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Analysis of Factors Influencing Adoption of Soil and Water Conservation Technologies in Ngaciuma Sub-Catchment, Kenya

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Abstract: The main study objective was to determine and examine factors influencing the adoption of soil and water conservation (SWC) technologies for sustainable watershed management and planning in the Ngaciuma sub-catchment. To achieve the goal of the study, pre-tested questionnaires were administered to 120 household farmers. Numerical tools for data analysis comprised of descriptive statistics (frequencies, percentages, means and standard deviations), non-parametric test (chi-square) and logistic economic model. It was found that terracing, tree planting, agroforestry, cover cropping, mixed cropping and contour vegetation strip were major SWC technologies in the area. It also came to light that household size, perception of soil erosion problem, training in soil erosion control, land ownership and access to institutional credit had significant effects on adoption of SWC technologies. The study further revealed that age, distance of farm from the Ngaciuma River, slope of cultivated land (significant at $P< 0.01$) and membership of an organization or group have positive influence on adoption while education, distance of farm from homestead and number of farm parcels have negative effect on adoption of SWC technologies in the catchment. It was obvious from the study findings that farmers consider personal characteristics, socio-economic, institutional, technology attributes and other exogenous factors before adopting SWC technologies in the catchment. The findings reinforce the fact that in order to achieve sustainable watershed management, institutional and economic factors should be given special attention. Based on the study findings, the following implications were drawn. There is need for sensitization of farmers to form groups to benefit from institutional credit facilities to enhance adoption of SWC technologies, formal training of all stakeholders in SWC technologies and capacity building of farmers in other livelihood areas to reduce pressure on watershed natural resources.

Key words: Adoption · Soil and water conservation technologies · Logit model · Ngaciuma sub-catchment · Kenya

INTRODUCTION

Soil erosion is a major global concern as it leads to topsoil removal and to loss of both applied and native plant nutrients [1]. This has been the cause of reduced agricultural productivity per unit area and high costs of production due to the rehabilitation of farmlands. Land degradation is estimated at about 35 percent of agricultural land in Asia, 45 percent in South America, 65 percent in Africa and 74 percent in Central America [2]. In Africa, the problem of soil erosion is estimated to cause a damage of $26 billion annually to productive soils of the continent [3]. This according to Angima *et al*. [4] leads to 5 million grams per hectare of productive topsoil being lost to lakes and oceans each year. This major land management problem is threatening the economic productivity of agricultural lands in the tropics and Sub-Saharan Africa [5, 3]. High and rapid population growth and imbalances in agricultural land resources allocation is to blame, leading to mismanagement and over exploitation [2].

The situation is not better for the agricultural and water sectors of Kenya's economy, most especially the Ngaciuma sub-catchment where soil erosion problem could lead to food insecurity and siltation of water bodies downstream of the entire Tana River basin [6]. Studies in Kenya Mati *et al*. [7] and Hai *et al*. [8] indicated that significant amount of soil and water losses occur in high rainfall areas. This is particularly burdensome for the Ngaciuma sub-catchment which is at the windward side of

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Mount Kenya and receives about 1200mm of rainfall annually [9]. The problem of soil erosion in the Ngaciuma sub-catchment has been attributed to high population growth, leading to continuous fragmentation of landholdings, agricultural intensification, shortening of fallow periods and subsequent reduction in soil fertility and crop yields. Soil erosion problem is further exacerbated by the steep slope of the area, high rainfall (1200mm annually), deforestation, overgrazing, low adoption of SWC technologies and unsustainable agricultural activities [9].

It is in this light that Abegunde *et al*. [10] argued that by the year 2020, soil erosion may pose a serious threat to food production and rural (as well as urban) livelihoods particularly in poor and densely populated areas of the developing world. They further advocated for policies that would encourage soil retention strategies, land improving investments and better land management if developing countries are to sustainability meet the food needs of their populations. The study is in line with the Kenya Government campaign for the conservation of soil and water resources in the country as enshrined in Vision 2030 Document [11]. This will enhance the fertility of the soil in the catchment to increase agricultural productivity and resource management of the catchment. Moreover, the catchment forms one of the most productive regions of the country and any research to identify factors influencing the adoption of SWC technologies will be in the right direction for the government to come out with institutional structures to assist farmers supplement its effort towards achieving its objectives of food security and environmental sustainability.

[12] worked on the adoption and continued use of stone terraces by farmers for soil and water conservation and soil fertility [13] concerned with soil and water conservation by means of crop rotation with leguminous shrubs in addition to improved fallows and no-tilled land. These soil and water conservation technologies they concluded reduced run-off and soil loss through improvement in soil structure, increasing infiltration and soil resistance to detachment due to increased soil cover [14] also asserts that coir geo-textile, which was used in the study in India proved well in reducing soil erosion, reducing runoff and enhancing soil moisture as well as vegetation growth. The study also revealed that the relative cheapness of the material in the study area enhanced adoption of the technology [15] however gave a comprehensive form of agroforestry practices adopted by Kenyan farmers to manage land and water resources to increase farm productivity.

The above literatures support the fact that most of the adoption studies on soil and water conservation target one specific technology to solve the problem of soil erosion and soil fertility to increase crop productivity. This study however did not address itself to a specific soil erosion management practice but aggregates them together as ‘‘soil and water conservation (SWC) technology’’. The study therefore investigated the adoption of different soil and water conservation technologies for integrated management and planning of the catchment. The study addresses the following key questions:

- What farmer personal characteristics and socio-economic factors are influencing adoption of soil and water conservation technologies in the Ngaciuma sub-catchment?
- What are the institutional and environmental factors influencing adoption of soil and water conservation technologies in the Ngaciuma sub-catchment?

MATERIALS AND METHODS

The Study Area: The study was conducted in Ngaciuma sub-catchment of 167 km^2 in Eastern Province of Kenya under Tana River Catchment. It has a population of about 36,000 people, representing a density of approximately 360 persons per km^2 [16]. The main part of the catchment is located within Meru Municipality, which falls under Buuri and Miriga Mieru Divisions. Geographically, it is bounded by Longitudes 37.5° E and 37.75° E and Latitudes 0.04°N and 0.15° N. The study area is specifically located within Naari Location (Upper Zone), Munithu Location (Middle Zone) and Thuura Location (Lower Zone) with a total number of households being 7,511 [9]. The climate of the catchment ranges from humid to semi-humid with Agro-ecological zones. Rainfall is bimodal falling during the long rains from March to May and short rains from October to December as depicted in Fig. 1. The mean annual rainfall ranges from about 1100 mm in the lower zone to 1300 mm in the upper zone, with annual temperatures ranging from 10°C to 30°C. The major soils are nitisols with some gleysols in the wetlands and andosols on hill slopes [9]. These soils are poorly consolidated hence with the steep slopes are susceptible to erosion and mass movement. Livelihood options include limited irrigated agriculture, dry-land farming (including khat, macadamia, maize and banana), animal husbandry and a variety of small businesses. Informal sector activities range from food processing and brewery,

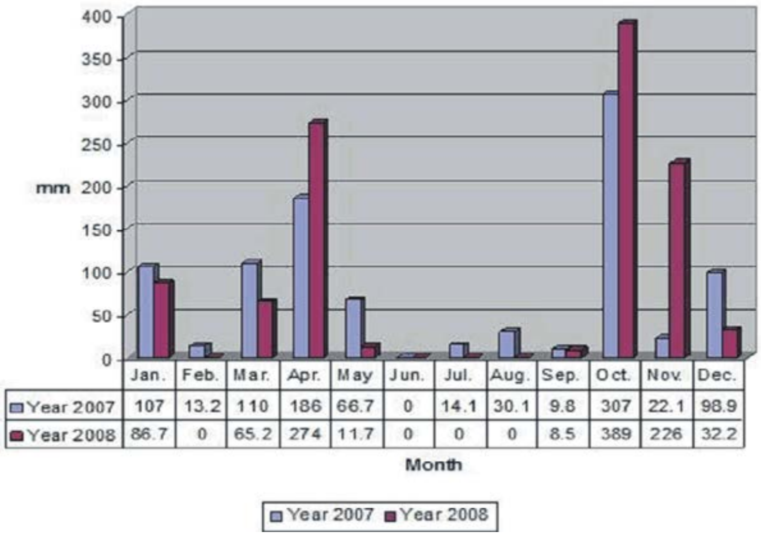

Fig. 1: Monthly Rainfall for Ngaciuma Sub-Catchment for 2007 and 2008
Source: Kenya Meteorological Department (2009)

to small-scale retailing of fruit and vegetables and low-cost household goods. Most households are involved in more than one of these activities at the same time in an effort to diversify sources of income [6].

Research Methodology: Both primary and secondary data were collected for the study. Primary data were collected using a pre-tested structured questionnaire for heads of household farmers, institutional questionnaire for in-depth interview of stakeholder experts, key informant interview guide for farmers who are well informed about SWC technologies in the catchment and on-farm observation guide to map SWC technologies using Global Positioning System (GPS). A total of 100 households were selected using stratified random sampling procedure. With this sample size for the sub-catchment, a proportionate stratified random sampling based on the proportion each zone contributes to the total number of households in the Sub-catchment was used. The proportionate random selection started from the division level then to location, sub-location narrowing down to the village and finally to the farmers' households. All these were based on the proportion each unit contributes to the total number of households in the sub-catchment to come out with the sample for each village. This calculation gives 46 households for Upper Zone, 26 households for Middle Zone and 28 households for Lower Zone. Additional information was collected from 20 representatives of stakeholder institutions in and around Meru Municipality using institutional questionnaire. The representatives were from Ministry of Agriculture, Kenya Forest Services, Water Resources Management Authority, Ministry of Environment and Mineral Resources, Non-Governmental Organizations (NGOs), Community-Based Organizations (CBOs) and Ngaciuma-Kinyaritha Water Resource Users Association.

To complement the information gathered, key informants who are mainly opinion leaders in the communities visited were interrogated in a face-to-face interview. This gave the researcher an opportunity to have an insight into the problem of soil erosion and the adoption of SWC technologies in the catchment. Furthermore, GPS receiver and digital camera were used to capture specific SWC technologies in the field. Prior to the main study, a pilot study was conducted to pre-test the research instruments and to work out the modalities of identifying all stakeholders. After the pilot survey, various items in the research instruments that were inconsistent and redundant were done away with and a final version prepared for the main research.

A literature search was undertaken from both published and unpublished materials on the study area, SWC technologies and adoption studies in general. This led to realistic interpretation of results by triangulation. Data analysis involved the use of descriptive statistics which dealt mainly with frequencies, percentages, means, minimum and maximum values and dispersion around the mean (range and standard deviation). In order to make a decision on whether or not a significant relationship existed between adoption of SWC technologies in the catchment and the variables investigated, a chi-square test was performed. The results were tested for significance at 0.05 (95 percent confidence level). Econometric model was also employed.

Econometric Model: For this study, a model that reflects the observed status of SWC technologies on farms in the catchment was required. Such observations reflect dichotomous variable, adoption or non-adoption of SWC technologies. Since they cause certain problems, linear probability models estimated by ordinary least squares (OLS) are thus not applicable. Instead, logistic model was applied [17]. According to [18],

> *"the use of probit and logit models, that give maximum likelihood estimates overcome most of the problems associated with linear probability models and provide parameter estimates which are asymptotically consistent, efficient and Guassian so that the analogue of the regression t-test can be applied*"

Logit and probit models are popular statistical techniques in which the probability of a dichotomous outcome (such as adoption or non-adoption) is related to a set of explanatory variables that are hypothesized to influence the outcome [19]. However, [18] acknowledged that the logit model that is based on the cumulative logistic probability function is computationally easier to use than the other types and was used in this study. The probit model was not used because of the nature of the variables used in the study since it assumes cumulative normal distribution [20] also rejects the use of the probit model on the grounds that it leads to inefficient estimators and that the estimated probabilities are not constrained to lie between the (0, 1) range demanded by probability theory.

Following [21], the logistic regression model characterizing adoption by the sample households is specified as:

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

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 ($\beta_1, \beta_2, \ldots \beta_k$) are the coefficients associated with each explanatory variables $X_1, X_2 \ldots X_n$)

The above function can be rewritten as:

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

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:

$$\ln\left[\frac{P}{1 - P}\right]$$

The positive coefficient means that the log of odds increases as the corresponding independent variable increases [19]. The coefficients in the logistic regression model are estimated using the maximum likelihood estimation method.
Specifically, the empirical model is specified as:

$$\begin{aligned} CLAD_i = {} & \beta_0 + \beta_1 EDU_i + \beta_2 AGE_i + \beta_3 DIS_i + \beta_4 DIR_i + \\ & \beta_5 FAS_i + \beta_6 NFP_i + \beta_7 SLP_i + \beta_8 MCP_i + e_i \end{aligned} \quad (3)$$

where:
β_0 is the constant term
β_1 to β_8 are unknown parameters to be estimated
e is the disturbance term

The meaning of the variables considered in specific model (3) and their *apriori* signs is summarised in Table 1.

RESULTS AND DISCUSSION

Results of SWC Technologies Identified: The results revealed that 76 percent have adopted at least one of the SWC technologies identified with 24 percent not adopting any of the SWC technologies at all. The high rate of adoption of SWC measures in the catchment might be linked to farmers desire to conserve water and land related resources as a means to improve upon agricultural productivity as the area is one of the productive regions in Kenya. Terracing (65 percent), tree planting (61 percent), agroforestry (33 percent), cover cropping (27 percent), mixed cropping (16 percent) and contour

Table 1: Summary of Variables Considered

Variable	Meaning	*Apriori* Sign
CLAD	Dependent binary variable. 1 for adoption of SWC technology, 0 otherwise	
EDU	Education of the farmer (years in school)	Positive (+)
AGE	Age of the farmer (in years)	Positive /Negative (+/-)
DIS	Average distance of farm from homestead (in metres)	Positive (+)
DIR	Distance of farm from the Ngaciuma river (in metres)	Positive (+)
FAS	Farm size of the farmer (acres)	Positive (+)
NFP	Number of farm parcels of the farmer	Negative (-)
SLP	Slope of land of the farm (1= steep slope, 0 otherwise)	Positive (+)
MCP	Membership of a Cooperative/ organization (1= yes, 0 otherwise)	Positive (+)

Source: Author (2010)

vegetation strip (19 percent) are the major SWC technologies being adopted by farmers due to their effectiveness in controlling soil erosion in the catchment. Farmers' choice of these soil erosion control measures are mainly due to the steep slope of the area and these technologies tend to reduce the speed of run-off down slope.

Descriptive Statistics of Factors not used in the Logit Model

Sex: The sample population was made of 55.0 percent male and 45.0 percent women. This large number of men is due to the fact that men are the heads of the households and as custom demands are answerable to anyone who comes to the house. More importantly, farming as an activity is a male dominated enterprise because of its strenuous nature. However, 45.0 percent of women involved in farming explained the assertion that women are gradually taking over the management of watershed resources. This is because women are highly dependent on watershed resources such as water and fuel wood to meet their day to day activities. This also confirms what one woman key informant in the catchment noted during the fieldwork:

> We are now in the off-season and most of the men have migrated to the big towns such as Meru, Nairobi and Mombasa in search of white collar jobs to supplement the family income. They will come during the planting season to help us and after that leave for their work places (Gakii, Oral Interview, 27/1/2010).

Women involvement in watershed management further came to light when the adoption percentage of SWC technology was assessed thoroughly. From the analysis in Table 2, females (82.2 percent) are better adopters than their male (72.7 percent) counterparts.

Table 2: Category of SWC technologies adoption by sex

Category	Frequency	Percent
Male Adopters	40.0	72.7
Male Non-Adopters	15.0	27.3
Female Adopters	37.0	82.2
Female Non-Adopters	8.0	17.8

Source: Field Survey (2010)

Table 3: Household size of respondents

Category	Frequency	Percent
1-2	6	6.0
3-4	39	39.0
5-6	41	41.0
7-8	7	7.0
9-10	6	6.0
10+	1	1.0

Source: Field Survey (2010)

This could be linked to women membership in local farmer groups which encouraged women to engage in tree planting and other SWC measures in the catchment. Notable among the groups were Green Belt Movement, Gaiture Farmers' Group, Merry-go-Round Group and Mwimenyeri Women's' Group. However, chi-square test indicated no significant relationship between adoption of SWC technologies in the catchment and sex ($\chi^2 = 1.000$, df =1, p = 0.317). This implies that sex does not influence adoption of SWC technologies. This is in agreement with those obtained by [22] in the Ethiopia highlands watershed on the adoption of stone terraces for soil and water conservation.

Household Size: This is a major determinant in SWC, especially with respect to poor resource farmers who depend solely on family labour to maintain their farms. It was not surprising that 39.0 percent and 41.0 percent of respondents (Table 3) had a household size of 3-4 and 5-6 persons, respectively.

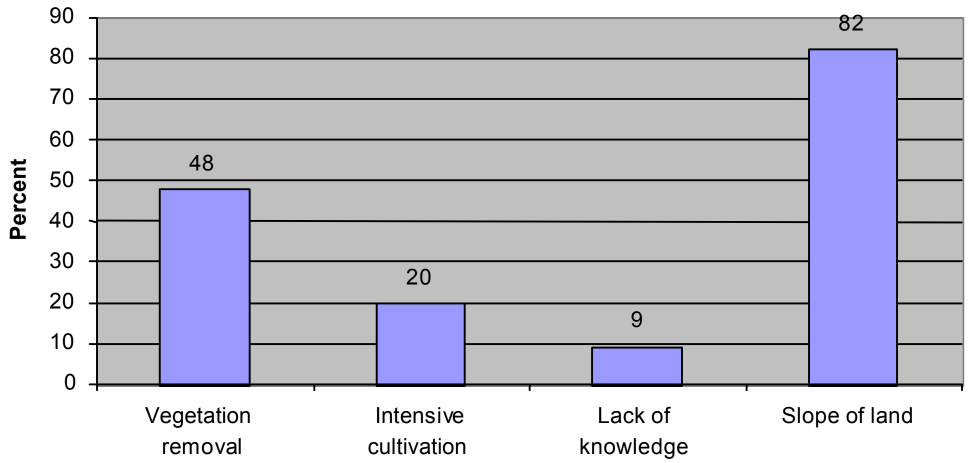

Fig. 2: Problems contributing to soil erosion in the catchment
Source: Field Survey (2010)

This might have a link with the high rate of adoption (76 percent) of SWC technologies in the catchment. Empirical studies confirmed this finding as noted by [23]:

> Household size 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.

Chi-square test proved that adoption of SWC technologies is influenced significantly by household size in the area (χ^2 = 99.440, df = 5, p = 0.000). However, other studies conducted by [24, 25] found the opposite. This they noted that in a family with a greater number of mouths to feed, competition arises for labour and investment in SWC technologies. Thus, labour is diverted from conservation activities in the farm.

Perception of Soil Erosion Problem in the Catchment: Majority of farmers interviewed (76.0 percent) attested to the fact that there exist soil erosion problems in the catchment. It is not surprising that the chi-square test indicated that a significant relationship exist between adoption of SWC technologies and perception (χ^2 = 27.040, df = 1, p = 0.000). Those who perceived the problem of soil erosion attributed it to the following reasons: vegetation removal (48.0 percent), intensive cultivation (29.0 percent), lack of knowledge (9.0 percent) and slope of the land (82.0 percent) as in Figure 2. This confirms the study of [25] that intensive cultivation and farming on marginal lands leads to severe soil erosion.

Training in Soil Erosion Control: The study revealed that 33.0 percent of the farmers have not had any formal training in soil erosion management or control. Although 67.0 percent of the farmers interviewed have received some form of training from Ministry of Agriculture officials (38.0 percent), Local Farmer Groups (27.0 percent), Forestry Department (15.0 percent) and German Technical Cooperation (2.0 percent), it still poses challenge to the conservation and management of watershed resources. This means quite a sizeable number of farmers are depending on their local indigenous knowledge which might be rudimentary in tackling soil erosion on the type of topography in the catchment. This also explains why soil erosion in the area is very visible. It is believed that farmers will embrace any scientific measure to conserve their soil resources. This is shown in the advantages they stand to gain in adopting soil erosion measures in their farms such as improved crop yield (76.0 percent), high income level (3.0 percent), soil retention (14.0 percent), soil fertility maintenance (62.0 percent) and more water supplies (5.0 percent) as captured in the study. When subjected to chi-square test, training in soil erosion measures was found to be dependent on adoption of SWC technologies in the catchment significantly (χ^2 = 11.560, df = 1, p = 0.001).

Source and Access to Information on Soil Erosion Control: From the sample households, fellow farmers (72.0 percent) and the media (64.0 percent) as in Fig. 3 have been the main source of information for farmers within the area. This might have something to do with Kenya Ministry of Agriculture new policy of extension services being demand driven. Where the farmer must

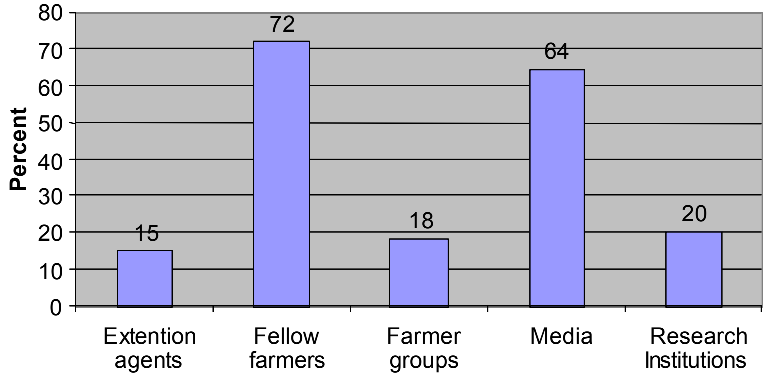

Fig. 3: Source of information for farming
Source: Field Survey (2010)

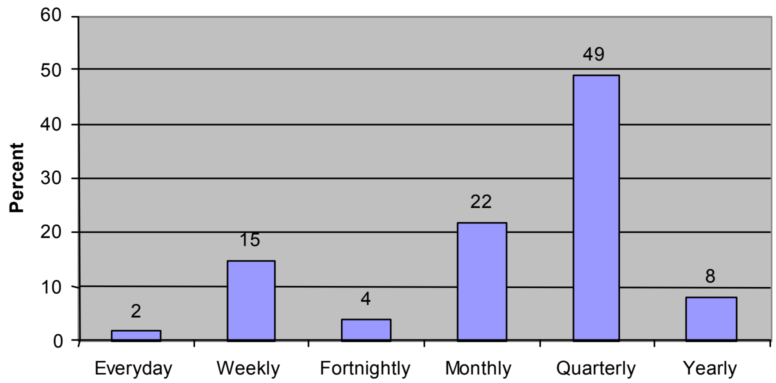

Fig. 4: Frequency of access to information
Source: Field Survey (2010)

assess his/her needs and book appointment with the nearest extension agent or office before he/she is attended to. The whole policy is very new to poor resource farmers who have to go through some processes and financial commitment. This is what is making farmers to seek assistance from fellow farmers and the media which costs them less in terms of time, money and other resources. The high patronage of the media can be attributed to the proliferation of Radio Stations (notably, Kimeru Radio) operating within the Meru Municipality which is part of the Ngaciuma sub-catchment. Other means of information to farmers as shown in Fig. 3 are extension agents (15.0 percent), farmers groups (18.0 percent) and research institutions (20.0 percent).

The frequency of access to information on farming and SWC technologies is mainly seasonal or quarterly (49.0 percent) and monthly (22.0 percent) as shown in Fig. 4. This is because farmers interact with each other during the planting seasons and at the same time programmes on agronomic practices are also aired on the radio stations during that time of the year to sensitise farmers on what do and what not to do in their farms. Low extension contact in the area as compared to fellow farmers and media is a source of worry. This is because the uptake of any technology, especially SWC technology is often influenced by the farmer's contact with extension agents [26].

Land Ownership: Almost all the respondents interviewed (99.0 percent) have their own land which were mostly purchased (17.0 percent), inherited (71.0 percent) and given (11.0 percent) as presented in Table 4. This explains the high level of adoption of SWC technologies as farmers who own their land tend to invest in SWC measures as no one can take over the land in the future. The chi-square test also proved a strong relationship between adoption of SWC technologies and land ownership ($\chi^2 = 96.040$, df = 1, p = 0.000).

Source of Finance for Farming: Access to rural banking facility to support both individual farmers and farmer-based organizations has not been encouraging in the catchment. This came to light during the survey.

Table 4: Land tenure systems in the catchment

Land Tenure	Frequency	Percent
Purchased	17	17.0
Inherited	71	71.0
Given	11	11.0
Rented	1	1.0

Source: Field Survey (2010)

Table 5: Source of finance for farming

Source of Finance	Frequency	Percent
Savings	97	97.0
Friends	4	4.0
Local Money Lenders	4	4.0
Banks	19	19.0

Source: Field Survey (2010)

Majority of the respondents interviewed (97.0 percent) depended on savings from own resources for farming activities, while friends (4.0 percent), local money lenders (4.0 percent) and banks (19.0 percent) (Table 5) give financial assistance in the form of credit or farm inputs to assist farmers maintain their farms. This is a source of worry as almost half of the respondents (44.0 percent) were not involved in any form of off-farm employment to supplement their income. This could put undue pressure on the already scarce natural resources leading to further degradation and depletion. Fig. 5 presents the amount of credit received by 27.0 percent of farmers in Kenya Shillings with an average figure of Ksh 60,259.26, (US$753.38) minimum value of Ksh 2,000 (US$25.00) and maximum value of Ksh 300,000 (US$3,750.00).

Table 6: Access to credit by gender and adoption

Category	Percent
Male Adopter Access	33.33
Female Adopter Access	37.07
Male Non-adopter Access	22.22
Female Non-adopter Access	7.40

Source: Field Survey (2010)

Poor rural households in developing countries lack adequate access to credit. This in turn has a significant negative impact on technology adoption, agricultural productivity, nutrition, health and overall household welfare [27]. In the study area, it was found that only 27 percent of the respondents have reported obtaining credit for the past one year. Whereas, the majority, 73 percent have not obtained credit from the sources in Table 5. When the data was analyzed by disaggregating into adopters and non-adopters of SWC technologies in the catchment based on gender, it was found that women were better adopters (37.04 percent) as compared to their male counterparts who scored 33.33 percent (Table 6). This also confirms that women are gradually becoming better managers of watershed resources.

This also indicates that farmers who have access to credit have a higher probability of adopting SWC technologies than those with no access. The chi-square test further confirmed that adoption of SWC technologies is significantly influenced by access to credit facilities ($\chi^2 = 21.160$, df = 1, p = 0.000). This may be explained by the fact that the requirement to pay back credits will motivate farmers to invest more on yield enhancing activities such as SWC measures and as a result great

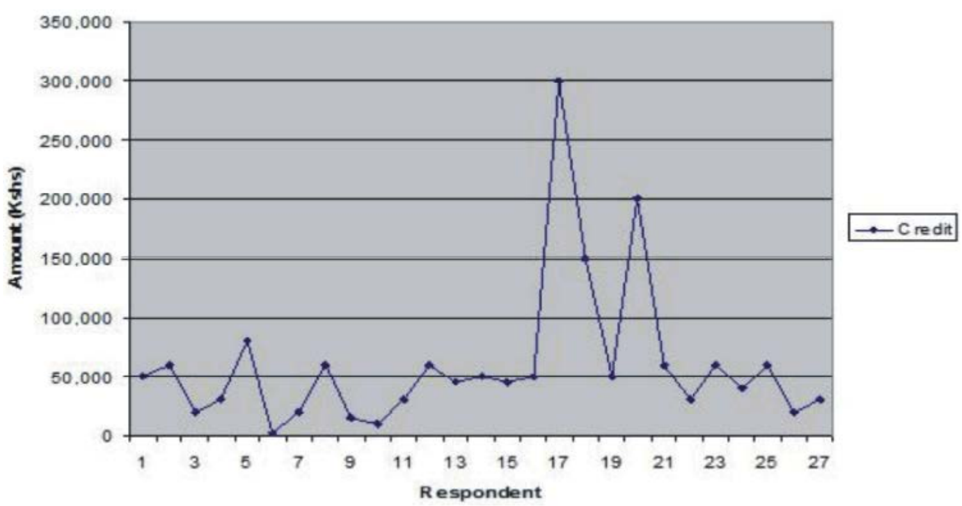

Fig. 5: Amount of credit received by respondents
Source: Field Survey (2010)

Table 7: Descriptive Statistics of Variables

Variable	Description	Mean	Max.	Min.	Std. Dev.
CLAD	Dependent binary variable: 1 for adoption and 0 otherwise	0.760	1.000	0.000	0.429
EDU	Education of the farmer (years in school)	10.230	15.000	0.000	3.776
AGE	Age of the farmer (in years)	54.240	80.000	22.000	13.256
DIS	Average distance of farm from homestead (in metres)	43.460	1000.000	5.000	116.968
DIR	Distance of farm from the Ngaciuma River (in metres)	724.700	5000.000	30.000	744.121
FAS	Farm size of the farmer (acres)	1.525	9.000	0.250	1.493
NFP	Number of farm parcels of the farmer	1.210	4.000	1.000	0.556
SLP	Slope of land of the farm (1= steep slope, 0 otherwise)	0.760	1.000	0.000	0.429
MCP	Membership of a cooperative/organization(1= yes, 0 otherwise)	0.760	1.000	0.000	0.429

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

Source: Field Survey (2010)

Table 8: Correlation Matrix of Variables

	CLAD	EDU	AGE	DIS	DIR	FAS	NFP	SLP	MCP
CLAD	1.000								
EDU	-0.153	1.000							
AGE	0.236	-0.168	1.000						
DIS	-0.167	0.161	-0.145	1.000					
DIR	-0.069	0.089	0.063	-0.119	1.000				
FAS	0.033	0.181	0.362	0.052	0.026	1.000			
NFP	-0.041	0.068	0.082	0.094	-0.003	0.304	1.000		
SLP	0.945	-0.153	0.239	-0.169	-0.078	0.033	-0.041	1.000	
MCP	0.123	0.115	0.195	-0.120	-0.029	0.222	0.129	0.123	1.000

Source: Field Survey (2010)

effort will be put in adopting and maintenance of the SWC technologies [28].The high level of farmers not having access to formal credit from the financial institutions in and around the catchment had been linked to lack of collateral or security to secure the loan. As one farmer puts it:

> We use savings or proceeds from our previous farming operations to finance the following year's farming activity. Due to crop failure and other risks involved in farming and high interest rates the banks are charging, we are shy of accessing their services (Kathigauti, Oral Interview, 28/1/2010).

However, some of the farmers use their off-farm employment or businesses such as petty trading, civil service and artisan works to secure loans from the financial institutions such as Barclays Banks, Cooperative Bank, Equity Bank and Agricultural Finance Cooperation operating in the area for the purchase of farm inputs. Notwithstanding the role of off-farm employment in the adoption of SWC technologies, when subjected to chi-square test, it was not significant at 95 percent confident interval (χ^2 = 1.440, df = 1, p = 0.230). This implies adoption of SWC technologies in the catchment is not influenced by off-farm employment of the people in the area. Thus, adoption is irrespective of the inhabitants' employment or income generating status. This is in line with the finding of [29], who found that income from migration or off-farm activities does not have influence on household's decision to invest in conservation measures.

Descriptive Statistics of Empirical Variables: The descriptive statistics of the variables used in the regression model are provided in Table 7. The mean age of the household head was 54 years. The average level of education was 10 years with a maximum of 15 years and minimum of 0 or none. The mean distance of respondents' farm from homestead was 43.5 metres with a maximum of 1000 metres and minimum of 5 metres. The mean distance to the Ngaciuma River which happens to be the main source of water for both domestic and irrigation purposes of the people in the catcthment was found to be 724.7 metres with a maximum distance of 5000 metres and minimum of 30 metres. The average farm size in the catchment was 1.5 acres with a maximum of 9 acres and minimum of 0.25 acres. The average number of farm parcel for a household was 1 with a maximum of 4 farms and a minimum of 1 farm.

Table 9: Logit Estimates of Variables

Variable	Coefficient	Standard Error	Odds Ratio	P-value
C	-3.3222	4.1109		0.4190
EDU	-0.0630	0.2393	1.34	0.7924
AGE	0.0176	0.0681	1.36	0.7965
DIS	-0.0001	0.0681	4.06	0.9831
DIR	0.0001	0.0009	1.98	0.8786
FAS	-0.0272	0.6249	3.33	0.9653
NFP	-0.1190	1.3732	2.60	0.9309
SLP	7.3306*	1.4657	0.00	0.0000
MCP	0.3445	1.7675	1.70	0.8455

Log likelihood: -9.3631, McFadden R-squared: 0.8300, Observations: 100
Likelihood ratio statistic (8df): 91.4897 (2.22E-16)
Wald chi (8): 95.5186 (0.0000) * denotes significant at 1.0 percent

Source: Field Survey (2010)

Results of the Logistic Regression Model: The empirical results are presented in this section. The model was tested for multicollinearity. The correlation matrix presented in Table 8 shows that multicollinearity was not a source of concern, since none of the explanatory variables were strongly correlated or related with each other.

Table 9 reports the logit estimates of the probability to adopt SWC technologies in the Ngaciuma sub-catchment. To measure the performance of the model, the McFadden R-squared and log likelihood are reported. The McFadden R-squared of 0.8300 indicates that the model explains the variation of adoption of SWC technologies in the study area for 83.0 percent of the sample. The likelihood ratio statistic of 91.4898 (8 df) shows that the model is different from zero and significant at 1.0 percent level.

Almost all the variables in the logistic model had the correct *a priori* signs or the hypothesized signs as expected with the exception of EDU, DIS and FAS. However, the variable AGE is indeterminate and can take any sign (either positive or negative).

Education (EDU): This variable was expected to take a positive sign; rather, it took a negative sign and insignificant. The basis of this was that highly educated farmers are expected to be better adopters of SWC technologies in the catchment than less educated ones. Educated farmers are presumed to have exposure to new technologies and innovations and are more receptive to new ideas and more willing to adopt, hence the null hypothesis that education has positive correlation with SWC technology adoption [30, 31, 32]. This implies that adoption of SWC technologies in the catchment is negatively influenced by education. The odds ratio, 1.34 implies that one unit increase in education level of a household head reduces the odds of adopting SWC measure about 1.34 times, keeping other variables in the model constant. This might be due to unattractive nature of farming in the catchment since more educated household heads would like to find job opportunities outside the catchment to meet their aspirations in life. The education levels of the respondents ranged from primary to college or polytechnic graduates. The insignificant association of education with adoption of SWC technologies could also be attributed to low level of educational attainment of farmers in the area. The average year of formal education of the sample households was 10 years.

Age (AGE): Age of the household head was expected to have either positive or negative effect on adoption of SWC technologies. Older farmers were likely to be relatively reluctant in their decisions to take up new technologies because of their short planning horizon. However, it is also true that older farmers were likely to have more farming experience and would therefore be likely to be more receptive to new SWC technologies [33]. On the other hand, younger farmers would be more accommodative to new ideas and would invest in new and long term innovations. For these reasons, the influence of age on adoption could not be determined *a priori*. However, in the analysis for this study, age took a positive sign and was not significant. Thus, older farmers are likely to adopt SWC technologies than their younger counterparts. This can be explained by the fact that older farmers have more farming experience as compared to the younger counterparts. The odds ratio, 1.36 implies that one unit increase in age of household head increases the odds of adopting SWC measure about 1.36 times, keeping other variables in the model constant. This finding is inconsistent with other researchers. For instance, [31], [34] and [33] reported 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.

Distance of Farm from Homestead (DIS): Inconsistent with the expectation of this study, the coefficient of distance of a farm from homestead (DIS) was found to be negative but not significant. The basis of this was that farmers with farms that are within residential area were expected to have higher probability of adopting SWC technologies. Moreover, farmers in the catchment live within a mean distance of 43.5 metres from their farms.

This should have given them the opportunity to pay more attention to nearby farms with less care to distant farms. Therefore, parcels of farms closer to farmers' residence must receive better attention and supervision than distant farms from the homestead. Based on empirical evidence, the null hypothesis was rejected in favour of the alternative. This finding is not in agreement with [33] who found significant and negative correlation between no conservation decision and distance of a parcel from the residence but positive correlation between distance of the plot and adopting conservation decision in Ethiopia [30] also found out that farmers invest more in soil and water conservation in fields situated near to residences.

Distance of Farm from River Ngaciuma (DIR): This variable took a positive sign as expected but was not significant. The basis of this expectation was that farming activities are carried out close to the Ngaciuma River. With the nature of the topography, farms closer to the river are predisposed to soil erosion; hence farmers were expected to take up SWC technologies. This implies that SWC technology adoption is positively influenced by the distance of farm from the Ngaciuma River. The positive influence can be attributed to the fact that majority of the sample households farms were not far away from the river, hence demanding adoption of SWC technologies as a preventive measure. The mean distance of 724.5 metres attests to this finding. The odd ratio, 1.98 implies that all things being equal, if a household's farm distance from Ngaciuma River increases by one unit, adoption will go up by 1.98 units' times in the catchment.

Farm Size (FAS): Farm size was found to influence adoption of SWC technologies in the Ngaciuma sub-catchment negatively but not significant. The negative influence might be explained by population pressure on land resources in the area over the years where land had been subdivided among family members leading to land fragmentation. Land fragmentation reduces the benefits associated with economies of scale. It has been demonstrated that, at a given point in time, there could be a lower limit on the size of adopting farms, such that farms smaller than a certain critical level will not adopt new or improved technologies [26]. The critical lower limit level might have been reached for the Ngaciuma sub-catchment. Table 10 reports category of farm size in the catchment. It has also been argued that farmers might have the capital to invest in SWC technologies in large size farms but the fragmented farms serve as a source of disincentive. This finding is in conformity with [35] who studied the adoption decisions of soil and water management technologies in the semi-arid eastern Kenya and [36] on their study of technology adoption in the production of horticultural export produce in Kenya.

Table: 10: Farm size of respondents in the catchment

Acreage	Frequency	Percent
0-1	60	60.0
2-3	31	31.0
4-5	6	6.0
6-7	2	2.0
8-9	1	1.0

Source: Field Survey (2010)

Number of Farm Parcels (NFP): Inconsistent with other studies and with theory, the variable NFP is negatively related with adoption of SWC technologies in the catchment and not significant [3, 29]. 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. Other variables held constant, the probability of adopting SWC technologies in the catchment reduces as the number of farm parcels increases by 2.60 units. Although the mean number of farm parcels in the catchment is 1.2 with a maximum number of 4.0, population pressure leading to fragmentation of farmlands in the area could be linked to this finding.

Slope of Land (SLP): As expected, the variable SLP took the hypothesized positive sign and significant. This implies slope of land influences adoption of SWC technologies positively. This is because slope is an indicator of soil and water loss from the farmland. Thus, farmers cultivating sloping fields perceive the threat of soil loss better than farmers who cultivate gentle or level sloping fields. This implies that farmers cultivating vulnerable fields are more likely to adopt SWC technologies in their farms than those cultivating less vulnerable lands. This is consistent with [24, 33] and [35]. The highly significant ($P<0.01$) influence of slope on the adoption of SWC technologies in the catchment implies that the slightest increase in slope of farmlands requires preventive measures. Moreover, the slope of land affects farmers' decision by influencing the magnitude and velocity of runoff, which in turn affects the economic significance of soil erosion, thus reducing the productivity of the cultivated land.

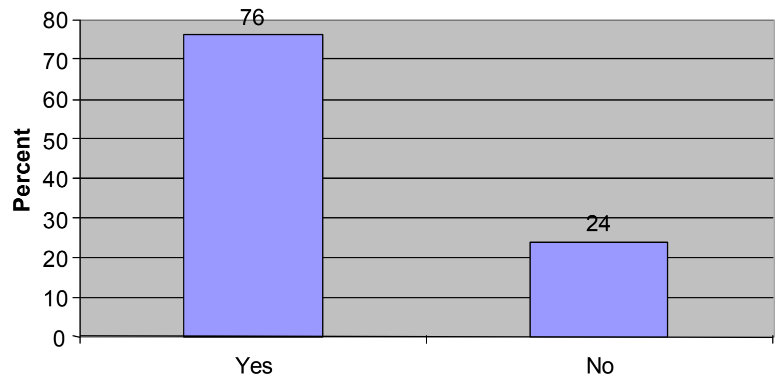

Fig. 6: Membership of cooperative in the catchment
Source: Field Survey (2010)

Membership of Cooperative (MCP): The MCP variable had a positive coefficient as hypothesized but not significant. The positive coefficient implies a positive correlation between SWC technology adoption and membership of cooperative or organization (Fig. 6). Farmers who are members of farmer-based groups or organizations in the study area such as Meru Green Society, Green Belt Movement, Kankanga Women's Group among others are better placed to adopt SWC technologies than those who did not belong to any organization. This is confirmed by Figure 6 as adoption level of SWC technologies in the catchment correlates with membership of cooperatives or organizations. 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 meet and exchange ideas. As noted by [22] and [37], 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 technology.

CONCLUSION

The study showed that terracing, tree planting, agroforestry, cover cropping, mixed cropping and contour vegetation strip as major SWC technologies in the area. It came to light that household size, perception of soil erosion problem, training in soil erosion control, land ownership and access to institutional credit had significant effects on adoption of SWC technologies. The study also revealed that age, distance of farm from the Ngaciuma River, slope of cultivated land (significant at $P< 0.01$) and membership of an organization or group have positive influence on adoption while education, distance of farm from homestead and number of farm parcels have negative effect on adoption of SWC technologies in the catchment. 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 interaction through membership in local groups. In this way, SWC technology adoption must be dependent on personal characteristics, socio-economic, institutional, technology attributes and other exogenous factors. These findings reinforce the fact that in order to achieve sustainable watershed management, institutional and economic factors should be given special attention. Based on the study findings, the following implications were drawn. There is need for sensitization of farmers to form groups to benefit from institutional credit facilities to enhance adoption of SWC technologies, formal training of all stakeholders in SWC technologies and capacity building of farmers in other livelihoods areas to reduce pressure on watershed natural resources.

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