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Factors Influencing the Uptake and Sustainable Use of Soil and Water Conservation Measures in Bubaare Micro-Catchment, Kabale District, South Western Uganda

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Abstract

Soil erosion and declining soil productivity still continue to manifest in most of the agricultural systems found in Sub-Sahara Africa. As a consequence, 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 Soil and Water Conservation measures in Bubaare micro-catchment. The study was conducted to assess factors (i) physical (ii) institutional and (iii) socio-economic influencing adoption and sustainable use of soil and water conservation measures in Bubaare micro-catchment in Kabale district. The study was cross sectional in nature employing both qualitative and quantitative approaches to capture data from a sample of 397 respondents using semi-structured questionnaires interviews and observation. Data was analyzed using SPSS version 16 to generate both descriptive and inferential statistics that aided in presentation and interpretation. It was found that 22.9% of the farmers in the area were conserving soil and water using mulches and cover crops, 21.9% agroforestry, 16.8% terraces, 11.3% surface drainage ways, 8% contour bunds, 8% grass bunds, 11% trenches/ditches and 3.3% woodlots. Factors that were statistically determined to significantly influence the adoption and sustainable use of soil and water conservation implementation in Bubaare micro-catchment were physical, institutional, and socio-economic factors. In this regard, several key recommendations were made which involved extending financial services to the farmers, communication and information access, training and experience sharing, strengthening research and development, education and awareness, providing technical and financial support.

Keywords: Adoption; Soil erosion; Water conservation; Micro-catchment; Kabale; Uganda

Introduction

Soil erosion is evident on most of the hill slope terraces although Soil and Water Conservation (SWC) measures have been emphasized since 1920's 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). In East Africa soil erosion is estimated to affect 50% of the total arable land area especially in the highland areas (Ssali, 2001). For the past two decades, soil erosion has remained the biggest environmental problem, threatening sustainability of crop plants in the East Africa (Asfaw, 2010), resulting in the reduction or loss of the biological and economic productivity, complexity of terrestrial ecosystems, including soil nutrients, vegetation and agricultural production (UN, 2003). Henao & Baanante (2006) argue that soil erosion poses a serious threat to food production and rural livelihoods particularly in poor and densely populated areas of east Africa.

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In Uganda, soil degradation has been reported by Aberha, (2008), Asfaw, (2010) and Pender et al. (2001) as one of the major environmental problem hindering agricultural production. The underlying causes of soil degradation relate to destructive, extractive, over-exploitation, erosion and inadequate conservation of the soil and water resources (Natai, 2004). This continuous soil degradation not only threatens agricultural productivity but has continued to affect biodiversity, water quality and the livelihoods of the poor farmers, of whom 90% depend on the natural environment for food and survival (World Bank, 2008). To address the problem of erosion, soil and water conservation (SWC) measures have been emphasized since 1920's to date (Pender & Gebremedhin, 2006). However these practices have not lived to their expectation according to recent data. The hill slopes have continued to lose a tremendous amount of fertile top soil and the threat of land degradation is alarmingly broadening despite the SWC measures being emphasized (Briggs and Twomlow, 2002). This continued erosion and degradation is an indication that either farmers' adoption of corrective technologies is too slow or there are some limiting social-economic, technological and institutional factors (Mhinte, 2000).

Kabale district is located in Southwest Uganda. It is characterized by steep slopes and intensely cropped hillsides. The highland areas of the district are steep and intensively cultivated using poor agronomic practices leaving them exposed to soil degradation. Constant soil erosion and degradation has been reported as major cause of declining soil and agricultural productivity in the area (Turyahabwe et al., 2013). The ever growing population in the area has led to pressure on land resources in terms of land fragmentation, and poor traditional practices with related effects like declining soil fertility and erosion. To overcome the problem, government through extension bodies has promoted the use of SWC measures though farmers in Bubaare micro-catchment still seem hesitant to adopt them due to unknown socio-economic concerns (Nkonya & Kaizzi, 2003). Therefore, this study sought to examine the physical, institutional and socio-economic factors that would influence the adoption and sustainable use of SWC measures in Bubare micro-catchment of Kabale district.

Bubaare micro-catchment is one of the residences to people of Kabale district in terms of shelter. It also enhances economic livelihoods of the people through supporting agricultural production. However much the importance of the micro-catchment to the community, the area has continued to experience soil degradation due to over cultivation without soil renewing technologies (Turyahabwe et al., 2013). This perhaps explains the declining soil fertility and erosion problem in the area. To address the issue, government introduced use of SWC measures (Nkonya & Kaizzi, 2003). The introduction of SWC measures such as contour buffer strips, agroforestry, gully/grade stabilization, mulching, water ways and cover cropping, was seen as an opportunity for replenishing the already depleted soils; however uptake of these measures has remained low due to un-known factors (Turyahabwe et al., 2013). Despite the fact that socio-cultural, economic and institutional factors had a strong influence on farmers' decisions to use SWC in other parts of Uganda like Bushenyi and Ibanda (Turyahabwe et al., 2013), it is not clear how these same factors affect SWC decisions in Bubaare catchment. On the other hand, it was not clear which of the physical, institutional and social economic factors had the greatest influence on farmer's decisions to practice SWC. The overall objective of the study was to establish the factors influencing adoption and sustainable use of soil and water conservation measures in Bubaare micro-catchment, Kabale district. The specific objectives were to; establish the SWC practices used by farmers to mitigate land degradation in the different landscape positions of the catchment, and investigate the physical, institutional and socio-economic factors influencing adoption and sustainable use of the practices.

Materials and Methods

The study was conducted in Bubaare micro-catchment that lies within Kabale district (Figure 1). The latter is located in Kigezi sub-region, approximately 420 kilometres (260 miles) by road, southwest of Kampala. The coordinates of Kabale are: 01 15 00S, 29 59 24E (Latitude:-1.2500; 29.9900). Bubaare micro-catchment is one of the seven micro-catchments under Maziba River sub-catchment that was identified during catchment status assessments and stakeholder consultation processes by government conducted in October 2013. The catchment covers parts of Butobere, Central and Nyabikoni wards of Kabale Central Division, Kijuguta, Rutooma, Upper Bugongi, Karubanda, Kirigime and Mwanjari wards of Kabale Southern Division. It occupies an estimated area of over 215 Sq.km. The catchment is supported by streams and tributaries that flow through: Hamurwa, Bubare, Kyanamira, Kitumba, Kamuganguzi, Buhara, Kaharo, Nyamweru and Maziba Sub-counties. The landscape of the catchment contains small, fragmented landholdings in mountainous terrains. The area is densely populated with an estimated density of 281 persons per sq.km (UBoS, 2015). Around 85% of the residents in the catchment depend on subsistence agriculture for livelihoods and survival.

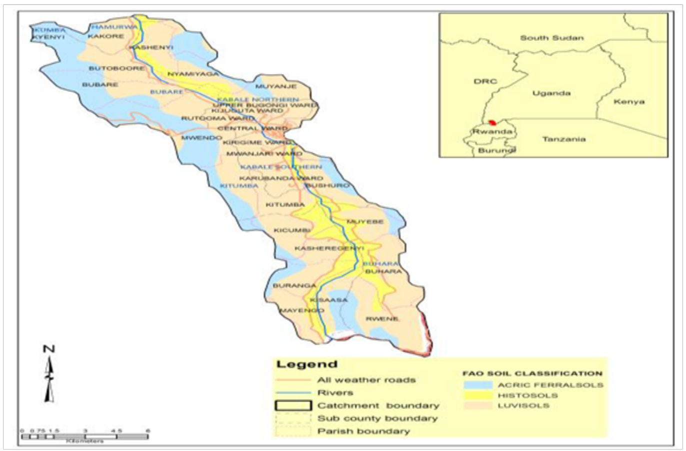

Figure 1: Map of Bubaare micro-catchment

A cross sectional study design which employed both qualitative and quantitative methods of data collection was used. All farmers involved in different agricultural activities, 5 local leaders, 2 agricultural and environmental officers at the district were included in the study.

A sample of 397 farmers was selected randomly using single population proportion formula with 95% level of confidence and 5% margin of error from a total of 69,363 residents in Bubare micro-catchment. Local leaders and other key informants were chosen on purpose. The sample size for the study was determined using Slovin's Formula as indicated below.

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

Where n= sample size, N= Estimated convenient number of respondents, e=marginal error or level of significance and it ranges from 1%-5% which is 0.01-0.05, thus

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

$$= \frac{69{,}363}{1+69{,}363\ (0.052)} \quad = \frac{69{,}363}{1+(69{,}363*0.0025)}$$

$$= \frac{69{,}363}{1+173.4} \quad = \frac{69{,}363}{174.4}$$

= 397 respondents

Structured questionnaires which were prepared to collect data in English for those who could read and write, and were translated by a local language teacher to Runyankore to capture data form farmers could not read and write. These questionnaires were researcher administered to give farmers those who could not read and write an opportunity to participate in the study. The questionnaires were checked for completeness, coded and entered into SPSS version 16 software package for cleaning and analysis. Key informant interview guide was chosen as the tool for qualitative data collection. It aimed at exploring and sharing experiences, thoughts, feelings, attitudes and ideas of participants on the factors for adopting SWC measures. This exercise was conducted with the key informants at their area of work.

The data was analyzed using Microsoft Excel and SPSS computer programs. Descriptive and inferential statistics were used to interpret the study findings. Data was analyzed quantitatively and qualitatively.

Quantitative data analysis was performed at two levels (Univariate and Multivariate) to establish the physical, institutional and socio-economic factors influencing the adoption of soil and water conservation. Univariate analysis was used to analyze the soil and water conservation practices used in the area and farmers' opinions on how to improve adoption of soil and water conservation measures. On the other hand physical, institutional and socio-economic factors influencing the adoption and use of SWC measures were investigated using a multi-factor linear regression model to assess the factors that were closely associated with the dependent variable more than the others. The model is specified below;

$$Yi= \beta_0+\beta_1X_{i1}+\beta_2X_{i2}+ \ldots + \beta_kX_{ik}+ e_i \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where Y= A dummy variable representing farmer's adoption of SWC measures. A farmer is considered to have adopted if they were using 1 or more SWC practices. The dummy was (1 = for adopters 0 for non-adopters)

β_0 = regression constant;

X_{ik} = Value of selected independent variable for farmer k

β_k = Coefficient on the kth predictor

K= Total number of selected factors believed to influence adoption

β_1 - β_{13} = coefficients;

X_1 = Age of household head (in years),

X_2 = Educational level of household head (in years)

X_3 = off- farm activities (dummy 1 = yes, 0= no)

X_4 = Household size (members at household)

X_5 = Access to land (dummy 1 = yes, 0= no)

X_6 = Type of land ownership (dummy 1 = own land, 0=otherwise)

X_7 = Provision of farmer training (dummy 1 = yes, 0= no)

X_8 = Access to credit (dummy 1 = yes, 0= no)

X_9 = Access to extension services (dummy 1 = yes, 0= no)

X_{10} = Distance to farmland residence (kilometers)

X_{11} = Slope of land (dummy 1 = yes,0= no)

X_{12} = Nature of soils (dummy 1 = yes, 0= no)

X_{13} = Soil erosion (dummy 1 = yes,0= no)

e = error term.

Results and Discussion

Socio-economic characteristics of the respondents

Female respondents were 50.7% while the male gender represented 49.3% of the pool. The fact that 50.7% revealed that agricultural activities were mostly coordinated by women farmers in many families despite the high intensity of labor required to carry out most of the implementation of most SWC practices. Age was found to have an influence on ownership and access to production resources like land, inputs and capital and investment in Soil and Water Conservation. The analysis indicated that the youngest respondent was 18 years and the oldest had 75 years. Averagely, most study participants were aged between 18 and 37. The reason was that those with old age are unwilling to invest in the conservation because either they are weak and cannot manage tiresome work or they have limited capital to invest in as they already have a lot of responsibilities for their families like buying food and paying school fees. From the findings reported, it was observed that a big number of respondents (54.1%) acquired land by purchasing using their own cash, (29.2%) acquired it by inheritance either from their parents or other relatives, and (12.5%) were renting the land for seasonal farming while (2.5%) were on leased land.

Soil and Water Conservation practices used in Bubaare micro-catchment

The most common soil and water conservation practices used included mulches and cover crops by (22.9%) of the farmers, agroforestry (21.9%), terraces (16.8%), and surface drainage ways (11.3%), contour and grass bunds (8%), Trenches/ditches (11%) and woodlots 3.3%. These results are shown in Table 1. Cover cropping, mulching, and agroforestry were widely used because farmers had easy access to materials, and perhaps have enough technical advice and resources to invest in such innovations. Given that the landscape of the area is characterized with steep slopes, mulching has been adopted to protect the soil surface from the kinetic energy of the raindrops. Farmers in the area believe SWC measures like mulching reduce water runoff by 70–90%, sediment loss by 80–95% and can also retain soil organic matter content in the long run. Cover crops were reported as effective conservation practice used to benefit the soil and optimize crop yields through restoring soil productivity. Agro-forestry trees have been grown to support crop and livestock fodder production which in turn provides organic manure to be used on the farm. Terraces are used to reduce the effect of the slope and runoff on soil erosion. Construction of terraces takes place in sloppy and stone available areas. Study findings are comparable to a study by World Bank, (2006) which also discovered a number of significant advances that have been made in the science and practice of soil fertility management in Africa. It stated that soil fertility degradation takes place over a long time and recuperation of soil quality can be equally slow. Therefore, lasting impacts of improved management require long-term investment of time and resources. But the impacts of improved management on crop yields are often dramatic even in the short term. Significant achievements from agricultural research have been demonstrated in improved livelihoods based on the development of soil management principles and in methodological approaches to address the major causes of poverty. Significant adoption of a range of improved technologies has been documented across a number of countries. The technologies include soil and water conservation structures, such as 'zai' pits in the Sahel, organic nutrient management systems such as high quality Manuring in intensive dairy systems in Kenya, and more integrated soil management practices.

Table 1: Soil and Water Conservation practices used in Bubaare micro-catchment

SWC practice	Frequency (f)	Percentage (%)
Terraces	67	16.8%
Trenches/ditches	30	7.5%
Contour bunds	32	8.0%
Surface drainage ways	45	11.3%
Agro-forestry	87	21.9%
Mulches and Cover crops	91	22.9%
Grass bunds	32	8.0%
Woodlots	13	3.3%
Total	397	100%

Sources: Field data, 2017

Physical, institutional and socio-economic factors influencing adoption and use of SWC

The factors influencing adoption and use of SWC were analyzed using the regression model in equation (2). The results of the model are shown in Table 2 below.

Table 2: Physical, institutional and socio-economic factors influencing adoption SWC measures in Bubaare micro-catchment

Model	Explanatory variables	Coefficient	Std. error	Sig.
1	(Constant)	3.087	.026	.000
Physical factors	Distance to farmland residence	−0.761**	0.032	.001
	Size of land	0.634**	0.037	.000
	Slope of land	0.885**	0.247	.000
	Nature of soils	-0.057*	0.074	.461
	Soil erosion	0.892	0.029	.000
Institutional factors	Type of land ownership	0.933**	0.120	.000
	Provision of farmer training	0.986***	0.131	.000
	Access to credit	0.687	0. 201	.002
	Access to extension services	0.508**	0.247	.003
Socio-economic factors	Age of household head	−0.560**	0.221	.002
	Educational level of household	0.857**	0.094	.000
	Off- farm activities	0.788	0.131	.000
	Household size	0.276**	0.063	.001
	Access to land	0.952	0.028	.000
	Community values and beliefs	-0.030	.912	.260

Source: computer output (SPSS) analysis, 2018

*** Significant at 1%, ** Significant at 5% and * Significant at 10%

The significant physical factors influencing adoption and use of SWC measures in Bubaare micro-catchment included; distance between residence and farm land areas of household heads [p = 0.001] at 0.05% of significance level, farm size [p = 0.000] at 5% level of significance, slope of farm land [p= 0.000] at < 5% of significant level and perception about soil erosion problem [p= 0.000] at < 5% level of significance.

Plot distance had a negative but significant effect on farmer's use of SWC measures. This can be explained by the fact that more time and energy is needed to reach distant plots relative to homestead farm lands. The lesser the plot distance from the residence area, the higher frequent farmers supervise their plots and care. This result also supported by Kibemo (2011) who in their Journal of Land Economics postulated that farm plot distance from the residence discouraged farmers to invest in soil conservation. Farm/land size had a positive and significant influence on the adoption of SWC measures in the study area. The positive coefficient of farm size implies that farmers with relatively larger holdings had higher probability of adopting soil conservation technologies. This can be attributed to the fact that conservation structures occupy part of the scarce productive land and farmers with larger farm size can afford retaining structures compared to those with relatively lower farm size. This was also supported by Alemeta (2010) who in their study around Lake Kivu area concluded that farmers who had large farm size showed interest to invest on SWC measures.

The slope of farmland was an important variable positively affecting the probability of using SWC technologies. The implication is that farmers invest on conservation practices where their farm lands/plots are located in higher slopes than in lower slopes. This is because soil erosion is more visible to the farmer's high steeper slopes than plots located at flat areas and this force the farmers to use conservation measures. This finding is in support of Genene &Wagayehu (2010) who in his study of Tulla District, Ethiopia observed a positive relationship between the gradient of the slope and the sustainability of soil conservation measures. Farmers with land that has steep slopes are more involved in continued use of soil conservation measures than those who own flat or gently sloping farmland. On steep slopes farmers construct soil bunds and fanya juu on their farmland to prevent soil erosion. The effect of steep slope on continued use of stone terraces is found to be significantly positive. The farmers were encouraged to continue to use the stone terraces due to effectiveness of the measure for erosion control on steep slopes. Soil erosion problem had a positive significant relationship with adoption of SWC measures. Farmers' perception of soil erosion as a problem is crucial for soil conservation undertakings and it influences their decision to adopt given soil conservation measures. Farmers do not invest in soil conservation and bear with the risks associated if they do not perceive significant threats posed on productivity due to soil erosion. Farmers perceive the effect of soil erosion when it reaches some critical level, which is very difficult to reverse the degradation by the subsistence farmers. Significant institutional factors influencing adoption and use of SWC measures in Bubaare micro-catchment included; land ownership type [P=0.000] at 5% level of significance, access to farmers training [p= 0.000)], access to credit service [p=0.002] and access to extension services [p= 0.003] at 5% level of significance

Access to extension services had a significant influence on the adoption of SWC measures. The positive co-efficient implied that farmers who had contact with extension workers acquire more information related to the benefits of SWC, techniques of implementation, and maintenance compared to farmers with no extension contact. Our finding contradicts Ayati et al., (2010) who in his study in Zambia indicated that, a large proportion of farmers who had contacts with agricultural support programs did not continue the improved practices. This is because the extension support provided is not aimed at the promotion of conservation practices and is more focused on crop production and other agricultural activities. Nonetheless, it is not sufficient to have extension support but the aim or purpose of extension service should also relate to the continuation of conservation work.

Land ownership and land size were positive and significant factors associated with farmer's adoption of SWC technologies. The effect of land ownership indicated that own land is more managed than rented or sharecropped land, whereas the effect of land size implied that farmers having wide farm land are more engaged in SWC practices than those who have small pieces of land. This study finding is in agreement with Kibemo (2011) who argued that lack of land ownership leads to short term planning horizons and practice low conservation measures. In owner operated farms, in which a farmer has a personal stake in lands' sustainability, the farmer concerned for his neighbors and the sustainable use of the land for the future generations.

Access to SWC training had significant effect with farmer's adoption of SWC technologies. Farmer's motivation to invest in SWC technologies and their access to trainings related to soil conservation and management. It can be inferred that farmers who participate in trainings are more aware of conservation technologies and their benefits than those who did not participate at all. The results of this study is in agreement with Mulugeta and Karl (2010) who in their study in the highlands of East and Central Africa reported that access of farmers to training and their participation in extension workshops improves their perception of soil erosion problems and facilitates the use of conservation technologies

Socio-economic significant factors influencing adoption and use of SWC measures in Bubaare micro-catchment included Age of household head [p=0.002] at 5% significance level, Educational level of household [p=0.000] at 1% significance level, household size [P=0.001] at 0.05% of level of significance and off- farm activities [P=0.000)] at 5% level of significance, and farmers access to land [P=0.000] at 5% level of significance.

Age of the farmer negative but significant on farmers' decision to practice SWC. Older farmers are reluctant to invest and participate in conservation activities compared with younger farmers. Moreover, younger farmers are more likely to have longer life which could in turn motivate them to invest in technologies whose benefits are realized over time. This result contradicts the findings of Kibemo (2011) who in his study in Zambia investigated the positive association between age and willingness to participate in conservation programs basically due to the long years of farming experiences by older farmers. Age influences utilization decision since of it influence the planning horizon.

Educational level was positive and significant on farmers' decision to use SWC technologies. The explanation is that educated farmers have better understanding about the consequences of soil erosion and the resulting benefits of soil and water conservation. This motivates the farmers to spend more time and money on conservation technologies. Moreover, literate farmers often serve as contact farmers for extension agents in disseminating information about agricultural technologies from government agencies. According to Alemeta (2010), education enhances farmers' willingness to adopt new management practices by improving the managerial capacity of a farmer. In his model predicted positive and significant association between education and utilization of conservation measures. Akudugu et al., (2012) as well indicated that education is an influential factor in the utilization of soil and water conservation practices. However, the study made in central Ugandan highlands explored that education is negatively related in adopting conservation structures on the farmlands though the relation was not significant.

Size of household members had strong relationship with the introduction and adoption of SWC measures/practices. The argument about this is that households with small family size are less likely to adopt SWC measures than households with more family size due to shortage of labor force than large family size household who can easily afford labor to invest in the design and implementation of these measures. This finding is agreement with Kibemo (2011) who argued that adopting conservation measures is costly since physical conservation measures impose some portion of the land to be out of production. The study conducted in Uganda reported that conservation measures take 10- 20% of cultivation land through embankments and ditches. Land taken by conservation structures out of cultivation increases rapidly with increasing slope. This makes the benefit that can be obtained from conserving the soil in small farms to be less likely to compensate for the decline in production due to physical conservation measures.

Access to land had strong a positive relationship with the use and adoption of SWC practices. The implication is that families with access to land were likely to adopt or use SWC measures compared to families with little land or without access to land. Households with small pieces of land tend to abandon SWC for a fact that the measures require huge space hence limiting or reducing on the space or land that would have been used for agricultural and food production. This finding is in line with Bongers, et al. (2012) who found that land tenure security influences farmers' decision to adopt conservation measures by influencing the length of farmers' planning horizon and sense of responsibility. According to them farmers not interested to invest in soil conservation measures when the land tenure is too insecure so that the benefits of soil conservation may not ensure to them. The study made in different parts of Uganda attributed the low level of success of natural resource conservation to insecure land tenure. Alemeta (2010) found negative association between land tenure insecurity and farmers decision to adopt and retain conservation structures. Genene & Wagayehu (2010) also found negative and significant association between land tenure insecurity and conservation practices. Therefore land tenure is very important for utilization of major conservation investments especially for terrace construction.

Farmer's opinions to promote the use of soil and water conservation in the area included; extending financial services to the farmers, communication and information access, training and experience sharing, strengthening research and development, education and awareness, providing technical and financial support are the ways through which soil and water conservation measures in Bubaare micro-catchment could be promoted and achieved.

Conclusions

This study concludes that farmers in Bubaare micro-catchment have responded to the problem of continuous soil erosion and fertility decline by adopting different SWC measures. However they still face a number of physical, institutional and socio-economic impediments during the course of adoption and use. This not only escalates the soil erosion problem but affects productivity as well. Supporting farmers through extending financial services, communication and information access, training and experience sharing, education and awareness, providing technical and financial services are some of the ways soil and water conservation measures can be promoted and achieved in and around Bubaare micro-catchment.

Recommendations

Overall results indicate that the farmers' willingness to accept and invest on SWC technologies was strongly correlated with physical, institutional, social and economic factors. Therefore, any SWC plans should 1) consider the farmers' willingness and factors impeding their practice before introducing SWC technologies; 2) create awareness on the farmers about the overall benefits and challenges of the technologies; 3) integrate newly introduced technologies with farmer friendly indigenous measures; and 4) follow bottom-up approach and include farmers in any decision making processes. Indeed, farmers will become aware of the long-term benefits of the technologies and will be initiated to implement the technologies on their own farmlands.

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