to low yields, among others (CIMMYT, 2014).

Mechanization plays a very important role in transforming agriculture in any agrarian economy. According to PASS Trust (2013), mechanization is a necessary condition for

farmers to improve productivity of labour and land by facilitating the timeliness and quality of cultivation and also has the potential to turn idle land into productive land for national economic growth. Agricultural mechanization also could importantly contribute to increases in profitability from increased crop production and reduced costs of cultivation, transport and processing by reducing expenditure on labor (FAO, 2006).

1.1.1 History of agricultural mechanization in Tanzania

Tanzania adopted an agricultural modernization approach during the First Five Year Plan from 1964 to 1969. The plan aimed at opening up new areas for modern and mechanized farming, by supplying tractors and machinery to farmers. However, implementation of this scheme failed for various reasons, including the lack of sufficient preparation and overcapitalization relative to returns (Mmari, 2012). The reliance on manual power has continued to dominate agriculture in Tanzania and in other Sub-Saharan Africa countries (FAO, 2008).

Partially due to the earlier failure of the mechanization scheme in Tanzania, the Second Five Year Plan from 1969 to 1974 stressed the use of draft animals instead of tractors in an effort to transform farming from manual or human-power dependence to animal power. Animal power, however, was confined to pockets around the country and became insufficient as the population grew and the area under cultivation increased (Mmari and Mpanduji, 2014). Although the use of four wheel tractors (4WTs) continued to expand on the medium and large scale state-owned farms, in the country overall, 4WTs decreased from 17 000 units in 1970 to less than 6 000 units in the 1990s due to various reasons such as poor performance of the economy, weak infrastructure and poor management (FAO, 1997). Through different Government interventions, since the 1990s a trend towards

mechanization has again occurred, with the use of 4WTs increasing (FAO, 2008). There has been a 300% increase in the number of 4WTs in use in Tanzania from 7 525 in 1995 to 21 500 in 2007, a country with 9 million hectares of arable land. Therefore the amount of arable land per tractor has been reduced from 1 196 ha in 1995 to 442 ha per tractor in 2007 (FAO, 2008; PASS Trust, 2013). Despite the recorded success over the last decade on 4WT use the literature shows that the majority of Tanzanian farmers (92%) still use hand hoes for cultivation (CIMMYT, 2014). This can be attributed to the fact that the approach used by the past initiatives may have been inappropriate, with a focus on large machines not suitable for small and fragmented fields that are too costly for many smallholders. Thus, the introduction of new and innovative technologies appropriate for smallholder farmers is important in transforming agriculture so as to increase food production and agricultural exports (Policy Forum, 2011).

1.1.2 Introduction and distribution of two-wheel tractors in Tanzania

The idea of using two-wheel tractors (2WTs) was introduced in Tanzania in the 1990s as an alternative to the animal drawn wheeled tool carrier when 10 2WTs were acquired from Japan (Mmari and Mpanduji, 2014). The number of 2WTs distributed in Tanzania increased annually from 100 in 2005 to 3 325 in 2010 (Fig. 1). The increase in imports has been due to government interventions through tenders to help small farmers' access farm mechanization (MAFC, 2010). Furthermore, an increase of 2WTs in Tanzania has been attributed to the "*Kilimo Kwanza*" (Agriculture first) initiative (Policy Forum, 2011). Moreover, between 2010 and 2014, the total number of 2WTs in the country is almost 6 000 units, with most distributed in Mbeya (1 073), Morogoro (327), Dodoma (215), Rukwa (242), Ruvuma (314) and Iringa (306) regions (MAFC, 2014). The remaining 2WTs are distributed in other regions.

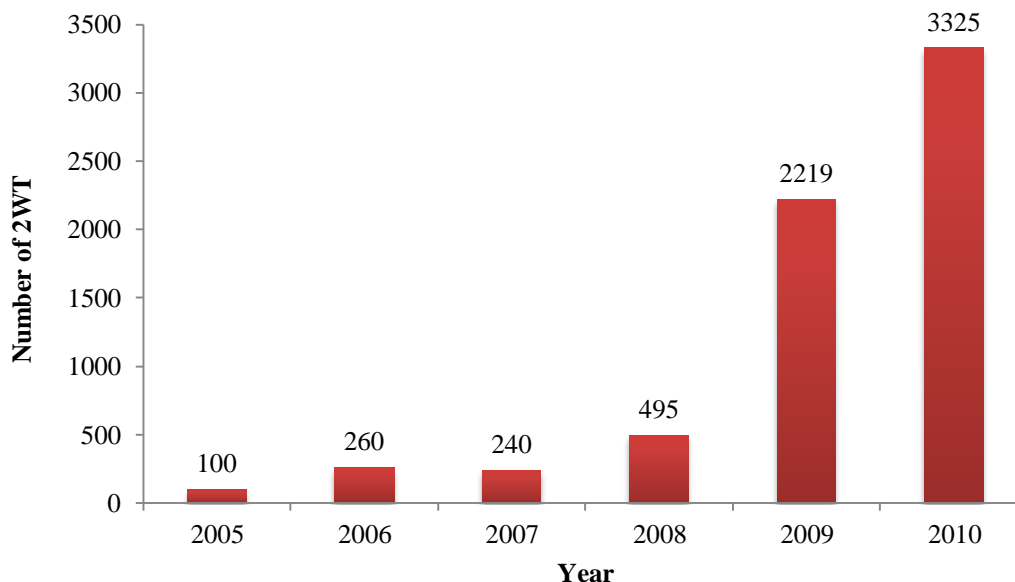


Figure 1: Trend of 2WT Introduction in Tanzania

Source: MAFC, 2010.

Two wheel tractors in Tanzania have been used in various operations: tillage (for maize, legumes, rice production, and vegetables), shelling/threshing (maize and beans), rotavation (rice), water pumping for irrigation, maize milling, and transportation (MAFC, 2010). Meanwhile other sources of power such as four-wheel tractors, oxen and hand hoes are still used in various farm operations. This study analyses farm power technologies used by smallholder farmers for different farm operations in rice production in Mbarali District, Mbeya Region.

1.2 Problem Statement and Study Justification

In Sub-Saharan Africa (SSA) countries the use of animal and manual/labour power is declining due to various reasons, including the decline in the number of draught animals, the decline in human labour particularly due to deaths, and migration, especially in rural

areas where agricultural activities are dominant (FAO, 2006). In addition most government-run tractor hire schemes are no longer existing (Fonteh, 2010). In this context two-wheel tractor technology is viewed as an appropriate alternative for most smallholder farmers in developing countries like Tanzania, given their common average size of farm and economic situation (Ademiluyi *et al.*, 2008). For example, in the 1990s Bangladesh focused on smallholder farmers with small sizes of farm and massive use of hand-operated mechanical tools and managed to promote 2WTs over the use of animal power for land preparation, transport, post-harvest operations and water pumping (Quayum *et al.*, 2012; Diao *et al.*, 2014). However, the choice of sources of power for any work on the farm depends on their relative costs for doing a particular unit of work under consideration (Sankaran and Mudaliar, 1984).

According to IRRI (2015), human/labour and oxen, as the source of farm power being used by most smallholder farmers, are multipurpose, and are easy to handle and replace. However, these tools are limited in daily working hours and require much more time to cover the same area of land than a tractor. Furthermore, four-wheel tractors are more efficient and able to work in rain fed conditions with less likely to get stuck, although they are not suitable for smallholder farmers with small and fragmented land, as the costs of acquisition and maintenance are high relative to their returns. This situation necessitates smallholder farmers to look for appropriate alternative tools for their operations.

Based on the important role of agricultural mechanization in Tanzania and the fact that the 2WT technology has been recently introduced two issues need to be considered. First, it is vital to understand what factors influence the type of power that farmers choose for farm operations, and second, how that choice influences production efficiency and farm profits.

It is not yet well known how the available types of farm power differ in terms of their technical and/or economic benefits when one is compared to another.

In Tanzania studies have been conducted to assess the performance of 2WTs in various aspects. For instance, Agyei-Holmes (2013) compared 2WTs from Japan and China focusing on mechanical elements and revealed that though 2WTs from Japan have superior engineering quality, by their nature they do not support the poor as far as the Chinese 2WTs do. Additionally, study by Mmari and Mpanduji (2014) on frugal innovation/engineering for inclusive development on 2WT in Tanzania revealed that 2WT machines are locally driven re-engineering – which suggests that the products were not initially engineered or designed for adaptations in different agro-ecological conditions. On the other hand, CIMMYT (2014), studied farm machinery focusing on tillage as a major farm operation in various crops in Northern part of Tanzania and revealed that 2WTs are more efficient when compared with oxen and the use of hand hoes for tillage operation in the cultivation of crops such as maize, beans and pigeon peas.

However, to date there is limited scientific studies in Tanzania that have documented the comparative analysis of farm power technologies in rice production and choice of the same by smallholder farmers. This study analyses four types of farm power (manual, draught animal, 2WT and 4WT) technologies for smallholders' farm operations in Mbarali District, Mbeya Region. The results of the study are therefore, expected to help farmers make decisions on the best type of farm power to use for certain farm operations in order to increase their profits. The study will serve as a reference for future studies of the same nature.

1.3 Objective of the Study

1.3.1 Overall objective

The overall objective of the study was to contribute to our understanding of the relative advantage of farm power technologies for smallholders' farm operations and factors influencing choice of technologies in rice production in Mbarali District, Mbeya Region, Tanzania.

1.3.2 Specific objectives

Specifically the study seeks to;

- i. Identify different farm operations by power sources used by smallholder farmers in paddy production in the study area;
- ii. Analyse costs and returns per unit area of using manual, oxen, 2WT or 4WT as sources of farm power in the study area;
- iii. Examine factors influencing smallholder farmers' choice of farm power technologies for use in selected farm operation.

1.4 Research Hypotheses

Based on the second and third specific objectives the following hypotheses were tested;

- i. There is no significant difference in costs and returns per unit area of using manual, oxen, 2WT or 4WT as sources of farm power in the study area.
- ii. Socio- economic, institutional, and other factors do not influence smallholder farmers' choice of farm power technologies for use in selected operation.

1.5 Research Question

- i. What types of farm power are used by farmers in performing different farm operations in the study area?

1.6 Organization of the Study

This study is organized into five chapters. The first chapter contains general background information of the study which includes problem statement and study justification, objectives of the study, research hypotheses and question. Chapter two presents the review of significant literature published and relevant to this study. It includes an overview of different farm power technologies in different small farm operations in paddy production from farm preparation all through harvesting and transportation. Chapter three presents a detailed description of the study area and methodology used in this study. A detailed description of the results and discussion is provided in Chapter four. The fifth Chapter presents conclusions and recommendations drawn from the study findings. The last section contains a list of appendices and the literature cited for the purpose of this study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of Terms and Concepts

2.1.1 Two- wheel tractors

Two-wheel tractors (2WTs) are increasingly common in rural areas of developing countries, and are known by different names, including "walk-behind tractor; iron-ox; walking tractor; mechanical ox; ox-machine; power tiller; rotary tiller; hand tractor; single-axle tractor; and in Asia, tok-tok". The names given are based on among other things; design, manufacturers, and functions they perform. For instance, in Sri Lanka, 2WTs are commonly called bush tractors or Kubotas, generic terms derived from the names of popular manufacturers (Ericson, 2010).

According to Ademiluyi *et al.* (2008) two-wheel tractors (2WTs) also known as power tillers are multipurpose power units designed for use in paddy, maize, wheat and beans fields, vegetable gardens and moderately hilly land.

There is a fair bit of confusion in naming machines of similar size/ configuration, which operate a single implement (such as power tiller; rotary tillers; rotary ploughs; rotavators; etc.). However, an important distinction between a 2WT and any of these machines is that 2WT is a single-axle, walk-behind machine designed to operate multiple interchangeable implements, whereas machines like power tiller, rotary tillers, and rotary ploughs only operate one implement such as a tiller (Ericson, 2010). Therefore, for consistency the term two-wheel tractor (2WT); a multipurpose power unit was used throughout the study (Plate 1 and 2).



Plate 1: 2WT in agriculture mode

Plate 2: 2WT in transport mode

2.1.2 Agricultural mechanization

The term “mechanization” is used to describe tools, implements and machinery applied to improve the productivity of farm labour and of land. It includes all forms of mechanical farm power sources and mechanical assistant to agriculture from simple hand tools like hand hoe, plough and motorized such as 4WT, 2WT together with their outfit (FAO, 2010). Moreover, Mada and Mahai (2013) define Agriculture mechanization as an enterprise that creates job opportunity with application of machines. It reduces drudgery and save time in of routine farm operations. Agricultural mechanization embraces the use of tools, implements and machines for agricultural land development, crop production, harvesting, preparation for storage and storage itself, and on-farm processing. In each stage of agricultural production, it is important that mechanization provide an alternative which is economically and ecologically sustainable (i.e. conservation agriculture).

2.1.3 Conservation agriculture

The concept of conservation agriculture is defined as a way of farming that conserves, improves, and ensures efficient use of natural resources. It aims to help farmers achieve

profits with sustained production levels while conserves the environment (FAO, 2000). It also aims to make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It contributes to environment conservation as well as to enhance and sustained agricultural production. Conservation agriculture maintains a permanent or semi-permanent organic soil covers. Soil nutrient balancing process cannot be disturbed through integrated management during mechanical tillage.

Dumanski *et al.* (2006) define conservation agriculture as an application of modern agricultural technologies to improve farm production while concurrently protecting and enhancing the land resources on which production depends. The application of Conservation agriculture promotes the concept of optimizing yields and profits while insuring provision of local and global environmental benefits and services.

According to Baudron *et al.* (2014) one of the potential synergy between mechanization and conservation agriculture may come from the reduced use of crop residues for animal fodder that is expected from a shift from animal draught power to tractor power, resulting in an increased fraction of crop residue potentially available for surface mulching.

2.1.4 Farm power technology

Farm power technology is referred to as major sources of power whether human, animal or motorized, which is a pre-requisite for any agricultural activity. According to FAO (2006), the technology can be broadly classified as hand-tool technology, draught animal technology and mechanical power technology together with their associated tools and implements based on the source of power. These technologies are used in most SSA

countries with human muscle constituting the most important power source where by 65% of agricultural land is prepared and weeded by hand.

2.1.5 Farm operation

Farm operation means the preparation of production stages and implementation of agro-activities leading to the realization of primary products. This involves the preparation of a systematic plan of management to be implemented during a whole course of farming production in the season (FAO, 2000). It may involve a plan for seedlings preparations, inputs preparations, mechanization plan and all on & off farm plan. The farm operations includes among other things land clearing, seedlings preparations, tillage/ploughing, puddling, transplanting or broadcasting, weeding, fertilization, irrigation, harvesting, shelling/threshing and Transportation. Farm operations vary depending on the type of crop being considered.

2.1.6 Livelihood

According to FAO (2006), the term 'livelihood' refers to the means of making a living. It represents the general living of people which involves their socio-economic involvement in production in order to meet their day to day needs. It involves a range of assets available in disposals which can be applied in production processes to earn the essential living. On the other hand, IISD (2003) defines livelihood as comprising the capabilities, assets and activities required for a means of living. Central to this definition however are livelihood assets which are natural, social-political, human, physical and financial capital.

In SSA a typical farm family that is reliant solely on human power can only cultivate in the region of 1.5 ha per year, 4 ha if DAP is available, and to over 8 ha if tractor power

can be accessed (FAO, 2006). Application of these alternative power sources can relieve pressure on human labour at critical times of heavy demand. Additionally, making more efficient use of these alternative power sources provides the best immediate strategy for reducing the problem of farm power shortage in SSA, thereby increasing agricultural productivity and improving farm families' livelihoods.

2.1.7 Partial budgeting

Partial budgeting (also known as marginal analysis) is a management tool that can compare the costs and returns that are affected by a potential change in a business. It is mostly useful in evaluating budgets that involve small, specific, and limited changes within a business by helping to determine the profitability of that change (Rabin *et al.*, 2007). According to (Roth and Hyde, 2002) partial budgeting is a planning and decision-making framework used to compare the costs and benefits of alternatives faced by a farm business. It focuses only on the changes in income and expenses that would result from implementing a specific alternative and allows producers to get a better handle on how a decision will affect the profitability of the farm.

Moreover, Rabin *et al.* (2007) noted that when a farmer is faced by two alternatives say 'A' and 'B', he chose to analyse what would happen if he stopped his current practice and opt for alternative 'A' or 'B' instead. It is thus necessary to prepare and evaluate two separate partial budgets in order to see the effects of two proposed changes against a current practice. The budget only indicates that the change will increase, decrease or not change on net income.

According to Rabin *et al.* (2007) the partial budget can be divided into three main sections: (I) Income reducing section (costs), (II) Income increasing section (benefits), and

(III) analysis. The analysis section includes net change in profits and a break-even analysis (also known as benefit/cost ratio).

The possible changes that can occur in a business or farm fall into four categories. These categories are added returns, reduced returns, added costs, and reduced costs (Lessley *et al.*, 1991). Added costs and reduced returns compose the cost section of the partial budget and they represent the negative effects of a proposed change. Added returns and reduced costs fall into the benefits section of the partial budget and are the positive effects of a proposed change in the business.

2.2 Farm Power Technologies of Choice and its Contribution to Agriculture

In many parts of sub-Saharan Africa agriculture remains at the core of rural livelihoods and farm power (from human, draught animal and tractor sources) is a crucial input in the agricultural production process (FAO, 2005). However, farm power in the region, relies to a large extent on human muscle power, based on operations that depend on the hoe and other hand tools. Manual power has been mostly used for primary land preparations, planting, weeding, and harvesting of various legume and cereal crops. Despite its massive use by many farmers, manual power limits the amount of land that can be cultivated per family. It reduces the timeliness of farm operations and limits the efficacy of essential operations such as cultivation and weeding, thereby reducing crop yields (FAO, 2008).

On the contrary, animal power and tractors in most cases have been used for land preparations primarily tillage/ploughing and puddling operations in cereal crops. According to FAO (2005) farming households using farm-power technologies other than a hand hoe gain considerable advantages in terms of area cultivated, crop diversity, yields,

levels of drudgery, opportunities to redistribute family labour, and household food security. This gives a clear indication that the use of improved farm power technologies has an important contribution to farmers and to the agriculture sector at large.

2.3 Conceptual Framework

A conceptual framework provides a guideline in identifying important variables and understanding of the theoretical relationships between the identified variables. It helps to indicate the most useful area to which the study must focus when the research resources are limited while ensure the relevant data to meet the need of the study objectives are collected (Scarborough and Kydd, 1992). The variables of the study are such as socio-economic factors, geographical factors, institutional factors, production efficiency or farm profit, and farm power technologies.

To improve agricultural productivity and rural livelihood require that farm power technology must be an essential component in farming systems. Demand for farm power is high in the whole process of agricultural production and varies across operations. In each stage of agricultural production, it is important that farm power technologies provide an alternative which is economically and ecologically sustainable (i.e. conservation agriculture). In implementing the approach to satisfy directly the need of smallholder farmers, this action need to be off and without compromising the available state of food security (FAO, 2006). For instance; Increasing demand and uses of a relative farm power technology to relieve the stress of the deficient labour power attributed to a decreasing man power in rural areas, need to be approached without effect in the individual household states of food security.

Generally, farmers' decision or choice on farm power technologies is therefore influenced by among others; socio-economic factors, geographical factors, Institutional factors, availability of the technology and the relative advantage of using such technology. Assuming that smallholder farmers are rational in decision making, their choice on available technologies will aim at increasing production efficiency and farm profit (net gain). Farmers' decisions might also have effect on the demand and supply of one farm power technology relative to another. Clear illustration of the relationship between variables hypothesized is given in Fig. 2.

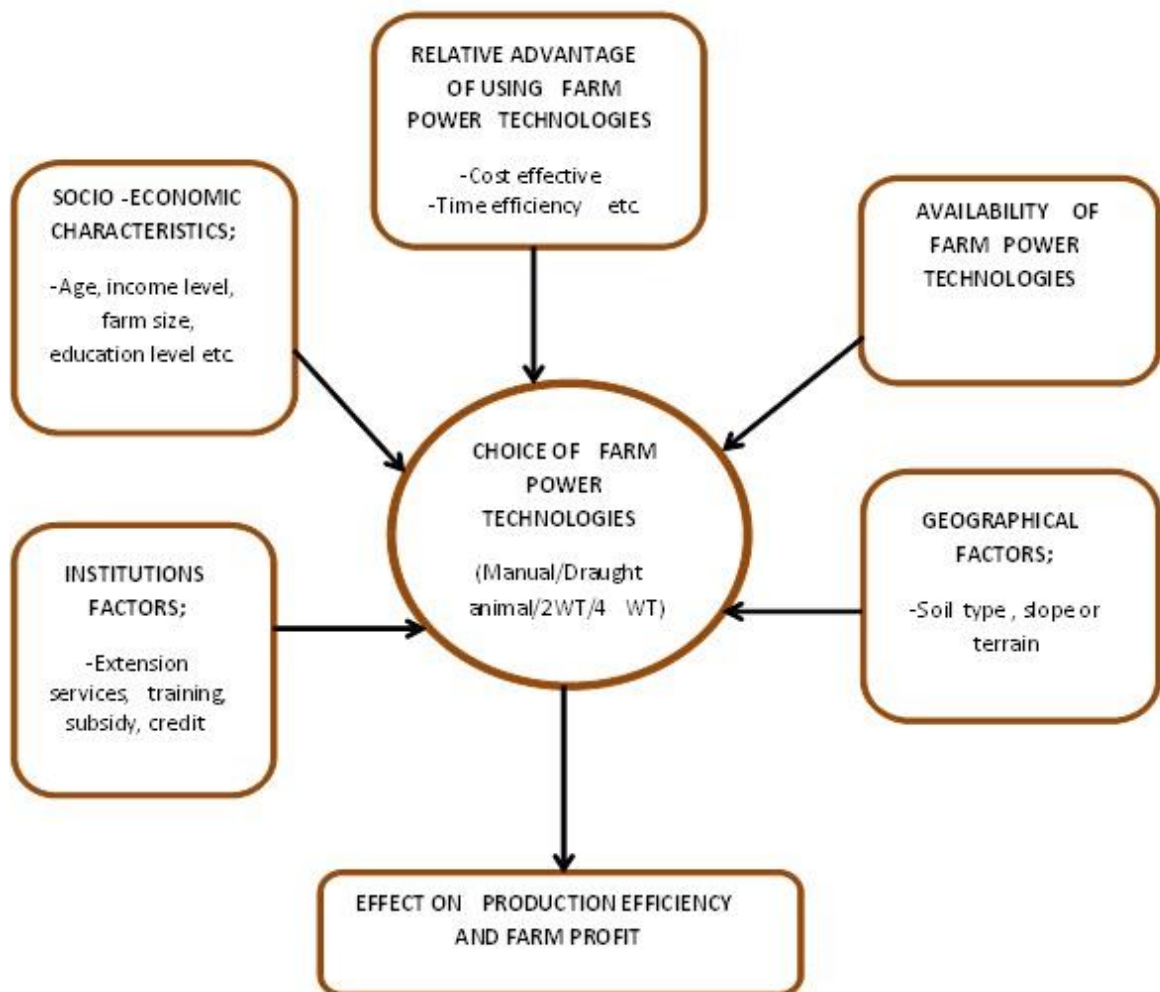


Figure 2: Conceptual framework for the study

2.4 Theoretical Review

This study is guided by rational choice theory. Rational choice theory is an economic principle that states that individuals always make prudent and logical decisions. These decisions provide people with the greatest benefits or satisfactions, given the available alternatives, and also in their best self-interest. In other words individual distinguishes the cost and benefits of alternative actions (their outcomes), with concern solely about her best self-interest (Burns and Roszkowska, 2016). The theory assumes that individuals try to actively maximize their advantages in any situation and therefore consistently try to minimize their losses. They choose the alternative with the most net gain or “utility” (Burns and Roszkowska, 2016).

According to Friedman and Hechter (1988) individual decisions and actions are shaped by rational preferences and constrained by resource scarcity, opportunity costs, institutional factors and information. Under rational preferences individuals are assumed to have explicit, complete, reflexive, and transitive rank ordered preferences over the possible outcomes of their actions (Bicchieri, 2004). Resource scarcity drives individuals to make choices to attain satisfactory ends consistent with their preference. Decision makers are assumed to conduct rational calculation and subsequently select the course of action likely to be associated with the highest outcome values.

An opportunity cost is another factor that affects individuals' decisions, when making a specific choice. These implicit costs are associated with the act of foregoing the next best alternative available to decision makers. Individuals must consider these implicit costs in their pursuit of maximum benefits and satisfaction (Rahelizatovo, 2002).

Likewise, Rahelizatovo (2002) noted that institutional factors, as well as access to better quality information at the time a choice has to be made, also influence individuals' decision outcomes. Individuals may also reduce the risk and uncertainty surrounding their choices by acquiring more information.

On an attempt to analyse the behaviour of individuals/ decision makers who face a finite set of alternative choices, discrete choice models an econometric modelling techniques is used. The models attempt to relate the conditional probability of a particular choice to various attributes of the alternatives, which are specific to each individual, as well as the characteristics of the decision makers (Judge *et al.*, 1985). Using a dichotomous dependent variable as in the case of binary choice models, the choice behaviour of individuals with only two alternatives can be examined. Different ways are adopted to approach such models but generally models relying on the linear random utility assumption are based on an individual decision maker maximizing his/her expected benefits or utility derived from the choice.

2.5 Empirical Literature Review

MAFC (2013) through District Agriculture Sector Investment Project (DASIP) reported that in order to boost crop production, there is a need to invest in small machines like 2WTs. Two wheel tractors are intended to enable farmers to expand their plots and perform operations like tilling, levelling, and transporting farm produce to markets. Some farmers have started to use their 2WTs to perform other operations such as hulling (in Tarime district) and water pumping in Magu and Ngara districts.

CIMMYT (2014) report on market performance of two wheel tractors revealed that 2WTs are more efficient when compared with oxen and the use of hand hoes for tillage operation

in the cultivation of crops such as maize, beans and pigeon peas in the Northern part of Tanzania. The study uses focus group discussions, literature review and interview as research tools. The report concluded that there is a profound economic benefit in using 2WT for preparation of land than using hand hoe in term of time and labour whereby one 2WT can till 1 hectare a day on sandy to loamy soils and use approximately 15 litres of diesel.

The above argument is supported by IRRI (2009) study on how Africa mechanizes its harvest and post-harvest resources to achieve food security in Sub Saharan Africa (SSA). Considering Rice as one the very important staple and cash crop in SSA the report shows that its productivity in East and Central Africa is still very low with the only yields averaging less than 2tons per hectare. In trying to explain why productivity is low, the study outlined that diseases like HIV/AIDS and rural-urban young people migration are just some of production constraints which lead to the problem. The study argued that increasing labour is not really an option to overcome the problem. Instead, small designed machines such as 2WT can be introduced to improve production as it will improve the timeliness of operations, efficiency and quality of the end product.

Furthermore, Baudron *et al.* (2014) writing on appropriate and equitable mechanization in Africa through conservation Agriculture, use of 2WTs, and involvement of the private sector, revealed that approaches used by past initiatives focused on large machinery, which are not suitable for small and fragmented fields, and too costly for many African smallholders. Moreover appropriate and equitable mechanization may be achieved by using 2WTs, which are perfectly suited to conservation agriculture.

CIMMYT (2015) studied on economics of 2WT technology in Tanzania by analysing the situation using Net Present value (NPV), Internal Rate of Return (IRR) and Break Even

Point (BEP). Based on the analysis the study concluded that Farmers who use 2WT in production increases productivity and became profitable. Moreover, if a farmer owns and uses a 2WT some of the production costs get reduced and income is more increased. This suggests that for the farms to be profitable, mechanization of 2WTs is inevitable especially for smallholder farmers with fragmented and small farms. Furthermore, the report revealed that profitability and viability of these machinery and equipment could be greatly increased if used for other off-farm activities.

Additionally, Quayum *et al.* (2012) examined the impact of power tillers on profitability of cropping patterns in selected areas of Bangladesh. Farmers were stratified into four groups based on the ownership and use of power tillers and/or draft animal power, and a stratified random sampling technique was followed for selecting sample farms. Structured questionnaires were used for collecting data from the farmers. Profitability analysis and benefit-cost ratio estimation were used to analyze the data. The findings indicated that there is a positive impact of power tiller usage on increasing profit and growing more crops in the same field year-round. Adoption of any suitable cropping pattern using power tillers in Bangladesh is more profitable compared to the use of Draft Animal Power and farmers benefited more.

On contrary, Teweldmehidin and Conroy (2010) researched the economic importance of draught oxen on small farms in Namibia's eastern Caprivi region, applying financial analysis techniques (mainly Net Present Value, Benefit Cost Ratio and Internal Rate of Return), crop enterprise budgets, and parametric analysis. Semi-structured interviews were conducted with farmers at their farms in the Caprivi region to evaluate the economics of the draught animal system. A structured questionnaire was used to obtain further

information on livestock production characteristics in the smallholder farming systems. The data were processed further to compare the economic differences between the oxen- and tractor-using farmers. The results indicate that ox farming is more financially feasible and economically viable from both parametric and financial analysis perspectives when compared with tractor farming.

Moreover, Simalenga *et al.* (2000) researched the profitability of using animal traction under smallholder farming conditions in Ciskei region, Eastern Cape, South Africa. To carry out the cost benefit analysis, six scenarios were considered. Results indicated that smallholder farmers in the study area use animals for draught power extensively and draught animal power is assessed to be profitable, as the net farm income when using the working animals for different agricultural purposes is positive. The study has confirmed that Animal Draught Power is still a realistic and cost-effective option for improving smallholder farming. Draught animals can perform several operations on the farm such as ploughing, harrowing, planting, and weeding and transport.

Ademiluyi *et al.* (2008) analysed the socioeconomic factors influencing power tiller use among sawah farmers in Bida, Nigeria. The study used descriptive statistics to analyse the socio-economic features of the farmers and the probit model to capture the socioeconomic factors influencing the use of power tillers among rice growing farmers. Important socio-economic characteristics that were found to be of crucial concern in the introduction of power tiller to sawah adopting farmers were age, educational level, membership of farmer group, farm size, land tenure, practice sawah, location/distance of sawah plot and cost of power tiller use. According to empirical results, the younger the farmers the more the use of power tiller on their plot and also the higher the level of education among farmers the more the use of the power tiller for productive purposes. The study findings also revealed

that farmers who are members of the farmers' association have higher probability of using power tiller because of high level of interaction among members of the same group and the ability to hire power tiller as a group. Also as the farm size increases, the probability of using power tiller also increases as farmers would be able to cope with the farm power demand due to large size.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Geographical location

The study was conducted in Mbarali District which is located at 08.85S° and 33.85E° in southern Tanzania (Mbeya Region). The District is at an altitude ranging from 1 000 to 1 800 meters above sea level. The District is bordered by Iringa and Njombe Regions on the North and East, Chunya District on the West, Mbeya Rural District on the South-West and Makete District on the South. A clear map of Mbarali District (Fig. 3) showing the study wards and villages is presented in the next page.

3.1.2 Climate and soil

The climate of Mbarali (which is found within the Usangu plains) is controlled by the Inter-Tropical Convergence Zone (ITCZ), in which rainfall is highly seasonal, with a single rainy season from November to April characterized by thunderstorms while July is recorded as the driest month. This rainfall pattern is revealed in the records, with rivers showing extremely peaked flow patterns and a clearly distinguishable wet and dry season. Rainfall is strongly correlated with altitude in which areas with high altitudes receive up to 1 600 mm of rain per year (WWF, 2010). However, the average annual rainfall is 713 mm. The mean annual temperature varies from about 18°C at high altitudes to about 28°C in the low. The soils of the study area can generally be described as clay soils and sandy loams. Clay soils which are suitable for growing paddy are found on the lower alluvial fans while sandy loams containing less clay which are suitable for growing maize and dry season crops are dominant on the upper alluvial fans and foothills.

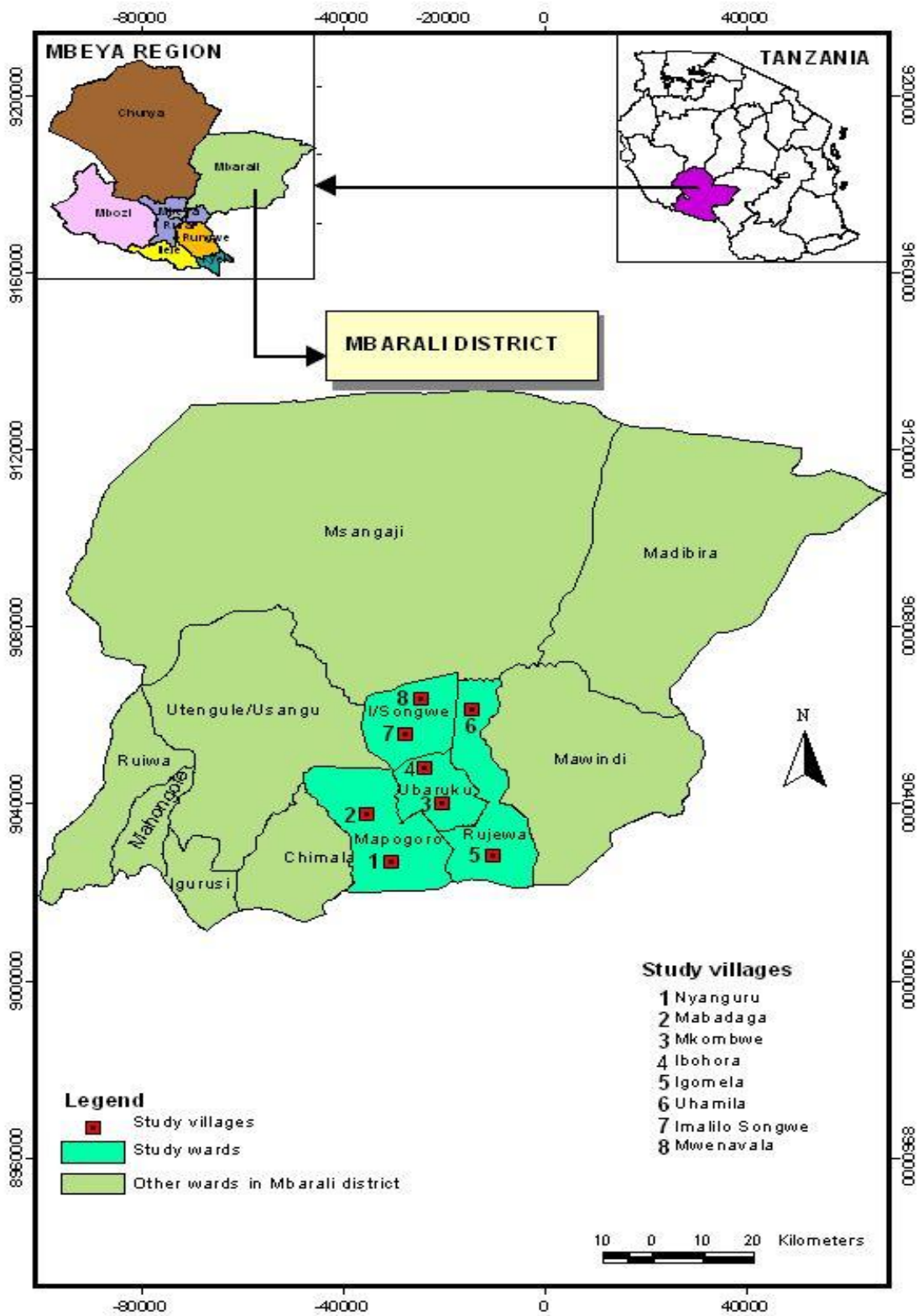


Figure 3: A Map of Mbarali District showing Wards and Villages under the study

3.1.3 Population

The district is among the highly populated district in Mbeya region. According to National Bureau of Statistics of the United Republic of Tanzania (2013) Mbarali District had an estimated population of 300 517 whereby 145 867 are males and 154 650 are females. The average household size was 4.3 and sex ratio of 94. Administratively, the District is divided in to 2 divisions (namely Ilongo and Rujewa), 20 wards, 99 villages, 371 hamlets and 69 888 households. Among 20 administrative wards, 4 selected wards for the study which are Mapogoro, Rujewa, Ubaruku and Imalilo Songwe cover one-third (94 692) of the total population of the District.

3.1.4 Agriculture and land use

Mbarali District is one of the unique districts with large estate farms owned by individuals or cooperative societies. Following expansion of Ruaha National Park, the district area size has been reduced to 7 000 km² from its original size of 16 000 km² implying that the land potential for agricultural activities has been reduced (Sirima, 2016). The size of arable land remained after expansion of park is 1 960 km². It is estimated that over 86% of the population are engaged in agriculture and livestock keeping with paddy being the predominant food and cash crop grown in the district.

3.1.5 Justification of the study area

Mbarali is one of the areas that form the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). The district is among the prioritized areas for agricultural mechanization by the ministry of Agriculture (MAFC, 2010). Different farm power technologies are used by farmers for their farm operations. Also, available data shows that about 97% of the total number of power tillers (which is a recently introduced technology)

in Mbeya region (1073) are distributed to rice cultivated area such as Mbarali District (PASS Trust, 2013). The district is also endowed by different farm sizes, terrains, soil types (clay and sandy loams) and institutional characteristics, and farming of crops like rice and maize is conducted by applying different forms of farm power.

3.2 Research Design

The study is based on cross sectional data. Cross sectional data are collected at a single point in time from a sample to represent a large population. The design is suitable in descriptive study and for determination of relationships between and among variables while taking into consideration limited time and financial resources (Babbies, 1993).

3.3 Sources, Types and Methods of Data Collection

Both primary and secondary data were used in this study. Primary data (farmer and farm characteristics, types of farm power used in production process, types of crops grown, time (work hours), costs of operations, yields, etc.) were collected through interview using structured questionnaire with both open ended and close ended questions (Appendix 1) and direct observation. To ensure reliability and validity of research data collected triangulation and probing were used when administering questionnaire to the respondents. Secondary data were obtained from various sources of information including the Ministry of Agriculture, Food security and Cooperatives (MAFC), Sokoine National Agriculture Library (SNAL), electronic sources such as the Internet and other documented sources of information. The study collected information from issues pertaining to agricultural mechanization and utilization of different farm power technologies in agricultural production.

3.4 Sampling Procedures and Sample Size

Probability and non-probability sampling techniques were adopted for this study. Mbarali district was purposively selected due to the fact that it is among the prioritized areas for agricultural mechanization and where paddy production is dominant. Multistage probability sampling was used to select wards and villages. At first, 4 wards (namely Mapogoro, Rujewa, Ubaruku and Imalilo Songwe) out of 20 wards in Mbarali district were randomly selected to be included in the study. Secondly, 2 villages from each of the 4 wards were randomly selected making a total of 8 villages (namely Mabadaga, Nyanguru, Uhamila, Igomelo, Mkombwe, Ibohora, Imalilo Songwe and Mwanavala). Simple random sampling procedure was adopted to select respondents from each study village by using table of random numbers. The study population was farmers engaged in paddy production and household was used as a unit of study. Given that the population size was known, the optimal sample size was obtained by using the following formula below by Kothari (2004).

$$n = \frac{Z^2 \times N \times p \times q}{e^2 \times (N - 1) + Z^2 \times p \times q} \dots \dots \dots (1)$$

$$\frac{(1.96)^2 * (6090) * (0.5 * 0.5)}{(0.05)^2 * (6090 - 1) + (1.96)^2 * (0.5 * 0.5)} = 361$$

Whereby;

Z is the standard variate at 95% confidence interval

N is population size

e =5% level of precision

p and q are sampling distribution of proportion of success and failure respectively.

The optimal sample size for the study was 361. However, due to the fact that most farmers have small plots and have similar operations coupled with limited resources, researcher

interviewed 240 respondents 30 from each study village. This sample size is considered adequate based on argument by Maas and Joop (2005) that the sample size of at least 30 respondents chosen at random is reasonably large in social science research studies to ensure normal distribution of the sample mean. Additionally, Matata *et al.* (2001) argued that having 80-120 persons are adequate for most socio-economic studies in Sub-Saharan Africa.

3.5 Data Analysis Techniques

Several statistical techniques and methodologies were employed to achieve the objectives of the study. Primary data were verified, coded and analysed using Statistical Package for Social Sciences (SPSS) computer software. Both qualitative and quantitative descriptive statistics were employed. The methodologies are described as follows.

3.5.1 Farm operations and types of farm power used

One of the specific objectives of the study was to identify different farm operations by types of farm power used by smallholder farmers in the study area. To achieve this objective, Descriptive statistics (means, frequencies and percentages) were used on variables such as types of farm power, farm operations and time required for specific farming operations.

3.5.2 Costs and returns of proposed change in farm operations

The partial budget was used as a tool to analyse costs and returns per unit area of using manual, oxen, 2WT or 4WT as sources of farm power. Partial budgeting is a planning and decision-making framework used to compare the costs and benefits of alternatives faced by a farm business. It focuses only on the changes in income and expenses that would

result from implementing a specific alternative and allows producers to get a better handle on how a decision will affect the profitability of the farm (Roth and Hyde, 2002). The partial budget can be used to analyze many practical farm management problems, such as substituting crop, changing input levels or types of inputs used (example farm power technologies), buying new or used machinery, equipment and so on.

In this study partial budget approach was adopted based on the fact that the expected change on the paddy production process is only partial (i.e. using the available alternatives- farm power technologies to perform a certain farm operation). Identification of major farm operations in paddy production which farmers undertake and the type of farm power used to perform those operations were done. Data on costs of performing the operation by using the available farm power (manual, draught animal, 2WT and 4WT) were collected. This was important as farmers will want to evaluate all the changes that are involved in adopting a new practice.

Considering the component of partial budget, (Added costs, reduced returns, added returns and reduced costs), the assumption was made that there will be no reduced returns and added returns as a result of the changes. This is because it is assumed that change in rice yields (increase/decrease) may be attributed to many other factors like the use of improved seeds, irrigation, fertilizer, drought and pests and diseases to mention few. Thus while there is some possibility that there may be added returns or reduced returns, this was considered as very soft numbers. A partial budget can be prepared following the format (Table 1).

Table 1: Partial Budget Format

I – Income reducing changes (Costs)	II - Income increasing changes (Benefits)
A. Additional Costs (<i>costs incurred as a result of using a new technology</i>)	D. Additional Returns (<i>returns received as a result of using a new technology</i>)
B. Reduced Returns (<i>returns that are given up as a result of no longer using the technology being used.</i>)	E. Reduced Costs (<i>costs that will no longer be incurred as a result of using the new technology.</i>)
C. Total Costs (A + B)	F. Total Benefits (D + C)
III - Analysis	
G. Net Change in Profits/Income (F – C)	

Benefit/ Cost Ratio is also calculated as ($F \div C$)

Decision: If the net benefit is positive, then the alternative may have some economic advantages while if the net benefit is negative the business/ producer would be better off staying with the current situation or look for a different alternative

Assumption: All aspects of farm profits that are unchanged by the decision can be safely ignored in the analysis.

The independent sample T-tests was used to ascertain whether there is a statistical difference in average costs and returns per unit area of using manual, oxen, 2WT or 4WT as sources of farm power.

3.5.3 Factors influencing farmers' choice of farm power technologies

The study also aimed at analysing factors influencing smallholder farmers' choice of farm power technologies for use in selected operation. This analysis focused on the use of two wheeled tractor technology over the other technologies in the selected operation. The focus was based on the fact that technologies like manual, oxen and four wheel tractors had few observations in the selected operation making it irrelevant to be treated separately. Therefore the three technologies were merged and treated as one category of 'other technologies' allowing for the use of binomial logistic regression model.

3.5.3.1 Binomial logistic regression model

A binomial logistic regression (often referred to simply as logistic regression), predicts the probability that an observation falls into one of two categories of a dichotomous dependent variable based on one or more independent variables that can be either continuous or categorical. While Heinrich *et al.* (2010) argue that there is no strong advantage to using a logit or probit model, Wianaina *et al.* (2012) and Baker (2000) argue for the use of logit model against the probit on the basis of consistency of parameter estimates because of the assumption of the error term having a logistic distribution.

Determinants of farmers' choice of farm power technologies were therefore analysed using binary logistic regression through maximum likelihood estimation procedures. Farmers choose farm power technology with higher utility (U) when compared to other farm power technology. Although the utility function cannot be observed, the relationship between the expected utility of each alternative is assumed to be a function of the vector of observed variables and an error term. The choice of two wheeled tractor technology over the other technologies was hypothesized to be influenced by socio-economic, geographical, institutional, and other factors. Therefore farmer's choice of a given technology is driven by a random utility function expressed as:

$$U_{ij} = \beta Z_{ij} + \varepsilon_{ij} \dots \dots \dots (2)$$

Whereby;

U_{ij} = Expected utility from choosing a given farm power technology

Z_{ij} = Vector of farmer's and other factors' characteristics

β = Parameter to be estimated

ε_{ij} = Disturbance term accounts for unobserved variation in preferences

From the utility function specified in equation 2, it can be seen that farmer makes decision to use either two wheeled tractor technology or other farm power technology subject to various social economic, geographical and institution factors. It follows that if the costs associated with a given technology are greater than the expected benefits, farmers will be discouraged to choose such alternative and opt for the one that maximizes utility. The probability of choosing two wheeled tractor technology is given as

$$P_{i1} = P(U_{i1} > U_{i0}) = P(Z_{i1} - Z_{i0} > \varepsilon_{i0} - \varepsilon_{i1}) \dots \dots \dots (3)$$

Wianaina *et al.* (2012) argue that if the error term are assumed to be independently and identically distributed, then the difference between the error terms follow a logistic distribution. According to Gujarati (2004), cumulative logistic distribution function is expressed as follows;

$$P_{i1} = E(Y=1 | X_i) = \frac{1}{1 + e^{-Z_{i1}}} \dots \dots \dots (4)$$

$$P_{i1} = \frac{e^{Z_{i1}}}{1 + e^{Z_{i1}}} \dots \dots \dots (5)$$

$$Z_{i1} = \beta_0 + \beta_1 X_1 + \dots \dots \dots + \beta_n X_n \dots \dots \dots (6)$$

If P_{i1} is the probability of choosing two wheeled tractor technology then $1 - P_{i1}$ is the probability of choosing other farm power technology given as;

$$1 - P_{i1} = \frac{1}{1 + e^{Z_{i1}}} \dots \dots \dots (7)$$

Odds ratio is obtained by dividing equation 5 by equation 7

$$\frac{P_{i1}}{1-P_{i1}} \text{ (odds ratio)} = \frac{e^{Z_{i1}}}{1+e^{Z_{i1}}} * \frac{1+e^{Z_{i1}}}{1} = e^{Z_{i1}} \dots \dots \dots (8)$$

Taking natural logarithm of equation 8 to obtain

$$L_i = \ln \left(\frac{P_i}{1 - P_i} \right) = \ln e^{Z_{i1}} = Z_{i1} = \beta_0 + \beta_1 X_1 \dots + \beta_{12} X_{12} + \varepsilon \dots \dots \dots (9)$$

Whereby;

L_i = Log of odds ratio

X = explanatory variables as briefly presented (Table 2)

P_i = probability of using a given farm power technology where P equals to 1 if farmer choose two wheeled tractor technology and 0 if farmer use other farm power technology

ε = an error term.

Table 2: Explanatory variables of binary logistic model

Variable (Xs)	Description and Values	Hypotheses
X_1 = Farming experience	Number of years of farming experience of the farmer	Positive (+)
X_2 = Availability of farm power technology	Dummy (1 – if available and ready for use, 0 - not available and ready for use)	Positive (+)
X_3 = Farm size	Total area cultivated by the farmer (in hectare)	Positive (+)
X_4 = Time	Number of hours required to complete an operation	Negative (-)
X_5 = Access to extension services	Dummy (1- has access to extension services, 0- no access to extension services)	Positive (+)
X_6 = Slope of land	Dummy (1 – Flat, 0 – Otherwise)	Positive (+)
X_7 = Distance	Distance from home to farm (kilometre)	Negative (-)
X_8 = Member of farmers' association	Dummy (1-Whether a farmer is a member of any association, 0- not a member of association)	Positive (+)
X_9 = Training	Dummy (1 – whether a farmer received training, 0 – no training)	Positive (+)
X_{10} = Age of household head	Categorical (categories are based on number of years from birth)	Positive (+)
X_{11} = Education level of household head	Categorical (categories are based on number of years of formal schooling)	Positive (+)
X_{12} = Credit	Farmers access to credit (1 – Yes, 0 – No)	Positive (+)

3.5.3.2 A priori expectations for the explanatory variables of the model

Among a number of factors which have been related to smallholder farmers' choice of farm power technologies, in this study, the following socio-economic, institutional, and other factors were hypothesized to explain the variation in the dependent variable.

Farming experience: This refers to the number of years the household head uses in farming business. The length of experience in farming is probably an indicator of a farmer's commitment to agriculture. Farmers having more experience in farming business have higher tendency towards using available alternatives so as to increase their farm outputs. Long farming experience according to Obinne (1991) is an advantage for increase in farm productivity since it encourages rapid adoption of farm innovation. Therefore, a farmer having more experience in farming business is hypothesized to be more likely to take up new innovations. Hence, this variable is assumed to have positive influence on the dependent variable.

Availability of technology: Is a dummy variable indicating the availability of farm power technology to the farmers. It takes the value of 1 if the technology is readily available and 0 if not. According to Ademiluyi *et al.* (2008) the availability of a technology is a prerequisite for its adoption. It is expected that farmers will choose to use the farm power technology which is readily available when compared to others and hence coefficient will be positive.

Farm size: The economic status of farmers positively influences access to improved technologies like 2WT. Farm size is hypothesized to positively influence the choice of 2WT technology. As the farm size increases, the probability of using 2WT also increases

as farmers would be able to cope with the farm power demand due to large size (Ademiluyi *et al.*, 2008).

Time: Number of hours required to complete an operation. The study hypothesizes that time will have a negative influence on the choice of farm power technology. The implication is that, the more time a farmer requires for tilling the less likely he/she is to choose 2WT technology as a source of farm power, hence negative sign.

Access to extension services: Extension is a major source of agricultural information that is required by farmers to make decisions on choice of inputs such as farm power. According to Sani *et al.* (2014) contact with extension agent is a major factor determining the level of adoption of agricultural innovation. Extension contact as source of information had a positive relationship with technology adoption implying that the higher the frequency of extension contacts the higher the rate of adoption. More contacts with extension service for delivery of information of new technologies are likely to result in better household' farming decisions including use of 2WT technology. Thus, study hypothesizes that contact with extension agents will have a positive influence on the choice of farm power technology.

Slope of land: A dummy variable with values 1 if land is flat and 0 otherwise. It is expected that farmers are more likely to use 2WT technology if farms are flat in nature than if it was not. The slope of land as one of the terrain observed in the area is therefore expected to have positive influence on the choice of farm power technology.

Distance to the farming plots: Distance is expected to have a negative influence because the longer the distance the higher the cost of farm operation and effectively reduces the

returns to rice production. Moreover, Ademiluyi *et al.* (2008) claims that there is inverse relationship between distance to plot and the probability of using power tillers technology. This indicates that an increase in this variable will lead to a decrease in the probability of using power tillers. It is therefore expected that this variable will negatively affect the choice of 2WT technology, hence a negative sign.

Member of farmers' association: Is a dummy variable which takes the value of 1 if farmer is a member of farmers' association and 0 if not. It is hypothesized that there is a positive relationship between the membership of farmers association and the probability of using 2WT technology. According to Ademiluyi *et al.* (2008) farmers who are members of the farmers' association have higher probability of using an innovative technology because of high level of interaction among members of the same group. The group influence can therefore affect the individual decision to use 2WT technology.

Training: Is a dummy variable which takes the value of 1 if farmer received training and 0 if not. The study hypothesizes that training will have a positive influence on the choice of farm power technology. Farmers who received training on different farm power technologies are more likely to use 2WT technology for their farm operation because of its relative advantage *ceteris paribus*.

Age (years from birth): Age of household head is a categorical variable and is measured in years. Schnitkey *et al.* (1992) argues that age determines how a farmer is experienced in the farm business. Older farmers are hypothesized to be more experienced in farming and wealthier in terms of resources than younger farmers thus, more likely to take up new innovations. Similarly, age of farmer is said to influence farmer's maturity and decision

making ability (Rahman *et al.*, 2003). It is expected to have positive sign meaning that, as the age increases, smallholder farmers are also more likely to use the 2WT technology for tilling their farms.

Education level: The education level of the household head is a categorical variable and is measured in years of formal schooling of the household head. Education plays an important role in the adoption of innovations/new technologies. A person with a higher education level is expected to have a better access to information and more understanding about emerging opportunities hence able to make informed decisions. Ademiluyi *et al.* (2008) argues that the higher the level of education among farmers the more the use of the innovative technology for productive purposes. It is expected that decision to use 2WT will increase with an increase in the level of education in the sense that educated farmers are eager to try new innovations; as such the expected sign for the coefficient will be positive.

Access to credit: Credit is a major source of agricultural financing that is required by farmers to make decisions on choice of farm inputs such as farm power. Access to credit service with reasonable requirements to farmers, is an incentive which is likely to result in better household' farming decisions including use of 2WT technology. Philip (2001) asserts that access to credit enables most farmers to use improved inputs which in turn have a direct positive impact on production performance. The study hypothesizes that access to credit will have a positive influence on the choice of farm power technology.

3.6 Limitation of the Methodology

The study adopted different methods and techniques for data collection and data analysis.

Study has employed questionnaire method for primary data collection interviewing farmers on the use of farm power technologies in rice production. Although the method is considered appropriate, integrating additional methods of data collection like focus group could have increased the scope and depth of analysis.

Considering partial budgeting technique which is an extremely useful and flexible tool for analysing business decisions, there are some limitations that need to be acknowledged. A partial budget compares only two alternatives thus to determine the best solution or to choose the profit maximizing alternative, all possible changes would need to be considered. It requires proper records and sound business judgment. Analysis does not in most cases account for the time value of money. To overcome these, other analytical procedures could be used to make this determination or more detailed analysis could be done with partial budget analysis, though this would make partial budgeting no longer quick and easy (Rabin *et al.*, 2007; Pflueger *et al.*, 1993). Therefore, if a change being considered may possibly impact several aspects of a farming operation; whole-farm budgeting procedures should be used.

Furthermore, the binary logistic model was used to determine farmers' preferences, examine effects of explanatory variables on the likelihood of choosing 2WT technology from other alternatives that were available in the study area. According to Reed *et. al*, (2013) logistic regression presents several advantages over more traditional approaches to the analysis of data (e.g., t-test and multiple-regression). However, there are a number of important considerations that need to be taken into account when planning research that will be analysed by logistic means. These considerations include: the use of a large sample size; the use of limited numbers of, and well-thought through, predictors; and an

assessment of the likely ratio of positive and negative outcomes. For instance it is argued that to achieve empirical validity a minimum sample size of 50 cases per independent variable should be sought. Therefore, to overcome these issues, study tried to use an adequate sample size and well thought independent variables.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-economic and Farm Characteristics of the Respondents

In order to understand the background of the respondents, socio-economic characteristics including age, marital status, sex, farming experience, household size and education level of respondents were studied. Such characteristics are considered to be important in influencing decision of individual farmer on choosing the farm power technology for specific farm operation in the study area.

4.1.1 Age of respondents and farming experience

Based on age distribution of respondents, it was found that the average age was 42.78 ± 12.33 years while the maximum and minimum age was 80 and 20 years respectively. The age group of 30 – 60 years constituted the majority (77.5%) of the respondents (Table 3). This implies that many of respondents in the study area were mature people who could be actively engaged in rice production to generate sufficient income to run their lives as well as their families. Similarly, age determines individual maturity and ability to make rational decisions. When considering the farming experience, the least experienced farmer had 1 year in farming activities while the most experienced farmer had 50 years in farming activities. On average farmers had an experience of 14.08 ± 10.82 years engaged in paddy production. This implies that most farmers are also aware of different types of farm power technologies used in rice production in the study area.

Table 3: Distribution of respondents according to age groups

Age group	Frequency	Percent
Less than 30 years old	34	14.2
Between 30 – 60 years old	186	77.5
More than 60 years old	20	8.3
Total	240	100.0

4.1.2 Sex and marital status of respondents

The study involved a total of 207 males and 33 females. This implies that many farmers family in the study area are male headed-households. The low proportion of females could be attributed by socio-cultural barriers where women are considered household heads only when they are widowed, divorced or separated. Another reason could be that, involvement of women in farming is normally constrained by their intra-house division of labour, responsibilities and the control and use of resources which have widespread implications in agricultural production. In most African societies, men still have a control over most of the production resources than women hence have power in decision making. A study by Mathania (2007) observed the same trend whereby involvement of female in the farming of crops was very low than that of males. Married respondents constituted the majority (85%) and the remaining (15%) were unmarried (Table 4). Marriage provides additional farm labour for the farmers thus most of the interviewed farmers being married couples is a reflection of stability of the family and the society at large. The implication of this is that most of the developmental innovations and new technologies can be easily adopted by the society.

Table 4: Distribution of respondents based on sex and marital status

Variable	Frequency	Percent
Sex		
Male	207	86.3
Female	33	13.8
Total	240	100.0
Marital status		
Married	204	85
Unmarried	36	15
Total	240	100

4.1.3 Household size and education level

The household composition considered in the study area were the residential groups whose members live together in close contact by sharing resources held in common, such as accommodation and foodstuffs. In this study, it was found that the household size ranged from 1 to 10 members while the average household size was 4 ± 1.59 members. Household size has an implication on the labour available for farming activities in the sense that large sized household may have more labour for farming activities.

Education level plays an important role in ensuring household access to basic needs such as food, shelter and clothing. Skills and education increase the working efficiency resulting into more income and food security. Furthermore education is important to manage the farm business as well as in decision making. Based on respondent's education, majority (78.3%) of the respondents had primary school education while 13.3% had secondary school education or college education. However, 8.3% of the respondents had no formal education. This implies that, majority of the respondents have more exposure and ability to understand and create necessary strategies for appropriate use of farm power technologies which lead to the increased production.

4.1.4 Farm size and nature of plots

Based on farm size, it was found that the average size was $1.25 \text{ ha} \pm 1.56 \text{ ha}$ while the maximum and minimum size was 17.40 ha and 0.10 ha respectively. Further, most of the respondents (75.8%) have their farm size ranging from 0.10 and 1.21 ha. Only 24.2% of respondents have the farm size of above 1.21 ha. On the other hand, nature of most farms was found to be flat (73.3%) while the remaining percentage (26.7%) indicates that farms had a little inclination. Farm size and nature of farm have an influence on the type of farm

power to be used for different operations. Some of the farm power can perform better in flat area while others can do so in flat and land with a little inclination.

4.2 Farm Operations and the Type of Farm Power Used

In rice production the farm operations identified in the study area were; land clearing, tilling or ploughing, puddling, transplanting, fertilizer application, weeding, harvesting and transport. All interviewed farmers (100%) identified tilling/ploughing, puddling, transplanting, weeding, harvesting and transport as major farm operations. Furthermore, 98.3% and 90% of respondents considered land clearing and fertilizer application as major farm operations respectively.

It was found that farmers in the study area use different types of farm power to perform their farm operations. In most cases operations like land clearing, transplanting, weeding, and fertilizer applications were normally done manually. On the other hand operations like tilling/ploughing and puddling were done by manual, draught animal, 2WT or 4WT with 2WT dominating in both operations.

The research findings indicate that in tilling operation 51.3% of the interviewed smallholder farmers in the area use 2WT, 31.3% use oxen, 10% use hand hoes and the remaining farmers (7.5%) use 4WT. Moreover, findings indicate that in puddling operation 85.8% of the interviewed smallholder farmers in the area use 2WT, 3.8% use oxen, 7.5% use hand hoes and the remaining (2.9%) use 4WT. These results are consistent with the results of Ademiluyi *et al.* (2008) who demonstrated that the use of power tiller among sawah practicing farmers in Bida area, Nigeria, is high (85%) in supporting their

rice production activities including tilling and puddling. From Fig. 4 the proportions of farm power technology use for tilling and puddling are presented.

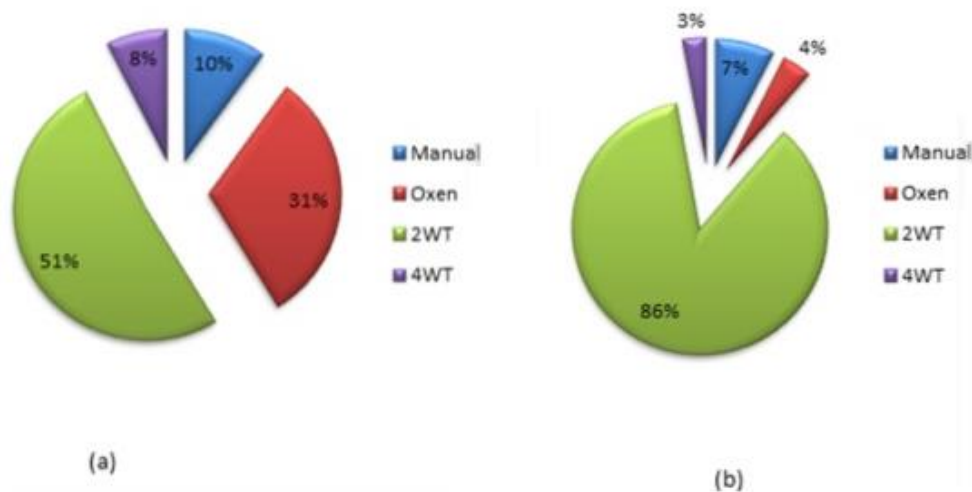


Figure 4: Proportion of farm power technology use for (a) Land tilling/Ploughing & (b) Puddling

Crop harvesting (cutting, gathering, threshing and winnowing) and transportation were also among farm operations identified in the study area. The study revealed that most farmers do harvest their crops manually (90.8%) while the remaining Percent of farmers (9.2%) were using small combine harvester recently introduced in the area. Means of transporting crops were subject to amount harvested among other things. Study findings shows that in transporting their crops from farm to home/store, 51.7% of respondents use 2WT, 42.1% use trucks, 3.3% use 4WT, 2.1% use manual and only 0.8% use draught animals (Fig. 5). The high use of 2WT for transport was attributed to the fact that most of the roads to the farms are very small and cannot support big trucks or 4WT to pass through.

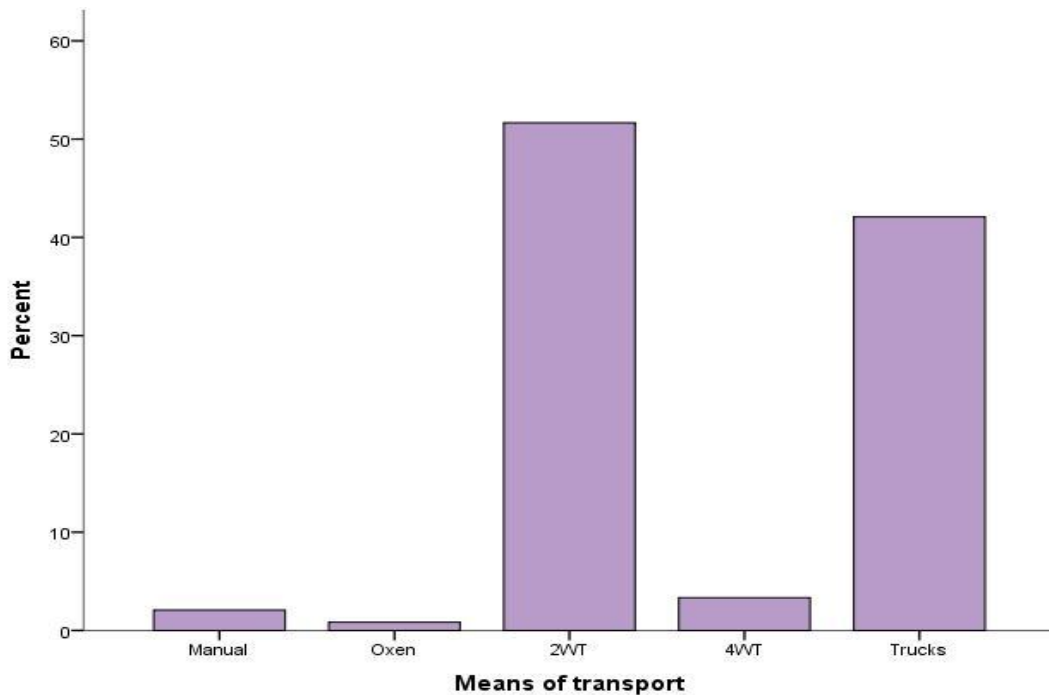


Figure 5: Means used by farmers to transport their crops from farm to home/stores

Generally, in the study area farm operations are performed using different sources of farm power. Some of the operations are exclusively manual while others are performed using a combination of farm power. Therefore making efficient use of manual power and application of the available alternative farm power technologies will reduce the challenge associated with various farm operations.

These results are in line with a study by FAO (2006) which revealed that it is quite common to combine available power sources in order to increase the area farmed, or to reduce the burden on humans. Tractors or draught animals can be used for primary tillage and subsequent planting, and weeding can also be done with a combination of power sources and technologies.

4.3 Time Required for Specific Farming Operations

After identifying the farm operations and the type of farm power used to perform those operations in the area, study went further into obtaining information on the average time required to complete an operation using different farm power technologies. When considering the work hour per hectare (h/ha) study results indicates that on average one person can take 50.43 for land clearing, 180.29 for tilling, 143.86 for puddling, 126.76 for transplanting, 118.49 for weeding, 2.87 for fertilizer application and 253.95 for harvesting. On the other hand, results shows that it takes an average of 20.95 hours to till one hectare using a pair of oxen, 5.26 hours per hectare using 2WT and 2.91 hours per hectare using 4WT. Furthermore, puddling one hectare takes an average of 17.15 hours using a pair of oxen, 4.60 hours using 2WT and 2.30 hours using 4WT (Table 5).

Study findings are consistent with that of Starkey and Simalenga (2000) which indicated that preparing a hectare of land for sowing of grain or legume food crops can take 750, 40, or 3.75 hours using manual labour, a pair of oxen or a tractor, respectively. Study found that 4WT is time efficient in tilling and puddling. However, its use was limited in the study area due to nature of farms which are small and fragmented, and was also considered as appropriate for large farms (Estate).

Moreover, farmers always aim at reducing the costs of different farm operations in order to increase production. In the study area manual transplanting, weeding and harvesting were found to be labour intensive, time consuming and thus limit area under cultivation. Beside the limitations farmers still rely on manual power to perform the operations. This could be attributed to the disadvantages of Oxen, 2WT and 4WT being able to perform few farm operations which may have an implication in decision making regarding

suitability of the technology. These results are consistent with that of FAO (2005) which indicated that in many farming system in SSA, the use of draught animals and tractors is confined almost exclusively to primary tillage while all other operations rely on hand power.

On the other hand, the multipurpose use of Oxen, 2WT and 4WT is subject to availability of appropriate implements or attachments for performing specific farm operation. These implements includes; plough, hallow, tiller, rotavators, planter, weeder, combine harvester, trailer etc. The study found that the limited use of these technologies to few farm operations were due to absence of appropriate attachments for performing operations like planting, weeding and harvesting. The availability of attachments would have saved farmers time, reduce drudgery and minimize post-harvest losses resulted from the use of manual power.

Table 5: Average time required for specific farming operations

Farm Operation	Manual power (work h/ha)	Oxen (team h/ha)	2WT (tractor h/ha)	4WT (tractor h/ha)
Land clearing	50.43	Na	Na	Na
Tilling/ ploughing	180.29	20.95	5.26	2.91
Puddling	143.86	17.15	4.60	2.30
Transplanting	126.76	Na	Na	Na
Weeding	118.49	Na	Na	Na
Fert. Application	2.87	Na	Na	Na
Harvesting	253.95	Na	Na	Na

4.4 Costs and Returns of Proposed Change in Farm Operations

The farmer analyzes only those costs and incomes that change with a proposed business adjustment. He can achieve this by using the partial budget, which means that only the

relevant costs and incomes are included in the analysis (Wander, 2001). This study adopted the partial budget as a tool to determine the profitability of proposed changes in the operation of a farm business specifically paddy production.

The expected/ proposed change on paddy production process was to use the available alternatives- farm power technologies (manual, draught animal, 2WT and 4WT) in performing the selected operations (tilling/ ploughing and puddling). Data on average costs of performing those operations by using manual, draught animal, 2WT and 4WT were analysed. In this study three alternatives were analysed on individual basis before making conclusion. All costs are in Tanzanian Shillings (TZS).

4.4.1 Alternatives available for tilling/ ploughing

In farm tilling/ ploughing three options were considered which includes; manual- 2WT, oxen- 2WT and 4WT- 2WT. Results for the analysed options are as presented (Table 6, 7 & 8).

Table 6: Partial budget for tilling one hectare using manual power or 2WT

I – Income reducing changes (Costs)		II – Income increasing changes (Benefits)	
A. Additional Costs	163,270.21	D. Additional Returns	0.00
B. Reduced Returns	0.00	E. Reduced Costs	217,246.63
C. Total Costs (A+B) =	163,270.21	F. Total Benefits (D+E) =	217,246.63
III - Analysis			
G. Net Change in Profits/Income:			
(217,246.63– 163,270.21) = 53,976.42			
Benefit/ Cost Ratio (217,246.63÷ 163,270.21) = 1.33			

Table 7: Partial budget for tilling one hectare using oxen or 2WT

I – Income reducing changes (Costs)		II – Income increasing changes (Benefits)	
A. Additional Costs	163,270.21	D. Additional Returns	0.00
B. Reduced Returns	0.00	E. Reduced Costs	154 424.17
C. Total Costs (A+B) = 163 270.21		F. Total Benefits (D+E) = 154 424.17	

III - Analysis

G. Net Change in Profits/Income:
 $(154\ 424.17 - 163\ 270.21) = -8\ 846.04$

Benefit/ Cost Ratio $(154,424.17 \div 163,270.21) = 0.9$

In Table 6 the information in Section I, analyzes what additional costs and reduced returns are incurred by making a change in current production practices. In this case, the farmer chose to analyze what would happen if he stopped tilling using manual power and use 2WT instead. On the other side (II) of the partial budget, additional returns and reduced costs of adopting a potential change were analyzed.

Results for this alternative indicates a positive net benefit implying that a farmer can be better off tilling one hectare of land using 2WT (53 976.42 TZS). Furthermore, the benefit/cost ratio value of 1.33 means that the alternative of using 2WT for tilling will return 1.33 TZS on every 1 shilling spent or a profit of 0.33 TZS. Therefore, considering current practice, partial budget results indicates that a farmer will be better off when choosing to use 2WT for tilling than manual power.

T- Test was used to ascertain whether the average costs and benefits per unit area of using different farm power were statistically different. Results indicate that the mean difference for the alternative (manual to 2WT) was statistically significant with t value (7.729) and Sig. value of (p = .000)

Results in Table 7 show that the analysed alternative has a negative net benefit (-8 846.04 TZS) implying that a farmer can be better off continuing with the current practice (tilling one hectare of land using oxen). However, study findings indicate that 51.3% of the interviewed farmers use 2WT for tilling while only 31.3% of farmers use oxen. This may imply that farmers' decision is not based on costs only but rather a combination of factors such as timeliness of operation, soil conservation issues, increased incidence of animal diseases and a need to reduce human drudgery among other things. The results of the T-Test however, indicates that mean difference for the alternative (oxen to 2WT) was statistically significant with t value (-2.518) and Sig. value of (p = .013).

Table 8: Partial budget for tilling one hectare using 4WT or 2WT

I – Income reducing changes (Costs)		II - Income increasing changes (Benefits)	
A. Additional Costs	163 270.21	D. Additional Returns	0.00
B. Reduced Returns	0.00	E. Reduced Costs	177 092.04
C. Total Costs (A+B) =	163 270.21	F. Total Benefits (D+E) =	177 092.04
III - Analysis			
G. Net Change in Profits/ Income:			
(177 092.04– 163 270.21) = 13 821.83			
Benefit/ Cost Ratio (177 092.04 ÷ 163 270.21) = 1.08			

Results presented in Table 8 shows that the proposed change indicated a positive net benefit implying that a farmer can be better off tilling one hectare of land using 2WT (13 821.83 TZS). Moreover, the benefit/ cost ratio value of 1.08 means that the alternative of using 2WT for tilling will return 1.08 TZS on every 1 shilling spent or a profit of 0.08 TZS. Thus, considering current practice, partial budget results indicates that a farmer will be better off when choosing to use 2WT for tilling than 4WT other things being the same.

4.4.2 Alternatives available for puddling

Under puddling three options were also considered which includes; manual- 2WT, oxen- 2WT and 4WT- 2WT. Results for the analysed options are as presented (Table 9, 10 & 11).

Table 9: Partial budget for puddling one hectare using manual power or 2WT

I – Income reducing changes (Costs)		II – Income increasing changes (Benefits)	
A. Additional Costs	156 449.99	D. Additional Returns	0.00
B. Reduced Returns	0.00	E. Reduced Costs	205 783.69
C. Total Costs (A+B) =	156 449.99	F. Total Benefits (D+E) =	205 783.69

III - Analysis

G. Net Change in Profits/Income

$$(205\,783.69 - 156\,449.99) = 49\,333.70$$

Benefit/ Cost Ratio $(205\,783.69 \div 156\,449.99) = 1.30$

Table 10: Partial budget for puddling one hectare using oxen or 2WT

I – Income reducing changes (Costs)		II – Income increasing changes (Benefits)	
A. Additional Costs	156 449.99	D. Additional Returns	0.00
B. Reduced Returns	0.00	E. Reduced Costs	140 026.27
C. Total Costs (A+B) =	156 449.99	F. Total Benefits (D+E) =	140 026.27

III - Analysis

G. Net Change in Profits/Income

$$(140\,026.27 - 156\,449.99) = -16\,423.72$$

Benefit/ Cost Ratio $(140\,026.27 \div 156\,449.99) = 0.9$

Table 9 present a case where, a farmer chose to analyze what would happen if he stopped puddling using manual power and use 2WT instead. Results in this alternative indicated a positive net benefit implying that a farmer can be better off puddling one hectare of land using 2WT (49 333.70 TZS). Furthermore, the benefit/ cost ratio value of 1.30 means that the alternative of using 2WT for puddling will return 1.30 TZS on every 1 shilling spent or

a profit of 0.30 TZS. Thus, considering current practice partial budget results for this option indicates that a farmer will be better off when choosing to use 2WT for puddling than manual power.

T- Test was also used to ascertain whether the average costs and benefits per unit area of using different farm power were statistically different. Results indicated that the mean difference for the alternative (manual to 2WT) was statistically significant with t value (8.205) and Sig. value of (p = .000).

Results in Table 10 shows that the analysed alternative has a negative net benefit (-16 423.72 TZS) implying that a farmer can be better off continuing with the current practice (puddling one hectare of land using oxen). On the contrary, study findings indicate that 86% of the interviewed farmers use 2WT for puddling while only 4% of farmers use oxen. This may imply that farmers' decision is not based on costs only but rather a combination of factors such as timeliness of operation, increased incidence of animal diseases and a need to reduce human drudgery among other things. Likewise, results of the T-Test indicated that mean difference for the alternative (oxen to 2WT) was statistically insignificant with t value (-1.947) and Sig. value of (p = .084).

Table 11: Partial budget for puddling one hectare using 4WT or 2WT

I – Income reducing changes (Costs)		II – Income increasing changes (Benefits)	
A. Additional Costs	156 449.99	D. Additional Returns	0.00
B. Reduced Returns	0.00	E. Reduced Costs	181 798.80
C. Total Costs (A+B) =	156 449.99	F. Total Benefits (D+E) =	181 798.80

III - Analysis

G. Net Change in Profits/Income

$$(181\,798.80 - 156\,449.99) = 25\,348.81$$

$$\text{Benefit/ Cost Ratio } (181\,798.80 \div 156\,449.99) = 1.16$$

Results presented in Table 11 shows that the proposed change indicated a positive net benefit implying that a farmer can be better off puddling one hectare of land using 2WT (25 348.81 TZS). Furthermore, the benefit/ cost ratio value of 1.16 means that the alternative of using 2WT for puddling will return 1.16 TZS on every 1 shilling spent or a profit of 0.16 TZS. Thus, considering current practice, partial budget results indicates that a farmer will be better off when choosing to use 2WT for puddling than 4WT holding other things constant.

4.5 Factors Influencing Farmers' Choice of Farm Power Technologies

Factors influencing farm power technology choice were estimated to determine how smallholder rice farmers behave in making decision for farm power choice in selected farm operation (tilling). This operation was selected due to the fact that a good number of respondents were using either 2WT (N=123) or other farm power; manual, oxen and 4WT (N = 117) for performing the operation. The estimation of these factors was conducted in order to test the hypothesis that Socio- economic, institutional, and other factors do not influence smallholder farmers' choice of farm power technologies for use in selected operation.

In order to determine significant factors that influence farmers in deciding which farm power to use for tilling amongst the available options in the study area, a binary logistic regression model was adopted. The binary logistic model accommodated the two options (of using either 2WT or otherwise) that were available in the study area to represent the categorical dependent variable which is dichotomous (1= tilling using 2WT; 0 = Otherwise).

The explanatory variables that were accommodated in the binary logistic equation included; Age of household head, Farm size, Education Level of the Household Head, Slope of land, Time required for operation, Experience in rice farming, Distance from home to farm plot, Group membership, Access to extension services, Availability of farm power technology, Training and Access to credit.

4.5.1 Factors influencing farmers' choice of farm power technologies

The binary logistic model was used to determine farmers' preferences, examine effects of explanatory variables on the likelihood of choosing 2WT technology from other alternatives that were available in the study area. A summary of the socio-economic factors hypothesized to influence smallholder rice farmers' choice of farm power technology used for tilling is provided in this section.

Results in Table 12 show that, the specified binary logistic model fits well the data as measured by Pseudo – R Square (Cox & Snell = 0.551 and Nagelkerke = 0.734). The values of Pseudo – R Square which are 55.1% and 73.4% for Cox & Snell and Nagelkerke respectively, suggest a good predictive ability of the model implying that the explanatory variables included in the model explain well the variation in the dependent variable. In other words, the values suggest that between 55.1% and 73.4% of the variability is explained by the set of explanatory variables included in the model. According to Louviere *et al.* (2000) pseudo-R Square at times although rarely, reaches values as high as those of R Square in linear regression; hence, the presented Pseudo – R Square are still considered to have a good fit. All these confirm that there is a relationship between the dependent variable and explanatory variables included in the model.

Table 12: Estimated results of the Binary Logistic Regression model

Variable	β	S.E	Wald	Df	Sig.	Exp(β)	95% C.I for Exp (β)	
							Lower	Upper
Farm size	.021	.058	.136	1	.713	1.022	.912	1.144
Farming experience	-.002	.030	.004	1	.948	.998	.942	1.058
Slope of land(1)	-.456	.530	.739	1	.390	.634	.224	1.792
Time	-.856	.120	50.642	1	.000***	.425	.336	.538
Distance	-.035	.043	.645	1	.422	.966	.888	1.051
Group membership(1)	.543	.593	.838	1	.360	1.721	.538	5.502
Extension services(1)	.496	.520	.912	1	.339	1.643	.593	4.548
Training(1)	.253	.606	.174	1	.676	1.288	.393	4.221
Credit access(1)	.572	.563	1.035	1	.309	1.773	.588	5.340
Availability of technology(1)	.949	.474	4.011	1	.045**	4.187	.933	5.980
EDU-level			1.612	2	.447			
EDU-level(1)	-.319	1.021	.098	1	.755	.727	.098	5.375
EDU-level(2)	.576	1.213	.225	1	.635	1.778	.165	19.167
AGE-G			5.189	2	.075			
AGE-G(1)	1.522	.724	4.427	1	.035**	4.584	1.110	18.930
AGE-G(2)	.643	1.159	.308	1	.579	1.902	.196	18.424
Constant	2.933	1.346	4.751	1	.029	18.779		

Note: *** and ** Significant at 0.01 and 0.05 levels respectively.

Number of observations = 240

Pseudo R-Square: Cox & Snell = 0 .551 and Nagelkerke = 0 .734

As shown in Table 12, some predictor variables influence the choice of farm power technology significantly. Of the 12 independent variables used in the model, one is statistically significant at 1% significance level and two are statistically significant at 5% significance level. In most of the cases, the signs of the estimated coefficients are consistent with the priori expectations.

The results suggest that the probability of choosing 2WT technology for tilling is significantly ($P = .000$) and negatively ($\beta = -.856$) influenced by time, which is consistent

with the priori expectations. The explanation behind the observed relationship is that, the more time a farmer requires for tilling the less likely he/she is to choose 2WT technology as a source of farm power. In other word, the likelihood of using 2WT for tilling was 0.425 (odds ratio) less when time required for performing such operation increases by one hour other things being constant.

Consistent with the priori expectation, the coefficient that was attached to the availability of technology revealed a positive impact on rice farmers' decision to use 2WT for tilling and was significant at 5% probability level ($P = .045$). This results imply that the likelihood of using 2WT for tilling was 4.187 (odds ratio) higher when its availability increases by one unit other things being constant. These results affirm findings of Ayandiji and Olofinsao (2015) that availability of machines has positive and significant influence in adoption of farm mechanization. Findings further claims that if machines are made available and at affordable prices and right time it will increase the likelihood of adopting these farm machines for use.

With regard to age, it is positively related to the dependent variable meaning that, as the age increases, smallholder farmers are also more likely to use the 2WT technology for tilling their farms. Considering age group, results indicates that age group of 30 – 60 years have a significant influence ($P = 0.035$) on the use of 2WT technology compared to the younger ones. This implies that respondents under that age group are mature people who could be actively engaged in rice production to generate sufficient income to run their lives as well as their families. Thus choosing a farm power technology (2WT) which can help them meet their obligation by saving time and energy is crucial. Similarly, age determines individual maturity and ability to make rational decisions. Furthermore, as farmers get old, they have more experience in farm production activities and resultantly

become risk takers to try new technology or practice. These results affirm findings of Aklilu (2006) that the age of farmer has positive and significant influence on adoption of the land management practices.

Variables such as group membership, extension services, training and credit access were found to have positive relationships with the dependent variable and are consistent with the prior expectations. For instance farmers who are members of the farmers' association/group, have access to extension services, received training and have access to credit have higher probability of using 2WT technology than those who did not. The four variables however did not contribute significantly to the model.

Farm size had a positive influence on the dependent variable implying that, as the farm size increases, the probability of using 2WT also increases as farmers would be able to cope with the farm power demand due to large size. However, the variable was found to have insignificant contribution to the model. On the other hand there is inverse relationship between distance to farming plots and the probability of using 2WT technology. This indicates that an increase in this variable will lead to a decrease in the probability of using 2WT technology. This may be due to the fact that serious road/infrastructure problems are associated with far farming plots which are not easily reached thus discourage the use of the technology due to the amount of labour they will have to put in. The results affirm findings of Ademiluyi *et al.* (2008) that distance to farming plots is inversely related to the probability of using power tiller technology.

Education level (primary) has a negative effect and statistically insignificant on influencing the choice of 2WT technology which is contrary to the prior expectation. On the other hand Secondary and college education level has a positive effect on influencing

the choice of 2WT technology which is consistent to the prior expectation. Despite the positive effect the variable did not contribute significantly to the model.

4.5.2 Overall test of the relationship

The Omnibus Tests of Model coefficients give an overall indication of how well the model performs. The existence of a relationship between the dependent and independent variables is based on the statistical significance of the final model chi-square (Table 13), termed model fitting information. In this analysis, the model reveals that the probability of the model chi-square (191.967) was 0.000, less than the level of significance of 0.01 ($P < 0.01$) indicating that coefficients for all variables included in the model are jointly different from zero. The hypothesis that socio-economic, institutional, and other factors do not influence choices of farm power technology among smallholder rice farmers is rejected.

Table 13: Model fitting information

Model	-2log Likelihood	Chi-Square	df	Sig
Intercept only	332.561			
Final	140.594	191.967	14	0.000

The Hosmer and Lemeshow test also supports the model as being worthwhile. Study results show that the chi-square value for the Hosmer-Lemeshow Test is 14.920 with a significant level of 0.061 which is larger than 0.05, therefore indicating support for the model.

4.6 Challenges Facing Smallholder Rice Farmers in the Study Area

The general challenges facing farmers were identified because these challenges in one way or another had impact on the use of available farm power technologies. The challenges

includes but not limited to inadequate training especially on the proper use of farm machinery as new innovation, lack of implements or attachments which would permit multiple use of farm machines, poor roads to access the farms, poor irrigation infrastructures, low access to extension services, high costs of inputs, low prices of output, unreliable markets of output, high interest rate charged on formal credits and lack of collaterals for financial institutions which forced many farmers to go for informal credits. Furthermore, farmers are subjected to drought and flood as a result of changing climate and crop pests and diseases which in general contribute into affecting farmers' decision on the use of farm power technologies.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study aimed at undertaking a Comparative Analysis of farm power Technologies in Rice Production for Smallholder Farmers in Mbarali District, Tanzania. The study had three objectives namely; identification of different farm operations by power sources used by smallholder farmers in paddy production, analysing costs and returns per unit area of using manual, oxen, 2WT or 4WT as sources of farm power and examining factors influencing smallholder farmers' choice of farm power technologies for use in selected farm operation.

Descriptive statistics, partial budget and econometric model were used to analyse the data collected from the study area. These analytical methods were meant to identify differences in choices of farm power technologies among smallholder rice farmers. A binary logistic regression model was adopted to test statistically whether choices of farm power technology were different. This model was estimated using SPSS 16 software.

In reviewing literature, mechanization in agriculture is described as a necessary condition for farmers to improve productivity of labour and land. Evidences obtained from literature and in the survey process indicates that based on their farm characteristics, smallholder rice farmers use a combination of farm power technologies in performing different operations with the intention to improve productivity and profit among other things.

Results from the analysis show that farmers in the study area use different types of farm power to perform their farm operations. In most cases operations like land clearing,

transplanting, weeding, and fertilizer applications were normally done manually. On the other hand operations like tilling/ploughing and puddling were done by manual, draught animal, 2WT or 4WT with 2WT dominating in both operations. Two wheel tractors are massively used in ploughing, puddling and transportation. It is considered more appropriate alternative than manual labour, animal drawn implement and tractors which are sometimes not available during the peak period of land preparation and transportation. Moreover, 4WT were found to be time efficient in tilling and puddling. However, its use was limited in the study area due to nature of farms which are small and fragmented, and was also considered as appropriate for large farms. Furthermore, oxen, 2WT and 4WT technologies were found not applicable to several farm operations compared to manual. The non-applicability of these technologies to several farm operations was attributable to absence of appropriate implements or attachments for performing operations like planting, weeding and harvesting.

This study adopted the partial budget as a tool to determine the profitability of proposed changes in the operation of a farm business specifically paddy production. Therefore, considering tilling and puddling by using manual power as current practices, partial budget results for the analysed options indicates a positive net change implying that a farmer will be better off when choosing to use 2WT for tilling (53 976.42 TZS) and puddling (49 333.70 TZS).

Considering tilling and puddling by using oxen as current practices, partial budget results for the analysed options indicates a negative net change implying that a farmer will be better off continuing with the current practices of using oxen for tilling (-8 846.04 TZS) and puddling (-16 423.72 TZS) than the proposed change of using 2WT. However, study

findings indicated that 51.3% and 96% of the interviewed farmers use 2WT for tilling and puddling respectively while only 31.3% and 4% of farmers use oxen for the two operations respectively. This may imply that farmers' decision is not based on costs only but rather a combination of factors such as timeliness of operation, soil conservation issues, increased incidence of animal diseases and a need to reduce human drudgery among other things. Considering tilling and puddling using 4WT as current practices, partial budget results for the analysed options indicates a positive net change implying that a farmer will be better off when choosing to use 2WT for tilling (13 821.83 TZS) and puddling (25 348.81 TZS).

In order to determine significant factors that influence farmers in deciding which farm power to use for tilling amongst the available options in the study area, a binary logistic regression model was adopted. Among the independent variables used in the model; time, availability of technology and age of household head between 30-60 years old were found to have statistically significant influence on farmers' choice of 2WT for use in tilling at 1% and 5% significance level respectively. In most of the cases, the signs of the estimated coefficients were consistent with the priori expectations.

Furthermore, results in this analysis as indicated by the overall model reveals that the probability of the model chi-square (191.967) was 0.000, less than the level of significance of 0.01 ($P < 0.01$) indicating that coefficients for all variables included in the model are jointly different from zero. The hypothesis that socio-economic and other factors do not influence choices of farm power technology among smallholder rice farmers was rejected in favour of the alternative hypothesis. In other words the study concludes that 'Socio-economic and other factors have influence on smallholder farmers' choice of farm power

technologies for use in selected operation'. Moreover, Study results show that the chi-square value for the Hosmer-Lemeshow Test is 14.920 with a significant level of 0.061 which is larger than 0.05, therefore indicating support for the model.

5.2 Recommendations

Based on the findings of the study the following recommendations are made for an improved best combination of farm power technologies for small holder rice farmers in the study area:

- i. Farm power technology especially machines should be made available and affordable at the proper time for use. If possible the price of machines should be subsidised to encourage aspiring farmers to use different farm machinery. This will improve their productivity which will in turn improve their income and thus ensures a better livelihood.
- ii. The provision of non-price incentives to smallholder rice farmers, in the form of supply of quality and durable farm power with more attachments to enable carrying out multi-operations, medical care, veterinary services and free training in proper use and maintenance of farm machinery.
- iii. Conducting thorough research on the needs of farmers in a targeted area priori to supplying of farm machinery.

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Code 1 = 1: MALE, 2: FEMALE

CODE 2= 1: Household Head 2: Spouse, 3: Own child, 4: Sibling, 5: parents 6: Parents in-laws 7: Aunt/uncle 8: Brother/sister- in –law 9: Niece/Nephew 10: cousin 11: Grandchild 12: House worker 13: Others (specify)

CODE 3 = 0= No Education, 1: Primary, 2: Secondary and above

CODE 4= 1: Single, 2= Married, 3: Divorced, 4: =widow: 5=widower

CODE 5= 1: Permanent resident 2: Permanent resident in local employment 3: Permanent resident school-going 4: Polygamist spending part of time in other households 5 Resident hired labour 6: Others

C: HOUSEHOLD ASSETS

2: Identify the following assets if you own

Assets	Quantity	Value (years)
Plough		
Car		
Tractor (2WT/4WT)		
Motorcycle		
Bicycle		
TV		
Radio		
Sprayer		
Shop		
Processing machine		
hand hoe		
Milling machine		
Grass thatched house		
Iron sheet thatched house		
Livestock		
Others (specify)		

3: Besides farming, what other activities are you undertaking? (1) Petty cash business..... (2) Public servant..... (3) Others (Specify).....

4: Identify types of crops cultivated last seasons in **order** of priorities

Types of crops cultivated last season (1)	Size of plot cultivate (acre) (2)	Total yield from area cultivated last seasons (bags/Kg) (3)	1=cash 2= Food 3=both (food & cash) (4)	How did you get the cultivated plots (See code below) (5)

Codes for (5)

1. Purchase
2. Rented

3. Inherited
4. Given by village government
5. Borrowed

5: How many years have you engaged in rice production?

6: How many plots of rice were cultivated last season

Plots	Size of plot cultivate (acre)	Rice Variety	Slope of land/plot 1. Flat 2. Medium 3. High	Total yield from plot cultivated last seasons (bags/Kg)	How did you get the cultivated plots (See code below)	Rate/Price per acre for purchased or rented plots (Tsh)
Plot 1						
Plot 2						
Plot 3						

Codes

1. Purchase
2. Rented
3. Inherited
4. Given by village government
5. Borrowed

D: FARMING OPERATIONS

7: What are the major farming operations/practices in rice production? (Mention them)

1.
2.
3.
4.
5.
6.
7.
8.
9.

8: Apart from using hand hoes, what other types of farm power are you using in your farming activities? (Put a tick).

1. Draught animal/Oxen.....
2. 2WT.....
3. 4WT.....

9: The use of farm power and time required for specific farming Operations

Farming Operations	Farm Power			
	Hand hoe (h/acre)	Draught animal (h/acre)	2WT (h/acre)	4WT (h/acre)
Land preparation				
Planting/Sowing				
Weeding				
Fertilizer Application				
Harvesting				
Transport				
Others(Specify)				
1.....				
2.....				

10: Suitability of selected farm power on different farm operations based on the slope of a plot (rank between 1-5)

Codes: (1) Very poor (2) Poor (3) Average (4) Good (5) Very good

Farming Operations	Farm Power			
	Hand hoe	Draught animal (Oxen)	2WT	4WT
Land preparation:				
• Flat slope area				
• Medium slope area				
• High slope area				
Planting/Sowing:				
• Flat slope area				
• Medium slope area				
• High slope area				
Weeding:				
• Flat slope area				
• Medium slope area				
• High slope area				
Fertilizer Application:				
• Flat slope area				
• Medium slope area				
• High slope area				
Harvesting:				
• Flat slope area				
• Medium slope area				
• High slope area				
Transport:				
• Flat slope area				
• Medium slope area				
• High slope area				
Others (Specify):				
• Flat slope area				
• Medium slope area				
• High slope area				

E: COMPONENTS OF COSTS AND RETURNS

11: What is the distance from your house to the farm in (km)?

.....

12: What are the costs associated with the use of the following farm power in performing different farm operations (Tsh/acre)?

Farming Operations/Practices	Farm Power			
	Hand hoe	Draught animal (Oxen)	2WT	4WT
Land preparations Other costs if any; <ul style="list-style-type: none"> • Interest on money used • Transport to and from farm • Food and water • Operator fee • Security fee • Fuel to and from farm 				
Planting/Sowing Other costs if any; <ul style="list-style-type: none"> • Interest on money used • Transport to and from farm • Food and water • Operator fee • Security fee • Fuel to and from farm 				
Weeding Other costs if any; <ul style="list-style-type: none"> • Interest on money used • Transport to and from farm • Food and water • Operator fee • Security fee • Fuel to and from farm 				
Fertilizer Application Other costs if any; <ul style="list-style-type: none"> • Interest on money used • Transport to and from farm • Food and water • Operator fee • Security fee • Fuel to and from farm 				

Harvesting Other costs if any; <ul style="list-style-type: none"> • Interest on money used • Transport to and from farm • Food and water • Operator fee • Security fee • Fuel to and from farm 				
Transport Other costs if any; <ul style="list-style-type: none"> • Interest on money used • Transport to and from farm • Food and water • Operator fee • Security fee • Fuel to and from farm 				

13: Other operation costs/fees which have not been identified in Question 12 (Specify if any and Explain)

.....

.....

.....

14: Where do you sell your farm produces? (Put a tick).

- (1) Through contracted buyer..... (3) Private market.....
- (2) Payment Voucher system..... (4) Government agency.....

15: What do you think should be the non- economic benefits associated with a shift from.....to.....farm power?

Explain.....

.....

.....

16: Do you keep records of your farm activities regarding costs and Returns for a season?

(1. Yes..... 2. No.....)? (Put a tick)

If yes, which methods are you using in keeping records? (Put a tick)

1. Books 2. Boards..... 3. Others (Specify).....

F: MEMBERSHIP, AVAILABILITY OF EXTENSION SERVICES, TRAINING AND CREDIT

17: Are you a member of any farmers' group or association (1. **Yes**..... 2. **No**...)? If **YES**, give name of a group/association.....

18: Did you seek Extension Services for rice production during the last two seasons (1.**YES**/2.**NO**)? If **YES** mention the purpose and if **NO** indicated the reasons in a space below

.....
.....
.....
.....
.....

19: Do you receive any training about the use of different farm power technologies in rice production? 1=**Yes**..... 2= **No**.....

If **yes**, from whom? 1. Researcher.... 2. Extension workers.... 3. Fellow trained farmers.

20: Do you take credit for your rice farming activities? 1. **Yes**..... ..2. **No**.....

If **yes**, indicate source of credit, the amount of credit obtained and the repayment period

Source.....	Amount	(Tsh).....
Period.....		

21: If the answer is **No** for question no. 20 explain why?

.....
.....
.....

22: Do you think credit is helpful (1.**Yes**... 2. **No**...)?

Explain.....
.....
.....

G: CHALLENGES AND OPINIONS IN USING FARM POWER TECHNOLOGIES

23: Are there enough service providers/dealers of oxen plow or farm machinery in your area? (1.**YES**....2.**NO**.....) (Put a tick).

If **NO**, where do you alternatively access or buying/hiring machines?

Explain.....
.....

24: Do you face challenges in using farm power technologies for different operations?

Yes...../No.....

If yes, what are those challenges? (Specify by filling in the box below).

	Farm Power			
Farming Operations	Manual	Draught animal (Oxen)	2WT	4WT
Land preparation
Planting/Sowing
Weeding
Fertilizer Application
Harvesting

25: What are your major challenges in Rice production apart from the uses of farm power technologies?

.....

.....

.....

.....

.....

26: What are your opinions concerning ways to improve the uses of farm power technologies?

Opinion 1.....

Opinion 2.....

Opinion 3.....

27: In your own views, what do you think is the best source /type of farm power to be used in various operations in the production of Rice?

..... Explain why?
.....
.....
.....

THANK YOU VERY MUCH FOR YOUR PARTICIPATION!