ADOPTION OF SUSTAINABLE LAND MANAGEMENT TECHNOLOGIES: REVISITING IMPACT TO COMMUNITY LIVELIHOOD IN WEST USAMBARA MOUNTAINS, TANZANIA

EMMANUEL JOHN TEMU

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE, MOROGORO, TANZANIA.

2013

ABSTRACT

This study attempts to revisit and to assess the adoption impact of sustainable land management technology practices on community livelihood in West Usambara Mountains. Primary data were collected through household questionnaires, focus group discussions, key informants interviews and personal observations while secondary data were collected from relevant local authority reports and records. A total of 160 households were interviewed. Descriptive statistics, binary logistic regression, multiple linear regression, household dietary diversity and independent T-test statistics were used to analyze the data. Research findings found that, the area is still experiencing soil erosion problem i.e. about 61.9% is still facing it. The binary logistic regression model reveals that total number of household members; farm total size and average income per year have significant positive impact on the adoption of sustainable land management. Furthermore, multiple linear regression model reveals that household head age, farmland ownership and household income have significant positive impact on improving community livelihood while sustainable land management non-adopters deteriorate it. The computed independent T-test for the mean income difference was statistically highly significance between adopters and non-adopters, suggesting that adopters were in better-off position to improve their livelihood. The study concluded that both adoption and practicing of sustainable land management (SLM) should simultaneously be taken for sustainable community livelihood. As they both significantly develop community livelihood. Despite the fact that sustainable land management is multifaceted and seemed to require formal knowledge or at least assistance from extension providers to farmers, the study recommended that policy makers in collaboration with the government should work on improving skills for quality extension staff specifically on land conservation practices, enhancing provision of land title, enhancing improvement of road quality and

initiate farmer group markets, these will help farmers both on more produces and good SLM practices and hence improved community livelihood.

DECLARATION

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

_______________________________ _______________

Emmanuel John Temu Date

(MSc. Agricultural Economics)

The above declaration is confirmed

_________________________________ _______________

Prof. Joseph P. Hella Date

(Supervisor)

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ACKNOWLEDGEMENTS

This Master's dissertation would not have been completed without the help and support from many people. I would like to extend my sincere appreciation to all those who made it possible.

It is an honor to express my heartfelt gratitude to my supervisor Prof. Joseph P Hella for his assistance and support all the way through the research study and for being always a great source of brainstorm. I am extremely obliged to his precious opinions, learning materials and feedbacks all through the study .Without him this dissertation would never have been realized.

I would also like to thank my family of Mr. John B. Temu and Mrs. Teckla J. Temu, for their support spiritually, financially and morally that lifted me up every day, encouraged me and gave me a reason to always look towards my goals. For these, I cannot thank you enough. May God bless you.

I am also owed my deepest gratitude to Lushoto District Executive Director (DED) Mr. Lucius Mwenda, Lushoto District Agricultural and Livestock Development Officer (DALDO) Mr. Hassan Shelukindo, Lushoto Extension Officers Mr. Ludendo Mwagilo, Mr. Adam, Mr. Jackson Saidiki, Ms. Imelda Mathew, Mr. Eric Osmond, Ms. Sabina Qwarda, Ms. Minael Simon, Ms. Neema Gideon and Ms. Jacqueline Julius for their guidance in selection of wards and villages and their tireless effort throughout data collection exercise. It is their compassion and tireless support that made the survey exercise unbeaten.

I wish to extend my sincere gratitude to all academic staff members of the Department of Agricultural Economics and Agribusiness and my contemporaries for their sincere support, opinions, and for providing a pleasant-sounding environment all through my stay at the University.

Above all, I would like to express my earnest gratefulness to God the Almighty for granting me with courage, strength, tolerance and guidance all the way through my study period. Glory be to His Heavenly name.

DEDICATION

This invaluable study is dedicated to my beloved parents Mr. John B. Temu and Mrs. Tekla J. Temu.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
AHI	African Highlands Initiative
CI	Confidence Interval
DALDO	District Agricultural and Livestock Development Officer
DED	District Executive Director
DFID	Department for International Development
DF	Degree of Freedom
Exp (B)	Expected Beta
FAO	Food and Agriculture Organization of the United Nations
FHM	Farm Household Model
IISD	International Institute for Sustainable Development
IFRCS	International Federation of Red Cross and Red Crescent Societies
LR	Logistic Regression
MLR	Multiple Linear Regression
NRI	Natural Resources Institute
NGO	Non-governmental Organization
NRM	Natural Resource Management
R	Multiple correlation coefficients
R^2	Coefficient of determination
SLM	Sustainable Land Management
SECAP	Soil Erosion Control and Agro-forest Project
SUA	Sokoine University of Agriculture
Sig	Significance level
SPSS	Statistical Package for Social Science

USSSA	The United States Social Security Administration
SL	Sustainable Livelihood
SWC	Soil and Water Conservation
TAFORI	Tanzania Forest Research Institute
TIPDO	Traditional Irrigation and Environmental Development Project
TSH	Tanzania Shilling
TARP II- SUA	Tanzania Agricultural Research Project, Phase Two
UNCCD	United Nations Convection to Combat Desertification
UNDP	United Nations Development Programme
VIF	Variance Inflation Factor
WB	World Bank
WOCAT	World Overview of Conservation Approaches and Technologies

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

On average, one out of every three people on earth is in some way or the other affected by land degradation, latest estimates indicate that nearly 2 billion hectares of land worldwide are already seriously degraded, some irreversibly (FAO, 2010). In Tanzania for example, soil erosion is one of the major threats to agricultural production (Tenge, 2005). Factors such as population growth, deforestation and poor farming techniques have been pointed out as the major causes. Human growth has resulted in increased human activities and land demand, which triggered overgrazing, deforestation and use of inappropriate farming practices (Semgalawe, 1998; Senkondo, 2009). To rescue the situation, the adoptions of sustainable land management technologies seem to be the best way.

Estimate put 300 000 to 400 000 hectares of forest that are cleared every year to meet the demand for farming land, timber, poles and firewood (Semgalawe,1998; Senkondo, 2009), while the re-generation is only 25 000 hectares per year (Senkondo, 2009). The West Usambara highlands are among the areas mostly affected by soil erosion in Tanzania; here, soil erosion is resulting in an annual loss of fertile topsoil of about 100 tones/ ha and consequently reducing crop yields (Pfeiffer, 1990; Shelukindo *et al*., 1993; Kaswamila, 1995; Lyamchai *et al*., 1998; Tenge, 2005).

According to Mowo *et al.* (2002) efforts towards careful management of natural resources in the West Usambara Mountains stretch many years back, such as Soil Erosion Control and Agro-forestry Project (SECAP) introduced through German support in 1981 for a period of 20 years (1981 – 2000). About 24% of the households were trained on various aspects (Johansson, 2001; Mowo *et al.*, 2002). In addition, about 10 000 000 trees have been planted on farmlands, which is about 20% of the required number of trees to meet the growing demand for fuel wood and reduce harvesting pressure on existing natural forests (Mowo *et al.*, 2002).

Tanzania Forest Research Institute (TAFORI), as the other project, was established in 1981. It aimed to generate sustainable methods for conservation of natural forests, to develop appropriate agroforestry technologies for smallholder farmers and establish databases on natural forests, agroforestry, and biodiversity. However, there is low adoption to those practices and continued soil erosion due to the incompatibility of this technology with the prevalent socio-economic farming conditions (Semgalawe, 1998; Senkondo, 2009).

In 1989, a Traditional Irrigation and Environmental Development Project (TIPDO) was established and supported by the Dutch organization started in the West Usambara Highlands. TIPDO approached soil and water conservation (SWC) by attaching it to an irrigation package. Prior to being granted support for investment in irrigation, farmers needed to conserve their fields through afforestation and terracing. Successes were observed in areas where there was growing dependency on irrigation and farmers' awareness of the need for SWC. In other areas farmers were still not willing to participate and soil erosion continued (Hella *et al.,* 2004).

Also, African Highlands Initiative (AHI) as the other project, started in 1998 aimed at integrated approach of combining soil conservation with other farming components such as improved crop varieties, dairy cattle, marketing, credit facilities and input stores (Tenge, 2005). Interestingly, the majority of farmers in the intervention areas adopted improved crop varieties such as banana, tomatoes and other vegetable crops. However, adoption of SWC was still not encouraging (Tenge, 2005). The limited achievements of all these great efforts necessitated an assessment and impact to community livelihood in West Usambara Mountains due to adoption and practices of sustainable land management technologies.

1.2 Problem Statement and Justification

Land degradation in West Usambara Mountains has been broadly covered. According to Pfeifer (1990), farmers in the Usambara's were actually practising effective soil conservation and soil fertility preserving methods like multi-storey agroforestry, mixed cropping and green manuring. However, according to Johansson (2001), this system and knowledge began disintegrating when German colonialism and cash economy set in these highlands which are home to the Sambaa people. In doing so, the natural resources on these highlands began degrading.

Soil Erosion Control and Agro-forestry Project (SECAP) are among many efforts that have been done in the area since then. Johansson (2001) argues that, though SECAP is reported as being successful, the major part of the Usambara is without conservation structures and degradation of natural resources goes on diminished. Among the recent attempts in this regard is the introduction of the African Highlands Initiative (AHI) in 1998. Although the approach was participatory as it had been involving farmers to see the advantage of conserving through a combined, individual and collective approach to resource conservation (Tenge, 2005) reported that, attention to participation, adoption to these conservation practices is still so low.

However, there are no studies done on assessing the impact on offered adoption of sustainable land management strategies on the community livelihood specifically on income and food security. Based on that fact, this study was designed to revisit sustainable land management technology practices in West Usambara Mountains, and to investigate how they have improved community livelihood, more particularly on income and food security. As suggested by Hewet *et al.* (2002) that these variables are the best variables for assessing livelihood outcomes. Furthermore, the same variables were used to measure the livelihood outcomes on hydrology and land use in the Republic of South Africa (Hewet *et al.*, 2002).

Knowing the impacts of practicing sustainable land management (SLM) to farmers, will enable the sustainability of land management practices in Usambara Mountains. In addition, findings will build the strong base to farmers whether offered land management practice are worthwhile undertaking or not. Furthermore, study findings will contribute in policy reforms especially on the land conservation practices.

1.3 Objectives

1.3.1 Overall objective

To revisit adoption of sustainable land management technology practices and to assess their impact on community livelihood in West Usambara Mountains.

1.3.2 Specific objectives

i. To determine factors affecting adoption of sustainable land management technologies in the study area.

ii. To determine the effect of adoption of Sustainable Land Management technology on household's food security in the study area.

iii. To determine the effect of adoption of Sustainable Land Management technology on household's income in the study area.

iv. To develop option for improvement of sustainable land management practices in the study area.

1.3.3 Research hypothesis

Hypothesis;

H_{o1}: The use of offered SLM technologies will not add considerably towards household's income.

H_{o2}: The use of offered SLM technologies will not contribute significantly to household's food security.

1.4 Organization of the Dissertation

This dissertation is presented in five chapters. Chapter one as an introduction, gives the background information of the sustainable land management worldwide all the way to Lushoto District in Tanga. It also comprises the problem statement, objectives of research and the research hypothesis. Chapter two gives the review of literatures based on factors for adoption of sustainable land management, sustainable land management and food security, sustainable land management and income and options for improvement.

The methodology adopted for the study is presented in Chapter three, which summaries the conceptual framework that links technology adoption and livelihoods, the theoretical framework that incorporated technology adoption in the farm household model, the analysis of sustainable livelihoods, the description of study area, the study design, sampling design, sampling frame, sample size and the method of how each of the specific objectives were analyzed. Chapter four gives findings and discussion on socioeconomic characteristics of respondents, nature of farmland degradation in Lushoto, the land use management practices, the findings and discussion to each objective, and the goodness of fit of the model used. Conclusions of the study findings and the recommendations are presented in Chapter five.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Land Management

According to Larsson (2010), land management can be defined as the process of managing the use and development (both in urban and rural settings) of land resources. It is the methods used in managing land resources – the 'how' of land uses (Webb, 2004). However, Land resources are used for a variety of purposes which interact and may compete with one another for example organic agriculture, reforestation, water resource management and eco-tourism projects (Larsson, 2010). Therefore, it is desirable to plan and manage all uses in an integrated manner.

2.1.1 Land degradation

Land degradation can be defined as the loss of land productivity through one or more processes, such as reduced soil biological diversity and activity, the loss of soil structure, soil removal due to wind and water erosion, acidification, salinization, water logging, soil nutrient mining, and pollution (WB, 2006). It impedes agricultural growth, increases poverty and vulnerability, and contributes to social tensions as populations rise and impose greater burdens on limited natural resources (UNCCD and FAO, 2009).

2.1.2 Sustainable land management

Sustainable Land Management is defined as knowledge-based procedure that helps integrate land, water, biodiversity, and environmental management (including input and output externalities) to meet rising food and fiber demands while sustaining ecosystem services and livelihoods (WB, 2006). The practices include: Diversified cropping systems (strip cropping and mixed intercropping), Integrated agro-forestry practices with the cropping system and Soil erosion control structures and practices that is contour farming and grass barriers (Roberts *et al.*, 2008). These practices are a key mechanism for effecting change in the sustainable use and management of land resources (Webb, 2004). Unsustainable land management practices can threaten biodiversity and increase the release of carbon especially through destruction of forests as well as impacting adversely on water resource management. On the other hand, they present opportunities for enhancing the livelihoods of the poor and fostering inclusive growth as well as for achieving environmental goals (UNCCD and FAO, 2009).

2.1.3 Factors that influence the adoption of sustainable land management

A farmer makes a decision to his farmland whether to adopt a practice or not by considering different factors. Such factors include individual, social, economic, institutional and environmental context. Cary *et al*. (2002) presented a model of land management practice appraisal. Central to the model is the notion of appraisal, the assessment of the 'fit' between a particular land management practice and the needs and desires of the landholder within a particular social, economic and environmental context. Appraisal has the elements of a 'black box' that may be objectively difficult to know the relative influences of the factors that impact on a decision to adopt a practice or not as shown in Fig. 1 below.

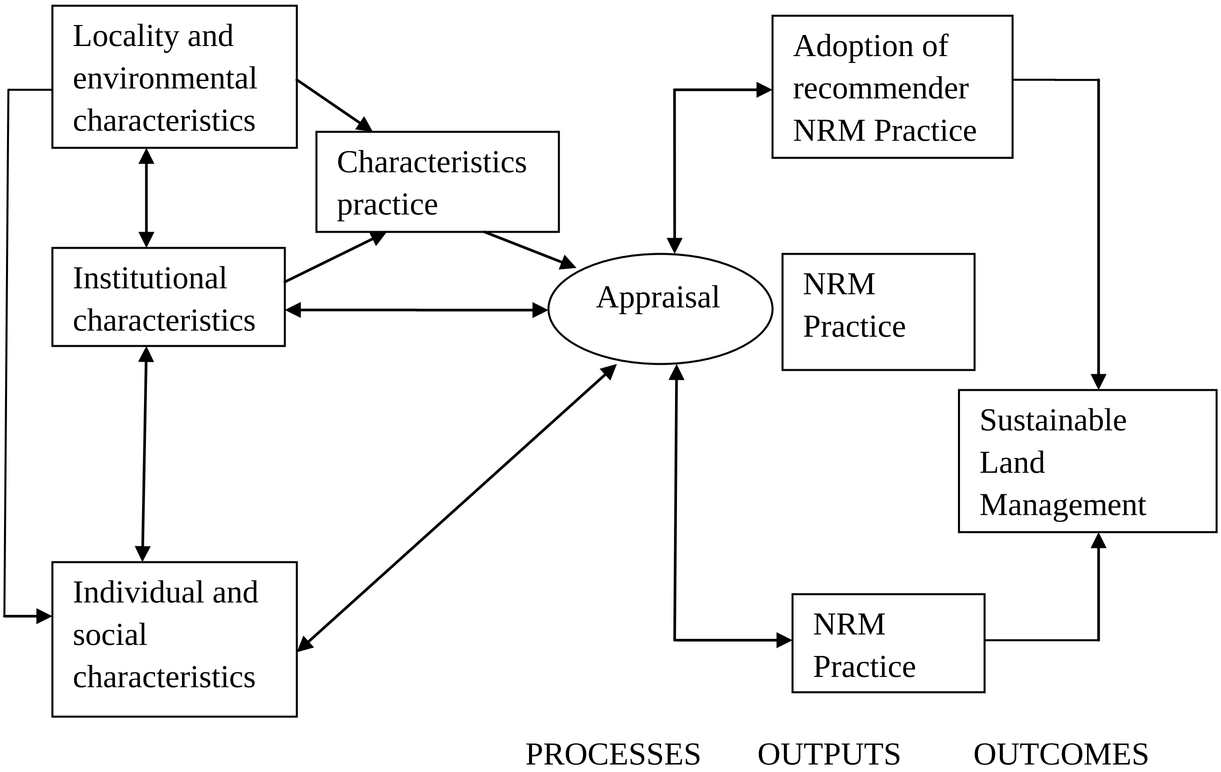

Figure 1: A model of land management practice appraisal

Source: Cary *et al.* (2002)

According to Cary *et al.* (2002) and Webb *et al.* (2004), characteristics of particular practices and their applicability to the landholders property are extremely significant in their appraisal. Different practices will have varying degrees of relevance to different landholders as a consequence of the practice itself and also as a consequence of local environmental factors. Institutional characteristics refer to the more formal structures that determine the 'social' environment within which landholder makes decisions concerning land management practices. These include the regulatory environment, government agency support structures, and government policy as reflected in incentive and information schemes. Individual and social characteristics include personal, family and demographic characteristics and the economic and property physical circumstances of a landholder.

2.1.4 The attributes of sustainable agriculture land management practices

According to Webb (2004), land management practices will have different implications for those considering their adoption and those promoting that adoption. For example, some land management practices may just require simple modifications to practices currently used by landholders, while others may require farm-wide changes to the systems of production. Other practices may not require changes to farming systems but focus on testing and monitoring levels of nutrients or chemical use; others may simply involve bookkeeping changes and record keeping and then some may require retirement of land from agricultural production. The nature of each practice will have different impacts in their adoption. According to Guerin (1994) and Webb (2004), have highlighted the significance of the following characteristics in adoption behavior of innovation in agriculture.

2.1.4.1 Relative advantage

This is normally interpreted in terms of financial advantage to the farm business. The perceived financial advantages of more sustainable agricultural practices have been shown to be one of the best indicators of their adoption. Barr *et al.* (1992) and Webb (2004) concluded that environmental innovations that were believed to be profitable were usually readily adopted, while those with a net financial cost were rarely adopted. Furthermore, the relative advantage of a more sustainable farming practice is unlikely to be similar in different localities. The relative advantage of given natural resource management (NRM) practices will vary in geographic space to a large extent (Webb, 2004).

2.1.4.2 Risk

Human behavior is more complex than simply being profit driven. Some practices will encompass greater risks than others in their application to a new property, and individuals will be willing to manage greater or lesser levels of risk. Many farmers are often motivated by a balance between the need for profit and a satisfaction with a comfortable living which minimizes risk and some will trade off profit maximization for risk reduction (Rendell *et al.,* 1996; Webb, 2004). Differing risk implications of different sustainable practices will be an important consideration in their adoption.

2.1.4.3 Complexity

In many times agricultural innovations which appear simple may in fact imply significant and complex changes to the farming system. More complex practices are less likely to be adopted (Vanclay *et al.,* 1995; Webb, 2004). Hence, farmers are more attracted to innovations which are simple to use and have significant impact to their produces.

2.1.4.4 Compatibility

This refers to the extent to which a new idea fits in to existing knowledge and existing social practice. If a new idea fits easily into an existing system it will be adopted more quickly.

Two systems are important, the current farming system and the social system embracing the region's farming or broader community. If a practice is not readily incorporated into a farming system then its adoption may be attenuated. Similarly if the ideas encompassing the new practice do not fit with local norms that will also work against adoption (Webb, 2004).

2.1.4.5 Trialability

Practices which can be trialed on a small scale prior to full implementation are more likely to be adopted. Trialing enables decisions about the utility of an innovation with minimal risk. Typically, farmers can easily assess a new crop variety by sowing one compound to the new variety before deciding upon more extensive adoption. Dryland salinity control is clearly not amenable to trialling. Because the benefits of salinity control may not be achievable for up to 50 years, a trial process will delay more extensive salinity control for a century (Vanclay *et al.,* 1995; Webb, 2004). Trialability is in turn dependent upon observability.

2.1.4.6 Observability

More sustainable NRM practices whose advantages are observable are more likely to be adopted. Traditionally, new variety of crop is often quite visible to passing observers and this visibility has been used to advantage. Many landcare groups have attempted to locate demonstrations along major roads to enhance visibility (Vanclay *et al.,* 1995; Webb, 2004).

Hence, regarding the above attributes of natural resource management practices, they may work more or less attractive to particular land user or holder. Usually, land user or holder will look for ways to reduce the riskiness of adopting a new practice. Those practices which are observable, trialable and less complex are frequently more quickly adopted than those which are unobservable, untrialable and complex (Webb, 2004). Additionally, the relative advantage of a practice normally depends on site specific and practices have to be regionally and locally appropriate to enhance their good looks.

2.2 Livelihood

Livelihood thinking dates back to the work of Robert Chambers in the mid-1980s (Kollmair, 2002). IISD (2003), defines livelihood as comprising the capabilities, assets and activities required for a means of living. Central to this definition are livelihood assets. The five forms of livelihood assets are given as natural, social-political, human, physical and financial capital.

Table 1: Livelihood assets framework

Human capital:	Skills, knowledge, health and ability to work
Social capital:	Social resources, including informal networks, membership of formalized groups and relationships of trust that facilitate co-operation and economic opportunities
Natural capital:	Natural resources such as land, soil, water, forests and fisheries
Physical capital:	Basic infrastructure, such as roads, water & sanitation, schools, ICT; and producer goods, including tools, livestock and equipment
Financial capital:	Financial resources including savings, credit, and income from employment, trade and remittances

Source: UNDP, (2010)

A livelihood is said to be sustainable if it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (IISD, 2003). Since livelihood is a broad concept with huge asset as pointed above, the study covered two concepts which were household food security and household income to make the study manageable.

2.3 Food Security and Sustainable Land Management Practices

The main benefit of put into practice sustainable land management practices is anticipated to be higher and more stable yields, increased system flexibility and, therefore, enhanced livelihoods and food security, and reduced production risk (FAO, 2006). Worth noting here is, there is a positive linear relationship between sustainable land management practices and the food security. To get into the details, we need first to know what food security is and then how the two link together.

2.3.1 Food security

IFRC (2006), defines food security as a person, household or community, region or nation is food secure when all members at all times have physical and economic access to buy, produce, obtain or consume sufficient, safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life. However, it is fundamentally about achieving reliable access to adequate, affordable and nutritious food supplies sufficient to avoid chronic hunger, crisis hunger and stunted development (Robbin, 2009).

2.3.2 Dimensions of food security

According to FAO (2006), this widely accepted definition (food security) points to the following dimensions of food security. First, food availability: the availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid). Second, food access: access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Third, Utilization: utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security. And last, Stability: to be food secure, a population, household or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security.

2.3.2 The link between sustainable land management practices and food security

Current projections indicate that the increased food production expected by 2050 (+70 per cent globally) will be met mostly through intensification, as opposed to expansion of cropland area (Bruinsma, 2009), thus indicating the need to promote sustainable land management practices of intensification. The next section summarizes findings from a global literature review on yield effects of the adoption of a specific sustainable land management practice that finally enhance food security.

2.3.2.1 Use of cover crops

Branca *et al.* (2011) reported that use of crops cover lead to higher yields due to decreased on-farm erosion and nutrient leaching, and reduced grain losses due to pest attacks. For example, Kaumbutho *et al.* (2007) showed that maize yield increased from 1.2 to 1.8-2.0 t/ha in Kenya with the use of mucuna (*Velvet Bean*) cover crop; Altieri (2001) showed that, there was a significant yield loss of about 31.4-42.4% in the long run and 36.7-48.5% in the short run for continuous maize planting compared to maize cropped using different cover crop types e.g. *Pigeon pea* and mucuna. Pretty *et al.* (2001) showed that farmers who adopted mucuna cover cropping benefited from higher yields of maize with less labour input for weeding (maize following mucuna yields 3-4 t/ha without application of nitrogen fertiliser, similar to yields normally obtained with recommended levels of fertilisation at 130 kgN/ha); (Altieri, 2001; Branca *et al.*, 2011) reported that maize yields in Brazil increased by 198-246% with the use of cover crops. Worth noting here, is the significant use of cover crops that enhance higher yields that ultimately improve food security.

2.3.2.2 Crop rotations and intercropping

They are designed to ensure differential nutrient uptake and use e.g. between crops, such as millet and sorghum and Nitrogen-fixing crops, such as groundnuts, beans and cowpeas will enhance soil fertility, reduce reliance on chemical fertilizers, and enrich nutrient supply to subsequent crops (Conant, 2010; Branca *et al.*, 2011), leading to increased crop yields (Woodfine, 2009; Branca *et al.*, 2011). For example, Hine and Pretty (2008), showed that in the North Rift and western regions of Kenya maize yields increased to 3,414 kg/ha (71% increase in yields) and bean yields to 258 kg/ha (158% increase in yields). Worth noting here, is the significant yield increase that enhances food security due to the use of crop rotation and intercropping as the ways of sustainable land management practices.

2.3.2.3 The use of improved crop varieties

According to Branca *et al.* (2011), the use of improved crop varieties is expected to increase average yields because of the greater seed diversity of the same crop. For example, (Pretty, 2001; Branca *et al.* 2011) showed that introduction of new varieties of crops (vegetables) and trees (fruits) increases yields in Ethiopia by 60%; the International Centre for Tropical Agriculture (CIAT, 2008; Branca *et al.*, 2011) showed that the average yield increase due to the introduction of new bean varieties in seven African countries was 44% in 2004-2005, although the gains varied widely across countries, ranging from 2% in Malawi to 137% in western Kenya. Hence, the use of improved crop varieties as a mechanism to sustain land management sustainably increases farmer’s yield produces that secure food security.

2.3.2.4 Adopting organic fertilization (compost and animal manure)

According to Branca *et al.* (2011), adopting organic fertilization is widely found to have positive effects on the yields. For example (Pretty, 2008; Branca *et al.* 2011) showed that maize yields increased by 100% (from 2 to 4 t/ha) in Kenya; (Parrot *et al.* 2002) showed that millet yields increased by 75-195% (from 0.3 to 0.6-1 t/ha) and groundnut by 100-200% (from 0.3 to 0.6-0.9 t/ha) in Senegal; (Altieri, 2001) quotes several examples from Latin America where adoption of organic fertilization and composting led to increases in maize/wheat yields between 198-250% (Brazil, Guatemala and Honduras) and in coffee yield by 140% (in Mexico); Also, enhancing inputs of nitrogen through nitrogen-fixing plants that are not harvested (green manure) is key to maximizing production and ensuring longterm sustainability of agricultural systems (Fageria, 2007).

2.3.2.5 Proper water management (Terraces and contour farming practices)

Proper water management can help capture more rainfall (Vohland *et al.,* 2009), making more water available to crops, and using water more efficiently (Rockstrom *et al.,* 2007), which are crucially important for increased agricultural production (Branca *et al.*, 2011). Bunds/Zai and Tied Ridge Systems generate higher yields, particularly where increased soil moisture is a key constraint (Branca *et al.*, 2011). However, terraces and contour farming practices can increase yields due to reduced soil and water erosion and increased soil quality (Branca *et al.*, 2011). (Altieri, 2001) showed that restoration of Incan terraces has led to 150% increase in a range of upland crops, Shively (1999), found that contour hedgerows can improve maize yields up to 15% compared with conventional practices on hillside farms in the Philippines.

Branca *et al.* (2011) reported building excavated terraces (bench/fanya juu) in the Ulugurus mountains in Tanzania has improved soil composition for example, soil testing results have shown that the average moisture level in areas with terraces/ fanya juu is higher than in areas without structures (1.6% vs 0.3%) and average soil compaction is lower than in areas with no terraces (1.05 km/m2 vs 3.05 km/m2). Consequently, crop performance in areas with interventions has improved in terms of crop growth rate and yields: maize and beans yields harvested on excavated structures increased three times. Also, farmers were able to introduce high value crops like tomato, cabbage and spices (Branca *et al.,* 2011). Worth noting here, is food security can also be archived through proper water harvest systems like terraces that act both as a mechanism to sustain land management and yield increase.

2.3.2.6 Agroforestry

Branca *et al.* (2011) defines agroforestry as land use practices in which woody perennials are deliberately integrated with agricultural crops, varying from very simple and sparse to very complex and dense systems. It embraces a wide range of practices (e.g. farming with trees on contours, intercropping, multiple cropping, bush and tree fallows, establishing shelter belts and riparian zones/buffer strips with woody species etc.) which can improve land productivity providing a favourable micro-climate, permanent cover, improved soil structure and organic carbon content, increased infiltration and enhanced fertility (WOCAT, 2011) reducing the need for mineral fertilizers (Garrity, 2004). For example, Parrott *et al.* (2002) reported yield increases of 175% on farms in Nepal. Worth noting here, is that, agroforestry as the means to sustain land productivity sustainably has also the significance importance for ensuring food security.

2.4 Income and Sustainable Land Management Practices

Income is money one receives such as wages, Social Security benefits and pensions. Income also includes such things as food and shelter (USSSA, 2012). In agriculture however, income can be defined in two approaches. One approach sees income as a reward that the owners of fixed factors of production receive as a result of allowing their land, capital and labour to take part in production while the other sees income as the flow of resources that households receive that may be spent on consumption and on saving (FAO, 2012).

2.4.1 Income measuring

When measuring income according to the approach as outlined above, the flow of resources towards households comes in three main forms. First, from gainful activities (mainly employment and self-employment), second, from the ownership of property (rent from land, interest from financial assets) and third, from transfers (mostly social transfers organized by government but also private ones, such as from family members working abroad) (FAO, 2012). The first form was considered by the study more specifically on farm self-employment, because the study's interest was on farm management practices on sustainable land management.

2.4.2 The link between household income and Sustainable Land Management practices

As previously seen, sustainable land management practices and how it links with household food security, we now have to see how it links with household income. The dynamic household model will be a useful tool to show the link. The ultimate goal is its effect on community livelihoods. According to Nkonya *et al.* (2008), the model assumes that land management decisions are determined by the quantity and quality of assets to which households have access (natural, physical, and human capital); the security of tenure to land; households' access to relevant services, such as agricultural technical assistance; the biophysical and socioeconomic endowments of the village (agroecological potential, access to markets and infrastructure, and resource scarcity); the opportunity cost of labor in the village; and local institutions for NRM, such as locally enacted community by-laws related to land management as shown on Fig. 2 below.

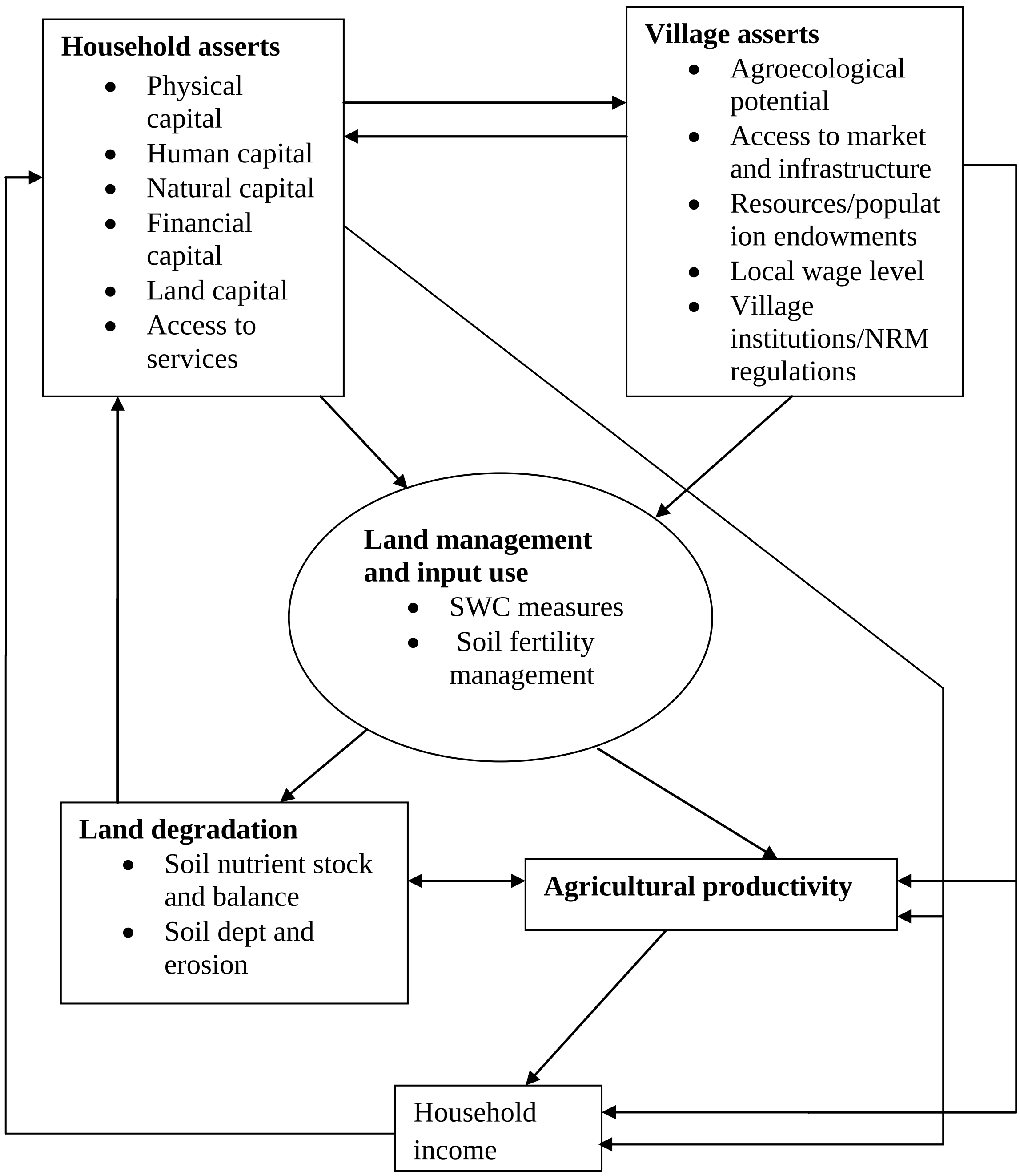

Figure 2: The dynamic household model

Source; Nkonya *et al.* (2008).

However, households' land management and input use decisions affect both agricultural production and land degradation. For example, ownership of farm equipment or draught animals, education, land quality, land tenure, access to agricultural extension and climate may all affect agricultural productivity, apart from their impacts on land management practices and input use. In addition, agricultural production also affects household income. Land degradation (on the farmers' own plots) affects household income through its impact on agricultural production. Here we are ignoring the value of nonagricultural goods and services taken from farmers' own plots, which may be affected by land degradation and which can influence income separately from agricultural production (Nkonya *et al.,* 2008).

2.3 Technology Adoption

Bridges to Technology (2005), defined technology adoption as a process that begins with awareness of the technology and progresses through a series of steps that end in appropriate and effective usage. It follows five basic steps process (Bridges to Technology, 2005), first, awareness – potential users learn enough about the technology and its benefits to decide whether they want to investigate further. Second, assessment – potential users evaluate the usefulness and usability of the technology, and the ease or difficulty of adopting. Third, acceptance – potential users decide to acquire and use the technology, or decide not to adopt. Fourth, learning – users develop the skills and knowledge required to use the technology effectively. And fifth, usage – users demonstrate appropriate and effective use of the technology. Hence, for a complete technology adoption, the five processes are of necessary to pass through.

2.4 Empirical Studies on Methodology of Analysis

2.4.1 Multiple linear regression

According to Spring (2013), multiple linear regressions (MLR) are a method used to model the linear relationship between a dependent variable and one or more independent variables. The dependent variable is sometimes also called the predictand, and the independent variables the predictors. It is based on least squares; the model is fit such that the sum-of-squares of differences of observed and predicted values is minimized.

Spring (2013) reported that, the model expresses the value of a predictand variable as a linear function of one or more predictor variables and an error term:

$$y_i = b_o + b_1 x_{i,1} + b_2 x_{i,2} + \ldots + b_k x_{i,k} + e_i$$

$x_{i,k}$ = value of k^{th} predictor in year i

b_o = regression constant

b_k = coefficient on the k^{th} predictor

K = total number of predictors

Y_i = predictand in year i

e_i = error term

In addition, there are various studies used multiple linear regression in the analysis such as Mirshahi (2010), investigated how hydrological modelling in data-sparse snow-affected semiarid areas in Iran. He concluded that, for data-sparse mountainous snow-affected semiarid regions, although more complex rainfall-runoff models may structurally be more accurate; in combination with uncertain simulated inputs, they have a worse performance. Also study done by Ezlit (2009), investigated on modeling the change in conductivity of soil associated with the application of saline-sodic water in Australia. He concluded that different amendments associated with appropriate irrigation management can be applied to sustain irrigation and prevent long term sodicity problems.

Furthermore, study by Kindschuch (2007), explored size and shape differences related to sex and ancestry from the hyoid bones of the Robert J. Terry Anatomical Collection in order to gauge its usefulness in the process of developing a biological profile. He concluded that, the use of linear regression analysis has the potential to assist the physical anthropologist in their sex determination of an individual. Also further research into the variety of conditions found during the study will only increase the accuracy of the method and increase its potential in the process of building a biological profile.

Interestingly, the application of multiple linear regression is by its definition, that is, a method used to model the linear relationship between a dependent variable and one or more independent variables (showing the causal effect relationships). Additionally, it works nicely given a continuous response (dependent, outcome) variable and a set of k numerical explanatory variables, x1, x2, ..., xk. So, based on the model application, the study used it to determine the effect of sustainable land management technology on household's food security.

2.4.2 Logistic regression

The same as in linear regression (LR), the objective is to estimate the regression coefficients in a model, given a sample of (X, Y) pairs. However, the crucial limitation of linear regression is that it cannot deal with dichotomous or categorical variables (Menard, 2002). With logistic regression, the X's can be numerical or categorical, but Ys are usually coded as dummy variable i.e. 0 for those who do not have the event or 1 for those who have the event (Summer, 2012).

Logistic regression determines the impact of multiple independent variables presented simultaneously to predict membership of one or other of the two dependent variable categories (Menard, 2002). According to Summer (2012), the simple logistic model is based on a linear relationship between the natural logarithm (ln) of the odds of an event and a numerical independent variable as follows:

$$L = \ln(0) = \ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X + \epsilon \qquad (1)$$

Whereby:

Y = is binary and represent the event of interest (response), coded as 0/1 for failure/success,

P = is the proportion of successes,

O = is the odds of the event,

L = is the in (odds of event),

X = is the independent variable,

β_0 = and β_1 are the Y-intercept and the slope, respectively

€ = is the random error.

According to Menard (2002), there are two main uses of logistic regression: first, is the prediction of group membership. Since logistic regression calculates the probability of success over the probability of failure, the results of the analysis are in the form of an odds ratio. Second, logistic regression also provides knowledge of the relationships and strengths among the variables (e.g. marrying the boss's daughter puts you at a higher probability for job promotion than undertaking five hours unpaid overtime each week).

Additionally, there are various studies used logistic regression such as Turuka *et al.* (2011) investigated the main determinants of demand for private veterinary services in Tanzania. He concluded that, producers who are more likely to use private services are those who have large herd, more experienced in livestock keeping, who are willing to spend on drugs, involved in farmers' organizations and those who are well educated and trained in animal husbandry. Also study by Kalineza *et al.* (2001) looked on factors influencing adoption of soil conservation technologies in Gairo district, Tanzania. He concluded that farmers who obtained knowledge on soil conservation through extension seminars as well as those with secure land ownership are likely to adopt soil conservation measures. Furthermore, study by Mignouna *et al.* (2008) investigated on the adoption of a new maize (IRM) and production efficiency in western Kenya. He concluded that, adoption of IRM significantly increased maize output also household size decreased inefficiency along with farm size.

Furthermore, the logistic regression has many applications as listed by Vasisht (2007), first, it can be used to identify the factors that affect the adoption of a particular technology say, use of new varieties, fertilizers, pesticides on a farm. Second, in the field of marketing, it can be used to test the brand preference and brand loyalty for any product. Third, gender studies can use it to find out the factors which affect decision making status of men/women in a family.

In addition, logistic regression is a choice modal that determines the probability of an individual making one choice rather than alternative, this study has adopted it to determine the factors affecting the adoption on sustainable land management technologies in the study area, due to its applicability and with the assumption that a farmer is considered either to adopt particular land conservation practices or not.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of Study Area

The West Usambara Mountain ranges in North East Tanzania, form part of the Eastern Arc Mountains. With elevation ranging from 900 – 2250 meters above the sea level they occupy about 80 % of Lushoto District in Tanga Region. More than 80 % of the population of Lushoto District, estimated at 526 278 (NRI, 2000; Mowo *et al.,* 2002) reside in the West Usambara Mountains (Mwihomeke, 2002) making it the most densely populated that is 100 person/km^2 in the country (Mowo *et al.,* 2002). The study was conducted in five wards, the wards are characterized as follows; soni and mbuzii (low landscape areas) and lukozi, malindi and shume (high landscape areas).

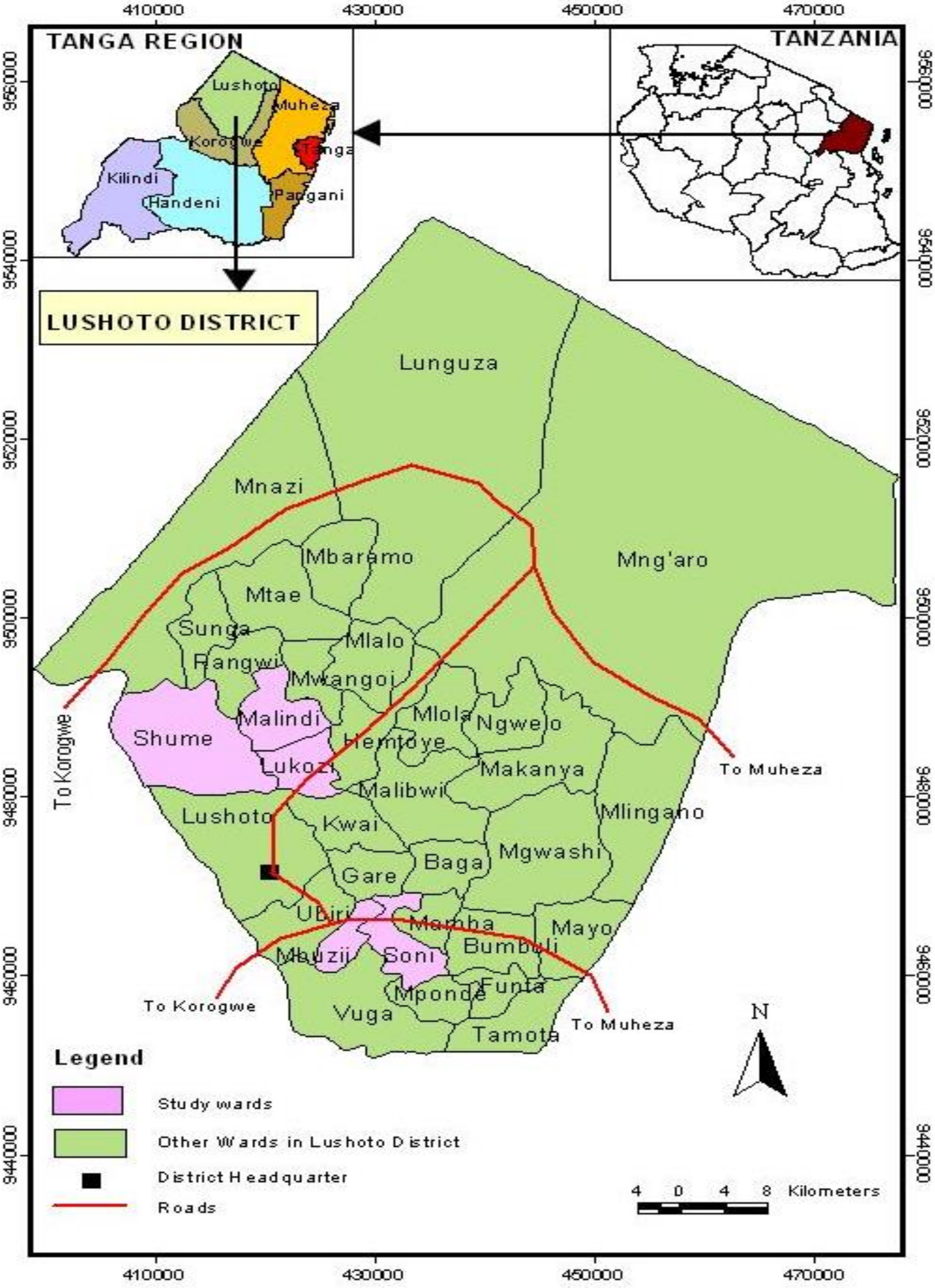

Figure 3: Map of Lushoto District in Tanzania showing study wards

3.2 Conceptual Framework Linking Technology Adoption and Livelihoods

The conceptual framework was adopted and modified from TARP II- SUA project 2005. It is based on the assumption that, after technologies have been developed from research institutions, NGOs and projects are then disseminated to farmers. Thereafter, farmers will adopt technologies and agree to be contract farmers if they respond to their needs. But also, farmers who will think otherwise will reject the technologies by not showing interest for becoming contract farmers. After some time of testing, the contract farmers will gain experiences with technologies and have more solid basis for accepting or rejecting them (Fig. 4).

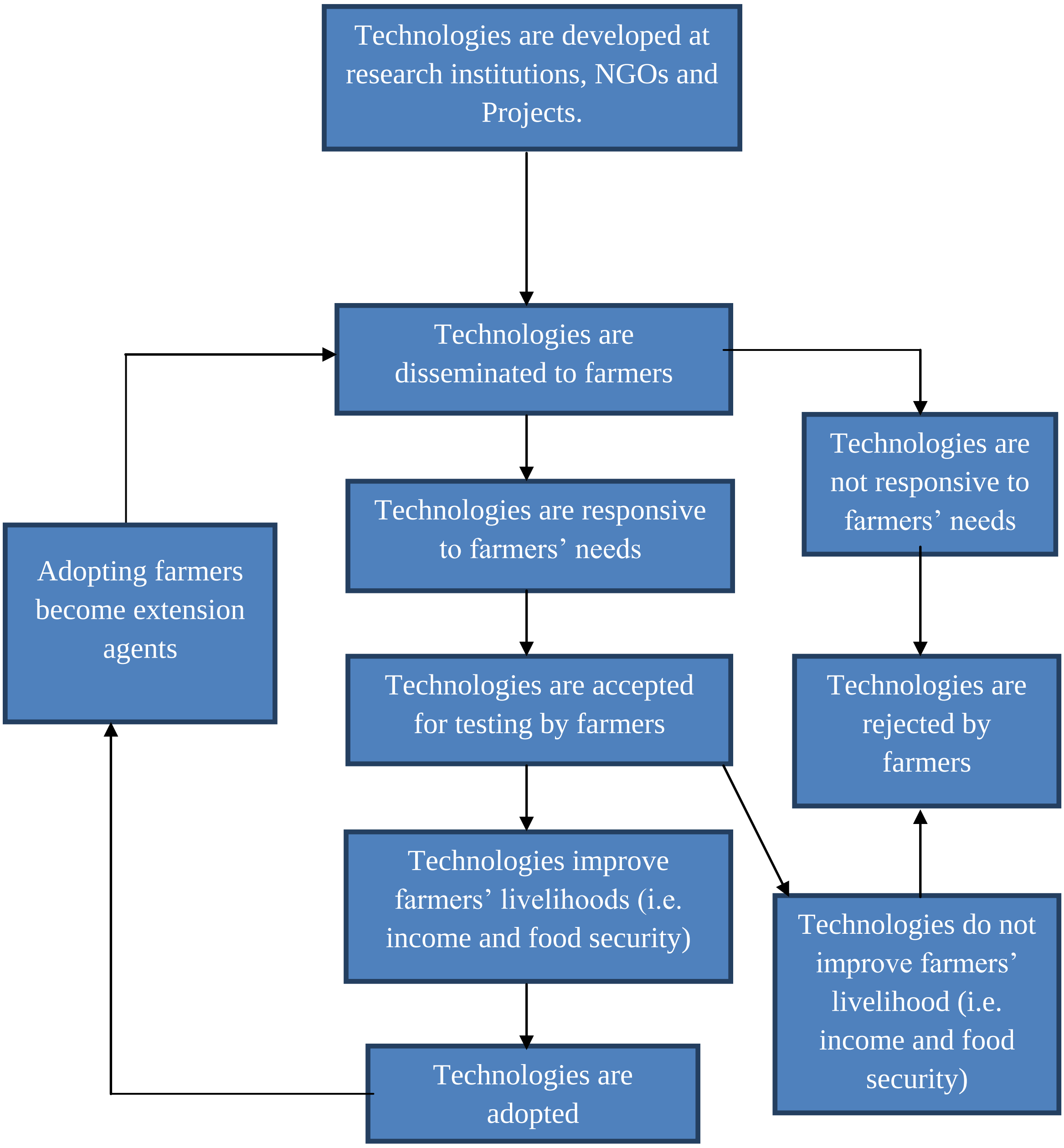

Figure 4: Conceptual Framework Linking Technology Adoption and Livelihoods

Source: Modified from TARP II-SUA Project (2005)

3.3 Theoretical Framework

3.3.1 Incorporating technology adoption in the farm household model

Farm household model (FHM) is model combines in a single framework the technology adoption and off-farm work decisions by the farmer and follows the analysis developed by Fernandez (2005). The model expands the farm household model offered by Huffman (1991), and with several additions to allow for technology adoption. According to the agricultural household model, farm households maximize utility U subject to income, production technology, and time constraints. Household members receive utility from goods purchased for consumption G, leisure (including home time) L= (L_o, L_s) for the farmer, and from factors exogenous to current household decisions, such as human capital H = (H_o, H_s), and other factors Ψ (including household characteristics and weather).

Thus:

Max U= U (G, L, H, Ψ)………………………………………………….……... (2)

Subject to the constraints:

Income constraint, P_g G = P_qQ – W_x X' + WM'+ A…………………….….….…. (3)

Technology constraint, Q = Q[X (Γ), F (Γ), H, Γ, R], Γ ≥ 0…………….…..…. (4)

Time constraint, T = F (Γ) + M + L, M≥ 0……………………….……….. (5)

Where;

P_g and G denote the price and quantity of goods purchased for consumption;

P_q and Q represent the price and quantity of farm output;

W_x and X are the price and quantity (row) vectors of farm inputs;

W = (W_o, W_s) represents off-farm wages paid to the farmer;

M = (M_o, M_s) is the amount of time working off-farm by the farmer;

F = (F_o, F_s) is the amount of time working on the farm by the farmer;

A is other income, including income (from interest, dividends, annuities, private pensions, and rents) and government transfers (such as Social Security, retirement, disability, and unemployment);

R is a vector of exogenous factors that shift the production function, and

T = (T_o, T_s) denotes the (annual) time endowments for the farmer.

The production function is concave and has the usual regularity characteristics. Some technologies offer simplicity and flexibility that translate into reduced management time, freeing time for other uses. In these cases, the amount of time working on the farm by the farmer F (and possibly the use of other farm inputs X) is a function of Γ, the adoption intensity of the technology. Therefore, the technology adoption decision condition is obtained from the optimality conditions, whereby, the value of marginal benefit of adoption is equal to the marginal cost of adoption. By taking the assumption that the farmer is rational, he will adopt the technology if the marginal benefit is greater than or equal to the marginal cost. However, the study was built on the farm household utility model, whereby the model at household level was used to analyze the proportion of crop area allocated to sustainable land management practices.

3.3.2 Sustainable livelihoods framework analysis

A sustainable livelihood (SL) is commonly accepted as comprising the capabilities, assets (including both material and social resources) for a means of living (DFID, 1999; Solesbury, 2003). It promotes poverty eradication, protection and better management of the environment, and places emphasis on people rather than resources (Carney, 1998; Hewet *et al.*, 2002). However, DFID (2001) differentiates between three groups of components in the livelihood framework: first, the asset portfolio forming the core element of livelihood, second, the Vulnerability Context and Policy, Institutions and Processes, and third, the loop linking livelihood strategies and livelihood outcomes.

The Vulnerability Context of livelihoods refers to shocks, trends and seasonality with their potential impact on people's livelihoods, while Policies, Institutions and Processes on the other side comprise the context of the political and institutional factors and forces in government and the private and the civil sectors that affect livelihoods as shown in Fig. 5 below.

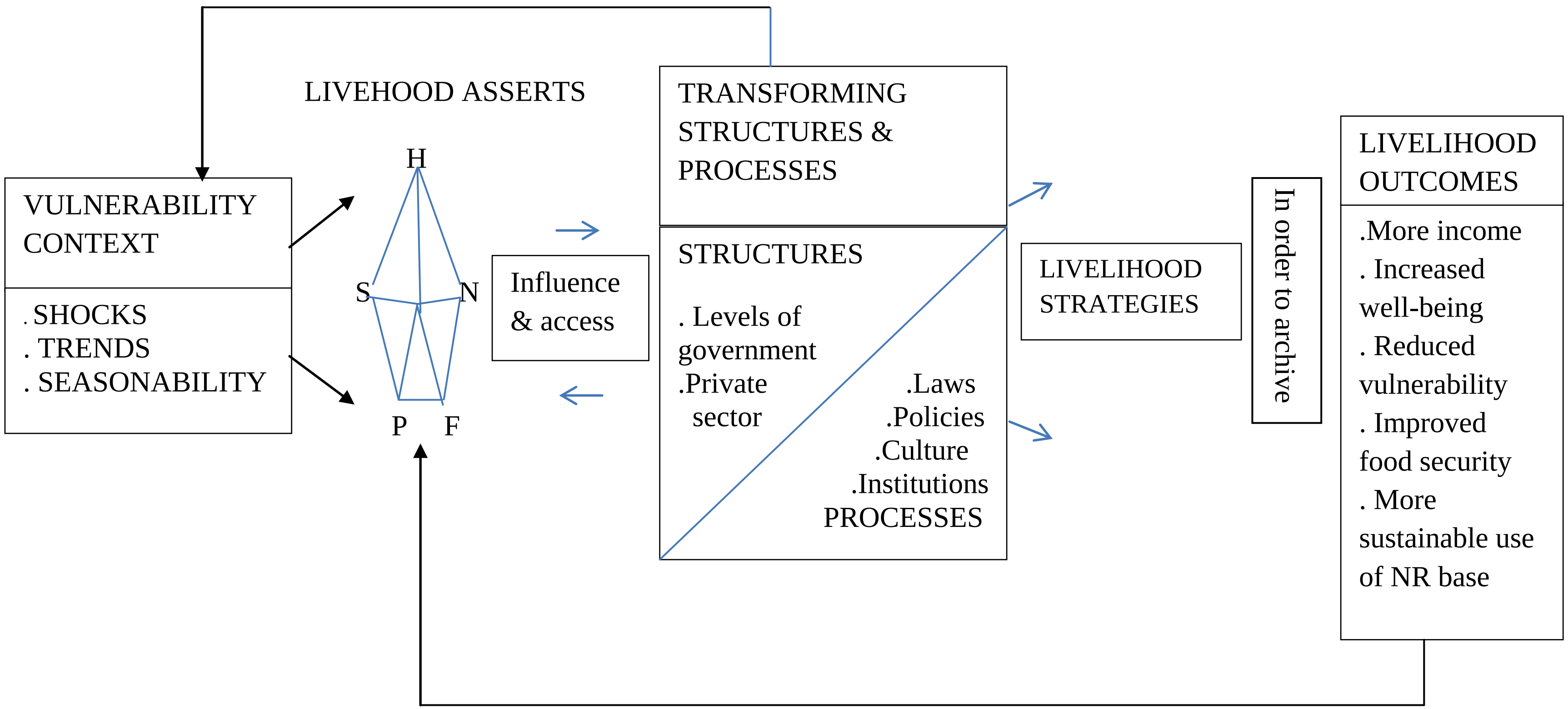

Figure 5: Main elements of the DFID Sustainable Livelihood Framework and Core Principles of Application

Source: DFID, (2001)

KEY; H=Human capital S=Social capital N=Natural capital P=Physical capital F=Financial capital

The SL framework provides a useful diagnostic tool to map and scope development interventions. It is, however, has a number of weaknesses. First, the SL framework does not shed any light on where the most effective poverty alleviation intervention may be located. Second, it is extremely 'data hungry'. Third, it is static. Fourth, it is very much a western, developed world construct, which leaves it open to criticism as to its relevance and applicability to developing countries, their development workers, and local communities. Finally, it has been criticized for failing to address fully the issue of power relations (Baumann, 2000).

Taking the due criticisms into consideration, the study was built on sustainable livelihood framework, where by the five livelihood asserts were assessed by household food security and household income as these variables are considered important due to their measurability. The same variables were also used by Hewet *et al.* (2002) to measure the livelihood outcomes on hydrology and land use in Republic of South Africa.

3.4 Study Design

The study used cross-sectional study design, where data are collected at a single point in time using a survey method. The reasons for choosing this design is because it is flexible and economic (Babbie, 1995). In addition, the subjects were tested once at the same time. Furthermore, it's easy to manipulate data and information obtained.

3.5 Sampling Design, Sampling frame and Sample Size

The target population for the study was farmers who cultivate crops, vegetables and fruits. A sampling frame is a list that identifies the target population (Kothari, 2004). The sampling frame for this study was obtained from administrative leaders in the selected study sites. Both purposive and systematic random samplings were employed.

Purposive sampling was used to select five wards that is soni and mbuzii (low landscape areas) and lukozi, malindi and shume (high landscape areas) in-order to get all scenarios of SLM practices in both locations. Purposive sampling was employed in order to have proportional samples from each ward.

Furthermore, Stratified sampling technique with a calculated sample size fraction or F-coefficient of 0.0126 was employed to get household samples from each ward that is Lukozi (31), Malindi (47), Shume (30), Mbuzii (18) and Soni (34). Stratified sampling was employed because, it increases accuracy without increasing the sample size, it ensures effective representation of all sections (high adopters' versus low adopters' farmers) and useful where population is divided into identifiable differentiated strata. Thereafter, simple random sampling was conducted for one to one household interview that made a total of 160 interviewed households.

3.6 Data Collection

Field data collection on sustainable land management (SLM) involved two stages. The first stage was focus group discussion with the key informants of Lushoto such as district agricultural and livestock development officer, three extension officers and group of 20 selected farmers of which 8 were female, with the aim of gathering information on adoption of sustainable land management practices in Lushoto and selection of wards for data collection as shown in Appendix 2.

Second stage, was the use of questionnaire whereby both close ended and open ended questions were asked. The information captured was on household and household head characteristics (e.g. age, sex, education, household size), farm size (acre), the type of sustainable land practices, type of inputs, quantities and costs for the inputs for production in the farm such as seeds, fertilizers, equipments, herbicides, pesticides, manpower and membership in farmer organizations. The number of working days (time) for each activity for production in the field, costs of land preparation, planting, weeding and harvesting. Frequency of cultivating per year, amount of outputs per acre, market price of the crops, vegetables and fruits harvested per kg and the income they obtain on that farming practices as shown in Appendix 1.

3.7 Data Analysis

3.7.1 Factors affecting adoption of sustainable land management technologies in the study area

Binary logistic regression model through enter method was employed to analyze the relationship between predictand and predictor variables. The model arises when the 'Y' variable is limited or censored from above or below. The response variable being sustainable land management adopter coded 1 versus non-adopter coded 0 and the predictor variables being household head age, household head sex, total number of household members, total farm size in acres, contact with extension officer, access to credits, member of farming group, ownership of the farm and the average household income per year, as these were assumed to be potential determinants of factors affecting the adoption on sustainable land management technologies.

Hence;

$$\ln \mathbf{Y} = ln\left(\frac{\mathbf{Y}}{\mathbf{1} - \mathbf{Y}}\right) = \beta_0 + \beta_1X_1 + \beta_2X_2 + \cdots + \beta_kX_k + u \qquad (6)$$

Where;

Y=the predicted probability of the event (Sustainable land management SLM) which is coded with 1= SLM adopter and 0= non SLM adopter

1-Y =the predicted probability of the of the other decision (non SLM adopter)

β_0 = constant.

X_1= AGE: age of household head (years),

X_2= SEX: sex (dummy: 1=male and 0=female),

X_3 = EDU: education in years of schooling (0=no formal education, 1=primary education, 2=secondary education 3= post-secondary education)

X_4= HSIZE: household size (number),

X_5 = FSIZE: farm size (number),

X_6= CEXT: contact with extension agents (dummy: 1=contact within the year and 0=contract not within the year),

X_7 = CRED: Access to credit (dummy: 0=No and 1=Yes),

X_8=MBER: Member of any farming group (dummy: 0=No and 1=Yes),

X_9= HHINCOME: Average household income per year

X_{10}= LANDOWNERSHIP: Household farm ownership (1=owned, 2=rented, 3=owned and rented)

In assessing the goodness-of-fit, both Cox & Snell R Square and Nagelkerke R Square were used to check the model fit. According to Denis (2010), there is a major problem with Cox and Snell's Pseudo R Square, which is that it's maximum can be (and usually is) less than 1.0, making it difficult to interpret. That is why Nagelkerke developed a modified version of Cox and Snell's measure that varies from 0 to 1. Therefore Nagelkerke's Pseudo R^2 will normally be higher than the Cox and Snell measure.

3.7.2 Effect of adoption of Sustainable Land Management technology on the household's food security

To determine the effect of adoption of Sustainable Land Management technology on the household's food security, household dietary diversity as the best tool to explain food security and multiple linear regression models were adopted by the study. According to Zezza *et al.* (2008) dietary diversity is the product of the food access, availability, and stability dimensions, but does not reflect the dimension concerning the utilization of food, its preparation, and care and sanitation practices that are instead subsumed in anthropometric indicators. However, the same modal was used by Zezza *et al*. (2008) to assess on how urban agriculture enhances food security from developing countries. Therefore, the analytical model is simplified and builds on the conceptual that links between household food security and households' agriculture participation on adoption of sustainable land management technologies.

The model is thus specified as follows;

$$Y = a_0 + a_1 adSLM + a_2(HHincome) + a_3 landown + a_4 hhsize + a_5 educave + a_6 agehead + \hat{e} \quad \ldots\ldots(7)$$

Where;

Y is the dietary diversity measure (simple count of food groups), as a variable for household food security. According to Swindale *et al.* (2006) suggested that to better reflect a quality diet, the number of different *food groups* consumed is calculated, rather than the number of different *foods* consumed. Knowing that households consume, for example, an average of four different food groups implies that their diets offer some diversity in both macro- and micronutrients. This is a more meaningful indicator than knowing that households consume four different foods, which might all be cereals.

adSLM is the dummy variable indicating whether the household adapt SLM or not, the expected relationship was assumed that adoption increases household dietary diversity.

HHincome denotes average household income per year, the expected relationship of this variable with food security was that as income rises, increases more chances for household dietary diversity. Similar to findings by Khalid *et al.* (2012) observed that household income associate positively with the household food security.

landown is a dummy variable identifying household that own land, the assumption put behind these variable was that the ownership of land increases household dietary diversity.

HHsize is the sum of members of the household, it is assumed that as the household size increases also increases household dietary diversity. Higher the number of people in the household associates with higher the difference in the taste and preference. Zezza *et al.* (2008) observed that the household size has a positive relationship with household dietary diversity.

Educave is dummy variable identifying the average education of the adult household members. It is hypothesized that the household dietary diversity increases with education of the head of the household. The assumption was that people with higher education are aware of nutritional advantages of diversifying their diet. This relationship was also found to be positive in the study by Zezza *et al.* (2008).

Agehead is the age of the household head, the age of head of household also is assumed to have a positive relationship with household dietary diversity. Study by Zezza *et al.* (2008) observed that age of head of respondent associate positively with household dietary diversity.

ê is the error term.

The analysis of variance (ANOVA) that tests the acceptability of the model from a statistical perspective was used. Although the ANOVA is a useful test of the model's ability to explain any variation in the dependent variable, but it does not directly address the strength of that relationship between the model and the dependent variable. To capture it, the goodness-of-fit statistics (R and R^2) were used to check model fit by considering the number of food groups eaten last week as a variable for household for food security. The multiple correlation coefficients (R) is the linear correlation between the observed and model-predicted values of the dependent variable while the coefficient of determination (R^2) is the squared value of the multiple correlation coefficient. The change in the R^2 statistic is produced by adding or deleting an independent variable. If the R^2 change associated with a variable is large, that means that the variable is a good predictor of the dependent variable.

Additionally, on assessing multicollinearity, the collinearity statistics (tolerance and variance inflation factor VIF), eigenvalue and condition index were used. But in order to assess multicollinearity, we first have to know it and its consensuses. Multicollinearity is a case of multiple regression in which the predictor variables are themselves highly correlated. However, if there is no linear relationship between the regressors they are said to be orthogonal, in such cases the inferences based on the regression model can be made relatively easily (Ranjit, 2006).

Ranjit (2006) suggests that, if the goal is simply to predict Y from a set of X variables, then multicollinearity is not a problem. The predictions will still be accurate, and the overall R^2 (or adjusted R^2) quantifies how well the model predicts the Y values. If the goal is to understand how the various X variables impact Y, then multicollinearity is a big problem. One problem is that the individual P values can be misleading (a P value can be high, even though the variable is important). The second problem is that the confidence intervals on the regression coefficients will be very wide. The confidence intervals may even include zero, which means one can't even be confident whether an increase in the X value is associated with an increase, or a decrease, in Y. Because the confidence intervals are so wide, excluding a subject (or adding a new one) can change the coefficients dramatically and may even change their signs.

3.7.3 Effect of adoption of Sustainable Land Management technology on the income in the study area

In order to link the effect of sustainable land management technologies on household income, the best way to do would have been to find the records of farmers' income per year before the adoption. But due to money and time constrains and farmers lacking those back records it was not possible to go to that detail.

However, descriptive statistics were used to calculate the mean income difference for adopters and non-adopters using the following formula;

$$\Pi g = \frac{\Sigma TIg}{Ng} \qquad \text{……………………………………………………….…………(8)}$$

Where;

g = Represent adopters or non-adopters group

Π = Represent the mean income from adopters or non-adopters

TI = Total income from a group (adopters or non-adopters)

N = Total number of respondent in a group

Thereafter, the Independent-Sample T-Test was employed to calculate the statistical significance mean income difference between adopters versus non-adopters.

3.7.4 Options for improvement of sustainable land management practices

To develop option for improvement, the descriptive statistics was used to calculate frequencies and percentages of land use and management practices based on their types and SLM practices/skills dissemination with respect to access and availability. As these aspects were assumed to give better insights for developing options for improvements.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Background Characteristics of Respondents

4.1.1 Demographic and economic characteristics

The research findings indicated that out of 160 sample household respondent, the following table 2 below summarizes respondents' sex, age and education status.

Table 2: Respondents' sex, age and education characteristics

Characteristics	Frequency	Percent
Sex		
Male	140	87.5
Female	20	12.5
Age		
Above 60 years old	17	10.6
25-60 years old	142	88.8
Below 25 years old	1	0.6
Education		
No any formal education	5	3.2
Primary education	146	91.2
Secondary education	9	5.6

Based on respondents' sex, the majorities (87.5%) are male and the remaining (12.5%) are female. This might be due to female reliance on their husbands in taking farming decisions (FAO, 2005) and most likely women are too occupied in farm activities a condition possibly made them less available for the interview.

With regards to respondents' age structure, more than half of respondent are aged between 25 to 60 years old. This suggests that the district has more active working age group (Table 2).

Interestingly, the maximum and minimum age of respondents were 23 and 80 years respectively with the mean age of 46, indicating that most of them were still in their middle age and likely to be receptive to sustainable land management technology practices. The family size of the respondent households ranges from 1 to 18 members. The mean family size is about 5, and the majorities (59.4%) have family sizes of five and above. Worth noting here, there is a relatively large household sizes and this offers an opportunity that relaxes the labor constrain for farming to the households. Additionally, more than half of the respondents have attained formal education (Table 2), this suggests higher probability to adopt new technologies and ideas offered since the majorities are knowledgeable.

Concerning economic activities, the research findings show that about 68.8% and 29.2% are full time farmers and farming/business, respectively. Only 2% are too old to work as shown on Fig. 6. This advocates that agriculture farming is the main support of the livelihood in the district.

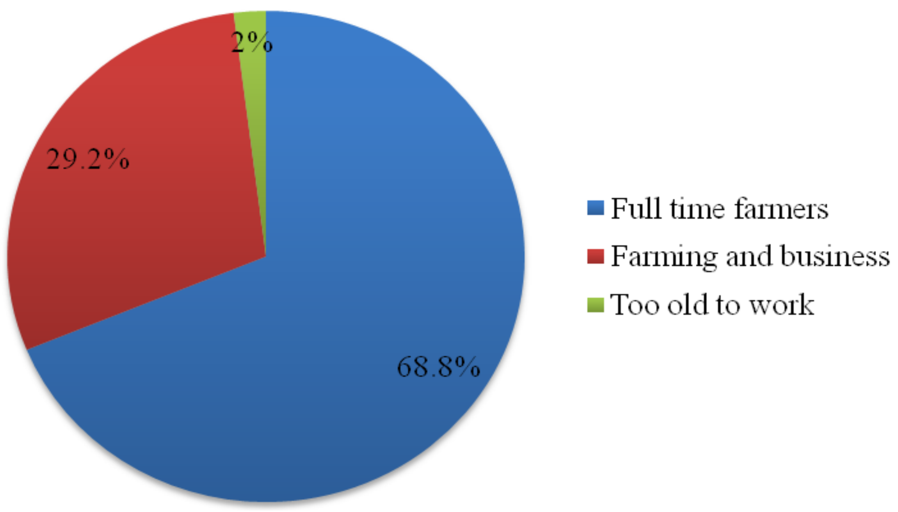

Figure 6: Respondents economic activities

The research found that, total area of respondent was 495.75 acres for farming, of which the larger parts (95%) of the farm are cultivated and owned by farmers and the remaining (5%) are both owned and rented by farmers. The farm sizes range from 0.50 acres to 15 acres, with the average mean land area of 3.1 acres. About 64.4% of the respondents have land shortage problem, this further indicate that, there is insufficient farming land to feed families with regards to household size in the District.

4.1.2 Characteristics of farmland and nature of land degradation

The characteristics of farmland position are among the factors that affect land use type and nature of land degradation in a particular area. In connection to this, the slope of farmland characteristics of the sample household heads was considered. The research findings show that 85 (52.8%) of the respondent cultivate in the middle slope, 38 (23.6%) upper slope, 19 (12%) valley bottom, 17 (10.7%) plateau flat and only 1 (0.9%) river bank as shown in the Fig. 7. This suggests that, land management should not be an option since more than half of the habitats are on sloping farming areas.

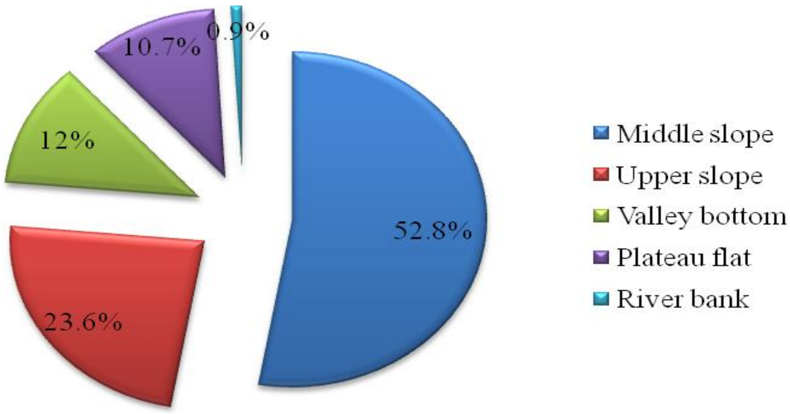

Figure 7: Nature of farmland arrangements use in Lushoto District

Out of 160 research sample, about 99 (61.9%) of the respondents indicated that soil erosion is still a problem to their farmlands. In view to this, 80 (50.0%) and 93 (58.1%) of the respondents, confirmed both decreasing of soil fertility and yield status to their farmland, respectively. Worth noting here, sustainable land management is still a problem and an urgent help is needed to resolve the problem of these farmers.

Despite the above facts, only 41 (25.6%) of the respondents see soil erosion is of very much concern. Worth noting here is the fact that there is still low understating of farmers on soil erosion. This further suggests that, extension officers have to play more of their roles on land management education to farmers.

4.1.3 General households' problems

Regarding the problems faced by households in their farming activities, respondents were asked different problems based on three magnitude criteria. That is not a problem, somewhat a problem and a serious problem. Table 3 below summarizes frequencies and percentages of the third criteria (a serious problem).

Table 3: Problems households face

Problem	Frequency	Percent
High price of fungicides	126	78.8
High price of fertilizer	123	76.9
High price of improved seed	123	76.9
Lack of money to hire farm equipments	105	65.6
Low productivity	105	65.6
Land shortage	103	64.4
Low price of produce	100	62.5
Pest and diseases attack	100	62.5
Insufficient rain	100	62.5
Lack of farm equipment e.g. tractors	87	54.4
Shortage of fertilizer	86	53.8
Pesticide/fungicide shortage	84	52.5
Shortage of improved seeds	68	42.5
Labor constraints	67	41.9
Inadequate transport	61	38.1
Soil erosion	51	31.9

4.2 Factors Affecting Adoption of Sustainable Land Management Technologies in the Study Area

The predictor variables were age of the household head, sex of the household head, total number of household members, total farm size in acres, contact with extension officer, access to credits, member of farming group, ownership of the farm, household head education and the average household income per year. Only average household income per year, total number of household members and total household farm size were found significantly predictors (Table 4).

Table 4: The binary logistic regression for factors that affect the extent of adoption of sustainable land management

Assumed Regressor variables	B	Wald	Sig.	Exp(B)	95.0% C.I. for EXP(B)	
					Lower	Upper
Total number of Household members **	.538	4.804	.028	1.713	1.059	2.771
Farm total size **	.523	5.060	.024	1.687	1.070	2.660
Average Income per year ***	.008	17.875	.000	1.000	1.000	1.000
Contact with Extensions	.873	1.459	.227	2.395	.580	9.882
Member of farming group	-.725	.692	.405	.484	.088	2.671
Age of the household head	-.044	1.340	.247	.957	.889	1.031
Sex of the household head	-.208	.024	.877	.812	.058	11.456
Household primary education status	.274	.006	.938	1.315	.001	1.303E3
Household secondary education status	2.044	.175	.676	7.718	.001	1.119E5
Land ownership (Owned)	1.068	.297	.586	2.910	.063	135.474
Land ownership (Rented)	2.105	.738	.390	8.205	.067	997.765
Access to credit	-19.827	.000	.999	.000	.000	.
Constant	10.027	.000	1.000	2.264E4		

Note: *** indicates significant at 1%, ** indicates significant at 5%

Total number of household members was assumed to have positive relationship (predicting adoption) with adoption of sustainable land management. That is, the more the number of members, the more the availability of household laborers. This relaxes labor constraints needed for land conservation and gives more chances for farm labor division. Hence, readily to accept any adoption technologies offered to them like sustainable land conservation managements. Consistent with this expectation, binary logistic regression showed total number of household members has a positive predictive power in explaining factors affecting adoption of sustainable land management. A unit increase of number of household members was found to have increased odds of adoption of sustainable land management by a factor of 0.538 and the result is statistically significant ($p<0.05$) (Table 4). Similar results were observed in southern Ethiopia by Mushir *et al.* (2012), that households with larger family size maintain conservation structures of land management than their counterparts, this is due to availability of laborers.

Total household farm size was assumed to have a positive relationship with adoption of sustainable land management. The assumption was that, farmers with larger farm sizes are expected to practice better land management practices. This can be due to input technologies and the nature of land conservation involved because land conservation requires space or large land holding. Consistent with this expectation, binary logistic regression showed total household farm size has a positive predictive power in explaining factors affecting adoption of sustainable land management. That is, a unit increase of farm size increases the odds of extent of adoption of sustainable land management by a factor of 0.523 and the result is statistically significant ($p<0.05$) (Table 4). Different studies conducted in Ethiopia by (Wegayehu *et al.*, 2003; Mushir *et al.*, 2012) found that, farmers who possess small farms or less than 1 ha are less likely to invest in soil conservation practices. This may be due to the fact that conservation structures occupy part of the scarce farming lands, therefore farmers with smaller farm size cannot construct and maintain conservation structures compared to those with relatively larger farm size.

Total average income per year was assumed to have positive relationship with adoption of sustainable land management. The assumption was that, as income increases, more of the farmland will be conserved i.e. the construction of terraces, cut-offs, integrated agroforestry and diversified cropping systems. As these demand more labor force (that has to be paid) to make them done. However, with this expectation, binary logistic regression showed total average household income has a positive predictive power in explaining factors affecting adoption of sustainable land management. That is, a unit increase of total average household income per year increases the odds of adoption of sustainable land management by a factor of 0.008 and the result is statistically significant ($p<0.001$) (Table 4). Similar results observed in Vihiga Western Kenya by Waithaka *et al.* (2007) found that increase in household income increases the adoption of sustainable land management.

Age of the household head was found insignificant and with negative relationship with the adoption of sustainable land management. This is inconsistence with the study done in Ethiopia by Aklilu (2006), found that the age of farmer has positive and significant influence on adoption of the land management practices. However, the negative relationship between household head age and the adoption of SLM practices can be due to fact that as age increases the activeness of an individual participation to adoption decreases.

In the analysis, male sex was coded 1 and for female sex coded 0. Male headed households being a reference group, sex of the household head was found insignificant and with negative relationship with the adoption of SLM practices. This is inconsistence with the study done in Ethiopia by Mberengwa (2012), found that sex of household head being significant and had a positive relationship with the land management practices. The negative relationship of being male and the adoption of SLM practices, could be explained by the fact that most male are bread winners in their family so they are highly participating in their non-farm activities in order to raise household incomes.

This tendency makes male more mobile and hence they have less time in participation in adoption of SLM practices.

Access to credit was found insignificant but with negative relationship with adoption of SLM practices. This is consistence with the study done in Ethiopia by Mberengwa (2012). The observed negative relationship could be due to the fact that, those who are likely to access credits are more likely in doing business than farming activities, unlike those who are unable to access credits they mainly depend on farming as their main livelihood option and hence more likely to adopt SLM practices.

Total number of household members was found insignificant but positive relationship with adoption of SLM practices. This is consistence with the study done in Ethiopia by Mberengwa (2012). It was expected that households with relative larger household sizes to adopt SLM since it has larger number of labour force of which part of it can be used in SLM activities. Contrary to this expectation in the study area, the large family size was associating with higher dependency ration. Hence the higher labour force in the family used to feed the dependants that leads to insignificance on adoption of SLM practices.

Contact with extension services was found with positive relationship with adoption of SLM practices. This is consistence with the study done in Ethiopia by Mberengwa (2012) but not significant, this could be due to the fact that most of extension officers in the study area are from government and they mostly based on extension services such as seed selection, spacing in planting and fertilizer uses but not on SLM practices. This further offers opportunity for project(s) based on land management should come with their owned extension officer(s) who are skilled with well background on land management practices that could easily disseminate these SLM practices to farmers.

Education of the household head was found insignificant but positive related to adoption of SLM practices. It was expected that education helps to enlighten people on the importance land conservation practices. However, the insignificancy relationship between education and adoption of SLM practices could be explained by the fact that land conservation education packages are yet covered in both primary and secondary curriculum.

Member of farming group was found insignificant but with negative relationship with adoption of SLM practices. It was expected that, farmers who are in a group could better practice SLM than those who are not in a group because the former can share and disseminate SLM knowledge to each other easily unlike those who are not in a group. The insignificance relationship between farming groups and adoption of SLM practices can be explained by the fact that, many of the existed farmer group in the study area are addressing other issues such as credits, social assistance like burials ceremonies, marriages etc other than SLM practices hence the increase of farming groups leads to insignificance on adoption of SLM practices.

In assessing the goodness-of-fit, Cox & Snell R Square and Nagelkerke R Square were both used to check the model fit. Nagelkerke's measure gives us a higher value (0.840) than does Cox and Snell's (0.624) as we would expect (by definition). Thus it indicates the model fit is good for our data as shown in Appendix 3.

4.3 Effect of Adoption of Sustainable Land Management Technology on the Household's Food Security in the Study Area

The response variable that predicts the presence or absence of characteristics or outcomes based on the value of a set of predictors or independent variables were farmland ownership, education of the household, age of the household head, total number of members in the household, household average income per year, and sustainable land management adopters versus non-adopters as these were assumed to be potential determinants of household food security. Farmland ownership, household head age, household average income per year, and sustainable land management non-adopters were found significantly predictor variables for household dietary diversity (Table 5).

Table 5: Multiple linear regression for household dietary diversity

Assumed Independent Variables	Standardized Coefficients Beta	t	Sig.	95% Confidence Interval for B	
				Lower Bound	Upper Bound
(Constant)		17.427	.000	5.809	7.294
Dummy sustainable land management non-adopter ***	-.887	-26.311	.000	-4.014	-3.453
Household head age **	.061	2.368	.019	.002	.019
Household Head Education level	-.004	-.167	.867	-.386	.326
Average income per year from farming activities **	.065	2.165	.032	.000	.000
Total number of members in the household	.050	1.662	.099	-.007	.079
Farmer land ownership **	.058	2.285	.024	.039	.542

Note: *** indicates significant at 1%, ** indicates significant at 5%.

It was earlier noted that, non-adopter has nothing to do with any negative connotations. Sustainable land management adopter versus non-adopter was the first considered as independent variable. It was expected that adopter to have significant positive influence on household dietary diversity due to its impact in raising level of farmers' produces, and the reverse for non-adopters. Consistent with this expectation, multiple linear regression showed sustainable land management non-adopter had a predictive power in explaining household dietary diversity. Farmers who have not adopted sustainable land management (non-adopters) have much higher chances for reducing their household dietary diversity. It indicates that a unit increase of non-adopters leads to a decrease of household dietary diversity by a factor of 0.887. This result is statistically highly significant ($p<0.001$) (Table 5).

Household head is an important person for decision making in the household**,** the age of head of household was assumed to have a positive relationship with food security. That is, as the age of the household head increase, increases the farming experiences and land holding (increases owned farmlands). This gives higher chances for the farmer to test different adoption technologies offered. Consistent with this expectation, multiple linear regression showed that age of the household head have a predictive power in explaining household dietary diversity. Households with higher household head age have many chances for increasing dietary diversity. It suggests that, a unit increase of household head age increases dietary diversity by a factor of 0.061. This result is statistically significant ($p<0.05$) (Table 5). The finding of positive association between household head age and household dietary diversity is consistent with initial assumption and it is also similar to findings by Zezza *et al.* (2008) observed that age of head of respondent in developing countries associate positively with household dietary diversity.

Average household income per year was assumed to have positive relationship with household dietary diversity. That is, as the income rises, it increases more chances for household to secure more food and hence household dietary diversity. Consistent with this expectation, multiple linear regression showed that average household income per year have a predictive power in explaining household dietary diversity. It indicates that, a unit increase of household average income per year increases household dietary diversity by a factor of 0.065. This result is statistically highly significant ($p<0.01$) (Table 5). The result of positive association household average income and dietary diversity is consistent with initial assumption and it is also similar to the findings in Pakistan by Khalid *et al.* (2012) who observed that household income associate positively with the household food security.

Farmland ownership was assumed to have positive relationship with household food security. That is, the bigger the size of farm household possess the more likely to produce differently crop types hence increases household dietary diversity. Consistent with this expectation, multiple linear regression showed that farmland ownership have a predictive power in explaining household dietary diversity. It suggests that, a unit (acre) increase of farmland household ownership increases household dietary diversity by a factor of 0.058. This finding is statistically significant ($p<0.05$) (Table 5). Similar findings in Kenya observed by Kassie *et al*. (2012) found that an increase in farm size holdings reduces vulnerability to food insecurity. This is possibly because farmers who have large farm sizes tend to have different plots with different crop varieties of which some tends to be diseases resistant crops and other drought resistant crops, hence ensured harvests that lead to food secured.

On assessing the analysis of variance (ANOVA), the regression sum of square found much greater than the residual sum of square, which indicates that more than half of the variation in household dietary diversity was explained by the model. The significance value of the F statistic is less than 0.05, which means that the variation explained by the model is not due to chance as shown in Appendix 4. The goodness-of-fit statistics (R and R^2) were also used, the multiple correlation coefficients (R) was found to be large (0.95), it indicating a strong relationship. In addition, the coefficient of determination (R^2) was found large (0.900), worth noting here, about 90% of the variation in household dietary diversity was explained by the model. This means that, the variables added are the good predictor of the dependent variable (Appendix 5).

On assessing multicollinearity, the tolerance (i.e. is the percentage of the variance in a given predictor that cannot be explained by the other predictors) was found to be 55.2% to 96.0%. Thus the small tolerance shows that only 4% to 44.8% of the variance in a given predictor can be explained by the other predictors. However, when the tolerances are close to 0, there is high multicollinearity and the standard error of the regression coefficients will be inflated. A variance inflation factor (VIF) greater than 2 is usually considered problematic, and the largest VIF was found 1.811 as shown in Appendix 6.

Thus, the collinearity diagnostics confirmed that there were no problems with multicollinearity. Since several eigenvalues are not close to 0, suggesting that the predictors were not intercorrelated. But also, the condition indices were computed as the square roots of the ratios of the largest eigenvalue to each successive eigenvalue. Values greater than 15 indicate a possible problem with collinearity; greater than 30, a serious problem. However, neither of the values were above 30 nor 15. This means, no problem with collinearity as shown in Appendix 7.

4.4 Effect of Adoption of Sustainable Land Management Technology on the Income in the Study Area

Regarding the income of adopters versus non-adopters, the mean incomes of the two groups were calculated. A total of 93 and 67 with mean income of 244 516 Tshs and 977 910 Tshs per year were non-adopters and adopters respectively. The computed independent T-test for the mean difference was statistically highly significance at t= 8.194 (p<0.001) (Table 6).

This suggests that households who have adopted sustainable land management practices are in better-off position to improve their livelihood than those who have not adopted. As the former can diversify and be able to afford SLM practices expenses, expensive synthetic fertilizers, improved seeds, keeping livestock and thus uphold their livelihood sustainable. This agrees with Parwada *et al.* (2010) as observed the adoption of sustainable land management technologies offer opportunities of improving the quality of the resource poor farmers.

Table 6: Effect of adoption of Sustainable Land Management technology on the income in the study area

Group category	Group mean income	Sig	t
Adopters	977,910	0.000	8.194
Non-adopters	244,516		

4.5 Option for Improvement of sustainable land management practices.

Respondents were asked on how spread and practised are SLM to their community, research findings show that, the majority 68 (42.5%) said that they are spread and practised but not that much that is some more efforts are needed, 49 (30.6%) said they are poorly spread and practised, 22 (13.8%) said they are not spread and practised at all while only 21(13.1%) said that they are very well spread and practised (evenly distributed). Worth noting here is, about half of the respondents suggest there are low practices of SLM and there is a needed strategic effort for making it being practised in study area. In addition, concerning land management practices, research findings show that, the majority 93 (45.8%) do not use any of the sustainable land practices, 70 (34.5%) use diversified cropping systems (strip cropping and mixed intercropping), 26 (12.8%) use cropping system and soil erosion control structures (contour farming, terracing and grass barriers) and only 14 (6.9%) use integrated agro-forestry practices (combining trees and shrubs with crops and/or livestock) as shown in figure 8.

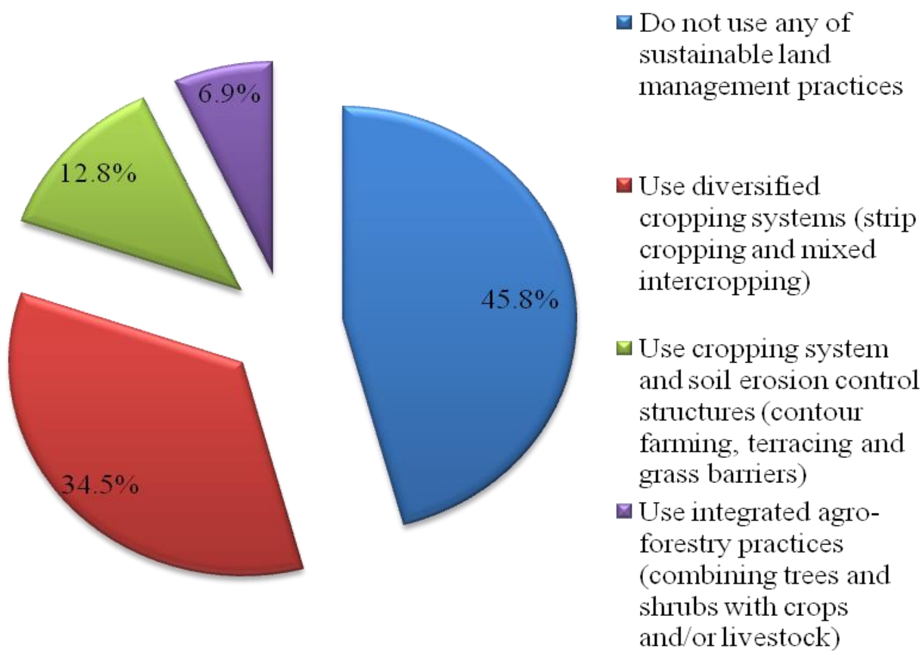

Figure 8: Land use and management practices in Lushoto District

Furthermore, access to information/skills on land management practices, research findings found that, 25 (15.6%) get through individual one to one (only one extension agent and the farmer), 86 (53.8%) through village meeting, 17(10.6%) through using mass media (e.g. radio, flyers, TV, magazines, books, journals, etc.), 28 (17.5%) from other farmers and only 4 (2.5%) get through farm field (Demonstrations plots) as shown in Fig, 9. Worth noting here, the farm field (Demonstrations plots) is of great importance to impact not only skills but also motivational spirit on adopting a practice offered, as it offers opportunities for sustainable learning venue to farmers (be it individual farmer or farmer-groups/association) to observe the proper soil management, crop growth and yield impact and hence impact strong basis for practice. Surprisingly, it is the one given very low priority.

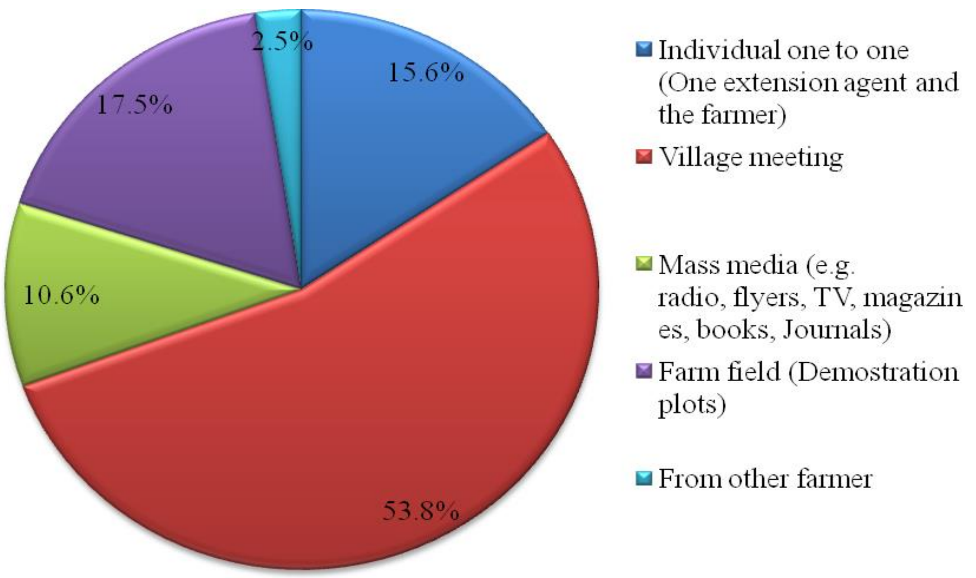

Figure 9: Sustainable land management practices/skills dissemination to farmers in Lushoto District

However, about 144 (90.0%) do not practise crop rotation in their farmland(s) as the mechanism for soil to gain its fertility. A focus group discussion revealed that, an increased population has made this happening. Its further suggests that, it’s among other sources for soil losing its fertility. Since farmers do cultivate three to four times a year, with very little replacement of organic manure due to shortage of grazing land. The majority 143 (89.4%) are practising zero grazing with few livestock that cannot sustain enough supply of manure to their farmland(s).

Furthermore, about 123 (76.9%) are faced by serious problem of high prices of fertilizer. Worth noting here, there is still a high need for managing soil fertility in the district. Focus group discussion revealed that, despite 15.6% get information of SLM practices through individual one to one (one extension agent and the farmer) but many of these extension officers have lower skills and in mostly cases they are not available. However, limited availability of extension officers with poor regular follow-ups, fewer motivational actions, few farmer groups/associations, limited and poor demonstration plots were pointed out as the core sources for the low adoption.

However, as an option for improvement, there is great need for, first, to increase the number of extension officers with respect to proper provision of education to them. Research finding shows that, about 132 (82.5%) of farmers do not contact extension officers for extension services and only 28 (17.5%) do contact extension officers, this fact calls for more of their availability.

Second, there should be a deliberate strategic efforts to construct demonstration plots as they build a strong basis for adoption (seeing is believing). As we can see from Fig. 9 that only 2.5% get SLM education practices through it, despite its vital impact role on disseminating the knowledge practices.

Third, there should be a reformation either from the previous or formation of new farmer-groups /associations, as they will give them vital power to address their concerns but also it's easy to get a help/assistance in group than in individually. The research findings show that, 143 (89.4%) are not member in any farmer group/association and only 17 (10.6%) are members in farmer group/associations. Worth noting here is, when farmers are not strong, many segment of the society are ready not only to tell the farmers what they should do, but even worse, to speak on their behalf, which in many times have been not their true concerns, so farmers' voice and their concerns cannot be obtained without farmers' groups/associations and hence easy to catch-up even on SLM adoption. Hence, to dissolve these problems, formation or reformation of farmers' group/associations is of great important.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDETIONS

5.1 Conclusions

The overall objective of the study was to revisit adoption of sustainable land management technology practices and to assess their impact on community livelihood in West Usambara Mountains. By using a binary logistic regression, multiple linear regression, household dietary diversity and independent T-test statistics, the study found that, we have enough evidence at t= 8.194 ($p<0.001$) to reject null hypothesis one (H_{o1}) which states that; the use of offered SLM technologies will not add considerably towards household's income. Additionally, we also have enough evidence at t=-30.25 ($p<0.001$) to reject null hypothesis two (H_{o2}) which states that; the use of offered SLM technologies will not contribute significantly to household's food security.

The study concludes that, both adoption and practicing of sustainable land management (SLM) should be fundamental for sustainable community livelihood. As they both significantly withstand the upgrading of community livelihood.

Additionally, households' farm total size, average household income per year and total number of household members were found significantly factors influencing adoption for sustainable land management. Conversely, sustainable land management non-adopters were found significantly deteriorating household food security while household farmland ownership, household head age and average household income per year were found significantly factors for improving household food security. With regards to average income for adopters versus non-adopters, they were found statistically significant different. That is adopters have higher significant incomes than non-adopters.

5.2 Recommendations

Sustainable land management practices are of great important for their significant positive impacts to our daily life. This has been observed from economic analysis and findings of this study. These results have important policy implications to recommend.

First, for sustainable land management non-adopters, despite the fact that sustainable land management is multifaceted and seems to require formal knowledge or at least guidance from extension providers to farmers, this call for quality extension staff. For this reason, government and policy makers should focus on improving skill of extension staff in-line with increasing their number and their availability for well-organized and useful dissemination of technologies, and hence a trickle-down effect to farmers. Such practices may have a significant impact for reducing the number of sustainable land management non-adopters, and for this reason farmers might have a considerable produces that could further reduce the burden for low incomes from their sells produce.

Second, there should be deliberate strategic efforts to construct SLM practices demonstration plots (demo plots). One of the most important tasks of extension officers is disseminating useful and practical information. The best way to do this is through well-planned and carefully-conducted demonstrations. Demo plots serve as one of the most effective extension education tools ever developed. Although complete demo plots require considerable time and effort, their impacts are much more worth considered. However, those farmers who observe demo plots on the latest techniques or practices and then apply to their own particular plot(s) become our present and future extension leaders. As we have earlier seen that shortages of demo plots have been pointed as one of the drawback for SLM adoption, it will be of great advantages now to put them into use.

Third, there should be either formation or reformation of farmers-group/associations. Shortage and dormant farmer-group/associations was among drawbacks of SLM practices adoption. As seen earlier, majority of the farmers are not in farmer-group despite many advantages for a farmer being in a group(s). Such advantages are: a help to lower the delivery costs of government, NGOs and private-sector agencies supplying development services to small farmer groups, as well as help allied groups in reducing their individual cost of accessing those services and sharing input purchasing, production, processing and marketing costs. But the most important is having a common voice that can be heard easily and quickly at a proper place, and likewise quick response and most appropriate would possibly be at their hands.

Fourth, for household income, even though modest can be done with respect to market improvements, policy interventions could improve road quality and traffic through improving existing road networks, maintaining existing ones and initiating farmers' group markets. Such investments are likely to have a positive impact on market integration, productivity and the bargaining power that will ultimately increases the household income that will stimulate adoption. But again, there should be a low income methods designed for land conservations, this will act as a backup mechanism for those low income farmers to adopt land conservation methods.

Fifth, for farmland ownership, although expansion of land is not feasible due to high population pressure that leads to land scarcity in west Usambara Mountains, policy makers and government should focus the following strategies; land ownership, intensification and diversification of high-value crops and livestock along with increasing off-farm income. Knowledge options for smaller farms could include increasing the quality of manure, composting plant materials and crop waste, increasing use of dung and crop residues, and application of fertilizers. For larger farms, potential of increasing land under fallow improvement are needed to take full advantage of returns to land. These will be of great help for households to escape from food insecurity and consequently ensures sustainable community livelihood. As it was seen, farmers who rent land for farming take little or no responsibility at all to conserve the rented land.

Sixth, there should be strategic plans of flowering plant (such as fruits trees) and bee keeping along farmers' farms. These will both serve as land conservation and income generating activity. These flowering trees are of long term periods unlike trees for timber of which after some time are to be harvested.

Seventh, there should be a low labour intensive method(s) designed for land conservations. This will be useful for adoption by those households with fewer people and hence increase land conservation for sustainable land uses.

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APPENDICES

Appendix 1: Questionnaire for Farm Household

A. General Information

Enumerator’s name……………………………………………..
Date... Region.............................. District.......................
Village name.............................. Ward................................ Division......................
Respondent’s name …………………………………..

B. Household Size and Characteristics

Household head marital status; 0=single, 1=married,2=divorced,3=widow (cycle one).

Description	**Name**	**Education***	**Sex****	**Age**	**Main activity***
Household head					
Spouse 1 2 3 4					
Children at home 1 2 3 4 5 6 7					
Relatives at home 1 2 3					
Children away from home 1 2 3 4					
Employees at home 1 2 3 4					
Others at home 1 2 3 4					

Key;
*** Main of activity:**
1= Full time farming; 2=School children; 3=too old to work; 4=young childrens;
5=Business;6=Emplyed Govt/NGO; 7=Farming/business; 8= Out migrated/Married but brings remittance to the household; 9= Out migrated but don’t bring remittance
**** Sex ;** 1=Male; 2=Female
*****Education ;** 0=no primary education, 1=primary, 2=secondary, 3=post secondary 4=others (specify)

C. Household Assets

Please provide the information(s) of the household asserts on the table below

How many Plots do you have?	Size in acre	Land Ownership*	Location (how far from home in km or hrs)	Crops/fruits/vegetab les grown	Type of SLM practices**	Plot position***	Plot status****	Amount paid in cash for land if rented yearly (Tshs)	Amount paid in produce for land if rented yearly (bags)	How long have you been practising SLM (give in years/ months)
1										
2										
3										
4										
5										
6										

Key;
*** Land Ownership**
1=By inheritance; 2=Bought; 3=Village offer; 4=Rented; 5=Clear natural forest
6 =Others (specify)...

**** Type of SLM practices**
1. Diversified cropping systems (strip cropping and mixed intercropping),
2. Integrated agro-forestry practices (combining trees and shrubs with crops and/or livestock),
3. Cropping system and Soil erosion control structures (contour farming, terracing and grass barriers)
4. Others (specify)...
5. No any SLM practices

*****Plot position**
1=plateau flat; 2=upper slope; 3=mid slope; 4=River bank; 5=periodic swamp; 6=valley bottom (Dambo);
7=others specify..

******Plot status** 1=increasing yield, 2=degreasing yield, 3=no change,
4=others (Specify)………………………………………………………….........................

D. Household Production and production costs

Please provide information(s) of the household production and production costs last season 2010/2011 in the table below

Plot number	Actual production (in kg/bags)	Land preparation costs (tshs)	Seed costs (tshs)	Planting and Weeding costs (tshs)	Agrochemical application costs (tshs)	Harvesting costs (tshs)	Transportation costs (tshs)	Other costs (specify)
1								
2								
3								
4								
5								
6								

i. In a week, how many days do you involve yourself for farming activities

…………………………………………………………………………………………

ii. Indicate your daily time allocation (hours) during farming and off-season

Activity	Farming season*	Off-season**
Farm work	..…………….……..	………………….
Non-farm (off-farm)	………….……..	………………….
Household activities	………..…….	………………….
Rest (including sleeping time)	……...................	…………………

Note * November - May **** June – October**

E. Household Food Security

i. Rank the sources of food in your household in order of importance

(1=Most important, 2=important, 3= normal (not that important), 4=not important at all)

Source of Food	**Rank**
Own farm	
Purchase	
Given by neighbours/friends/relatives	
Government	
Others (specify)	

ii. On average, how many months in a year, your household is able to adequately feed itself?..(Number of months)

iii. Are you able to feed yourself from? (cycle one)

1=own produced food, 2=own produced and purchases, 3=Others (Specify)

iv. On average, how many meals per day can your household provide to its members?

....(Number of meals)

v. What food items do you consider to be luxury or of high value?

………

vi. How often do you consume these high value foods per week? (cycle one)

1=Very often, 2=Often, 3= Rarely, 4. Not at all

vii. Compared to the past, has the food security situation improved, remained the same or decrease since you started crops/fruits/vegetable cultivation? (cycle one)

1=Increased, 2=Remained the same, 3=Decreased

viii. Now I would like to ask you about the types of foods that you or anyone else in your household ate last week during the day and at night.

	Questions	**Coding Categories**
A	Any bread, rice noodles, biscuits, or any other foods made from millet, sorghum, maize, rice, wheat, or [E.G. UGALI]?	A...|___|
B	Any potatoes, yams, manioc, cassava or any other foods made from roots or tubers?	B...|___|
C	Any vegetables?	C...|___|
D	Any fruits?	D...|___|
E	Any beef, pork, lamb, goat, rabbit wild game, chicken, duck, or other birds, liver, kidney, heart, or other organ meats?	E ....|___|
F	Any eggs?	F...|___|
G	Any fresh or dried fish or shellfish?	G...|___|
H	Any foods made from beans, peas, lentils, or nuts?	H...|___|
I	Any cheese, yogurt, milk or other milk products?	I ....|___|
J	Any foods made with oil, fat, or butter?	J ....|___|
K	Any sugar or honey?	K...|___|
L	Any other foods, such as condiments, coffee, tea?	L ....|___|

ix. What portion of your produce do you use for your own consumption?

……………………………………………………………………………………

x. How much in a year do you save for home consumption/food? (give it in Tshs or number of bags)

....

F. Household Income

i. On average, how much income (Tshs) did you get from crops/fruits/vegetable cultivation last year (2010/2011)?

....

Note; if given in number of bags (i.e. not sold yet) then how much it could be in Tshs.

ii. On average how much income (in Tshs) from last three years did you get for your crops/fruits/vegetable cultivation? (cycle one)

1=50,000---100,000, 2=150,000---200,000, 3=250,000---300,000, 4=350,000---400,000, 5=450,000---500,000, 6=550,000 and above, 7=other (specify)

iii. What is the average selling price of your farm produce(s) (give it in price per kg or per bag)

………………………………………………………………………………………

Would you say your household income has increased, remained more or less the same or decreased after getting involved in crops/fruits cultivation (cycle one)

1=Increased, 2=Remained more or less the same (No change), 3=Decreased

iv. What are other sources of income apart from crop/fruits/vegetable cultivation?

	Source of Income	**Amount earned per month (Tshs)**
1	Salaried employment	
2	Business (Gross income- costs)	
3	livestock farming	
4	Selling charcoal/fire wood	
5	Transfer payments	
6	Other sources	
	Total	

v. Please indicate household assets (and their value) which were purchased using income obtained from crop/fruits/vegetable cultivation

Type of Assets	**Number**	**Value**
Physical e.g. land, livestock, new house construction or rehabilitation of old house etc		
Land		
New house constructed (Indicate stage of new house)		
Rehabilitation of old house		
Livestock purchase		
Equipment and tools acquired e.g. ox-carts, TV, radio, mobile phone, plough, hand hoe etc		

vi. Please indicate amount of income from crop/fruits/vegetable cultivation used for education

Item	**Number of Children**	**Cost**
Fees		
Books and stationery		
Others (specify)		

G. Sustainable Land Management (SLM) Practises and general scale measurement

This part intends to probe on farmers' behaviour, attitude or perception on issues related to production, Sustainable Land Management (land degradation and conservation). The scale ranks from 1, if you fully disagree with the statement and 5 if you strongly agree with.

Fully disagree **Strongly agree**

1 2 3 4 5

i. I intercropping to avoid total failure due to drought or pest attack \------\ \------\ \ -----\ \ -----\ \------\

ii. I plant before rains because I get higher yield \------\ \------\ \ -----\ \ -----\ \------\

iii. Rainfall is too low for most crops \------\ \------\ \ -----\ \ -----\ \------\

iv. I get low yield because of lack of industrial inputs \------\ \------\ \ -----\ \ -----\ \------\

v. I intercrop because I get more total yield than with monocropping \------\ \------\ \ -----\ \ -----\ \------\

vi. I get low yield because of low soil fertility \------\ \------\ \ -----\ \ -----\ \------\

vii. In case of crop failure we usually depending on inter-house transfers (gift in cash or kind) \------\ \------\ \ -----\ \ -----\ \------\

viii. In case of crop failure we buy food from cash generated from off-farm activities \------\ \------\ \ -----\ \ -----\ \------\

ix. In case of crop failure sale of fixed and movable assets to buy food \------\ \-----\ \ -----\ \ -----\ \------\

x. Wind has become more stronger in recent years \------\ \------\ \ -----\ \ -----\ \------\

xi. In recent years rainfall has become more irregular in space and time \------\ \------\ \ -----\ \ -----\ \------\

xii. Surface soil has become hard than before \------\ \------\ \ -----\ \ -----\ \------\

xiii. The fallow (unplanted/unused/uncultivated) period has decreased in recent years \------\ \------\ \ -----\ \ -----\ \------\

xiv. Erosion is caused by high rainfall intensity \------\ \------\ \ -----\ \ -----\ \------\

xv. Erosion is caused by too long dry spell \------\ \------\ \ -----\ \ -----\ \------\

xvi. Erosion is caused by poor agricultural practices \------\ \------\ \ -----\ \ -----\ \------\

xvii. Erosion is caused by grazing animals \------\ \------\ \ -----\ \ -----\ \------\

xviii. Erosion is influenced by shifting cultivation \------\ \------\ \ -----\ \ -----\ \------\

xix. Erosion is influenced by lack of knowledge on soil conservation \------\ \------\ \ -----\ \ -----\ \------\

xx. Soil erosion is a natural phenomenon \------\ \------\ \ -----\ \ -----\ \------\

xxi. Is soil erosion a problem to any of your plots (YES/NO) _______ \

xxii. Would soil loss in any of your farms be of very much concern, moderate concern, or no concern to you? (cycle one)

1=Very much concern, 2=Moderate concern, 3=Minor concern

xxiii. Explain why you feel so

....

....

xxiv. Most of farmers here in Tanzania are experiencing problems on sustainable land management particularly in soil and water. Please would you tell me whether or not you experience each of the following problems and how serious is each of them to you

					Plot number					
Problem	Have it	Do not have it	Major problem	Minor problem	1	2	3	4	5	6
Presence of gullies and rills due to water erosion	1	2	3	4						
Rain wasting away top soil	1	2	3	4						
Wind blowing away top soil	1	2	3	4						
Decreasing yield from your farm	1	2	3	4						
Decreasing soil fertility from your farm	1	2	3	4						

xxv. How much is each of the following a problem to your household (put a tick ‘√’)

	Magnitude of problem		
Problem	Not a problem	Some what a problem	A serious problem
Insufficient rain			
Pest and diseases attack			
Land shortage			
Soil erosion			
Infertile soil			
Low price of produce			
Inadequate transport			
Lack of farm equipment e.g. tractors			
Shortage of fertilizer			
Pesticide/fungicide shortage			
Shortage of improved seeds			
Labour constraints			
High price of fertilizer			
High price of improved seed			
High price fungicides			
Low productivity			
Lack of money to hire farm equipments			

xxvi. Do you do any of the following to solve some of the soil and water problems that you experience

(Put a tick '√')

PRACTICES	Yes	No
Planting more crops in annual ridges		
Planting more crops in permanent ridges		
Leave crop residue on ground after harvesting		
Plant trees on areas with gullies		
Increase use of manure		
Increase use of commercial fertilizer		
Mulching		
Abandoning the field and look for another somewhere else		
Practice zero grazing		

xxvii. Based on your experiences, Have your farming activities improved your community's livelihood (that is Poverty reduced, Well-being and Capabilities improved, Livelihood adaptation, vulnerability and resilience enhanced, Natural resource base sustainability ensured)? (cycle one)

1=very well improved, 2=Improved, 3=Remained more or less the same (No change), 3=Decreased

xxviii. Explain why you feel so

....

....

xxix. What do you see as positive and that went particularly well in using sustainable land management on soil and water conservation to your community? (cycle one)

1=there are great improvements to both soil and water conservation, 2=there are Improvement but there should be some more efforts to make them better, 3=Remained more or less the same (No change), 3=Decreased (there is persistent dis-improvement to both soil and water conservation), 4=others (specify)

xxx. Explain why you feel so

....

....

xxxi. How spread and practised are SLM here in your community? (cycle one)

1=they are very well spread and practised (evenly distributed), 2= they are spread and practised but not that much (some more efforts are needed), 3= they are poorly spread and practised (unevenly distributed), 4= not spread and distributed at all

xxxii. Explain why you feel so

....

....

xxxiii. Based on your experiences here in lushoto, which villages do you think are well succeeded on sustainable land management practices? (name them)

…………………………………………………………………………………………

…………………………………………………………………………………………

xxxiv. Explain why you feel so

....

....

xxxv. Do you usually have contact(s) with an extension officer?

1=yes, 2=no

xxxvi. If yes, how many times did you have contact(s) last year (2010/2011)

……………………………………………………………………………………

xxxvii. If no, give reason(s)

……………………………………………………………………………………

....

xxxviii. Do you have access to credits for your farming? (cycle one)

1=yes, 0=no

xxxix. If yes, specify the source(s)

……………………………………………………………………………………

xl. If no, how do you run your farming?

……………………………………………………………………………………

xli. Are you a member of any farming group(s)? (cycle one)

1=yes, 0=no

xlii. If yes, specify the most two and their responsibilities

……………………………………………………………………………………

xliii. If no, give reason(s)

……………………………………………………………………………………

xliv. How are sustainable land management practises/skills disseminated to farmers in your community? (cycle one)

1=village meeting, 2= farm field, 3=individual one to one (only one extension agent and the farmer), 4= using mass media (e.g. radio,flyers,TV, magazines,books,journals,etc.), 5=others farmer, 6=others (specify)

xlv. Based on the above answer(s), how do you rank them? (Cycle one)

1=they are most effective (easy to adopt and spread), 2=effective, 3=normal, 4=ineffective, 5=most ineffective

xlvi. Explain why you feel so

....

xlvii. How do you rank their complexities (SLM technologies) for farm practises? (cycle one) 1=very simple, 2=simple, 3=normal, 4=complicated (there must be deliberate efforts to make them understood), 5=very complicated (they can't be understood)

xlviii. Explain why you feel so…………………………………………………………….

xlix. How do you rank the technology compatibility with your farming (in relation to farming costs that is farm preparations, planting, weeding and harvesting)? (cycle one)

1= very appropriate, 2=appropriate, 3=normal, 4=inappropriate, 5=very inappropriate

l. Explain why you feel so...

THANK YOU VERY MUCH FOR YOUR TIME AND CO-OPERATION

Appendix 2: Focus Group Discussion Guiding Questions

1. Name the wards that manage land well and those which do not with reference to;
   i. Weather conditions, such as intense rain events, flash floods, greater than or lower than average rainfall in recent years, etc.
   ii. How land productivity has changed in the recent past, e.g. the land used to produce larger and better crops, now with every rain event we lose more soil, the streams are full of soil after every rain, etc.
   iii. communal soil and water conservation measures to protect uplands and enhance production,
   iv. control of bush or grassland burning to safeguard vegetation cover and biodiversity,
   v. grazing management / control to allow restoration of pasture / range and improve livestock productivity
   vi. improved crop and / or livestock rotations and agronomic practices to restore soil fertility and crop and livestock productivity
   vii. control of settlement expansion to prevent loss of productive lands
   viii. crop expansion into fragile lands or loss of wetlands and their functions
   ix. control of irrigation and drainage to prevent over exploitation of limited water supply and reduce risk of salinity and increase productivity
2. Show a sketched map of those wards
3. What is the history and pattern of settlement in the area?
4. What are the main/important
   i. land use types differentiated by the community and
   ii. Water resources available and used by the community in the study area?

5. What are the main livelihood / production activities during the
    i) Rainy and
    ii) Dry seasons (include the main things people do for subsistence and to generate income)?
6. What are the main natural resources that the community uses for production /livelihoods? (e.g. cropland, grazing land, fuel wood, timber, medicinal plants, dry season water sources etc.).
7. What are the important types of land degradation in the territory?
8. For each distinct type:
    i. What do you consider are the main causes?
    ii. What are the main impacts?
9. What are the livestock management strategies and related problems in terms of degradation or related benefits in terms of sustainable land management?

    (Strategies could include, for example, range enclosures, rotational grazing, ranching, stall fed animals, seasonal livestock movements (agropastoralism), permanent livestock movements (nomadic pastoralism), cattle grazing corridors, as well as relevant byelaws (e.g. relating to the control of livestock numbers or burning etc.)
10. Are there any conflicts in relation to land and water uses in the area?
11. What are the main livelihood problems / difficulties (i.e. serious / long term); (less serious / short term) faced by rural households (food insecurity, poverty, access to resources, access to markets)?
12. Are there successful areas where land degradation control (i.e. conservation, restoration and or improvement of land resources) has been achieved?

13. What were the main sustainable land management (SLM) practices or measures (policies, legislation, bye-laws etc.) to prevent land degradation that were implemented in specific land use systems / types?
14. Were they aimed:
    - i) To improve or restore the productive capacity of the land (e.g. soil fertility, use of water); or
    - ii) For conservation / protection of resources (soil, water, vegetation, wildlife, biodiversity).

THANK YOU VERY MUCH FOR YOUR TIME AND CO-OPERATION

Appendix 3: The Goodness of Fit for Factors of Adoption of Sustainable Land Management

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
60.921[a]	.624	.840

Appendix 4: ANOVA[b] for household dietary diversity

	Sum of Squares	Df	Mean Square	F	Sig.
Regression	623.348	6	103.891	239.924	.000[a]
Residual	67.252	153	.433		
Total	689.600	159			

Whereby;

a. Predictors: (Constant), Dummy sustainable land management non-adopter, Household head age, Household Head Education level, Average income per year from farming activities, Total number of members in the household, Farmer land ownership

b. Dependent Variable: Number of food groups eaten last week

Appendix 5: The goodness-of-fit of the model for household dietary diversity

R	R Square
.950[a]	.900

Whereby;

a. Predictors: (Constant), Dummy sustainable land management non-adopter, Household head age, Household Head Education level, Average income per year from farming activities, Total number of members in the household, Farmer land ownership

Appendix 6: Collinearity Statistics[a] for assessing multicollinearity in regressor variables

Regressor variables	Tolerance	VIF
(Constant)		
Household Head Education level	.960	1.041
Household head age	.958	1.044
Total number of members in the household	.680	1.470
Average income per year from farming activities	.693	1.442
Farmer land ownership	.973	1.027
Dummy sustainable land management non-adopter	.552	1.811

a. Dependent Variable: Number of food groups eaten last week

Appendix 7: Collinearity diagnostics[a] to confirm multicollinearity in regressor Variables

Model	Dimension	Eigenvalue	Condition Index
1	1	5.592	1.000
	2	.843	2.576
	3	.250	4.733
	4	.143	6.254
	5	.082	8.253
	6	.075	8.651
	7	.015	14.093

a. Dependent Variable: Number of food groups eaten last week