Determinants of Soil Water Conservation and Nutrient Flow Management in Bufundi Sub- Catchment, Kabale District, Uganda

By

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Declaration

This thesis is my original work and has not been presented for a degree or any other award in any other university.

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Dedication

To my dear parents, Mr. Maseruka David and Mrs. Caroline Namuyiga, my brothers Dan Ssebakijje, Isaac Ssubi Kalagala, Eriya Maseruka and my sisters Nakasi Diana, Nakibuuka Phiona, Namulidwa Sanyu , Nakitende Lucy, Kabandole Joan, Kabandole Lillian and Kabandole Victoria, my grandfather George William Sempala Kaliisa, grandmother Sefoloza Nabakooza, aunts Nakanwagi Lucy, Nalwanga Margret, uncles, Kigula John Mary, Lubega Matia, Muwanga Herbert and the memories of my late aunt Annet Nambooze.

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Acronyms and abbreviations

AHI: African Highland Initiative

BNF: Biological Nitrogen Fixation

CGIAR: Consultative Group on International Agricultural Research

COL: Common Wealth of Learning

DAAD: German Academic Exchange Service

DST: Decision support Tool

EROAHI: Eco-Region of African Highland Initiative

ESWC: Erosion Soil and Water Conservation Group

FARA: Forum for Agricultural Research in Africa

FGD: Focus Group Discussion

GDP: Gross Domestic Product

GIZ: German International Cooperation

IP: Innovation Platform

ISFM: Integrated Soil Fertility Management

ISWM: Integrated Soil and Water Management

IWM: Integrated Watershed Management

IWMNET: Integrated Watershed Management Network

KAZARDI: Kabale Zonal Agricultural Research Institute

LKPLS: Lake Kivu Pilot Learning Site

NAADS. National Agricultural Advisory Services

NGO: Non Government Organization.

NRM: Natural Resource Management

NUTMON: Nutrient Monitoring

OC: Organic Carbon

ODLN: Open and Distance Learning Network

PPU: Primary Production Units

RU: Redistribution units

SACCOs: Savings and Credit Cooperatives

SOM: Soil Organic Matter

SPSS: Statistical Package for Social Sciences

SPU: Secondary Production Units

SSA: Sub-Saharan Africa

SSA-CP: Sub-Saharan African -Challenge Programme

SWC: Soil and Water Conservation

SWU: South Western Uganda

TLU: Tropical Livestock Unit

TN: Total Nitrogen

Abstract

Soil erosion and declining soil productivity still continue to manifest in most of the agricultural systems found in Sub-Sahara Africa and this has threatened the agricultural productivity, biodiversity, water quality and availability as well as the livelihoods of the poor who depend on land. In Uganda, this has been attributed to poor land use practices with inadequate SWC measures and persistent nutrient mining of the soils with little or no replenishment. Highland areas of Kabale are reported to be severely affected by soil erosion and declining soil fertility despite continued efforts by farmers to conserve soil and water resources. The study examined the determinants for SWC and nutrient flow management in Bufundi sub-catchment. The study was premised on analyzing physical, institutional and social economic factors as they were perceived to strongly influence SWC and nutrient flows within the different farm slope positions of Bufundi sub-catchment. Ninety five (95) structured questionnaires, key informant interviews and transects were conducted in the month of January 2011. Also 30 soil samples were collected from agricultural fields on the predominant SWC measures (terrace benches) in addition to nutrient monitoring using the NUTMON questionnaires, transfer functions and a NUTMON monitoring guide. Data analysis was done using SPSS 17.0, E-view 3.0 and NUTMON 3.6 software for the different types of data. The results of the survey show that family size, age, land tenure, perception of soil erosion, sources of income, formation of Innovation Platforms (IPs), farm size, collective marketing under IP, slope, collective action and training in SWC are among the major factors that positively and significantly influence adoption and use of soil and water conservation measures. Education, sex, off-farm activities, visits by extension agent, showed no significant influence on adoption and use of soil and water conservation measures. Soil data in the predominant SWC measures (terrace benches) revealed that: pH, organic matter, and nitrogen were below the critical values on all the terrace farms. It was revealed that organic manure (IN2) was significant at ($p<0.05$) between farms and contributed between 44%, 78% and 62% of the total farm inflows for N, P and K, respectively. The major avenues for nutrient inflows and losses are organic manures (IN2), biological nitrogen fixation (IN4), crop residue (OUT2a), crop products harvested (OUT1) and soil erosion (OUT5) whilst no mineral fertilizer use (IN1). It is recommended that effective bench terrace management coupled with integrated soil fertility management and SWC awareness should be a priority in addition to forward-backward linkages in order to contribute more favorable balances in the predominant SWC measures. More efforts should target, social, physical, financial and human capitals on bench terrace management in addition to use of complimentary sources of soil nutrients besides the organic manure.

CHAPTER ONE

1 INTRODUCTION

1.1 Background to the problem

Globally 20 million hectares of arable land are reported to be degraded by soil erosion each year (Davidson, 1992). Degraded arable land in Asia is estimated to be at 35 % of the total agricultural land, while 45% is in South America, and 74% in Central America (CGIAR, 2003). In Africa, 65 % of the arable land is degraded by soil erosion (CGIAR, 2003). Estimates in SSA show that 320 million hectares of land are affected by human induced soil degradation and this is estimated to cause a damage of US $26 billion annually on the continent (Lal, 1994).

Tenywa and Bekunda (2008) report that the underlying cause of this degradation is as a result of the destructive, extractive, over-exploitation and inadequate conservation of the soil and water resources. This has continued to threaten agricultural productivity, biodiversity and water quality (Scherr and Yadav, 1995) as well as the livelihoods of the poor, of whom 90% depend on the natural environment for their survival (World Bank, 2008).

In East Africa, soil erosion is estimated to affect 50 % of the total arable land area especially in the highland areas (Ovuka, 2000). In Uganda, soil degradation has been reported by Stoorvogel and Smaling (1990), Wortman and Kaizzi (1998) and Pender *et al.* (2001) as one of the major environmental problem hindering agricultural production.

Slade and Weitz (1991) estimate that the annual cost of environmental degradation in Uganda is US $170 to 460 million. They further observe that soil erosion accounts for 85% of the environmental degradation cost, water contamination contributing 10%, biodiversity loss 4% and deforestation 1%. In addition, Nkonya *et al*. (2002a) report that 95% of the 2.5 million rural households in Uganda have a negative nutrient balance of an average cost of US $152.6 and a total environmental cost of US $362.4 million, that is estimated to be 9.1% of the 2000/01 GDP of US$3.983 billion as a result of erosion.

Highlands that are steep and intensively cultivated are prone to land degradation (Nkonya, 2002). In Uganda, highlands occupy around 25 percent of the country’s land area (that is Kabale, Kisoro, Mbale, Sironko, Bundibugyo, and Kapchorwa) and contain 40 % of the country’s population (Nkonya *et al*., 2002a). Kabale is located in Southwest Uganda with steep slopes and intensely cropped hillsides. Soil erosion and consequent soil degradation have been reported to be a major problem even before independence (Carswell, 2000).

Although soil erosion is evident on most of the hill slope terraces, SWC technologies have been emphasized since 1920s to date (Miiro, 1999), nevertheless the achievements are still far below the expectations, the hill slopes still lose a tremendous amount of fertile top soil and the threat of land degradation is alarmingly broadening despite the SWC measures being promoted (Briggs and Twomlow, 2002). Continued degradation may imply that adoption of corrective technologies is either too slow or limited probably owing to the nature of the technology itself, social-economic and institutional factors (Makokha *et al.*, 1999).

Despite the fact that soil conservation studies have been done, (Tukahirwa 1996; Ssali 2001; Briggs and Twomlow 2002 and Siriri *et al*. 2005), these studies have largely centered on quantifying the rates of soil erosion, nutrient losses and the effects on biophysical environment and in many cases ignoring the role of social, cultural, economic and institutional determinant in use and adoption of SWC in the district. On the other hand, the studies that have targeted social-economic and institutional factors for soil conservation (Nkonya, 2002) have largely remained broad on scale and recommendations for policy rather than at a level of a catchment. The few success stories for SWC where the catchment approach has been adopted by AHI, SSA-CP, ESC, EROAHI, IWMNET to mention but a few do flourish amidst difficulties of past institutional failures, low incentives, poor market linkages, poor policies and supply driven technology developments.

African Highland Initiative (AHI 2002) baseline report concludes that the poor SWC management decisions in most of the catchments in Kabale have not been based on site, institutional and social economic circumstances for adoption and application. This is in line with Boesen *et al*. (2004) conclusion that in order to improve agricultural production in a catchment, appropriate technology is necessary to suit the local economic, cultural and geographical conditions of that catchment.

Although Hatibu *et al.* (2004) report that the reasons for limited adoption of SWC technologies is by and largely due to a variety of reasons summarized as limited use of more holistic systems approach that integrate biophysical and social economic concerns, the same phenomena is poorly understood for Bufundi sub-catchment. Therefore, this study examined the physical, institutional and social economic factors influencing use and adoption of SWC measures in Bufundi sub-catchment across the different landscapes.

1.2 Statement of the problem

Despite the fact that these factors (social-cultural, economic, institutional and physical) strongly influence farmers’ decisions for SWC elsewhere, it is not clear how the same factors influence SWC decisions in Bufundi catchment. On the other hand, it is not clear which of the bio-physical, institutional and social economic factors has the greatest influence on farmers decisions to practice SWC and soil nutrient flow management on the upper, middle and lower slopes, and whether these factors influence their decisions variably at the different landscape positions, cropping systems and nutrient levels. Therefore, this study examined the determinants for SWC and nutrient flow management. The factors examined include; physical, social-economic and institutional factors in the various slope angles and nutrient levels.

1.3 Justification of the study

The study is valuable to different categories of stakeholders, namely; farmers, researchers the Local Government as well as NGOs involved in SWC in both the catchment and outside. To the farmers, their benefits from this study are that the recommendations proposed are more effectively targeted for their catchment and their livelihood. The study identified intervention areas to increase investments in NRM, nutrient flow management, ecological institutional demand driven innovations and household market-economic driven conservation.

1.4 Research questions of the study

The study was guided by the following questions:

i. What are the existing soil and water conservation measures used by farmers to mitigate land degradation in the different landscape positions?

ii. What are the physical, institutional, social, cultural and economic factors influencing adoption and use of SWC measures in the catchment?

iii. What are the nutrient balances under the predominant SWC measures and slope angles/positions?

1.5 General objective

The overall objective of the study was to improve our understanding of the determinants of SWC and nutrient flow management in Bufundi sub-catchment, Kabale district.

1.5.1 Specific objectives

The study was based on the following objectives:

i. To establish the current soil and water conservation practices (indigenous and improved) used by farmers to mitigate land degradation in the different landscape positions.

ii. To examine the physical, institutional, social, cultural and economic factors influencing adoption and use of SWC measures in the catchment.

iii. To examine the nutrient balances in the predominant SWC measures and slope angles/positions of Bufundi sub-catchment.

1.6 Hypotheses

The following hypotheses were tested during the study

i. There is no significant relationship between adoption of newly introduced SWC practices in the catchment and institutional Innovations for SWC.

ii. Investments in soil and water conservation does not increase with levels of incentives such as institutional arrangements and markets access.

iii. There is no significant negative nutrient balance of N, P and K in the predominant SWC measures.

1.7 Significance and anticipated outcomes

Outcomes and recommendations of the study are indeed of high expectation towards adoption and use of demand- driven economic SWC practices that cater for household nutrient flow management, sustainable land use management at a level of a farm and a catchment as well as contribution of knowledge in the field of SWC for catchment studies. To the policy makers, the study revealed that a linear extension supply driven SWC approach is inadequate in adoption and use of appropriate SWC measures thus the need to pursue a demand driven multistakeholder approach for SWC. The findings can also empower farmers and other multistakeholder to determine which SWC measures bring faster and tangible benefits in terms of ISFM and income while sustaining the natural resource base. The findings have also revealed to researchers that SWC is better understood at a catchment scale than at a broad scale because of the ecological differences in landscapes/biophysical environments of different catchments.

1.8 Scope and limitations of the study

The study was conducted in the water catchment area of Lake Bunyonyi within Bufundi Sub county between the month of January 2011- April 2011. SWC measures used by farmers were studied within the different landscapes (upper, middle and lower). Analysis considered farmer personal characteristics, land use types, socio- economic, institutional and household nutrient flows between the slopes of 10-50% using a composite soil sampling technique. Analysis of nutrient flows for selected farms was also done using the NUTMON 3.6 software. Survey data from 95 households was collected using a questionnaire, on-farm observations and in-depth interviews targeting farmers and other stakeholders working under the framework of FARA supported Bufundi Innovation Platform. Limitations during the study were language barrier and false responses from respondents, however, efforts like triangulation, consultations and critical observations were put in place to mitigate the impact on outcomes of the study.

Operational definition of terms and concepts

1.9.1 Adoption

It refers to the stage in which a technology or innovation is selected for use by an individual or an organization (Rogers, 1995). Adoption expresses the acceptance of an innovation by an individual farmer, where the innovation is SWC technology to control the problem of soil erosion, adoption also measures the speed with which the SWC technologies are being adopted.

1.9.2 Soil and Water Conservation Measures

These express the soil erosion management practices which have been introduced to farmers. The SWC technologies in the sub-catchment include crop rotation, cover cropping, terracing, Fanya juu trenches, trees, use of cut-off drains among others. The study did not address itself to a specific soil erosion management practice but aggregates them together as ‘‘SWC measures’’.

1.9.3 Sub-Catchment

This is defined as “drainage basin, or an area of land within which all waters flow to a single river system” (Heathcote, 1998). The sub-catchment where the study was conducted is Bufundi-sub-catchment draining into Lake Bunyonyi in SW Uganda.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Introduction

This section presents related literature on SWC types, factors that influence adoption and use of SWC technologies, cases of success stories in SWC, institutional environment for SWC in Uganda, the relationship between SWC and nutrient flows/balances in a catchment as well as the contribution of SWC for sustainable livelihoods.

2.2 Soil and water conservation

The aim of SWC is preventing or at least reducing the effects of soil erosion while maintaining the soil quality (Graaff, 1993). SWC consists of any set of measures and practices in order to ensure the soil functions for long-term use by humans and nature (Grohs, 1994). SWC practices can be divided into mechanical and biological practices (Hudson, 1981). Mechanical practices control soil erosion, after the soil starts moving. Biological practices, however, prevent erosion by intercepting raindrops and thus not allowing the erosion process to start (Sfeir-Younis and Dragun, 1993). SWC practices can be subdivided into annual practices and one-time investments. Annual SWC practices form part of ploughing and cultivation practices, and requires an effort within each cropping season. Annual SWC practices are: mulching, contour ploughing, organic fertilizers, cover crops, crop rotation among others. One-time investments are mainly mechanical practices. They require a one-time investment of labour and capital, and afterwards recurrent maintenance activities. It often involves modification of the slope, like terracing, and preventing runoff water through infiltration ditches, benches, hedgerows, among others. The major benefits of erosion control are conserving water and retaining of soil nutrients and organic matter, as well as maintaining soil depth and soil structure (Pimentel, 1993). Posthumus (2005) cautions us that these SWC-induced processes can be masked by climatic changes, pests and diseases, technology changes, markets among others.

2.3 Factors influencing SWC

There are different factors related to use and adoption of SWC measures, (Figure 2.1). Ervin and Ervin (1982) summarized them as personal, social, economic, institutional and physical.

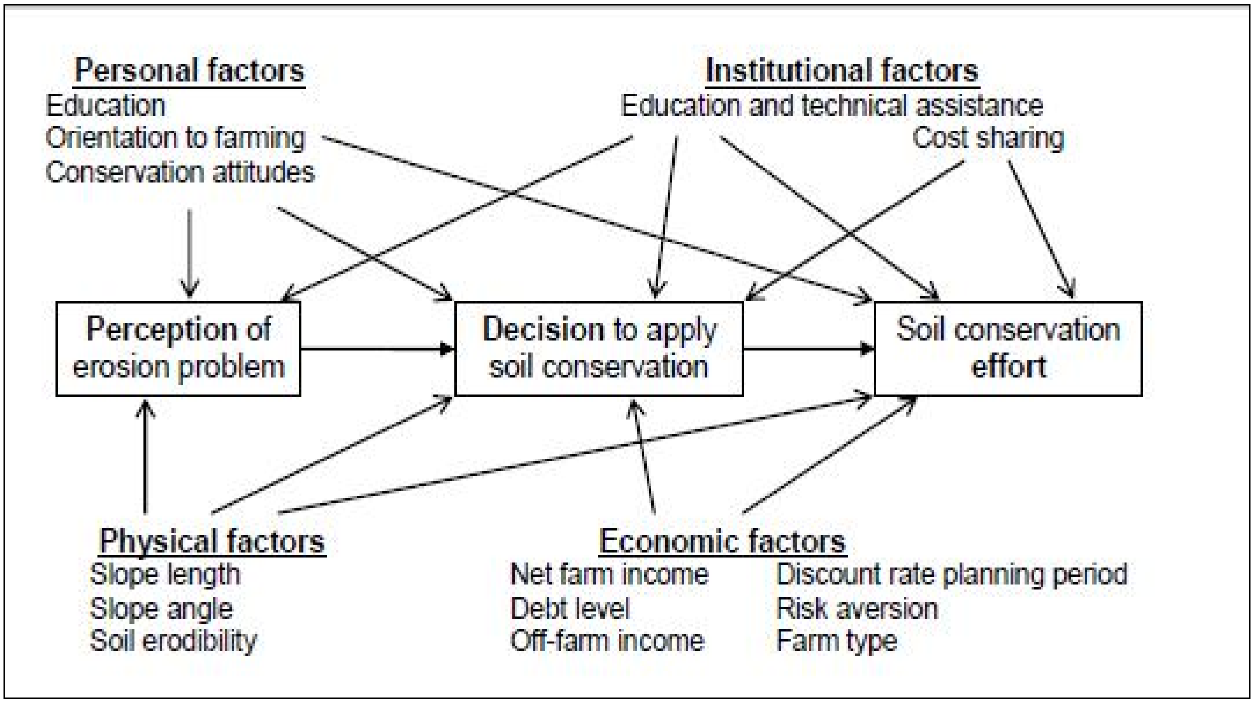


Figure 2.1 Conceptualized factors influencing SWC adopted from Ervin and Ervin (1982)

Ervin and Ervin (1982) tried to conceptualize the decision-making process towards SWC. This process starts by the recognition that there is an erosion problem. This perception is influenced by personal factors (human capital) as well as physical factors of the land (physical capital) and institutional factors (awareness raising). The second stage is the decision itself whether to implement SWC practices. Besides the factors influencing the perception, also economic considerations start to play a role. In the final stage the SWC effort (a function of the extent of individual practices on the farmer's land) is determined. Posthumus (2005) concludes that this conceptual model is a simplification of the adoption process, as in real life the decision process is continuous and dynamic. In Figure 2.1, Sinden and King (1990) included an extra step between perception and decision; recognition. A farmer might perceive soil erosion, but that does not mean that he/she thinks the problem is worthwhile to solve by adopting a conservation technology. Whether or not these stages should be resolved simultaneously depends on the situation.

2.4 Decision-making on soil and water conservation adoption

Decision-making is a complex process. Farmers' livelihood strategies are influenced or dictated by the biophysical, socio-economic and policy environments in which they operate (Enters, 1998). Lutz *et al.* (1994a) report that farmers often face numerous constraints such as land tenure problems, liquidity constraints, the need to meet consumption requirements and also compensation for missing or incomplete markets. However within these constraints, a "room of manoeuvre" is left, in which each person can make different decisions. Final decisions are made based on own experiences and preferences, opinions of family and relatives, and other incentives. But even the decision maker him/her self can often not define exactly which signals influenced to what extent this decision, as some signals are received unconsciously. Each case of adoption behavior is thus unique.

The decision to adopt a new technology is a dynamic process that is determined by the characteristics of the new technology and by the characteristics of the decision maker as well. Farmers' perceptions of the relative advantages and disadvantages of the innovation, and the efforts made by extension services to disseminate these technologies also influence the adoption process (Batz *et al*., 2003). Graaff (1996) and Ellis-Jones and Mason (1999) summarized a number of preconditions needed before a household considers adoption of conservation technologies (Table 2.1). It is assumed that farmers experience the following stages during the decision-making process: perception, need, knowledge, competence, and willingness. However, many constraints are likely to constrain the adoption behavior of farm households.

Table 2.1 Decision-making process on adoption of SWC practices, adopted from (Jones and Mason, 1999)

Preconditions necessary for household adoption of conservation practices		
Preconditions Are erosion symptoms recognized? ↓ Yes	→ No	**Possible reasons for no adoption** Very slow process More land readily available Tillage by labourers
Are erosion effects recognized? ↓ Yes	→ No	Climatic fluctuations Infrequent use or visits of land Lack of knowledge Other disturbing factors
Is erosion taken seriously? ↓ Yes	→ No	Not the farmer's land Deep soils, high fertility Considered as a downstream problem
Is farmer aware of SWC technologies ↓ Yes	→ No	Lack of knowledge Inadequate extension Poor information flow within community
Is farmer able to undertake SWC technologies? ↓ Yes	→ No	No Limited labour and capital Not land owner Socio-economic constraints Need to secure food production on short-term Incompatibility with present farming system
Is farmer willing to undertake SWC technologies? ↓ Yes	→ No	Insecure land tenure Poor financial return Benefits are too long-term Other priorities Downstream problem
Is farmer ready to undertake SWC technologies? ↓ Yes Possible adoption	→ No	No adequate extension / training Too high initial investment required Too much risk Lack of credit Limited market access

In general, it is assumed that the adoption process is influenced by factors such as technology characteristics (performance, risk, complexity, investment, and appropriateness), farmers' attitude towards risk, adoption costs (investment) and availability of capital (cash resources and access to credit; natural, social and human resources), labour availability and land tenure (Jones and Mason, 1999; Batz *et al.*, 2003).

The following factors were found empirically to affect adoption of SWC practices significantly according to Posthumus (2005):

2.4.1 Physical factors

In some cases it was found that the rate of land degradation positively influences the adoption of SWC technologies (Marsh, 1998; Baidu-Forson, 1999).

2.4.2 Technical factors

The new technologies proposed should be appropriate within the given farming system and not too complex (Marsh, 1998; Bunch, 1999). Because of lack of creativity in developing new technologies, often a limited number of technologies is introduced which might be appropriate at one place, but inappropriate at another. Bunch (1999) reported that, the focus of soil conservation technologies is often on structures and retention rather than on vegetation and cover, whereas the latter are more effective in preventing soil erosion, are less expensive and can provide lateral benefits. McDonald and Brown (2000) proposed that it is better to have a broader focus like land husbandry or sustainable rural livelihood approaches.

2.4.3 Personal factors

Perception: recognition of soil erosion and positive attitude towards soil conservation influences the farmer’s attitude and increases his/her effort in soil conservation according to (Shiferaw and Holden, 1998). In addition, subjective preferences for characteristics of new agricultural technologies are important determinants of adoption behaviors (Adesina and Baidu-Forson, 1995). It is reported by (Lapar and Ehui, 2004) that human capital (like education, experience) influences positively the attitude and perception of the farmer, and his/her adoption behavior. Education is found to stimulate significantly adoption of innovations in many studies (Asfaw and Admassie, 2004), yet age is found to influence the adoption decision negatively in some cases according to (Shiferaw and Holden, 1998).

2.4.4 Economic factors

Many economists (for example: Graaff, 1996; Enters, 1998; Bunch, 1999; Giger, 1999) argue that a major reason of the non-adoption of SWC practices is that they are not cost-effective for the farmers to apply them. The investment costs are too high, and the benefits are too low, uncertain and achieved on long-term. The economic effect is measured in terms of on-site profitability, as well as the change in the farm household’s production system. Soil conservation represents a capital investment that does not necessarily generate a new income flow, but rather reduces the rate of decay of an existing income flow. Especially physical structures like terraces imply a long payback period. While the investment costs of SWC are readily determined, measuring the benefits is more problematic.

Profitability is a prerequisite for adoption according to (Bunch 1999). The new technology itself should be appropriate and provide economic advantage to farmers or result in a higher utility level than the traditional technology if farmers are to adopt it. The benefits (production, risk reduction, income) should be immediate and tangible (McDonald and Brown, 2000). Also a new technology implies an initial investment for its implementation (Lapar and Ehui, 2004). Access to capital or credit influences the adoption rate, especially in the case of indivisible technologies (Lapar and Ehui, 2004).

Perception of risk and uncertainty should be considered important in adoption of technologies according to (Marsh, 1998), as innovations entail a subjective risk. Marsh (1998) report that farmers are expected to prefer technologies with short-term benefits, on the other hand, Marra *et al*. (2003) affirms that farmers, who are willing to take risk and make investments, will adopt a new technology more easily. Also labour availability influence adoption in either way, as some new technologies are labour saving and others labour demanding (Barbier and Bishop, 1995).

2.4.5 Institutional factors:

Institutional inefficiencies in the development and delivery of relevant knowledge and assistance are asserted to be a major reason why conservation technologies are not adopted (Baidu-Forson, 1999). Therefore integration of SWC technologies into institutional, local information and assistance networks can facilitate the adoption process (Baidu-Forson, 1999).

Lynne *et al.* (1988) reported that when attitudes are strengthened through extension and training, there may be less need for dependence on technical assistance and other net income-enhancing programmes like tax incentives. McDonald and Brown, (2000) observe that programmes and institutes should be flexible in their approach. SWC programmes should focus more on processes (communication, participation, learning, adaptation and empowerment) rather than being output driven.

Empirical studies do not always find a clear relationship between land tenure and adoption, but in some cases tenants are less likely to adopt a certain new technology than owners. If tenure is insecure, farmers are unlikely to invest in long-term activities (Gebremedhin and Swinton, 2003). On the other hand, farm size can either have a positive or negative effect on adoption, depending on the characteristics of the technology (economies of scale) and the institutional setting (Feder *et al*., 1982). Due to imperfect rural land markets, the user's costs of soil erosion may not be reflected adequately in, or even bear any relation to, land values. Thus the lack of effective rural credit markets may distort the farming household's decision whether it is worthwhile investing in soil maintenance and its future productivity or exploiting it for immediate gains. If the farm household has to borrow in the short-term to invest in conservation, then distorted or non-existent local capital markets may make the direct costs of conservation too high.

2.5 Factors for the “islands of success” in SWC

Tenywa and Bekunda (2008) in their study on the state of SWC in SSA acknowledge that although several success stories of local SWC activities in SSA exist as practiced by farmers there are still challenges of scaling these successes for wider implementation across the diverse and complex watersheds. In Africa, some islands of success for SWC are reported in East Africa by EROAHI, AHI, IWMNET in Bwanthonaro and Ngaciuma-Kenya, ESWC, GIZ in Ethiopia and SSA-CP Innovation platforms in Rwanda, Uganda, Democratic Republic of Congo, Nigeria, and South Africa among the few.

The reasons for the success is attributed to adoption of a catchment approach that is based on economic and institutional innovations in form of collective action for SWC, social capital mobilisation/catchment associations, participatory catchment management plans, desire for farm-based scientific research for SWC, functioning by-laws on SWC, local/provincial government involvement and multi-stakeholder consultations in decision making. Tenywa *et al.* (in press) report that adoption and coordination of the catchment approach is very demanding in terms of NRM, productivity enhancement, policy and market innovations. Limited attention in the past has been directed towards a linear supply driven technology adoption syndrome rather than a demand driven institutional approach (FARA, 2009). They also acknowledge that prospective opportunities for better SWC lie in integrated soil and water management (Swift and Shephard, 2007), water harvesting and irrigation, that design and reflect multiple functions and priotization depending on the soil types, average rainfall and landscape positions (Bationo *et al.*, 2006).

2.6 Institutional environment for SWC in Uganda

Boyd *et al*. (2000) in their study document that changes in the wider political environment in Uganda at both national and local levels have affected investment in SWC through changes in the capacity and perceived authority of institutions that have been entrusted with SWC. Since the colonial period, responsibility for promoting SWC has been delegated to local leaders and administrations. The decentralization policy also reinforces these deliberations and thus an indicator of the state's committement for SWC. However, the notion of SWC is not necessarily high on the agenda of local administrations, as they have limited capacity and expertise to promote it. Support from agricultural extension staff is limited by retrenchment, low motivation and a shortage of resources. We need to note that this kind of institutional arrangement has remained supply driven under the linear research-extension-farmer technology transfer model as opposed to the economic and institutional approach. This study was therefore used to compare weather economic demand driven SWC practices being promoted by Bufundi IP influence adoption and use of SWC in the catchment.

2.7 Sustainable livelihoods for SWC at household level.

Boyd *et al*. (2000) in their study on livelihood strategies for both Uganda and Kenya compared the contribution of SWC and sustainable livelihoods. Their study examined a range of agro-ecological, socio-economic, institutional and policy factors that influence farmers' decisions to adopt SWC practices. Their key findings suggest that there were important differences between and within communities with respect to the contribution that SWC makes to livelihoods. They acknowledge that it is difficult for an outsider to judge what constitutes a positive or negative outcome. The outcomes people aspire for vary greatly at all levels within households, within communities, within regions and so on as a result of the differences in personal, physical, economic and institutional circumstances. At a broad level, common livelihood outcomes might include: more income; increased well-being; reduced vulnerability; improved food security; and more sustainable use of the natural resource base. Although their findings are interesting, their study does not explore institutional innovation that target demand driven SWC activities, also it neglects the specific roles of multistakeholder collaboration in soil and water conservation .

2.8 Soil fertility management in relation to SWC and slope position

Alemayehu (2007) compared the relationship between terracing as a SWC measure and soil fertility determinants in Ajeni- Ethiopia. The findings reveal that upslope areas had lower nutrient concentrations than lower areas as a result of erosion of top soil and subsequent deposition on lower slope positions. Similar findings have also been reported by Wang *et al.* (2001) and Gregorich *et al.* (1998) on progressive organic carbon losses in upslope shoulder slope positions, while lower slope positions undergo organic carbon accumulation, which is attributed to erosion and depositional processes. Walle and Sims (1999) also reported a decreasing fertility gradient down slope in naturally formed terraces as a result of deposition of eroded sediment. On the other hand, Hao *et al.* (2002) found an insignificant difference in soil organic carbon between upper and lower slope positions under various soil water conservation measures. Siriri *et al.* (2005) in SWU reported that tillage erosion plays an important role in soil quality variations in a landscape, as it contributes to the removal and redistribution of topsoil

On the other hand, Moges and Holden (2008) in their study of nutrient status with respect to land use class and slope position on smallholder farms of Umbulo catchment in southern Ethiopia hypothesized that soil fertility and physical properties vary by land use class (garden, grassland, and outfields) and relative slope position (upper, middle, and lower). Their findings reveal that OC and TN were high in the upper and middle slopes when compared to the lower slopes. The low levels of OC and TN in the lower slopes was attributed to deposition of coarser subsoil sediment on the lower slope due to the gully systems, leaching on the lower slopes and low soil temperatures causing less decomposition of plant residues and manure. They recommend that soil fertility intervention require different approaches/SWC measures at different landscape positions, for example, on the lower slopes agricultural management needs to focus on making use of the runoff (building water conservation ponds and channels) and identification of crops that are tolerant to deposition of sediment (like sugarcane). However, they caution that it is necessary to examine social and economic perspectives in order to achieve sustainable agricultural management that would actually be adopted by farmers.

2.9 Conceptual framework

Rogers (1995) has defined the adoption process as “the mental process an individual passes through, from first hearing about an innovation to final adoption.” According to Rogers (1995), there are three phases in the adoption process: the acceptance phase, the actual adoption phase and the continued use phase. Adoption and use of SWC measures at all these phases is strongly influenced by physical, institutional, social, cultural and economic factors, it was not clear how the same factors influenced adoption and use of SWC technologies in Bufundi sub-catchment thus forming a basis for investigating the factors influencing adoption and use of SWC in Bufundi.

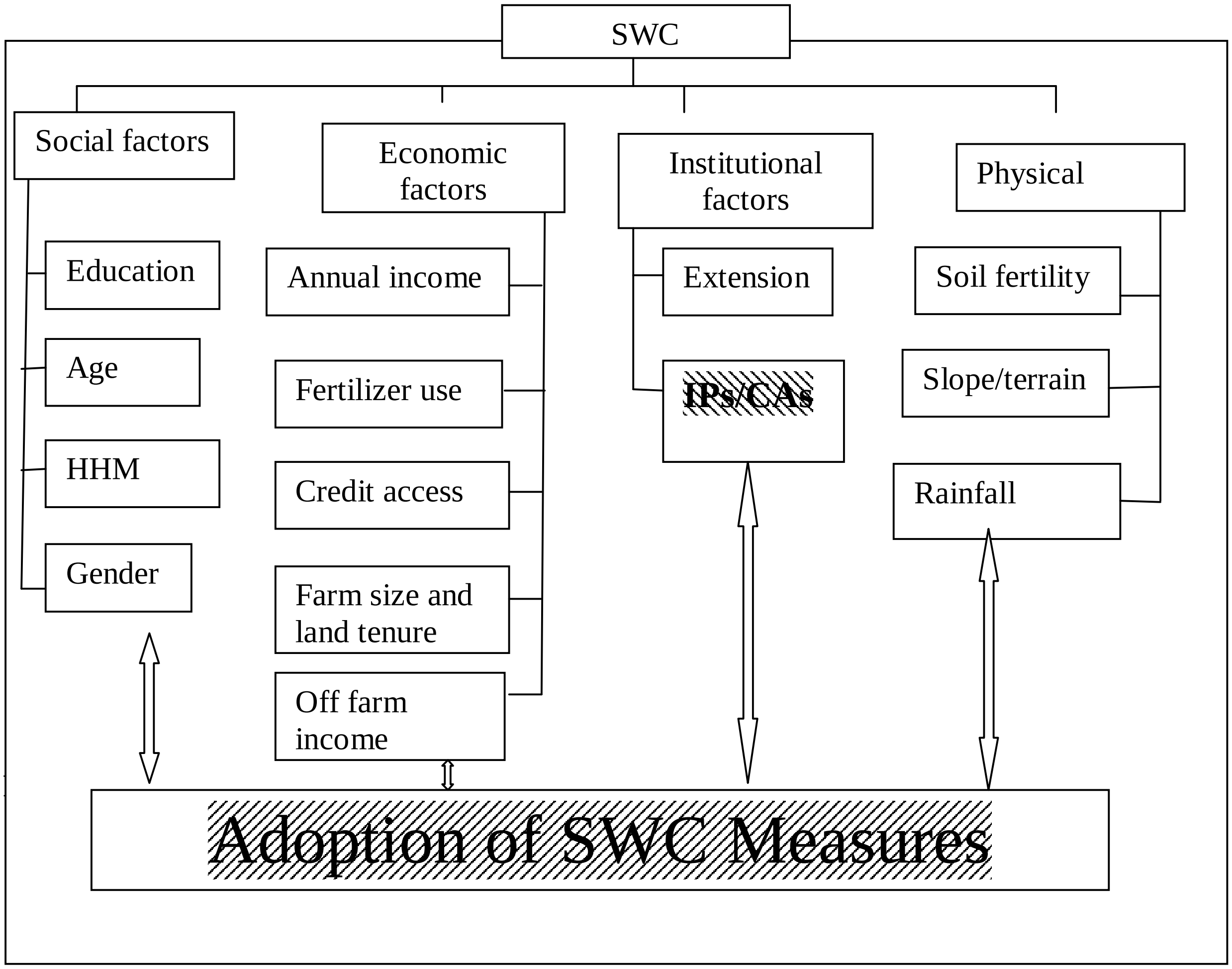


Figure 2.2: A conceptual framework adopted and modified from Eleni (2008)

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Study area and methods

This section highlights the tools and methods that guided the study, the research design, sampling frame and the tools of data analysis. Both quantitative and qualitative tools of data collection and analysis were employed in the study.

3.2 Study area

Bufundi water catchment is geographically located in Kabale district, between $1^0$14'S and $1^0$26'S latitudes and $29^0$48'E and 29^0 55'E longitudes and it covers an area of up to 20 square kilometers (Figure 3.1) and a population of 31,011 people equivalent to 1800 households (FARA,2009). The terrain is dominated by hills and valleys ranging between 12 to 50% but some as steep as 80% (FARA, 2009). Bufundi has a bimodal rainfall pattern, the "long rains" occur in mid-February and June while the "short rains" occur from mid-September to mid-December. The average annual rainfall in the catchment varies between 900 mm to 2200 mm with a mean annual temperature of 16.7ºC. Soils are classified as luvisols, acric ferralsols and histosols (Figure 3.1) relatively fertile but susceptible to extreme soil erosion (FARA, 2009). The most land use practices are crop farming, livestock, pastures, woodlots of eucalyptus and limited agro forestry. Nearly 60% of the land area is intensively cultivated and the crops grown include: Irish potatoes, beans, sorghum, sweet potatoes, maize and vegetables.

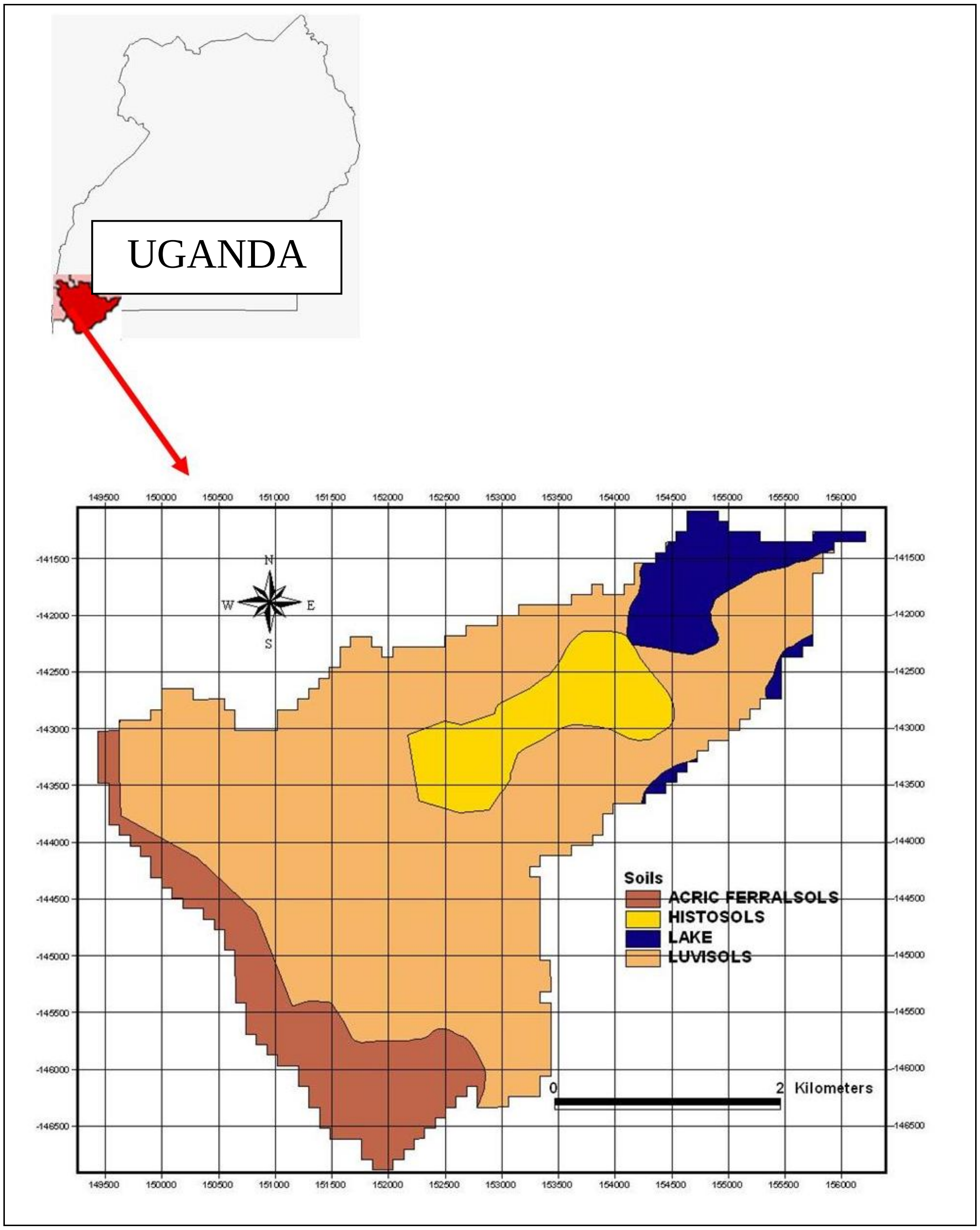


Figure 3.1: Map of Bufundi sub-catchment Source: FARA (2009)

3.3 Research design

One month before the commencement of the study a pilot survey was conducted in the study area. The purpose of this study was to identify the existing SWC measures practiced, but also to get informed consent from SWC institutions, leaders, respondents, identification of research assistants and lastly to pre-test the research instruments. This was also an entry point to the community as well as the community members to appreciate the purpose of the study in their catchment.

In order to understand how the physical, social, cultural, institutional and economic factors influence use and adoption of SWC in the catchment, a survey was conducted in the month of January 2011 using a structured questionnaire administered to 95 households selected from 1800 households living in the sub-catchment (FARA, 2009). In addition, three FGDs of 6-10 people were conducted for some selected key informants representing the existing institutions involved in SWC namely: Innovation platform stakeholders, local government leaders, NGOs and religious institutions working in the sub-catchment. In addition, 160 farms were visited along three transects in the upper, middle and lower parts of the sub-catchment using an observation guide (APPENDIX 1V) and later analyzed using a descriptive analysis.

3.4 Selection and training of research assistants

Four research assistants were selected from the study area based on their ability to speak English and the local language called Rukiga. The research assistants were given a one day training on how best to translate the questionnaire from English language to Rukiga. Thereafter, the research assistants simulated the questionnaire with support and supervision of the researcher.

3.5 Sampling procedure

Selection of the sample size from the total population of 1800 households was calculated using the formula proposed by Yamane in 1967 and reflected in Glenn (1992).

$$n = \frac{N}{1 + N(\alpha)^2} \qquad (1)$$

Where n = sample size
N = total number of households
α = margin of error set at 10%

With the above formula, the sample size derived was 94.73 (approximately 95). With this sample size, a proportionate stratified random sampling based on equal proportions of each zone contributed to the total number of households from each landscape position that were selected for the study.

3.6 Computing nutrient flows and balances

Besides the SWC questionnaire (Appendix 1) that was used to achieve objectives 1 and 2, a NUTMON structured questionnaire was also administered independently to only 30 household sample farmers. These were purposively selected at equal proportions of 10 households per landscape position (upper, middle and lower) to give a nutrient balance and flow management representation from the main sample size of 95 households to address objective 3 of this study.

These farmers were requested to draw their resource maps and then a farm tour in their fields that were near their homes only. Inflows were mainly through nutrient inputs and outflows in the form of farm products. To quantify the soil nutrient stocks, soil samples were taken from 0 to 30 cm depth from fields on farm section units (major local soil units) identified with farmers on respective farms for analysis of total N, P and K, pH and organic matter following the standard sampling procedures described by Okalebo *et al.* (2002).

Data on physical variables (slope angle/position) was collected and analyzed in relation to the practiced SWC practices. This was achieved using field observations, an abney level and collection of data on observable SWC measures at different slope angles (upper, middle and lower) for each of the 3 transects that were conducted. In order to understand the nutrient flows in the different landscapes, 30 farmers' fields were characterized using soil chemical and physical characteristics that were obtained from soil samples collected from the 0-30 cm depth. pH, Soil organic matter (SOM), total nitrogen (N), extractable phosphorus (P) and exchangeable potassium (K) were measured using the standard sampling procedures described by Okalebo *et al.* (2002).

Soil samples for the soil nutrients were taken to the soil science laboratory at Makerere University. They were air dried, graded and sieved through a 2 mm sieve and then analyzed, for pH using a pH meter (1:2.5 soil: water), SOM using the Walkley and Black method, total Nitrogen (N) using the kjeldahl method, Phosphorus (P) using the ascorbic blue method while Potassium (K) using the flame photometry.

3.7 Farmer managed nutrient flows and outflows

The NUTMON questionnaire was used to collect two forms of data sets. The first data set involved quantifiable data from farmers on the following inflows and outflows and this was directly collected using the NUTMON questionnaire:

- IN1: Mineral fertilizers
- IN2a: Organic fertilizers
- IN2b: Manure from external grazing
- OUT1: Harvested products
- OUT2a: Exported crop residue &manure
- OUT2b: Animal manure outside the farm

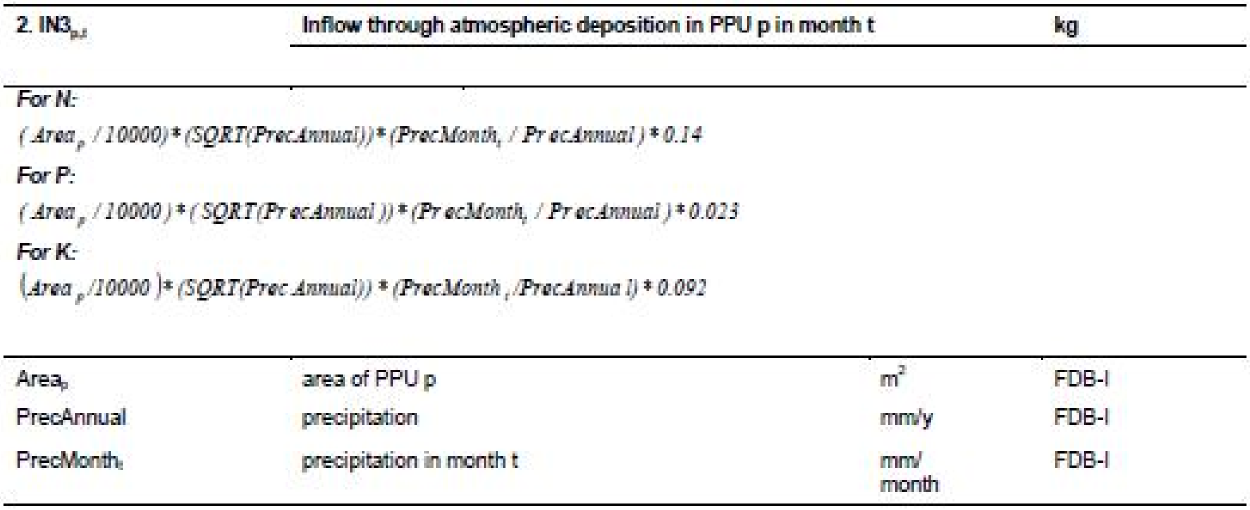
In order to achieve other inflows and outflows that are not easily quantifiable by farmers, the use of transfer functions were computed in NUTNON using the following sets of data

- Soil data
- Rainfall data
- SWC measures applied
- Slope angles/positions
- Economic data

3.7.1 Transfer functions for other inflows and outflows

3.7.2 Atmospheric Deposition (IN3)

Combined wet deposition (nutrients in precipitation) and dry atmospheric deposition (nutrients in dust) are calculated using the following transfer function, linking the nutrient input with the mean annual rainfall.



2. $IN3_{p,t}$	Inflow through atmospheric deposition in PPU p in month t	kg	

For N:

$$(Area_p / 10000) * (SQRT(PrecAnnual)) * (PrecMonth_t / PrecAnnual) * 0.14$$

For P:

$$(Area_p / 10000) * (SQRT(PrecAnnual)) * (PrecMonth_t / PrecAnnual) * 0.023$$

For K:

$$(Area_p / 10000) * (SQRT(PrecAnnual)) * (PrecMonth_t / PrecAnnual) * 0.092$$

$Area_p$	area of PPU p	m^2	FDB-I
PrecAnnual	precipitation	mm/y	FDB-I
$PrecMonth_t$	precipitation in month t	mm/ month	FDB-I

3.7.3 N-Fixation (IN4)

Non-symbiotic N fixation (IN 4b) is calculated using a function relating N fixation with mean annual precipitation. It is assumed that symbiotic N fixation can take place within all primary production units. For primary production units with leguminous (annual or perennial) species, a crop-specific percentage of the total N uptake is assumed to be the result of symbiotic N fixation. The total N uptake is defined as the sum of the amounts of N in the crop product and the crop residues.

3.7.4 Leaching from soils (OUT3), Smaling (1993) model for N leaching

A simple transfer function was computed, expressing N leaching as a percentage of Soil N and Fertiliser N. Soil N is defined as the amount of mineralised N in the upper 20 cm of the soil profile during the monitoring month. Fertiliser N refers to the N in mineral and organic fertilisers applied. The leaching fractions are calculated as a function of the clay percentage of the soil and mean annual precipitation.

3.7.5 K Leaching

Potassium leaching is assumed to be a function of exchangeable K and fertiliser K (Smaling, 1993). Fertiliser K refers to mineral and organic fertilisers. The total K leaching is calculated as a function of the clay percentage of the soil and mean annual precipitation.

3.7.6 Gaseous N losses from RUs (OUT4)

The manure excreted in corrals and the composts in compost pits are assumed to be subject to gaseous losses, calculated using user defined loss percentages for. Loss percentages can be adjusted based on the presence of concrete floors and roofs.

3.7.7 Erosion (OUT5)

Erosion is calculated by the Universal Soil Loss Equation (USLE). The NUTMON-Tool calculates a hypothetical soil loss per FSU, assuming bare soil, based on typical FSU characteristics (slope, slope length and the presence of anti-erosion measures (P-factor)) and soil characteristics of the soil assigned to the FSU(s). This hypothetical soil loss is the basis for the calculation of nutrient losses through erosion per PPU. The average crop cover factor (C-factor) of a PPU is calculated by averaging the C-factors of the individual crops within a PPU. For each

PPU, the hypothetical soil loss (in kg/ha/year) of the FSU in which it is located is multiplied by the average crop factor, the total nutrient contents of the soil and an enrichment factor.

Nutrient losses through erosion are corrected for the nutrients in the deeper soil that come within reach of plant roots after the top soil has eroded. This is done using a soil formation factor of 0.75, which means that 75% of the eroded nutrients are compensated by soil formation.

3.7.8 Human Excreta (OUT6)

A user-defined amount of human excreta is assumed to be produced per consumer unit. The nutrient contents of human excreta are user-defined. Human excreta can be entered into PPUs or RUs. A RU can be labelled latrine and all nutrients routed to a latrine are by default entirely lost from the agricultural systems.

3.8 Data analysis

Data of the questionnaires from respondents was coded, cleaned and entered into SPSS software for a descriptive analysis. Determinants of adoption of SWC by farmers were determined using both a non parametric test (chi-square) and a logit model. Nutrient balances were computed using the NUTMON software version 3.6 for inflow and outflow data at a level of a farm and micro catchment position. Results were then exported from NUTMON to microsoft excel data sheets and then imported to SPSS version 17 for statistical analysis. Significances were tested using a T test for farm balances (Ebanyat, 2010). A Pearson’s correlation was also performed to identify the relationships between on farm and household variables influencing nutrient balances and farm economic returns. Only variables that were not significantly correlated were used as explanatory variables. All statistical analysis was performed using SPSS.

3.9 Non-parametric test

For a study of this nature where many factors were assumed to be influencing adoption and use of SWC measures in the catchment, there was a need to test variables identified to influence adoption and use of SWC measures using a non-parametric statistical tool and this was a chi-square. A Chi-square test is a statistical test used to determine if observed data deviate from those expected under a particular hypothesis (Mugenda and Mugenda, 1999). In this study however, a chi-square was used to ascertain the relationship between adoption of SWC technologies and variables not used in the logit model. The variables tested with adoption of SWC technologies were: sex, household size, land ownership, training in soil erosion measure, perception of soil erosion problem, off-farm employment and access to agricultural inputs, participation and perception of collective action in SWC. The chi-square formula used was:

$$X^2 = \sum \frac{(o-e)^2}{e} \qquad (2)$$

Chi-square (χ^2) is the sum of the squared difference between observed (o) and the expected (e) data, divided by the expected data in all possible categories (Grant and Warren, 2001). The results were then tested for significance at 0.05 (95 percent confidence level). The chi-square test was used due to the qualitative or categorical nature of data collected (Grant and Warren, 2001).

3.10 Analytical model

Feder, Just and Zilberman (1985) show that many models used in adoption studies fail to meet the statistical assumptions necessary to validate the conclusions based on the hypothesis tested, and they advocated the use of qualitative response models. The two models used in adoption studies are the logit and probit. The advantage of these models is that the probabilities are bounded between 0 and 1. Moreover, they compel the disturbance terms to be homoscedastic because the forms of probability functions depend on the distribution of the difference between the error terms associated with one particular choice and another. Usually a choice has to be made between logit and probit, but as Amenya (1981) has observed, the statistical similarities between the logit and probit models make such a choice difficult.

Choice of any model is therefore not dominant and may be evaluated aposterior on statistical grounds. Although in practice, there are no strong reasons for choosing one model over the other, for this study a logit model was used because the dependant variable is dichotomous and the model is computationally simpler. Logit and probit models are popular statistical techniques in which the probability of a dichotomous outcome (such as use of old or new SWC technologies) is related to a set of explanatory variables that are hypothesized to influence the outcome (Neupane *et al*., 2002). Pindyck and Rubinfeld (1998) acknowledge that, a logit model that is based on a cumulative logistic probability function is computationally easier to use than the other types and thus was used in this study. The study focuses on farmer’s decisions to use and adopt both old and new SWC measures promoted in the catchment. Furthermore, the study quantifies probabilities of significant factors influencing the decision to adopt SWC measures in the catchment. Following Gujarati (1999), the logistic regression model characterizing adoption by the sample households is specified as:

$$P_i = F(\alpha + \beta X_i) = \frac{1}{1 + e^{-(\alpha + \beta X_i)}} \quad (3)$$

Where:

subscript *i* denotes the i-th observation in the sample,

P_i is the probability that an individual will make a certain choice given X_i,

e is the base of natural logarithms and approximately equal to 2.718

X_i is a vector of exogenous variables

α and β are parameters of the model (β1, β2,…..βk) are the coefficients associated with each explanatory variables X_1, X_2… X_n)

The above function can be rewritten as:

$$I_i = \text{In}\left[\frac{P_i}{(1 - P_i)}\right] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} \ldots\ldots \beta_k X_{ni} + e_i \quad (4)$$

Where:

e_i is a disturbance term and the parameters β_1 are estimated using maximum likelihood techniques.

It should be noted that the estimated coefficients do not directly indicate the effect of change in the corresponding explanatory variables on probability (P) of the outcome occurring. Rather the coefficients reflect the effect of individual explanatory variables on its log of odds.

Where the expression for log of odds is given as:

$$In\left[\frac{P}{(1-P)}\right] \qquad (5)$$

The positive coefficient means that the log of odds increases as the corresponding independent variable increases (Neupane *et al.*, 2002). The coefficients in the logistic regression model are estimated using the maximum likelihood estimation method.

For this study, the empirical model is specified as:

$$CLAD_i = \beta_0 + \beta_1\mathrm{EDU}_i + \beta_2\mathrm{HHM}_i + \beta_3\mathrm{IPM}_i + \beta_4\mathrm{AGE}_i + \beta_5\mathrm{PER}_i + \beta_6\mathrm{SLP}_i + \beta_7\mathrm{YOF}_i + \mathrm{e}_i \qquad (6)$$

Where:

β_0 is the constant term

β_1 to β_7 are unknown parameters to be estimated

e is the disturbance term

The meaning of the variables considered in specific model (6) and their apriori signs are summarized in Table 3.1

Table 3.1: Summary of variables considered in the logit model

Variable	Meaning	Apriori Sign
CLAD	Dependent binary variable. 1 for adoption of new SWC technology, 0 otherwise	
EDU	Education of the farmer (years in school)	Positive (+)
HHM	Members of the household (in numbers)	Positive (+)
IPM	Membership of a Cooperative/ organization (1= yes, 0 otherwise)	Positive (+)
AGE	Age of the farmer (in years)	Positive /Negative (+/-)
PER	Number of farm parcels	Negative (-)
SLP	Slope of land of the farm (1= steep slope, 0 otherwise)	Positive (+)
YOF	Years of farming (in years)	Positive (+)

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discusses the findings from the research conducted in Bufundi Sub-catchment in SW Uganda. Results of SWC adoption levels, types of SWC technologies, statistical analysis of factors influencing adoption of SWC measures using a chi-square test and a logit model as well as nutrient balances/flows of the predominant SWC measures (terrace benches) in the catchment are presented and discussed.

4.1.1 Types of soil and water conservation measures used by farmers

As shown in table 4.1, bench terraces (93%) were the dominant form of mechanical SWC practice along the different slope positions of Bufundi Sub-catchment. They were naturally maintained without any artificial reinforcement.

Table 4.1: Old and new SWC measures used by farmers in Bufundi sub-catchment.

	Description of the SWC	Traditional SWC	Newly introduced SWC	Number of plots N=160	% of the total farms
1	Bench terraces	√		149	93
2	Traditional Cut off drains	√		51	31
3	Improved Cut off drains		√	0	0
4	Trees	√	√	97	61
5	Fallowing	√		37	23
6	Fanya ju trenches		√	19	12
7	Application of animal manure	√		62	39
8	Crop residue	√		89	56
9	Multiple cropping	√		21	13

Miiro (1999) reported that terraces (plate 4.1) were introduced in Kabale in the early 1920s with strict guidelines for their development and management, which were enforced by the colonial government using by-laws like coercive measures, persuation and incentives to develop and maintain terraces. Also terraces were part of the indigenous and cultural ways of adopting agriculture given the steep nature of land in SW Uganda. He revealed that the impetus to use terraces arises from the need to control soil erosion, maintain good crop yield and to separate farmer plots from their neighbours.

Plate 4.1: An example of a bench terrace in Bufundi sub catchment

While terraces were the predominant SWC measure, their management differed among the various farmers in Bufundi- sub-catchment. Some farmers planted grass along the terraces (Napier and local grass) while others did not, others were under fallow yet other farmers had removed the terrace benches completely joining their plots with the neighbouring farms thus exposing them to the risk of excess soil erosion as shown in plate 4.2. On almost all the farms visited the terraces were collapsing with little or no maintenance at all yet in some cases were totally removed without redevelopment of new ones as seen in plate 4.2.

Plate 4.2: An example of a terrace bund removed by the farmer

The reasons why most of the terraces were collapsing were different among farmers and policy makers interviewed in the study as shown in (Figure 4.1). In addition, farmers have for long integrated the practice involved with terrace management through breaking down and re-developing of the terrace bunds/ risers to create more space for farming as well as the need for accumulated fertility within the terraces (Miiro, 1999), an example of this practice is presented in Plate 4.2. It is reported that most farmers destroy terraces after about 5–10 years (when the terrace riser becomes high) to allow development of new terraces behind grass strips but very few are replaced and managed appropriately (Miiro, 1999, Siriri, 2005).

Grazing of animals on fallowed terraces was reported the major factor leading to the collapse of these terraces by farmers (39%) as shown in Figure 4.1. Other reasons reported were weak by-laws for terraces (22%), low extension (17%), labour (10%), slope gradient and soil type (7%) and low motivation by farmers (10%).

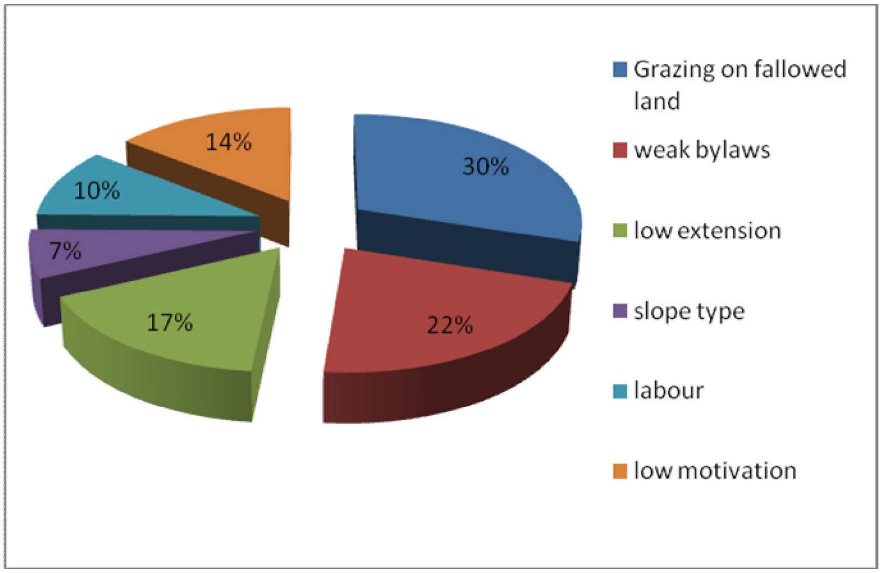


Figure 4.1: Reason reported why the terraces are collapsing in Bufundi sub-catchment

In addition to the reasons reported in Figure 4.1, Miiro (1999) reported that farmers intentionally remove their bench terraces to acquire more land for cultivation, join their farms, remove bad weeds on the terrace bunds as well as to destroy hiding places for rodents but in most cases do not replace them with new ones and a similar case was also observed in the catchment.

4.1.2 Crop residue use and management in SWC

Management of crop residue for SWC differed among the different farmer plots with bean, maize and sorghum trash reported the major types of crop residue used by farmers in SWC. In (Figure 4.2) majority of the farmers (53%) reported that they placed the maize and sorghum trash on the upper and lower parts of the terrace, first to act as a buffer for excess water flowing to the farm but also as a source of manure the next season after composting. Twenty two percent (22%)

of the farmers heaped the residue in their gardens while 17% opted to burn it and 8% used it as mulch for their banana plantations.

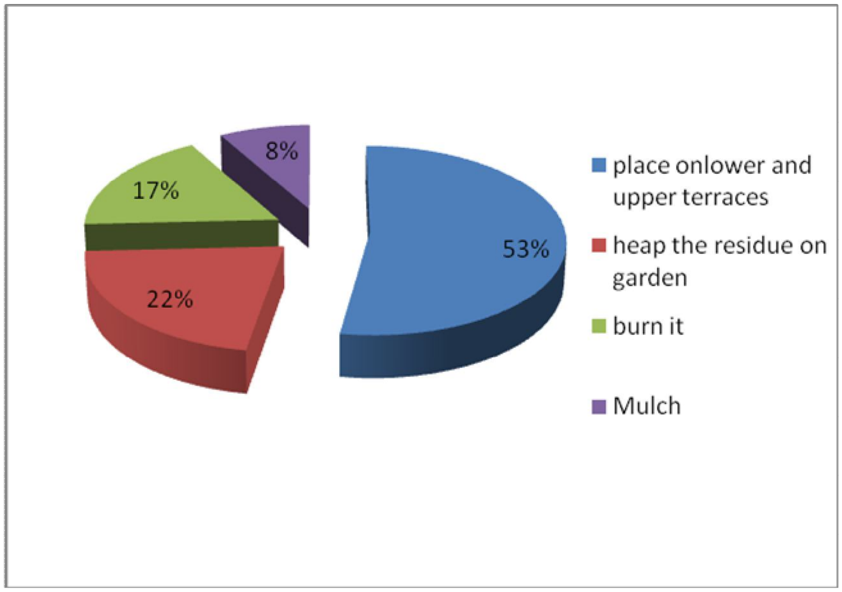


Figure 4.2: Crop residue and how it is managed by farmers in Bufundi

However, on the 20 banana farms that were visited, 80% of them were partly mulched while others were not. Farmers could not generate enough residues for effective use in SWC; this also had implications from the sources where the residues were taken from.

On the other hand gender conflicts and labour implications on crop residue management were reported in the FGDs where some women opted to burn the residue as a means of reducing labour required to manage the residue while men preferred to heap the residue thus leading to gender conflicts of use and in some cases neglect of farm activities for SWC by some men.

4.1.3 Tree planting as a SWC measure

The data derived indicate that tree planting is not a major soil and water conservation measure in the sub-catchment. The results (61%) of the farms visited were planted with woodlots of eucalyptus while others had combined pine and bamboo. Despite the fact that woodlots were common on almost all the farms, they were not a form of SWC measure on most of the farms but rather a form of converting the degraded parcels into economic use. This is justified by the fact that on almost all the woodlots visited, 91% of the terraces under woodlots had collapsed beyond recognition with little or no underground cover and were major sources of extreme soil erosion for the nearby farms, an example is shown in Plate 4.3. Whereas tree planting is associated with reducing soil erosion and replenishing of the soils, it should not be taken as a guarantee under the diverse ecological niches, in Bufundi trees (Eucalyptus woodlots) were hotspots for soil erosion. An example of a badly damaged woodlot where even the terrace benches used to exist had been washed away as a result of soil erosion.

Plate 4.3 One of the damaged woodlot with soil erosion

4.1.4 Fanya juu trenches

On 12% of the farms visited (Table 4.1), their owners had adopted Fanya juu trenches as a SWC measure. These Fanya juu trenches are constructed by digging a ditch on the contour and throwing the soil on the upslope side of the garden to form an embankment (Morgan, 1995). An example of the adopted Fanya juu and fanya chini trenches in the catchment is presented in Plate 4.4. The low adoption (12%) of fanya juu trenches for SWC was attributed to farmer perception of fanya juu trenches that require space and labour, given the fact that 60% of the farmers own farms not exceeding 0.25 acres (FARA, 2009). Fanya juu practices were reported to be a new re-invented SWC measure being promoted by the IP where farmers are shown the benefits of fanya juu trenches in forms of training and collective action in SWC.

Plate 4.4: A fanya juu trench for SWC on one of the farms visited

4.1.5 Application of animal manure

Two forms of manure application were identified being practiced in the catchment by farmers. In the conventional way, farmers applied manure near their homesteads, rather than on the plots far away from the house, also a similar case is reported by Briggs and Twomlow (2002) for farmers in SW Uganda where they apply manure on nearby farms and almost neglect the far away farms with little or no manure application at all.

For the farms in the extreme up-slopes, some farmers owning animals used a traditional practice of rotating their animals on their fallowed farms for a period of between 3-6 months and later the accumulated animal manure could be spread on the farm and this could be coupled with good agronomic measures that conserve water and soil on the farm.

4.1.6 Traditional cut-off drains

In Table 4.1 it is reported that 31% of the farms visited had traditional cut-off drains as a SWC measure. An example of such traditional cut-off drains used by farmers in the catchment is presented in Plate 4.5. Traditional cut-off drains are constructed to allow excess water to infiltrate easily and to drain out of cultivated land via an artificial or natural water way. In the catchment, traditional ditches are dug on the upper side of the cultivated lands to act as cut-off drains by protecting the fields from runoff that comes from higher parts of the terraces. Traditional cut-off ditches are known for draining excess water from cultivated fields, and also to protect the soils from being washed away by runoff as well as surface run-off generated within the cultivated land as shown in (Plate 4.5).

Plate 4.5: A traditional cut-off drain on one of the plots visited

4.1.7 Crop rotation

All the farmers interviewed acknowledged the practice of crop rotation as a SWC measure on their farms. The main crops that farmers rotated were beans, potato and sorghum on the seasonal basis. Tenywa *et al* (in press) reports that the people of south western Uganda have for long used the traditional practice of rotating beans and potato and as a form of indigenous soil fertility management in a form of Biological Nitrogen Fixation (BNF) and litter nutrient recycling. Such indigenous knowledge needs to be integrated with science in conserving soil and water resources in the catchment in future.

4.1.8 Fallowing

Fallowing as a SWC measure is practiced in the catchment especially on the upper slopes of the catchment than in the middle and lower slopes. From the survey, 23% of the farms visited were under fallow especially on the extreme upper parts of the terraces. From most of the observations, fallow was practiced on severely degraded land and most of the fallows were under animal grazing. In the catchment, fallowing is restricted to highly degraded lands which cannot be restored within a short period of time for example in (Plate 4.6), this piece of land had been cultivated before and abandoned into fallow after severe degradation. From the FGD it was revealed that the fallow period was between 3-10 months and most of the fallows were under pressure for cultivation and eucalyptus farming thus leaving them with limited time to regain their fertility. Fallowing is one of the best methods to reduce soil fertility loss (Hudson, 1992).

Plate 4.6: A fallowed and abandoned piece of land

4.1.9 Multiple cropping

Thirteen percent (13%) of the farm had multiple cropping as a SWC practice (Table 4.1). Multiple cropping as a SWC measure involves a practice of growing more than one type of crops on the same piece of land. Apart from being a risk avenue strategy by farmers, intercropping also ensures that the soil is protected by abundant crop canopy of different species of crops (Koskey, 2005).

4.1.10 Challenges hindering SWC

The most predominant challenge reported by farmers (52%) hindering SWC activities in the sub catchment is land fragmentation (Table 4.2). Briggs and Twomlow (2002) also reported that land fragmentation has a major impact on SWC management strategies used by farmers in SW Uganda. The non-contiguous nature of field ownership on a hillside makes it unattractive for a farmer to invest in any form of intensive SWC strategies if the farmers who own land parcels up-slope, down slope, or in adjacent fields do not wish to invest in SWC. Without some collective investments an individual’s efforts in SWC will be largely wasted.

Table 4.2 Challenges reported to be hindering SWC by farmers in the catchment

Type of challenge	**Frequency**	**Percent**
Financial investment	11	11.6
Land fragmentation	52	54.7
Technical support	11	11.6
Labour	21	22.1
Total	**95**	**100.0**

Twenty one percent (21%) of the farmers report that labour was a challenge in SWC. This was attributed to the fact that most of the children of which 43% above 15 years and above are involved in universal primary and secondary education yet the few who would have been involved in SWC activities are partly involved in various off-farm activities. Other challenges reported by farmers were financial and technical support in SWC activities that was reported to be limited.

4.2 Personal factors in relation to adoption of SWC in the catchment

4.2.1 Sex

Out of the total (95) interviewed farmers, 52% of them were women while 48% of them were men. Women were more involved in the research since they are perceived in the catchment to be more involved in day to day farming activities than men. Out of the total households interviewed 83.2% were married, 3.2% were single, 2.1% were divorced and the remaining 11.6% were widowed (Table 4.3).

Table 4.3: Marital status of the household heads interviewed

Marital status	**Frequency**	**Percent**
Single	3	3.2
Married	79	83.2
Divorced	2	2.1
Widowed	11	11.6
Total	**95**	**100.0**

Sex is not significantly associated with adoption of SWC measures in the catchment ($X^2 = 0.095$, df=1, p=0.758). This is in agreement with Amsalu and de Graaff (2006) who also found sex not influencing adoption of stone terraces for soil and water conservation in the Ethiopian highlands. Whether male or female, both sexes do not significantly influence adoption of SWC measures in the catchment.

4.2.2 Labour for SWC

Seventy three percent (73%) of the labour used for SWC activities is provided by members of the household (Table 4.4). Eighteen percent (18%) of the farmers reported that they combined both their own labour and the hired labour for SWC activities. Collective exchange of labour was not reported for SWC activities at a farm level basis on individual farms. There was a significant relationship between use and adoption of SWC measures and the different sources/types of labour ($X^{2=}$ 126.516, df=3, p<0.001)

Table 4.4: Types of labour in SWC applied by farmers in Bufundi

Labour types in SWC	**Frequency**	**Percent**
Hired labour	6	6.3
Own family labour	70	73.7
Collective exchange of labour	1	1.1
Hired & own labour	18	18.9
Total	**95**	**100.0**

Keil (2001) reports that household labour influences the decision of farmers to undertake the conservation measures given household labour is the whole supplier of the required labour for undertaking the farming and soil conservation operation. On average, a household had between 2-15 members living together. Fifty six percent (56%) of these household members had between 0-15 years while 43% were between 16-64 years (Figure 4.3)

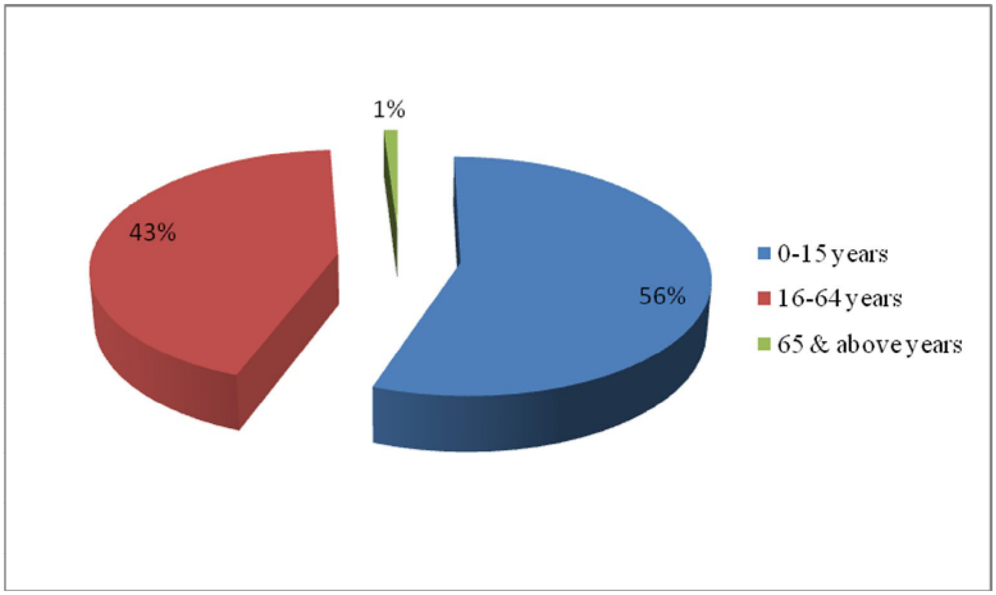


Figure 4.3: Age categories of household members

4.2.3 Perception of soil erosion

A significant relationship exist between adoption of old and improved SWC technologies in the study area and perception of the problem of soil erosion ($X^2 = 29.56$, df = 1, $p<0.001$). Majority of the farmers (93%) acknowledge that soil erosion is indeed a problem on their farms, such farmers are expected to be in position to adopt at least a SWC as observed in Table 4.5.

Table 4.5 Perception of soil erosion and adoption of SWC

Perception of soil erosion	Frequency	% of farmers	Number of plots visited	frequency	% of plots
Adopting farmers YES	88	92.6	Plots with at least a major SWC	149	93
Non adopting farmers	7	7.3	Plots without any conservation measure	11	7
Total	**95**	**100**	**160**	**160**	**100**

Farmers who perceive soil erosion as a problem having negative impacts on productivity and who expect positive returns from conservation are likely to decide in favor of adopting available conservation technologies (Semgalawe and Folmer, 2000; Gebremedhin and Swinton, 2003). On the other hand, when farmers do not acknowledge soil erosion as a problem, they will not expect benefits from controlling erosion and it is highly likely that they will decide against adopting any conservation technologies.

4.2.4 Training in soil erosion control

Adoption of SWC is dependently significant with different sources of information that farmers use in Bufundi sub-catchment ($X^2 = 47.667$, df=4, $p<0.001$). Most of the farmers reported using farmer to farmer means as the most used source of information about SWC, however, during the FGDs and the non formal interviews it was discovered that promotion of farmer to farmer means of communication for SWC was being promoted by the IP. Farmers cannot adopt technologies if they do not have access to all the relevant information, but the information they are given is often incomplete, focusing only on the technical aspects and overlooking some key criteria from a farmer's point of view (Fikru, 2009).

While institutions like NGOs, government- extension workers and research centres are believed to be influential for knowledge dissemination and training for SWC, their impact was hardly felt by farmers in Bufundi sub-catchment (Figure 4.4). Sixty six percent (66%) of the respondents reported that they were getting trainings in soil erosion control from the innovation platform multi-stakeholders rather than from solely NGOs, KAZARDI research station and government extension workers.

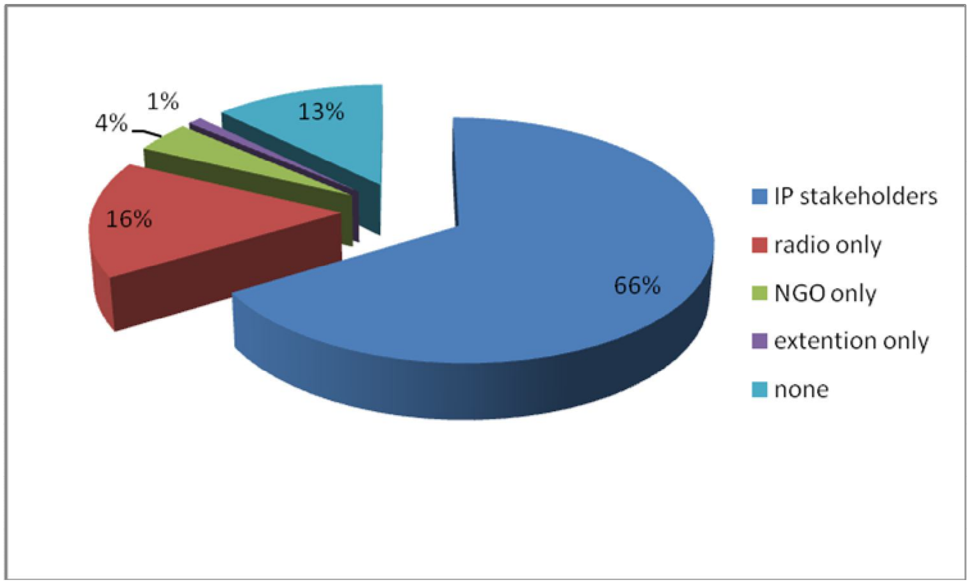


Figure 4.4: Different sources of information for SWC.

Visits of extension agents to households are likely to increase their awareness about the effects of land degradation and the knowledge about the SWC technologies and their benefits (Nkonya, 2002). However, from the survey it was reported that extension services for SWC were still weak.

Boyd *et al*. (2000) reported that changes in the wider political environment in Uganda at both national and local levels have affected investment in SWC through changes in the capacity and perceived authority of institutions that have been entrusted with SWC. Since the colonial period, responsibility for promoting SWC has been delegated to local leaders and administrations. The decentralization policy reinforces this approach and this is an indicator of the state's committement for SWC. However, the notion of promoting SWC is not necessarily high on the agendas of local administrations, as they have limited capacity and expertise to promote SWC. Support from agricultural extension staff is limited by retrenchment, low motivation and a shortage of resources. Perhaps extension was supply driven rather than being demand driven.

Innovation Platform (IP) meetings that are conducted weekly, monthly or quarterly are significantly associated with adoption and use of existing SWC measures. ($X^2=71.30$, df=6 $p<0.001$) as shown in (Table 4.6). Monthly and quarterly meetings conducted by the Innovation Platforms for SWC were reported more organized and informative of SWC technology use and adoption. However, during the FGD, local leaders acknowledged that they had received trainings on SWC from other multistakeholder of the IP including KULIKA and AFRI-CARE local NGOs as well as government. Also during the FGD it was revealed that the Innovation Platform demand-economic driven interventions for SWC aimed at increasing the productivity and profitability of farmer products while at the same time targeting NRM using farmer decision support tools (DST) in SWC.

Table 4.6: Frequency of SWC trainings reported by farmers

Period of training	Frequency	Percent
Weekly	8	8.4
Monthly	13	13.7
Quarterly	39	41.1
Yearly	3	3.2
Once	18	18.9
None	14	14.8
Total	**95**	**100.0**

4.2.5 Land tenure

Land in the study area is scarce mainly due to population pressure. On average, farmers have between 0.25-3 acres of land (FARA, 2009). Most of the land was individually owned by farmers in a form of tenure known as customary-individual ownership. In most of the non-formal discussions with farmers, land tenure insecurity was not a problem hindering farmers to invest in sustainable SWC practices. Thirty eight (38%) of the respondents had inherited their land while 37% had inherited some of the plots and purchased some of the plots (Figure 4.5)

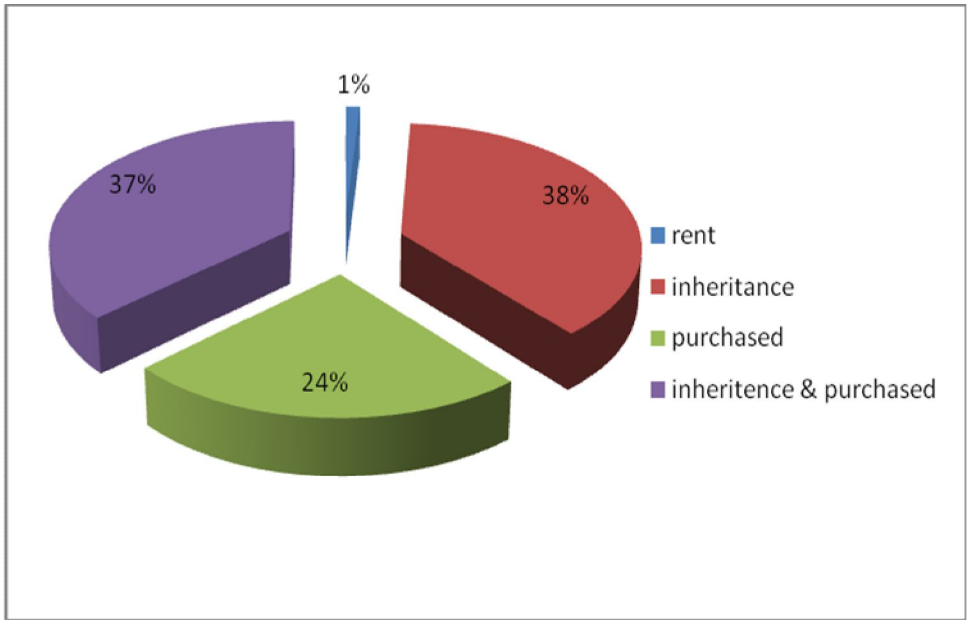


Figure 4.5: Types of land tenure in the catchment

The chi-square test also proved a strong relationship between adoption of existing SWC technologies and land ownership ($X^2 = 33.463$, df = 3, $p < 0.001$). This explains the current levels of adoption of SWC technologies as farmers who own their land tend to invest in SWC measures because of perceived tenure security.

4.2.6 Sources of money to invest in SWC activities

The major source of money for investing in soil conservation in Bufundi by farmers is after sale of agricultural products. Sixty eight percent (68%) of the farmers reported their main source of income as sale of their agricultural output. On the other hand, 22% of the farmers got their source of income for investment through off-farm activities while 5% used group savings. A significant relationship exist between adoption of SWC technologies in the study area and the sources of income for investing in SWC ($X^2=45.78$, df=4, $p<0.001$). This is attributed to sales that farmers reap from their annual crops (beans, potatoes and sorghum) that are highly demanded. All the farmers interviewed had never accessed any form of loan from a bank or the rural micro-financial agencies. However, efforts to link farmers under the IP to input dealers, NAADS, and SACCOs for financial credit were under negotiations with support from FARA, ODLN and COL.

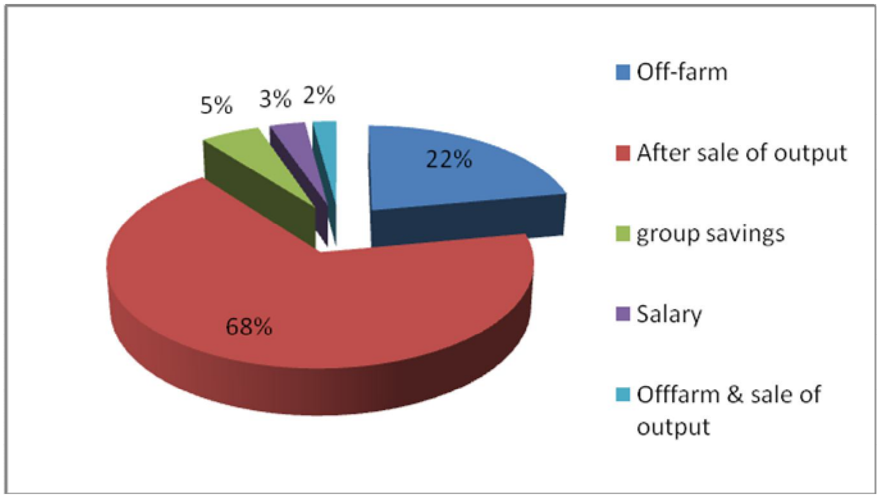


Figure 4.6: Sources of money farmers use to invest in SWC

Diagne and Zeller (2001) reported that Poor rural households in developing countries lack adequate access to credit, on the other hand Nkonya (2002) and Tenywa *et al.* (in press) report that when farmers are linked to markets, they are attracted to take credit and meet market demands and in the process they implement SWC.

Access to agricultural inputs was reported to be individualistic rather than group and institutional based. Ninety five percent (95%) of the farmers accessed agricultural inputs individually according to an individual's base of income, involvement in off-farm activities and access to the market

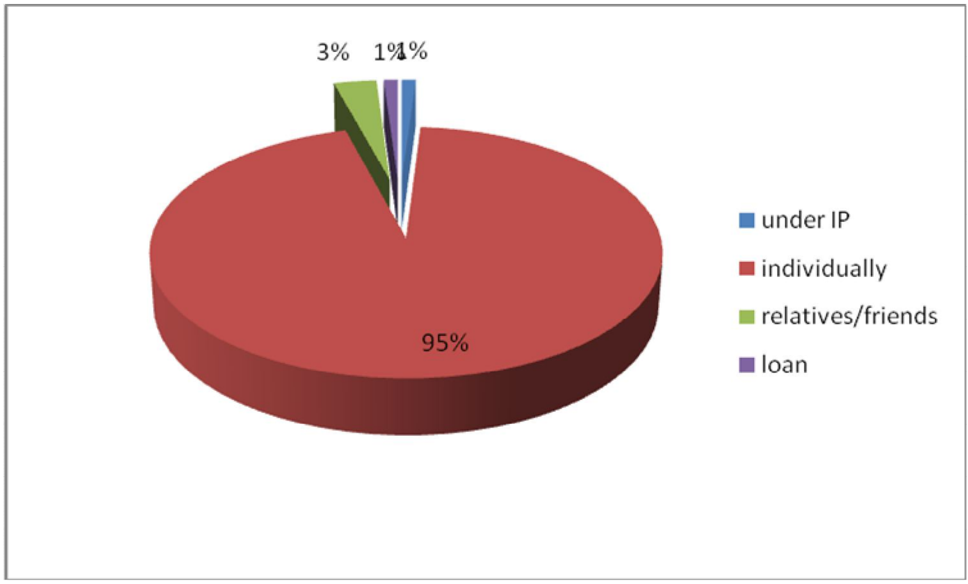


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Figure4. 7: Farmers' access to agricultural inputs

4.2.7 Off-farm activities as a determinant for SWC

The survey showed that only 39% of the farmers were not involved in any forms of off-farm activities (Figure 4.8). That means 61% of the respondents were involved at least in a certain form of off-farm activity. Thirty nine percent (39%) were involved in small scale trading especially men, other forms of off farm activities were artisan 7%, civil service 3% and others 17%.

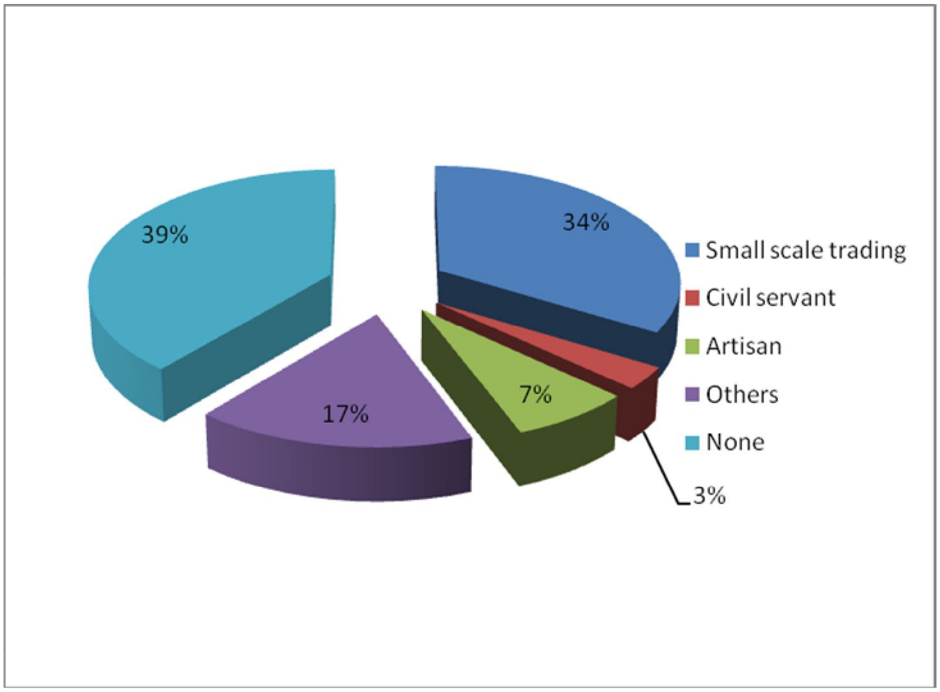

Figure 4.8: Types of off-farm activities in the catchment

The relationship between off-farm employment and adoption performance of SWC is poorly understood according to Kessler, (2006). Off-farm activities may have a negative effect on the adoption behavior of SWC due to reduced labour availability. When the farmer and family members are more involved in off-farm activities, the time spent on their farmland will be limited and hence the family is discouraged from being involved in construction and maintenance of SWC structures. On the other hand, off-farm activities can be a source of income and might encourage investment in farming and SWC.

Men contributed the highest category of household members involved in off-farm activities (25.3%) when compared to women. Twenty one percent (21.1%) of the household member categories were not involved in any form of off-farm activities as shown in (Table 4.7).

Table 4.7: Category of Household members involved in off-farm activities

Household member	**Frequency**	**Percent**
Man only	24	25.3
Woman only	8	8.4
All family members	17	17.9
Children only	16	16.8
Man and woman	10	10.5
None	20	21.1
Total	**95**	**100.0**

Despite the fact that 61% of the respondents were involved in off-farm activities as shown in Figure 4.8 (small scale trading, civil service, artisan, others), there was no significant relationship between SWC activities and a category of a household member involved in off-farm activities from the chi-square test (X^2=11.421, df=5, p=0.044). That means any category of household members involved in off-farm activities is independent to invest (neither time nor money) in SWC activities/measures. Each household member category involved in off-farm activities does not translate into investment in SWC activities but rather it is a form of contribution to household food and other needs given the high numbers of family members.

Most of the off-farm activities were conducted on market days (43.2%) and most of the people involved were children and women. 27.4% reported being involved in off-farm activities all the year as shown in (Table 4.8)

Table 4. 8: Time spent doing off-farm activities reported by farmers

Time of off-farm activities	Frequency	Percent
Quarter day	1	1.1
Half day	4	4.2
Whole day	23	24.2
All the year	26	27.4
Market days	41	43.2
Total	**95**	**100.0**

4.2.8 Perception on institutional innovations for SWC

Areas under woodlot and river banks in the catchment were the major areas where collective action was being promoted collectively by members of the Innovation platform (Figure 4.10). Social capital has been shown to have important economic effects at the micro and macro levels (Nyanena, 2005). Re-inventing the wheel of social capital in the catchment is being championed by the Bufundi Innovation Platform with the support of multistakeholders. Social capital is generally interpreted as the degree of trust, cooperatives, norms and networks and associations within a society. Collective action for SWC was reported instrumental in information dissemination on soil erosion and training in SWC as well as promotion of new SWC technologies in the catchment.

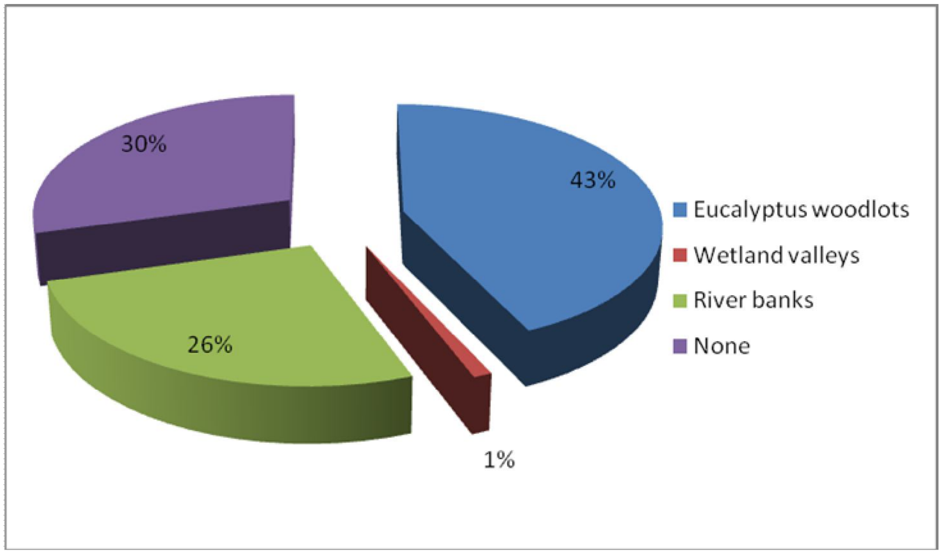

Figure 4.10: Hotspot areas rehabilitated under collective action for SWC

Various arguments have been advanced as to why higher levels of social capital can lead to improved economic performance; these include the reduction of monitoring and enforcement costs, improving information flows, fostering of exchanges for mutual benefits by developing reputation dissemination and promotion of consultative decision making and collective action that minimizes negative externalities and promotes the production of public goods.

The chi-square test proved that there was a significant relationship between adoption and use of SWC technologies and the perception of people about the changes brought by the IP on SWC activities ($X^2 = 42.81$, df=3 $p<0.001$). Fifty (50) of the respondents reported some form of change within the community members on SWC technology use and adoption (Table 4.9)

Table 4.9: Perception on SWC changes and why there are these changes

Perception of change	Reasons for the changes in the catchment								
	IP formation	Collective labour	Collective marketing	Attitude Change	IP leaders	By-laws by IP	Inputs from IP	No reason	Total
No change	0	4	0	1	0	2	0	16	23
Some change	12	8	5	6	5	12	1	1	50
Remarkable change	2	3	0	1	1	2	0	1	10
Do not know	0	4	0	1	1	2	0	4	12
Total	**14**	**19**	**5**	**9**	**7**	**18**	**1**	**22**	**95**

The change in perception and attitude can be attributed to the adoption of a multi-stakeholder catchment approach that is demand driven for SWC and this is the IP. Tenywa *et al* (in press) report that most of the SWC approaches in SSA are supply-driven in nature rather than being demand-driven, and predominantly use the linear research-extension-farmer technology transfer model as opposed to the economic and institutional approach at a level of a catchment. The framework for economic and institutional approaches is rooted from Lopez (1977) who stipulates that if institutional dynamics pre-dominate environmental dynamics, new institutions that protect the land emerge, and consequently livelihoods of farmers improve. However, if environmental dynamics predominate institutional dynamics conflicts arise and the soil erosion problem is exacerbated. The IP is recognized as a new institution that has emerged to protect and conserve the catchment and its resources, therefore institutional innovations brought about by the IP are indeed promising for sustainable SWC adoption in the catchment.

4.2.9 Descriptive Statistics of Empirical Variables

The descriptive statistics of the variables used in the regression model are provided in (Table 4.10). The mean age of the household head was 45 years. The average level of education was 5.74 years with a maximum of 15 years and minimum of zero or none. Household members on average were 5.77 with a maximum of 15 children and a minimum of zero or none. The average number of plots was 7.29 with a maximum of 16 and a minimum of 2 plots. The mean slope in the catchment was 3.52, on the other hand the mean farming experience was 24 years with a maximum of 50 years and minimum 3 years.

Table 4.10: Descriptive statistics of variables

Variable	**Description**	**Mean**	**Max**	**Min**	**Std-dev**
CLAD	Dependent binary variable: 1 for old SWC measures and 0 for otherwise		1	0	
EDU	Education of farmer in years	5.7	15	0	3.53
HHM	Number of household members	5.7	15	0	2.49
IPM	IP membership (1=member 0 otherwise)		1	0	
AGE	Age of farmers (in years)	45.1	78	21	12.6
PER	Farm size (number of plots)	7.2	16	2	2.3
SLP	Slope	3.51	5	0	0.7
YOF	Years of farming (in years)	23.6	50	3	12

Note: Max. is Maximum Value, Min. is Minimum Value and Std. Dev. is Standard Deviation

Farmer traits (age, years of experience in farming, level of education, membership of IP, number of children in a household, slope and farm parcels owned were all hypothesized to influence SWC in the study area and this was analyzed using the logistic regression model.

The empirical results are presented in this section where the explanatory variables were tested for multicollinearity. The correlation matrix presented in Table 4.11 show that multicollinearity was not a source of concern, since none of the explanatory variables were strongly correlated with each other.

Table 4.11: Correlation matrix of the variables in the logit model.

	CLAD	EDU	HHM	IPM	AGE	PER	SLP	YOF
CLAD	1.000							
EDU	-0.236	1.000						
HHM	-0.016	-0.240	1.000					
IPM	-0.057	-0.106	-0.087	1.000				
AGE	0.265	0.113	0.061	0.297	1.000			
PER	-0.075	0.138	0.057	0.186	0.087	1.000		
SLP	0.007	0.022	0.022	-0.074	-0.153	-0.139	1.000	
YOF	0.038	-0.039	0.094	0.028	-0.131	-0.014	0.373	1.000

Table 4.12 shows the logit estimates of the probability to adopt SWC technologies in Bufundi Sub-catchment.

Table 4.12: Logit estimates for the seven predictor variables

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.063	3.504	0.303	0.761
EDU	-0.766	0.294	-2.601	0.009
HHM	-0.286	0.262	-1.088	0.276
IPM	-2.147	1.131	-1.898	0.057
AGE	0.168	0.063	2.663	0.007
PER	-0.010	0.177	-0.061	0.951
SLP	0.106	0.529	0.201	0.839
YOF	0.058	0.055	1.058	0.290
Mean dependent var	0.855	S.D. dependent var		0.357
S.E. of regression	0.323	Akaike info criterion		0.8110
Sum squared resid	6.403	Schwarz criterion		1.0700
Log likelihood	-19.98108	Hannan-Quinn criter.		0.9138
Restr. log likelihood	-28.55279	Avg. log likelihood		-0.2891
LR statistic (7df)	17.143	McFadden R-squared		0.3002
Probability(Lstat)	0.0164			

Source: Field Survey (2011)

Almost all the variables in the logistic model had the correct a priori signs or the hypothesized signs as expected with the exception of HHM, IPM and EDU. However, the variable AGE is indeterminate and can take any sign (either positive or negative).The strength of the regression model was assessed using the Mc Fadden’s R-Squared. This is a pseudo R-Square which significant values are between 0.2-0.4, therefore the Mc Fadden’s R-Squared of 0.3 (Table 4.12) indicates that the model was better to predict adoption and use of SWC technologies in the catchment.

4.2.10 Education (EDU)

This variable was expected to take a positive sign rather, it took a negative sign, and the basis of this was that the higher the level of formal education one attains in number of years the less is he/she expected to engage in farming and thus adoption of SWC technologies. These finding differ with the findings of Krishana *et.al* 2008, Caswell *et al.*, 2001; Long, 2003 and Traore *et al.*, 1998 who found that education of the household head was positively related to the adoption of improved SWC technology. Educated farmers are presumed to have exposure to new technologies and innovations, and are more receptive to new ideas and more willing to adopt. This implies that adoption of SWC technologies in the catchment is negatively influenced by the level of formal education attained by a household head at primary, secondary and tertiary levels.

4.2.11 Household Member (HHM)

This variable was expected to take a positive sign; rather, it took a negative sign and insignificant. Despite the fact that 74% of the labour force for SWC measures is provided by the household members in a form of farming (Figure 4.9), it does not imply that there is adoption of SWC measures. These finding are in line with Wagayehu and Lars (2003) who indicated that in the large families with greater numbers of mouths to feed, competition arises for labour and investment in SWC technologies thus priority and labour is diverted to off-farm activities that generate food. The results in the model reveal that the more the number of household members the less the adoption and use of SWC technologies. This might be due to the large numbers of family members of which 61% are being involved in off-farm activities to compliment their incomes and food. On average households have between 0-15 members of which 56% are below the age of 15 years and 43% between 16-64 years (Figure 4.3).

4.2.12 Innovation Platform member (IPM)

This variable was expected to take a positive sign; rather, it took a negative sign. This implies that an individual's membership in the existing innovation platforms does not automatically guarantee that a farmer will adopt all the necessary and required SWC measures in the short run especially if profitability and productivity of the technology are not assured. Farmers who are members of the newly formed innovation platform among others are not better placed to adopt soil conservation technologies than their counterparts. This contradicts with farmer perceptions about the formation of the IP when the chi-square was run. This is because of the snapshots in the categorical nature of the data.

Institutional innovations are reported by Lopez (1977) who stipulates that if institutional dynamics pre-dominate environmental dynamics, new institutions that protect the land emerge, and consequently livelihoods of farmers improve. Therefore, the IP during the FGDs was reported as the new institution that has emerged as a result of integrated planning using the catchment management plans being promoted by the multi-stakeholders but this does not guarantee full adoption of required technologies. Membership to such organizations enables farmers to acquire information on proper agronomic practices, credits, productive inputs as well as attend seminars and workshops at which stakeholders would meet and exchange ideas. As noted by Coleman (1998) and Dikito (2001), self-help grouping and formation of cooperatives is a more reliable and pragmatic means of achieving social capital and ensuring dissemination and adoption of innovative technologies.

4.2.13 Age of the respondents (AGE)

Age took a positive sign as predicted and was significant. Therefore as a farmer's age increased it also increased the likelihood of a farmer to indentify soil erosion indicators and threats and thus adoption of SWC measures. It was also expected that older farmers were likely to have more farming experience and would therefore be likely to be more receptive to new SWC technologies (Wagayehu and Lars, 2003). These finding differ with the findings of Long (2003), Lichtenberg (2001) and Wagayehu and Lars (2003) who have reported a negative association between adoption of SWC technologies and age, as older farmers are believed to have higher personal preference which can reduce the net present value of return from investment on long term soil conserving technologies. Also the results differ with the finding of (Sidba, 2005) who reported that older farmers were likely to be relatively reluctant in their decisions to take up new technologies because of their short planning horizon (Sidba, 2005).

4.2.14 Parcels of land owned (PER)

Consistent with other studies and with theory, the variable PER (farming size in numbers of plots) is negatively related with adoption of SWC technologies in the catchment and not significant. This is expected, as the number of farm parcels of a farmer increase, the attention and care given to proper farming practices reduces drastically, affecting adoption of improved technologies and maintenance of existing structures (Long, 2003; Kessler, 2006; Ertiro, 2006). It is reported in the FARA report of 2009 that on average farmers in Bufundi own between 0.25-3 acres of land that is scattered across the different landscapes. Although the mean number of farm parcels in the catchment is 7.26 plots with a minimum of 2 plots and a maximum of 16 plots, population pressure is leading to fragmentation of farmlands in the area.

4.2.15 Slope of land (SLP)

As expected, the variable SLP took the hypothesized positive sign, but not significant. This implies slope of land influence adoption and use of SWC technologies positively. This is because slope is an indicator of soil and water loss from the farmland. This implies that adoption of SWC technologies in the catchment is positively influenced by slope. Thus, farmers cultivating sloping fields perceive the threat of soil loss more than farmers who cultivate gentle or low sloping fields. This implies that farmers cultivating vulnerable fields are more likely to adopt and use SWC technologies in their farms than those cultivating less vulnerable lands. This is consistent with other studies by Bekele (1998); Wagayehu and Lars (2003) and Bett, (2004).

4.2.16 Years of farming (YOF)

As expected, the variable YOF took the hypothesized positive sign, but not significant. This implies that the number of years a farmer has spent farming influence adoption and use of SWC technologies positively. From the study findings the mean years spent farming was 23.67 with a minimum of 3 years and a maximum of 50 years in farming. Fitsum and Holden (2003) reported that experienced farmers in farming are likely to manage their land in a better way than the less experienced farmers. On the other hand, it is also observed that as the age of household head increases, the ability of applying fertilizer and any conservation measure decreases (Fitsum and Holden, 2003).

4.3. Nutrient flows and balances in the predominant SWC measures

4.3.1 Soils

The mean values of the different soil properties in the predominant SWC measures (bench terraces) are indicated in (Table 4.13). The mean values for pH from all the micro catchment positions were below the critical values but were slightly moderate for the mid slope positions (Table 4.12). Soil organic matter was higher in the mid slopes when compared to other micro catchment positions (Table 4.13). This is attributed to the fact that most of the farmers interviewed lived in the midslope positions and given the fact that most of the farms sampled were near the homesteads. Soil organic matter (SOM) and pH are among the factors determining the inherent fertility of Uganda soils and crop yields according to Foster (1978) and Kaizzi (1998).

Table 4.13: Mean values of selected soil properties from different micro catchment positions

Soil property	Upslope	Midslope	Lower slope	Total mean	Critical values
pH	4.841	5.434	4.739	5.086	5.5
SOM%	3.7418	5.5881	3.930	4.430	3.45-6.89
N%	0.1754	0.1934	0.189	0.186	0.2
P(mg/kg)	22.2878	62.207	22.887	35.827	20-80
K(cmol/kg)	0.4547	0.8076	0.49822	0.586	0.2-1.5

Briggs and Twomlow (2002), Walaga *et al.* (2002) and Ssali (2000) also observed that farmers in SW Uganda replenish more farms near their homes with organic manure and crop residue more when compared to the farms that are very far away from their houses.

Mean values for N were below the critical values (Table 4.13) on all the farms in the three micro catchment positions. Tenywa *et al* (in press) also observe that N is the most limiting factor to increased agricultural productivity in Bufundi sub-catchment that needs urgent attention for policy makers. All the farmers interviewed, reported none use of inorganic fertilizers (IN1) but rather reported use of organic manure (IN2a) as a major nutrient inflow for most of the farms. Organic manure was applied more on farms near homes that are mostly located in the mid slope positions (Table 4.14) when compared to other micro catchment positions

Table 4.14: Mean flows for the different micro catchment positions

	Nitrogen			Phosphorus			Potassium		
Inflows	**upper**	**middle**	**Lower**	**upper**	**Middle**	**lower**	**Upper**	**Middle**	**lower**
IN1	0	0	0	0	0	0	0	0	0
IN2	13	38	17	1	2	1	11	35	12
IN2b	1	2	0	2	1	1	1	2	4
IN3	3	3	3	1	1	1	2	2	2
IN4	1	3	4	0	0	0	0	0	0
∑Inflow	**18**	**46**	**24**	**4**	**4**	**3**	**14**	**39**	**18**
Outflows									
OUT1	-5	-11	-8	0	-2	0	-3	-10	-4
OUT2	-8	-20	-11	-1	0	-1	-5	-11	-4
OUT2b	-1	-2	-1	-1	-1	0	-2	-4	-1
OUT3	-3	-4	0	0	0	0	-1	-1	-2
OUT4	-1	-4	0	0	0	0	0	0	0
OUT5	-5	-8	-2	-1	-2	-1	-3	-2	-1
OUT6	-1	-3	-3	0	-1	-1	-1	-1	-1
∑Outflow	**-24**	**-52**	**-25**	-3	**-6**	-3	**-15**	**-29**	**-13**
Nutrient balance	**-6**	**-6**	**-1**	**1**	**-2**	**0**	**-1**	**10**	**5**

IN1 Mineral fertilizers, IN2a Organic manures, IN2b Grazing, IN3 Atmospheric deposition, IN4 Biological nitrogen fixation, OUT1 Crop products, OUT2a Crop residues, OUT2b Manure, OUT3 Leaching, OUT4 Gaseous losses, OUT5 Erosion, OUT6 Human excreta Balance = ∑IN – ∑OUT

N inflows were lowest in the upslope terraced positions (18 kg/ N ha^{-1}) but were higher in the lower terraced parts of the catchment (24 kg/ N ha^{-1}) and highest in the mid slope terraced positions of the catchment(46/ kg N ha^{-1}). On the other hand, more nutrient outflows in form of crop products (OUT1) (-11 kg/ N ha^{-1}) and crop residue (OUT2a) (-20/ kg N ha^{-1}) were highest in mid slope terraced areas when compared to other outflows (Table 4.14).

Farm-level nutrient flows were variable and differed between different terraced farms in the study area (Table 4.15) when a T-test was run. Organic manure (IN2) significantly differed between terrace farms at ($P<0.005$). Crop residue (OUT2a) also was significant at ($p<0.005$) for N,P and K outflows thus implying high depletion rates via these avenues. This can be attributed to high volumes of crop residues harvested and used as mulch, fuel, fodder and building materials whilst limited use of other inflows (Table 4.15). Soil erosion (OUT5) was a major outflow for N and K on all the farms. The contribution of inflows of major nutrients on the farms due to organic manure amounted to 44%, 78% and 62% of the total farm inflows for N, P and K respectively (Table 4.15).

Table 4.15: A T- test showing flows and balances of major nutrients (kg ha^{-1}) on farms in Bufundi

N	**T value**	**Sig**	**P**	**T value**	**Sig**	**K**	**T value**	**Sig**
IN1	0	-	IN1	0	-	IN1	0	-
IN2	4.14	0.000*	IN2	12.24	0.000*	IN2	5.291	0.000*
IN2b	1.193	0.242	IN2b	1.193	0.242	IN2b	1.193	0.242
IN3	1.911	0.066	IN3	2.173	0.038	IN3	2.173	0.38
IN4	2.173	0.038	IN4	0	-	IN4	0	-
∑inflow	**9.4**			**15.6**			**8.6**	
OUT1	-1.482	0.149	OUT1	-1.614	0.117	OUT1	-1.55	0.323
OUT2	-3.308	0.003*	OUT2	-3.308	0.003*	OUT2	-3.308	0.003*
OUT2b	-1.0	0.326	OUT2b	-1.00	0.326	OUT2b	-1.000	0.
OUT3	-1.227	0.230	OUT3	-1.01	0.321	OUT3	-1.098	0.283
OUT4	-1.415	0.160	OUT4	0	-	OUT4	-1.097	.282
OUT5	-3.489	0.004*	OUT5	-1.194	0.242	OUT5	-3.520	0.001*
OUT6	-.896	0.378	OUT6	-.876	3.88	OUT6	-0.954	.348
∑outflow	**-12.8**			**-9.002**			**-12.5**	

IN1 Mineral fertilizers, IN2a Organic manures, IN2b Grazing, IN3 Atmospheric deposition, IN4 Biological nitrogen fixation, OUT1 Crop products, OUT2a Crop residues, OUT2b Manure, OUT3 Leaching, OUT4 Gaseous losses, OUT5 Erosion, OUT6 Human excreta

Biological nitrogen fixation (IN4) was the second major nutrient inflow on all the terraced farms contributing 23% of the total N (Table 4.15), this is attributed to an interesting traditional practice of rotating beans and other crops the next season that is mostly practiced in the catchment. Smithson and Giller (2002) and Vanlauwe and Giller (2006) reported that opportunities exist through growing of leguminous crops to improve soil fertility, especially increasing nitrogen supply through biological nitrogen fixation if other limitations like low P in soils are addressed.

Contributions of other inflows that included grazing (IN2b), atmospheric depositions (IN3) were small, whilst no mineral fertilizer (IN1) use were done on any of the terrace farms. Similar cases of no or very little use of inorganic fertilizers (IN1) in most of the Ugandan farming systems (1 kg $^{-}$ha) are reported by Ebanyat (2010), Walaga *et al.* (2002), Ssali (2000), Nkonya and Kaizzi (2005), Walaga (1999) and Wortmann *et al.* (1998). The major nutrient outflows include crop residues (OUT2a) contributing 27%, 37% and 26% of total N, P and K outflows respectively on the terraced farms and soil erosion (OUT5) contributed between 27% and 28% of total N and K outflows respectively (Table 4.14). Briggs and Twomlow (2002) also observed that, export of crop residues is leading to a decline in soil fertility and increasingly severe limitations to crop productivity in SW Uganda. Organic matter is the key to soil fertility and productivity in agricultural systems where there is no use of inorganic fertilizers (Greenland and Dart, 1972). Yet in many tropical cropping systems, little or no organic residues are returned to the soil (Briggs and Twomlow 2002).

Mineral fertilizers (IN1) are not important sources of nutrient inflows for the sample farms. They contributed none of the total inflows on the terraced farms studied, this is attributed to the very high prices of mineral fertilizers, farmers also reported that the markets for these fertilizers are very far in Kabale market and the distance from Kabale market to Bufundi is between 45-55 kilometers on a poor road, this is coupled with very low extension and information on use of mineral fertilizers by most of the farmers.

The sources of nutrient outflows from the terraces are crop and animal products sold or given away, crop and animal residues exported; gaseous losses and soil erosion of nutrients. For all the three nutrients (NPK), crop residues (OUT2a) are the major outflow, accounting for more than 27% of N outflows, crop products (OUT1) contributed up to 12% of N outflows and soil erosion contributed up to 27% of N out flows (Table 4.15) from the terraces. Soil erosion is the most important outflow for K accounting for up to 28% of total K lost from these terraces. Soil erosion is a major contributor to nutrient losses since much of soil nutrients in tropical agriculture are in the top 5 to 10 cm. of the soil according to Keeney (1982). The negative balances for N are attributed to high soil losses as a result of soil erosion on most of the terrace farms.

The Pearson's correlation coefficient for selected variables influencing the flows of major nutrients (Table 4.16) showed a significant relation between household labour for PPUs and the labour for SPUs because of the incomes farmers expect from PPUs and SPUs. This strongly informs us that agriculture is the major source of livelihood for people in Bufundi. It also showed a significant relationship with off-farm labour and household net cash flows earned. Given the fact that most of the farm holdings are small, less than one hectare, most of the households are involved in off farm activities to compliment their incomes and food.

Labour in form of PPUs, off-farm activities and SPUs were all significant with household net cash flows earned by households in the study area (Table 4.16). This implies that these were the biggest contributors of incomes to farmers. Despite the fact that they were the greatest contributors of incomes to farmers, they did not translate into a significant investment on farmers land (returns to land). This implies that farmers could not use their incomes to buy inputs like fertilizers and high yielding clean seeds. This could imply that the inputs were either very expensive or not accessible to farmers given the fact that Bufundi is very far from the main input-output market (about 50 kilometers from Kabale market). Other explanations could be low extension services, poor market chains, high soil erosion and poor land management practices. Nkonya and Kaizi (2002) observed that inadequate extension services are likely to contribute to unsustainable land management practices if farmers adopt improved crop varieties without adopting soil fertility management practices that would restore the additional nutrients utilized by the high yielding varieties. Also Ssali (2002) in SW Uganda noted that farmers complained that productivity of plots previously planted with improved varieties decreased substantially and this impacted on farmers adoption behaviors negatively. On the other hand, Tenywa *et al* (in press) also report that farmers may resort to low yielding technologies especially under market price fluctuations if they had adopted high yielding varieties before.

TLU showed a significant relationship between household labour required for SPUs but showed no significant relationship with PPUs (Table 4.16) this implies that there was limited use of animal manure especially on most of the farms, this is attributed to the fact that very few farmers own animals as sources of manure. Similarly, Briggs and Twomlow (2002) report that the current livestock and animal manure management practice is unsustainable in SW Uganda, most of the manure from extensively grazed animals is wasted on paths or grazing land and much of it is washed away with the rains. Consequently, the quantities of manure that can be easily collected from pens and night shelters is relatively small. The situation is further compounded by the poor manure storage and handling practices that result in major losses of nutrients, particularly nitrogen due to volatilization, oxidation and leaching. However the study revealed a sustainable traditional practice where some farmers with animals seasonally rotated their animals on their different plots especially on very hilly farms after a period of 3-6 months thus reducing labour and transportation difficulties of animal manure on the upslope farms.   On the other hand, Ebanyat (2010) reported the use of animal manure (IN2b) as a major nutrient inflow in the Teso farming region of Eastern Uganda but this is totally different with Bufundi sub-catchment where farmers have very few animals that could generate significant amounts of animal manure.

There was also significant relationship between household labour for PPUs and off-farm activities. This implies that household labour for PPUs could easily be channeled to off-farm activities than on PPUs/farms especially those that were very far away from farmer’s homes. A similar scenario is also reported by Nkonya and Kaizi (2002). There was also a significant relationship between household labour for PPUs and the distance to farms. This implies that labour for SWC (crop residues and soil erosion) was available for farms that were near the homes than the farms that were far away from homes. These findings are line with the finding of Nkonya and Kaizi (2002), who also reported that average distance from residence to the farmer’s parcels increased nutrient outflows from crop residues and soil erosion. The positive association between distance to parcels and outflow through crop residue according to Nkonya and Kaizi (2002) was associated to greater theft or grazing of residues by neighbors on distant parcels, since owners are too far away to have effective control on access to such parcels. More nutrient loss through erosion for distant parcels were also reported due to use of more erosive practices on distant parcels (Nkonya and Kaizi 2002). For instance, results reported by Nkonya *et al* (2002b) show that farmers are less likely to apply manure, compost, mulch or household residues on distant parcels, and are more likely to use slash and burn during land preparation.

Table 4.16: A Pearson's correlation for selected variables influencing nutrient flows and balances

	Total farm area	HH labour PPU	HH labour SPU	Off-farm labour	TLU	Net farm income	Farm net cash flow	HH net cash flow	Returns to land	Distance to farm
Total farm area	1									
HH labour PPU	-.028	1								
HH labour SPU	.001	$.692^{**}$	1							
Off-farm labour	-.043	$.978^{**}$	$.739^{**}$	1						
TLU	.052	.284	$.567^{**}$	.264	1					
Net-farm income	.255	.043	.221	-.002	.100	1				
Farm net cash flows	.189	-.106	.294	-.039	.147	$.458^{*}$	1			
HH net cash flows	.135	$.467^{**}$	$.669^{**}$	$.537^{**}$	.274	$.385^{*}$	$.822^{**}$	1		
Returns to land	.128	.086	.297	.031	.153	-.122	.267	.243	1	
Distance to farm	-.003	$-.459^{*}$	-.342	$-.427^{*}$	-.018	$.952^{**}$	.079	-.177	-.179	1

* $P<0.05$ and ** $P<0.01$

There was also a significant relationship between net farm incomes and farm net cash flows, this is because most of the farmers earned their incomes from sale of their agricultural products and their by-products like sorghum, beans, potatoes, eggs, milk, sale of livestock like chicken, goats, wood fuel, crop residues among others. There was also a significant relationship between net farm income and household net cash flows at the end of the season but with no significant association with the returns to land. This implies that farmers will only invest in their land (SWC) if only they have assured productivity and profitability of the SWC technologies. A similar case is also reported by (Tenywa and Fungo, 2011) in Chahi IP of Kisoro district where farmers adopted high yielding maize varieties after being linked to assured market, inputs, credit, knowledge and appropriate SWC technologies. Farm net cash flows were also significant with household net cash flows. This implies that farmers solely invested in SWC on the little incomes they earned without other options like credit. There was no established credit system to assist farmers with credit to invest in SWC. (Nkonya and Kaizi 2002) reported that farmers with access to credit are likely to adopt SWC than farmers without access to credit. There was also a significant relationship between net farm incomes and distance to farm. This implies that distance of the farm influenced the choice of SWC, farm yields and incomes after sale of outputs from these farms.

From the nutrient balance study, conclusions can be drawn in the predominant SWC measures (bench terraces) that there were more nutrient outflows than inflows in most of the farmers' plots. The returns to land were also minimal implying that farmer's investment in sustainable soil and water management practices were low and this could be explained by a number of conclusions ranging from, poverty, poor market access, soil exhaustion, weak by-laws, lack of inputs like fertilizers, land fragmentation, low extension services, ignorance of farmers, low motivation to manage terraces, high population to mention but a few. The results are thus manifested in form of collapsing terraces, severe soil erosion, poor terrace maintenance and conversion of already degraded farm parcels into woodlots of eucalyptus thus leading to negative nutrient balances.

CHAPTER FIVE

5 SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Study objectives and methodology

The major objective of the study was to understand the determinants for SWC use and nutrient flow management in Bufundi sub-catchment. The study was premised on existing social, economic, institutional, physical, agricultural and cultural factors and sought to address the following objectives.

i. Establish the current soil and water conservation practices (indigenous and improved) used by farmers to mitigate land degradation in the different landscape positions.
ii. Examine the physical, institutional, social, cultural and economic factors influencing adoption and use of SWC measures in the catchment.
iii. Examine the nutrient balances in the predominant SWC measures and the different slope angles/positions.

Empirical tools used for data collection were: structured questionnaires, IP institutional questionnaires, key informant interview guides, on-farm observation guides and a NUTMON tool box questionnaire and check list. Data tools were mainly descriptive statistics (frequencies, percentages, means and standard deviations), non-parametric test involving the use of chi-square test, a logit model and lastly the NUTMON 3.6 software.

5.2.1 Summary of SWC measures used by farmers in the catchment

The study identified the following SWC technologies in the Sub-catchment, where use of bench terrace as a SWC measure was the most predominant SWC measure (93%), traditional cut off drains (31%), trees (61%), fallowing (23%), fanya juu trenches (12%), application of animal manure (39%), crop residue (56%) and multiple cropping at 13%.

5.2.2 Factors influencing SWC in Bufundi catchment

The major factors influencing adoption and use of SWC measures were sex, age, education, size of household, land tenure, number of farm parcels, training in SWC, sources of information on SWC, membership of the innovation platform, off farm income, slope and years of farming, However, issues which came out clearly in the study show that membership of the Innovation platform, perception and knowledge about soil erosion, land tenure, sources of labour, sources of money for SWC, perception of collective action, participation in IP activities, slope, years of farming and training in SWC are among the major factors that positively and significantly influence use and adoption of SWC measures. Education, sex, numbers of farm parcels owned, household size and off-farm activities showed no significant influence on use and adoption of SWC when subjected to both a chi-square test and logit analysis. Thus, it is obvious from the results that before adopting any SWC technology in the catchment, farmers consider information about the technology, topography of the farmland and social interactions brought by institutional innovations for SWC.

5.2.3 Nutrient flows and balances in the predominant SWC measure

In the predominant SWC measures (terrace benches), nutrient flows and balances differed significantly on the different farms and slope positions. N balances on all the farms were negative implying that the current low- external input is not sustainable. Mean values for N were below the critical values in the three micro catchment positions. Also N inflows were lowest (18 kg/ N ha$^{-1)}$ in the upslope terraced positions when compared to (24 kg/ N ha^{-1}) and (46/ kg N ha^{-1}) in the lower and middle slopes terraces respectively. Nutrient outflows in form of crop products (OUT1) (-11 kg/ N ha^{-1}) on plots near homesteads and crop residue (OUT2a) (-20/ kg N ha^{-1}) were highest in mid slope terraced areas when compared to other outflows

Organic manure (IN2) significantly differed between terrace farms at ($P<0.005$). Crop residue (OUT2a) also was significant at ($p<0.005$) for N,P and K outflows thus implying high depletion rates via these avenues. The contribution of inflows of major nutrients on the farms due to organic manure amounted to 44%, 78% and 62% of the total farm inflows for N, P and K, respectively. For all the three nutrients (NPK), crop residues (OUT2a) are the major outflow, accounting for more than 27% of N outflows, crop products (OUT1) contributed up to 12% of N outflows and soil erosion contributed up to 27% of N out flows

5.3 Conclusions

The study revealed that farmer perceptions of the likely benefits in SWC, assured market, personal and trainings of the IP significantly influence use and adoption of SWC than any other factor in the catchment. These findings reinforce the facts that in order to sustain use and adoption of SWC bench terrace management should be given a strong priority for long term SWC use. Farm-level nitrogen balances on all the farms were negative. Phosphorus and Potassium balances were also lower than expected implying that the current low- external input is not sustainable in the short and long term whilst no inorganic fertilizer use. N was found to be a limiting factor for sustainable agricultural productivity and this is likely to affect SWC/NRM efforts if urgent interventions are not prioritized.

5.4 Recommendations

From the findings of the study, it is recommended that the district agricultural office and the Innovation Platform multi stakeholders promote the conservation of bench terraces as it is the predominant SWC measure since even during colonialism. It was observed that most of the terraces were collapsing yet others were intentionally removed by farmers in order to increase space for farming thus excercebating soil erosion problems. The problem was further worsened by different management practices on terraces, therefore a uniform management of terraces should be promoted and this can be achieved through institutional innovations like new bylaws on terrace management.

Given the fact that trees (eucalyptus woodlots) were not geared towards SWC but rather a form of abandoning degraded parcels, it is recommended that farmers adopt other tree species that give similar or multiple benefits than eucalyptus but this should be carefully supported with empirical scientific proof than basing on this study.

Given the fact that crop harvests, residues and soil erosion were the major outflows for most of the bench terraces whilst limited use of organic manure and no mineral fertilizer use, integrated soil fertility management should be a priority for all the multistakeholders. This can take different forms ranging from crop rotation, intercropping, composting, mulching, use of rhizobia, mineral fertilizers, trash lines among other methods. This should be attained through massive sensitization, training, use of social capital and collective access to input and output markets.

Due to high costs, non availability and other constraints related to input use especially mineral fertilizer use and scarcity of ready markets for the outputs in this area, farmers have limited access to these markets. The feasible option is increased use of other sources of N P K as indicators for sustainable fertility management especially if high yields are to be maintained. However, farmer market institutional linkages should be supported more to tap premium prices, increase profitability and increase investments in soil fertility management. Forward – backward linkages should also be strengthened in order to contribute more favorable balances.

For sustainable investments in SWC/ NRM to be realized, Kabale district and the different multistakeholder (KAZARDI, NGOs, and NAADs among others) should focus on strengthening the existing Bufundi IP. This can be supported through strengthening collective action for SWC, use of social capital and participation in SWC, economic demand-driven institutional arrangements that use the integrated watershed management planning are reported by (FARA, 2009; and Tenywa *et al*, in press) to be more practical for SWC in the catchment in preference to the supply driven SWC research-extension technology transfer model that was used before.

5.5: Area for further research

For the purpose of comparability, the research can be replicated in Bufundi sub-catchment using a larger sample size (for example 350 respondents). Further studies should be carried out to carefully monitor and assess nutrient flows but at the same time observing farmer response in SWC with changes in nutrient balances and stocks over the years. Potential areas for research and development in the catchment include:

(i) An assessment of land tenure systems on soil, water and biomass resources management and conservation

(ii) Examining the status, management and trend of collapsing terraces in SWC

(iii) Land use/cover changes and nutrient balances for sustainable NRM.

REFERENCES

Adesina, A. A and Baidu-Fuson, J. (1993). Farmers' perception and adoption of new agricultural technology. Evidence from analysis in Bukina Faso and Guinea West African Agricultural Economics (13) (199)-1-9.

African Highland Initiative, AHI (2002). Strengthening institutional innovations for integrated natural resource management in the highlands of East and Central Africa Phase 4: AHI participatory research. African Eco-regional Programme, ICRAF- Nairobi.

Alemayehu, A (2007). Impact of terrace development and management of soil properties in Aujen area west Gojan. Masters thesis School of graduate studies Addis Ababa University.

Amemiya, T. (1981). "Qualitative response models: A survey," Journal of Economic Literature, American Economic Association, vol. 19(4), pages 1483-1536.

Amsalu, A. and de Graaff, J. (2006)."Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed". In: Journal of Ecological Economics 20: 30-45. Available at: http://www.sciencedirect.com. Accessed on: 5th /01/2011.

Anderson, J.M. and Ingram, J. (1993). *Tropical soil biology and fertility programme*: Methods handbook. 2nd Edn., CAB, Oxford, England, ISBN: 0851988210.

Asfaw, A. and. Admassie, A. (2004). The role of household member's education on the adoption of agricultural inputs under different environments in Ethiopia. Agricultural Economics, 215-228

Baidu-Forson, J. (1999). "Factors influencing adoption of land-enhancing technology in the Sahel: Lessons from a case study in Niger." *Journal of Agricultural Economics* 20 (3): 231-239

Barbier, E. B. (1995). "The economics of soil erosion: Theory, methodology and examples." Paper presented at the fifth biannual workshop on economy and environment in Southeast Asia. Singapore, November 28–30.

Barbier, E. B. and Bishop, J. T. (1995). "Economic values and incentives affecting soil and water conservation in developing countries". Journal of Soil and water Conservation, March-April, pp. 133-137.

Batiano, A., Hartemink, A., Lungu, O., Naimi, M., Okoth, P., Sambling, E. and Thiombano L. (2006). African Soils: Their productivity and profitability for use. A paper presented at the African Fertilizer Summit June 2006 Abuja- Nigeria.

Batz, F.J., Janssen, W and Peters K. J. (2003). "Predicting technology adoption to improve research priority setting." Agricultural Economics 28 (2): 151–64.

Bate, F., Janssen, W and Peter, K (2003). Predicting technological adoption to improve research priority settings. Agricultural Economics. 28 151-164.

Bekele, W and Drake, Lars, (2003). "Soil and water conservation decision behavior of subsistence farmers in the Eastern highlands of Ethiopia: A case study of the Hunde-Lafto area," Ecological Economics, Elsevier, vol. 46(3), pages 437-451.

Bett, C. (2004). Farm adoption decisions of soil and water management techniques in Semi-arid Eastern Kenya. A paper presented at the 48th annual conference of the Australian Agricultural and Resource Economics Society. Melbourne, 11th-13th February, 2004, Australia, 30 pp

Boyd, C., Turton, C., Hatibu, N., Mahoo, H.F., Lazaro, E., Rwehumbiza F.B., Okubal, A .P. and Makumbi, M.B. (2000).The contribution of soil and water conservation to sustainable livelihoods in semi-arid areas of Sub-Saharan Africa. Agricultural Research and Extension Network Department for International Development (DFID) UK.

Briggs, L. and Twomlow, S.J. (2002). Organic material flows within a small holder highland farming system in South West Uganda. Agriculture, Ecosystems and Environment 89:191-212.

Bunch, R. (1999). “Reasons for non-adoption of soil conservation technologies and how to overcome them.” Mountain and Research Development 19 (3): 213–20.

Carswell, G. (2000). Farmers and fallowing: Agricultural change in Kigezi district, Uganda. *Geographical Journal* 168 (2):130-140.

Chomba, G. N. (2004). Factors affecting smallholder farmers adoption of soil and water conservation practices in Zambia. MSc thesis, Department of agriculture.

Coleman, J. S. (1998). “Social capital and the creation of human capital.” American Journal of Sociology, 94, 95-120.

Consultative Group on International Agricultural Research, CGIAR. (2003). Water and people in catchments. Challenge program on water and food. Cali, Colombia, 56 PP.

Davidson, J. (1992). No time to waste: Poverty and the global environment: Oxford oxfarm.

De Graaff, J., Amsalu, A., Bodnar, F., Kessler, A., Posthumus, H. and Tenge, A. J. M. (2008). Factors influencing adoption and continued use of long-term soil and water conservation measures in five developing countries. Applied geography, ESW Group, Wageningen University, The Netherlands.

Diagne, A. and Zeller, M. (2001). *Access to credit and its impact on welfare in Malawi.* International Food Policy Research Institute (IFPRI), Washington, D.C., USA.

Dikito, M. S. (2001). *Social capital: empowering women to achieve food security.* International Food Policy Research Institute (IFPRI), Brief 9 of 12, Washington DC, USA.

Ebanyat, P., Ridder, N., De Jager, A., Delve, R., Bekunda, M. and Giller, K. (2010). Drivers of land use change and household determinants of sustainability in smallholder farming systems of Eastern Uganda Popul Environ (2010) 31:474–506 Springer.

Eleni, T. A. (2008). Continued use of soil and water conservation practices: A case of Tulla district Ethiopia: Masters thesis unpublished, Erosion and Soil and Water Group, Environmental Group, Wageningen University, The Netherlands.

Ellis-Jones J and Mason T. (1999). Livelihood strategies and assets of small farmers in the evaluation of soil and water management practices in the temperate inter-Andean valleys of Bolivia. Mountain Research and Development. 19(3): 221-234.

Enters, T. (1998). Methods for the economic assessment of the on-and offsite impacts of soil erosion. International Board for Research and Management Issues in Sustainable Land Management NO. Bangkok IBSRAM 60p.

Ertiro, H. (2006). Adoption of physical soil and water conservation structures in Anna watershed, Hadiya zone, Ethiopia. M. A. Thesis, Regional and Local Development, School of Graduate Studies, University of Addis Ababa, Ethiopia, 128 pp

Ervin, C. A. and Ervin, D. E. (1982). “Factors affecting the use of soil conservation practices: Hypotheses, evidence and policy implications.” Land Economics 58 (3): 277–92.

Feder, G., Just, R and Zilberman D (1985) Adoption of agricultural innovations in developing countries. A survey, Economic Development and Cultural Change 33 (2), 255-298.

Feder, Gershon., Just, R.E and Zilberman, D. (1982). Adoption of agricultural innovations in developing countries. A survey. World Bank Working Paper No 542 Washington D.C.

Fikru, A.M. (2009). Assessment of adoption behaviour of soil and water conservation practices in the Koga watershed, high lands of Ethiopia. Masters thesis, Cornell University.

Fitsum, H. and Holden, S. (2003). Tenure security, resource poverty, risk aversion, public programs and household plot level conservation investment in the highlands of northern Ethiopia: http://www.arts .cornell.edu/econ/75devconf/papers/hagos doc accessed on 10th November 2010

Forum for Agricultural Research in Africa, FARA. (2009). Status of natural, social, financial, human and physical capital in the Lake Kivu Pilot Learning Site. Sub-Saharan African Challenge Programme. Accra, Ghana.

Gebremedhin, B. and Swinton, S. M. (2003). “Investment in soil conservation in Northern Ethiopia: The role of land tenure security and public programs.” Agricultural Economics 29 (1): 69–84.

Gebremedhin, B., Ahmed, M and Ehni (2003). “Determinants of improved forage technologies in crop-livestock mixed system: Evidence from the highlands of Ethiopia”. Tropical grasslands vol 37 pp 262-73.

Giger, M. (1999). *Avoiding the shortcut*: Moving beyond the use of direct incentives. Development and Environment reports No. 17. Berne: CDE, University of Berne

Glenn, D.I. (1992). Sampling the evidence of extension program impact. Programme Evaluation and Organization Development, IFAS, University of Florida. PEOD-5.

Graff, J.de (1996). The price of soil erosion. An economic evaluation of soil conservation and watershed development. Leidn. Backheys publishers.

Grant, G. R., and Warren J. E. (2001). *Statistical methods in bioinformatics*. Springer, New York, USA.

Gregorich, E.G., Greer, K.R., Anderson, D.W. and B.C. Liang. (1998). Carbon distribution and losses: Erosion and deposition effects. Soil predicting tillage effects on soil physical properties and processes. Tillage Res. 47:291–302

Grohs, F. (1994) Economics of soil degradation, erosion and conservation: A case study in Zimbabwe. Kiel, Wissenschaftsvertag vauk.

Gujarati, D. (1999). *Essentials of econometrics*. Irwin/McGraw-Hill, Boston, USA

Hao,Y., Lal, R., Owens, L.B., Lzaurralde, R.C. Post, W.M and Hothem, D.L (2002). Effects of cropland management and slope position on soil organic carbon pool at the North Appalachian experimental watersheds. Soil Tillage 68. 133-142.

Hatibu, N., Mahoo, H.E., Lazaro, E., Rwehumbiza, F.B., Okubal, P. and Makumbi. (2000). The contribution of soil and water conservation to sustainable livelihoods in semi-arid areas of Sub-Saharan Africa. Agricultural Research and Extension Network paper 102.

Heathcote, I.W. (1998). *Integrated watershed management.* New York: John Wiley and Sons.

Hilhorst, T and Muchena, F.N. (2002). *Nutrients on the move-soil fertility dynamics in African farming systems.* International Institute for Environment and Development, London, UK.

Hundson, N. W (1981). *Soil conservation*, Batsford London.

Jagger, P. (2001). “Evolving roles for programs and organizations: Promoting sustainable land management in Uganda”. In: Jagger, p and Pender J (eds). Policies for improved land management in Uganda. EPTD workshop summary paper No.10. International food Policy Research Institute (IFPRI) Washington DC, P.51-56.

Keil, A. (2001). Adoption of leguminous tree fallows in Zambia. Discussion Paper No. 33, Universität Göttingen, Germany.

Kessler, M. (2006). “Decisive key-factors farm households’ soil and water conservation investment”. Journal of Agriculture, Ecosystem and Environment 65: 95-102.

Kessler, A. (2006a). Managing people towards collective action in soil and water conservation’s experience from the Bolivian Mountain valleys. PHD dissertation, Wageningen University.

Krishana, R., Bicol, K., Ingrid, 1. P., and Giridhari, S. (2008). Determinants of farmers’ adoption of improved soil conservation technology in a middle mountain watershed of Central Nepal. Environmental Management. Springer New York.

Lal, R. (1994). Methods and guidelines for assessing sustainable use of soil and water resources in the tropics. Soil Management Support Services. USDA Soil Conservation and USAID, SMSS Technical Monograph No. 21.

Lapar, M., Lucila A and Ehui S. K. (2004). “Factors affecting adoption of dual-purpose forages in the Phillippine uplands.” Agricultural Systems 81 (2): 95–114.

Lichtenberg, S. (2001). “Adoption of soil conservation practices: A revealed preference approach”. *Journal of Agricultural Economics* 45: 57-65.

Long, L. (2003). Conservation practices adoption by agricultural land owners. PhD thesis, Department of Agricultural Economics, Northern Illinois University. Delealb, Illinois, United States of America

López, R.E. (1977). "Productivity Measurement: A Market Equilibrium Approach," in Developing a Framework for Assessing Future Changes in Agricultural Productivity, Resources for the Future, Washington, D.C.

Lutz, E., Pagiola, S. K and Reiche, C. (1994). “The costs and benefits of soil conservation: The farmers’ viewpoint.” World Bank Research Observer 9 (2): 273–95.

Lynne, G. D., Shonkwiler J. S and Rola, L. R.(1988). “Attitudes and farmer conservation behavior.” American Journal of Agricultural Economics 70 (1): 12–19.

Magunda, M. and Tenwya, M.M. (2001). Soil and water conservation in Uganda. Agriculture in Uganda: volume 1-general information, ed.J. Mukiibi, 145:85-168 Fountain Publishers, Kampala.

Makokha, M., Odera, H., Maritim, H.K., Okalebo, J.R. and Iruria, D.M. (1999). Farmers' perception and adoption of soil management technologies in western Kenya. African Crop Science Journal. 9.7(4) 549-558.

Marra M., Pannell, D. J and Ghadim, A. A. (2003). "The economics of risk, uncertainty and learning in adoption of new agricultural technologies: Where are we on the learning curve?" Agricultural Systems 75 (2–3): 215–34.

Marsh S. P. (1998). "What can agricultural researchers do to encourage the adoption of sustainable farming systems?" SEA Working Paper 98/05. Nedlands, Agricultural and Resource Economics, University of Western Australia.

McDonald, M. and Brown, K. (2000). "Soil and water conservation projects and rural livelihoods: Options for design and research to enhance adoption and adaptation." Land Degradation and Development 11 (4): 343–61.

Miiro, R. (1999). Factors enhancing terrace use in the highlands of Kabale district Uganda. In Stott, D.E, Mohtar, R.H and Steinhardt, G.C (eds) 2001. Sustaining the global farm: 356-361, paper for the 10th International Soil Conservation Organization Purdue University.

Moges and Haidu. N.M. (2008). Estimating the rate and consequences of gully development. A case study of Umbulo catchment in Southern Ethiopia. Land Degradation and Development (19) 574-586.

Morgan, R. P. C. (1995): Soil erosion and conservation. Longman Group Limited, Essex, UK.

Morgan, R.P.C and Rickson, R.J. (1995). Water erosion control PP 133-199. In Morgan, R.P.C and Rickson, R.J. (eds). Slope stabilization and erosion control. A bioengineering approach. E and FN Spon. London.

Mugenda, O. M. and Mugenda, A. G. (1999*)*. *Research methods*: Quantitative and qualitative approaches, ACTS Press, Nairobi, Kenya, 256 pp.

Neupane, R. P., Sharma, K. R. and Thapa, G. P. (2002). "Adoption of agro forestry in the Hills of Nepal: A logistic regression analysis". Journal of Agricultural Systems No.72, Vol**.**3: 177-196.

Nkonya, E. (2002). Soil conservation practices and non-agricultural land use in the south western highlands of Uganda. The International Food Policy Research Institute (IFPRI) 2033 K Street, N.W. Washington, D.C. 20006.

Nkonya, E.M., Pender, J.P., Sserunkuuma, D., Jagger, P. (2002a). *Development pathways and land management in Uganda*. Paper presented at the conference on policies for land management in the East African highlands, United Nations Economic Commission for Africa (ECA), Addis Ababa, Ethiopia, April 24 – 26, 2002.

Nkonya, E. and Kaizzi, C.K. (2003). Poverty- natural resource management linkages: Empirical evidence from Uganda. Paper presented at the Planning workshop for research on poverty-NRM linkages in Uganda, Hotel Africana Kampala, January 23-24, 2003.

Norman, D. and Douglas, M. (1994). Farming systems development and soil conservation Rome: Food and Agriculture Organisation, United Nations.

Nyamangara, J., Bergstrom, L.F., Piha, M.I. and Giller, K.E. (2003). Fertilizer use efficiency and nitrate leaching in a tropical sandy soil. J. Environ. Qual., 32: 599-606.

Nyangena. (2005). Social capital and institutions in rural Kenya: Is Machakos Unique? PhD Dissertation. Economics Department Goteborg University, Mimeo.

Okalebo, J. R., Gauta, K. W. *and* Woomer, P. L. (2002). Laboratory *methods of soil and plant analysis*. A working manual 2nd edition. Tropical Soil Biology and Fertility Project (TSBF). *TSBF-CIAT, Nairobi, Kenya.*

Ovuka, M. (2000). ‘More people, more erosion? Land use, soil erosion and soil productivity in Murang’a District, Kenya Land Degradation and Development, 11 111-124.

Pender, L.J. and Kerr, J. M. (1998). Determinants of farmers’ indigenous soil and water conservation in semi-arid India, Agricultural Economics 19: 113–125.

Pender, J., Jagger, P., Nkonya, E. and Sserunkuuma, D. (2001). Development of Pathways and Land Management in Uganda: Causes and Implications. Paper presented at a workshop on policies for improved land management in Uganda International: Food Policy Research Institute (IFPRI) Washington D.C 11-19.

Pimentel, D., Harvey, C., Resosudarino, P., Sinclair, D., Kurz, D., Menair, M., Crist, S., Shprits, L., Fitton, L., Saffouri, R and Blair, R (1995). Environmental and economic cost of soil erosion and conservation benefits. Science 267 (24) 1117-1123

Pindyck, R. S., Rubinfeld, D. L. (1998). *Econometric models and economic forecasts*. McGraw-Hill, London, UK.

Posthumus, H. (2005). “Adoption of terraces in the Peruvian Andes.” Ph.D. thesis, Wageningen University.

Posthumus, H and De Graaf, J. (2005).Cost-benefit analysis of bench terraces, A Case Study in Peru. Land Degradation and Development 16: 1-11.

Rogers, E.M. (1995). *The diffusion of innovations* 4th edition, The Free Press, New York.

Scherr, S.J. and Sadav, J. (1995). Land degradation in the developing world : Implications for food agriculture and the environment to 2020. Vision for food, agriculture and environnent 2020 Discussion paper 14 C. Science and plant analysis 27.365-386, Washington D.

Semgalawe, Z. and Folmer, H. (2000). Household adoption behavior of improved soil conservation: The case of the North Pare and West Usambara mountains of Tanzania. Land Use Policy, 17: 321-336.

Sfeir-Younil, A and Dragun, A.K. (1993). Land and soil management, technologies, economics and institutions Boulder: Westview press.

Shiferaw, B. and Holden, S.T. (1998). Resource degradation and adoption of land conservation technologies in the Ethiopian highlands: a case study in Andit Tid, North Shewa, Agricultural Economics 18: 233–247.

Sidibe, A. (2005). Farm-level adoption of soil and water conservation technologies in the Nortern Bukina Faso. Agricultural Water Management 71:211-224

Sinden, J. A. and King, D. A. (1990). “Adoption of soil conservation measures in Manilla Shire, New South Wales.” Review of Marketing and Agricultural Economics 58 (2–3): 179–92.

Siriri, D., Tenywa, M. M., Raussen, T. and Zake, J. K. (2005). Crop and soil variability on terraces in the highlands of South Western Uganda. Land Degradation and Development Volume 16 Issue 6, Pages 569 - 579 John Wiley and Sons, Ltd. New York.

Slade, G. and Weitz, K. (1991). Uganda environmental issues and options. Unpublished masters thesis, Duke University, Durham N.C.

Smaling, E. M. A. (1993). An agro ecological framework for integrated nutrient management with special reference to Kenya. PhD Thesis. Wageningen Agricultural University, Wageningen.

Smithson, P. L., and Giller, K. E. (2002). Appropriate farm practices for alleviating N and P deficiencies in low nutrient soils of the tropics. Plant and Soil, 245(1), 169–180.

Ssali, H. (2001). Soil organic matter in Uganda and its relationship to major farming system. A resource paper submitted to the International Food policy Research Institute (IFPRI).

Stoorvogel, J. and Smaling E.M.A. (1990). *Assessment of soil nutrient depletion in Sub- Saharan Africa 1983-2000*. Report 28 DLO Winand starring Center for integrated land, soil and water research (CSC-DLO), Wageningen Netherlands.

Swift, M.J. and Shepherd K. D. eds (2007). Saving Africa's soils: science and technology for improved soil management in Africa. World Agroforesty Centre, Nairobi, Kenya.

Swinton, S. M and Lowenberg, D. J. (2001). "Global adoption of precision agriculture technologies: Who, when and why?" Paper presented at the third European conference on precision agriculture, Montpellier, France, Agro Montpellier.

Tenywa, M.M., Rao, KPC., Majaliwa, M.J. G., Cyamweshi R.A., Fungo, B., Kuule M., Luswata K.C., Kaliisa, R. and Gabiri. G. (in press). Natural resource management and productivity enhancement in Lake Kivu Pilot Learning Site. Sub Saharan African-Challenge Programme.

Tenywa, M.M. and Bekunda, M. (2008). Managing soils in Sub-Saharan Africa: Challenges and opportunities for soil and water conservation, doi:10.2489/isw.64.1.44.A journal of Soil and Water Conservation Society.

Tenywa, M.M. and Fungo, B. (2008). Lake Kivu Pilot Learning Site. LKPLS. Bulletin volume 1 Sub-Saharan Challenge Programme, FARA Accra Ghana.

Traorè, N., Rèjean, L. and Nabil, A. (1998). "On-farm adoption of conservation practices: The role of farm and farm characteristics, perception and health hazards". Southern Journal of Agricultural Economics 19: 104-110.

Tukahirwa, J. M. B. (1996). Status and trends in soil and water conservation in Uganda. In Tenywa, M. M and Bekunda, M. A (Eds.), Proceedings of the workshop on the past, present and prospects of soil and water conservation in Uganda. Kampala: Soil and Water Conservation Society.

Wagayehu, B. and Lars, D. (2003). "Soil and water conservation decision of subsistence farmers in the Eastern Highlands of Ethiopia: A case study of the Hunde-Lafto". Journal of Agricultural Economics 18:125-133.

Vanlauwe, B., and Giller, K. E. (2006). Popular myths around soil fertility management in sub-Saharan Africa. Agriculture, Ecosystem & Environment, 116(1/2), 34–46.

Vanlauwe, B., Tittonell, P. and Mukulama, J. (2006). Within-farm soil fertility gradients affect response of maize to fertilizer application in Western Kenya. Nutrient Cycling in Agroecosystems 76:171-182.

Vlaming, J., Van den Bosch, H., van Wijk, M.S., de Jager, A., Bannink A. and Van Keulen, H. (2001). Monitoring nutrient flows and economic performance in tropical farming systems (NUTMON). Annex. Alterra, Green World Research, Wageningen and Agricultural Economics Research Institute, The Hague, The Netherlands.

Walaga, C. (1999). Experiences in participatory soil fertility research and development in Kabarole and Pallisa Districts, Uganda. Environmental Alert, Soil and Water Conservation Society of Uganda Conference Proceedings.Uganda. ISBN 9970 814 01 0

Wang, L., Shao, M.A. and Hou, Q.C. (2001): The primary research on dried soil layer in the Loess Plateau. Journal of Northwest A. and F. University 29(4), 34–38 (in Chinese with English abstract)

World Bank, (2008). *World Development Report,* Oxford University Press, New York.

Wortmann, C. S. and Kaizzi, C. K. (1998). Nutrient balances and expected effects of alternative practices in farming systems of Uganda. Agriculture, Ecosystems and Environment, 71(1), 115–129.

Yamane, T. (1967). *Statistics. An introductory analysis*, 2nd Ed, New York: Harper and Row.

Zake, J. Y., Magunda, M. K. and Nkwiine, C. (1997). “Integrated soil management for sustainable agriculture and food security. The Ugandan case”. Paper presented at the *FAO* workshop on integrated soil management for sustainable Agriculture and Food security in southern and Eastern Africa, Harare, Zimbabwe, Dec. 8-12, 1997.

APPENDIX I: SAMPLE QUESTIONNAIRE

Hello, I am called Robert Kaliisa**,** studying at Kenyatta University, Nairobi and currently undertaking my research work in Bufundi Sub-catchment Kabale District in Uganda. The topic of study, "Factors influencing soil and water conservation in Bufundi sub-catchment is indeed related towards addressing the challenges of soil erosion in this area, please you have been selected to contribute towards this research. All answers provided in this study will be kept strictly confidential, so feel free Thank you in advance.

INSTRUCTION: Please tick/circle on the response appropriately

Questionnaire ID ☐

A: Identification Information

Name of interviewer………………………………..Date………………

Village………………………..GPS location Nothings……………….. Eastings………………

Tel number………………………………

B: Section A: Background Information

A1: Name of respondent/head of household head……………………………

A2: Sex; 1=Male, 0=Female

A3: Age.☐

A4: Marital status: 0=Single, 1=Married, 2=Divorced, 3=Windowed

A5: Education: 0=None 1=Primary 2=Secondary 3=Post secondary (Certificate, Diploma, University), 4=others

A6: Occupation 0=Farmer, 1=Self employed, 2=Government, 3=NGO, 4=others specify

Farm Characteristics

Variable	Plot 1	Plot 2	Plot 3	Plot 4
Size (ha)				
Distance to farmland				
Ownership type 0=inheritance, 1=rented,2=purchased,3=leased)				
Land use 0=Annual crop, 1=perennial crop, 2=pasture, 3= grazing,4=others				
Years of farming				
Fertility status (High/medium/low)				
Slope 0=Flat 2=gentle, 3=moderate, 4=steep, 5=very steep				
Erosion type on farm: 0=No erosion,1=Sheet, 2=Rill, 3=Gully				

1: Which of these physical/mechanical technologies do you use on your farm?

0=terraces, 1=trenches, 2=contour bunds, 3=Surface D/Ways

2: What about on these vegetative structures?

0=Cover crops, 1=mulch, 2=trees, 3=grassbunds,4=woodlots,5=others

3: Which of these soil fertility practices do you practice on your farm?

0= animal manure, 1=cover crops, 2=crop rotation, 3=intercropping, 4= BNF, 5=chemical fertilizers 6=others.

4: Which crop management practices do you practice?
0=row planting, 1=plating on raised beds.
5: What benefits do you realise when you adopt practices listed above?
0=control erosion 1=conserve moisture 2=increase crop yields 3=none
6: What challenges do you experience that might hinder you to adopt SWC?
0=requires investment 1=labour 2=Technical support 3=reduced crop land
7: Conflicts that might hinder SWC and their resolution (tick the most 5)?

0=boundary conflicts, 1= cutting trees, 2=bush burning, 3=land inheritance conflict,4=eviction from farm/wetland, 5= gender conflict, 6= theft, 7= land grabbing/selling, 8=livestock grazing, 9=animal raiding crops, 10= terraces destroyed by neighbours

8:How do you resolve these conflicts?
C- 0= IP, 1=neighbour, 2=relative of offender, 3= village/clan leaders, 4= LC courts, 5=chiefs/sub-county chiefs, 6=police, 7= magistrate courts, 8=church leaders

Economic variables
9: In the past two years how much money have you ploughed back to invest in SWC? (........000/=)?
0=0-50 /=, 1=50-100/=, 2=100-200=, 3=200-300/=, 4=300-400/=, 5=400-and above
10: Where have you got money for SWC/NRM?

0= bank, 1=Off-farm, 2=after sale of output, 3=group saving, 4=salary, 5=Friends, 6=none

11: Are you engaged in any of-farm activity? Yes, no

12: If yes, which of them do you engage in?

0=Trading,1=civil servant, 2=artisan, 3=others,…………………………

13: How many hours in a day do you take in these activities?

0= Quarter day 1=Half day 2=whole day, 3=all the year,

14: How have you ploughed back in SWC?

0=Hired labour, 1=Own/family labour, 2=Collective exchange of labour, 3=Out of force

15:What have you realised in ploughing back in SWC?

0=Reduced soil erosion, 1=water use efficiency, 2=Reduced river sedimentation, 3= Improved on-farm yields,4=improving income 5= none

16: **In your view which economic benefits have you realised from participation in IP collective action on SWC?**

0=Group marketing, 1=Negotiation of good prices, 2=formation of marketing associations, 4=market information,

Institutional variables

17: Which of these institutions have visited your farm/trained you in SWC?

0=Research stations, 1=government/sub county, 2=, NGO, 3=CBO, 4=Schools, 5=religious institutions, 6= Community Demonstration farm, 7=none

18: How often do these institutions train/inform you on SWC?

0=Every day, 1=weekly, 2=monthly,3=quarterly,4=year, 5=none

19: Which is the most important source of information for SWC to you?

0=IP, 1=Radio 2=NGO, 3=Farmer to farmer, 4=Extensionist, 5=Visitors,

20: What areas under collective action have you rehabilitated under collective action for SWC?

0=Area under eucalyptus, 1=Wetland valleys, 2=Area under crops, 3=Water channels and ways, 4= collapsing terraces 5=none

21: Reasons for your participation?

0=Material benefits, 1=Increased production of my land, 2=Access to collective markets, 3= It is a social capital, 4=Fun, 5=protect my catchment, 6= IPs negotiate for higher prices.

22:Are there institutional changes on SWC in the catchment?

0=Yes, 1-no

23:If yes, Why are there these changes ?

0=Formation of IPs, 1=collective action, 2=collective marketing, 3=attitude change of Stakeholders, 4=good leadership of IPs 5= formation of bylaws by IPs, 6=access to inputs by IPs,

Is there any other issues you would like to discuss with me…………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

Thank You

APPENDIX 11: ON-FARM OBSERVATION GUIDE

The following Soil and Water Conservation (SWC) Technologies will be observed in the field:

1.0 Agronomic Techniques of Soil Protection and Conservation

- Strip Cropping
- Multiple Cropping
- Questions on the Mode of Crop Rotation
- Cover Cropping
- Mulching
- Farms under Crop residue after harvesting

2.0 Mechanical Measures of Soil Conservation and Erosion Control

- Trenches /Fanya juu/fanya kini
- Terraces Maintained the collapsing ones

3.0 Soil type

4.0 Typology/Slope angle in percentages

- Main farming activities in each slope angle
- The types of SWC both physical and vegetative
- Upstream and downstream activities (areas of settlement,)

APPENDIX 111: NUTMON Farm inventory questionnaires

FARM INVENTORY

FARMCODE: . . . . **Date: . . / . . / 200 .**	Enumerator:. . . . .

Inventory (part 1) - Information to ask the farmer

1a General Farm Data

Name of household head	
Persons interviewed	

District/Location/Sub-location		
Village		
Distance to most important market	*Km*	*Name of market: . …..............…. . . . . . .*

2 Demographic structure of household

Farm Code: . . . . Date: . . . / . . . / 200 .

Household member number [HHM]	*Household member name* *(optional)*	*sex*	*age or year of birth*	*relation to household head* *(optional)*	*main occupation* *(optional)*	*highest education level* *(optional)*	*% of time in household*	
							consumer	*labour*
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								

Farm Code: . . . . Date: . . . / . . . / 200 .

Definition of Household: A group of people who usually live in the same house or group of houses and share food regularly. This implies that resident non-relatives can be part of the household	**M**ale **F**emale		HH Household head WH Wife / Husband FA Father MO Mother SO Son DA Daughter BR Brother SI Sister OR Other relatives NR Non-relatives	FF Farming family fields HK House keeping AS Attending school OE Off-farm employment OF Off-farm empl. farming OT Others	NE non educated PS primary or elementary school PV post primary vocational SS secondary school SV post secondary vocational AS formal education above secondary level OT others

3 Implements owned and agriculture related constructions

Description: List of implements, machinery and agriculture related constructions present on the farm

Implement or construction type	*number*	*remarks*

Jembe / Hoe
Forked jembe
Panga
Slash
Sickel
Spade
Axe

Tractor
Plough (tractor)
Plough (animal)
Harrow
Cultivator (tractor)
Cultivator (animal)
Ridger
Planter

Wheelbarrow
Secateurs
Chaf cutter

Storage
Fencing (in units of 100m)

Others - (specify and add to this list)

Farm Code: . . . . Date: . . . / . . . / 200 .

4 Dependence on off-farm income

Description: Estimation of dependence on off-farm income by the farmer for the previous and the current year.

Dependency on off-farm income	
previous year [%]	*Current year (%)*

Farm Code: . . . . Date: . . . / . . . / 200 .

5a Farm Section Units (FSU)

Description: Inventarization of homogeneous tracks of land within farm.

FSU serial number *[FSU]*	*Description of farm section* *e.g. positionon farm, soil characteristics, major crops, distance to compound etc. Basically as reference for questionnaire users.*	*Ownership of farm section*	*Land rent* *[Sh/year]*	*Estimated land value of FSU* *[Sh/ha]*	*Local soil name*	*Start month*	*End month*

Definition Farm Section Unit (FSU): Part of the farm considered to be homogeneous for soil, slope, permanent SWC maeasures, flooding and ownership characteristics.	OW Owned LT Long term landuse rights OUT Rented out or lent out IN Rented in or borrowed in	*only to be asked in case of FSU hired in or out*	*of bare land (without crop)*	*main local soil type name or description*	*Record only when new FSUs appear half way the monitoring or when FSUs are no longer used.*

Farm Code: . . . . Date: . . . / . . . / 200 .

5b Farm Section Units (FSU) - Farm Sketch

Picture representing the Farm Sections Units as described in 5a and 5c.
Preferably from exact (surveying) measurements, otherwise based on generalization of farmers' soil map.

Farm Code: . . . . Date: . . . / . . . / 200 .

10a Primary Production Units (crops)

Description: Continuous list of all cropping activities occurring during monitoring.

PPU Serial	*Description of activity*	*Crop Components*				*Area*		*Managed by*	*Located in FSU [FSU and %]*					
number	*e.g. crop components, intercrop?, location, other characteristics*	*1st*	*2nd*	*3rd*	*4th*		*unit*	*[HHM]*	*FSU*	*%*	*FSU*	*%*	*FSU*	*%*
PPU 1														
PPU 2														
PPU 3														
PPU 4														
PPU 5														
PPU 6														
PPU 7														
PPU 8														
PPU 9														
PPU 10														
PPU 11														
PPU 12														
PPU 13														
PPU 14														
PPU 15														
PPU 16														
PPU 17														

Farm Code: . . . . Date: . . . / . . . / 200 .

10b Primary Production (crop calendar)

Description: Monthly list of of all cropping activities present.

		Presence of PPU in monitoring month																	*Short-term SWC measures present? (contour tillage, muclhing, ridging, etc)*
	Perio	*Jan*	*Feb.*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	
Description	*PPU*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	
	1																		
	2																		
	3																		
	4																		
	5																		
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	14																		
	15																		
	16																		
	17																		
	18																		
	19																		
	20																		

Farm Code: . . . . Date: . . . / . . . / 200 .

10c Sketch of PPUs on the farm - sheet 1 - 1st season

Picture representing the crop activities as described in Form 10 Use a photocopy of 5c as background.	Only when major changes in cropping pattern take place

Farm Code: . . . . Date: . . . / . . . / 200 .

10c Sketch of PPUs on the farm - sheet 2 - 2nd season

Picture representing the crop activities as described in Form 10
Use a photocopy of 5c as background.

Only when major changes in cropping pattern take place

Farm Code: . . . . Date: . . . / . . . / 200 .

20 Secondary Production Units (livestock)

Description: List of the different animal-management groups within the farm.

SPU serial number [SPU]	*Livestock Type &*	*Breed*	*Description* *(animal type and management system)*	*Managed by [HHM]*
SPU 1				
SPU 2				
SPU 3				
SPU 4				
SPU 5				

	Cattle (1) Goats Sheep Horses Donkeys Pigs Poultry (2) Chicken Goose Ducks Guinnea Fowls Pigeons Rabbits Fish Others - (specify and add to this list)	e.g. Local breed, Friesian, Cross-breed, Zebu, etc	Definition Secondary Production Unit (SPU): “Group of animals of the **same species** within the farm which are **managed** by the farmer **as one unit**. “ All domestic animals influencing farm nutrient management are given a SPU serial number according to the groups in which they are managed. The biggest/most important animals are usually mentioned first. (1) Animal types within cattle management group are not defined here but in form 200. (2) An exeption for the “same species” prerequisite is made for poultry. Mixed poultry groups can be defined to facilitate monitoring.

Farm Code: . . . . Date: . . . / . . . / 200 .

30 Redistribution Units - Stables, Kraals, Manure and Compost heaps

Description: Identification/listing of all the Redistribution units within the farm and some characteristics

Redistribution Unit serial number *[RU]*	*Description of RU*	*Type of RU*	*size of RU* *[m^2]*	*Presence of ..*			
				roof? *[y/n]*	*Concrete floor ?* *[y/n]*	*enclosed?* *[y/n]*	*slurry drain?* *[y/n]*
RU 1							
RU 2							
RU 3							
RU 4							
RU 5							
RU 6							
..							

Definition RU: A unit within the farm (other than PPU, SPU, Stock) where nutrients accumulate and from which they are deliberately redistributed.	ST Stable (boma / kraal / corral / pen / coop / house / 'parc') FP Fish Pond MH Manure heap (separate from stable) GH Garbage heap CH Compost heap LA Latrine	Remark: In some cases the house is also defined as a 'stable' when animal like poultry or pigs are confined to the house for certain periods.

Farm Code: . . . . Date: . . . / . . . / 200 .

Inventory (part 2) - Information from measurements and other sources

5c Farm Section Units (FSU)

FSU serial number [FSU]	*Area of farm section*		*Average FSU slope [%]*	*maximum slope-length of FSU [m]*	*USLE P -factor*	*Long-term Soil and Water Conservation measures* *(terraces, dams, etc)*	*Irrigation infra-structure (yes/no)*
	Area	*Unit*					
FSU 1							
FSU 2							
FSU 3							
FSU 4							

Farm Code: . . . . Date: . . . / . . . / 200 .

1b General Farm Data – soils data

Identification			*Estimations*		*Measurements*						*from literature*	
Farm code	FSU	Sample id(s)	Rootable depth [m]	Mineralization rate [%/year]	Bulk density [g/cm^3]	Clay [%]	C-total [%]	N-total [%]	P-total [%]	K-Exch [meq/100g]	USLE K-factor [-]	Enrichment factor [-]

Farm Code: . . . . Date: . . . / . . . / 200 .

1b General Farm Data – precipitation data

Monthly precipitation [mm]						
	Meteo station: *. . . . .* *Mean annual precipitation : . . . . [mm]* *USLE R-factor:* *. . . . .*		*Meteo station:* *. . . . .* *Mean annual precipitation : . . . . [mm]* *USLE R-factor:* *. . . . .*		*Meteo station:* *. . . . .* *Mean annual precipitation : . . . . [mm]* *USLE R-factor:* *. . . . .*	
Month	*Year :*	*Year :*	*Year :*	*Year :*	*Year :*	*Year :*
Jan						
Feb						
Mar						
Apr						
May						
Jun						
Jul						
Aug						
Sep						
Oct						
Nov						
Dec						

Farm Code: . . . . Date: . . . / . . . / 200 .