Links between Farmers’ Socio-demographics and Adoption of Soil Conservation Technologies in Hilly Terrains of Nandi County, Kenya

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Author’s contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JAERI/2020/v21i530143

Editor(s):
(1) Dr. Gopal Krishan, National Institute of Hydrology, India.

Reviewer(s):
(1) Ampadu-Ameyaw Richard, CSIR-Science and Technology Policy Research Institute, Ghana.
(2) Pradip Kumar Bora, Central Agricultural University, India.

Article Information

Received 23 March 2020
Accepted 28 May 2020
Published 11 June 2020

ABSTRACT

Smallholder farms in Kenya continue to suffer from crop-productivity declines due to loss of soil quality as a result of soil erosion among other factors. Low adoption of soil conservation technologies persists in spite of previous interventions. This study was conducted to investigate links between farmers’ socio-demographic factors and the adoption of soil conservation technologies. The study adopted a descriptive cross-sectional survey design. Purposive and multi-stage random sampling techniques were used to select a sample of 150 farmers from six catchment areas of the hilly terrain of Tindere in Nandi County, Kenya. A total of 138 participants were accessed. Questionnaires administered by enumerators were used to collect data. Data was analysed to generate descriptive statistics. Kendall-Stuart Tau-c and Goodman-Kruskal’s gamma were used to estimate correlations between socio-demographic factors and adoption. Age, Gender, duration of residence and farm size were not significantly associated with adoption ($P > 0.05$). Education levels, household size, level of awareness and income were positively associated with adoption (Gamma = .359, $P = .034$), (Gamma = .229, $P = .088$), (Gamma = .485, $P = .000$) and (Gamma = .282, $P = .042$) respectively. It is recommended that stakeholders address soil erosion problems through farmers’ capacity-building, particularly for low-income farmers.

Keywords: Soil fertility; land productivity; soil erosion; land degradation; socioeconomics; adoption.

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ABBREVIATION

MOA: Ministry of Agriculture, Kenya.

1. INTRODUCTION

Tropical and subtropical countries continue to suffer from loss of soil quality due to soil erosion. It has contributed heavily to persistent low crop productivity. Soil erosion and the subsequent crop productivity declines are particularly severe in small farms located in steep topographies [1]. Losses of soil organic matter, soil Nitrogen and soil Phosphorous due to soil erosion and poor cropping systems are estimated at 270 million tons per year in Africa [1]. These huge losses in soil nutrients underpin the importance of soil conservation measures. The concern for soil conservation measures in Kenya is historical. Soil and water conservation measures started following serious erosion problems in the 1930s. There was concern about land degradation both in the African native reserves and in the European settler-farms. Conservation practices somehow were made compulsory by the then colonial government through the African Land Development Plan, ALDEV (1946-1955) and the Swynnerton plan of 1954 to 1959 [2]. The two long-term development plans were focused on rehabilitating the damage on land that was caused by population pressure on the productive settlement areas. Emphasis was made on strict measures to raise land productivity through soil conservation measures [3].

Efforts to rehabilitate degraded lands in Kenya continued after independence. There was, however, some slack period in the conservation efforts immediately after independence [4]. According to the author, efforts picked up in the 1970s on the realization that there was a threat of a severe decline in land productivity occasioned by expansion in farming activities. These efforts concentrated on conserving soils for improved food security. The Government of Kenya with some assistance from the international community such as the Swedish Government (1974-2000) implemented soil and water conservation programs [4]. Through these deliberate measures, many farms were conserved. It is estimated that about 1.4 million farms were conserved between 1974 and 1993 [5]. There was, however, a continued increase in population resulting in further pressure on the natural resources.

Kenya’s population continues to grow and there has been an increasing pressure on land; many times accompanied by deterioration in soil, water and vegetation resources. As more and more land is cleared for production the soil and water resources are exposed to degradation. Loss of vegetation accelerates soil loss and soil loss accelerates the loss of vegetation and the cycle continues. The result of land degradation is the loss of soil nutrients resulting in soil fertility decline and deterioration in land productivity. This degradation has led to considerable direct negative consequences on food security and sustainable agriculture [6].

It has been recognized that policies of food security in Kenya cannot be promoted without addressing the issue of progressive decline in soil fertility particularly that which is caused by soil erosion [7]. In 1987, the Kenyan Government, through a program funded with support from the Swedish Government, implemented a National Soil and Water Conservation Program (NSWCP) using a catchment approach. The approach involved bringing together community members to form groups and collectively conserve catchment areas [7]. A catchment covered an area which extended from hill-tops to the riverbanks. Such catchment areas covered one or two villages sharing common hydrological watersheds and therefore required similar soil conservation measures. To sustain the conservation measures, the Kenyan Government implemented a National Agriculture and Livestock Extension Program (NALEP) between 2000 and 2012. Serious soil erosion, however, still persists in many parts of Kenya [8]. Soil erosion through run-off is even more severe in hilly terrains as observed recently in one catchment area in Kenya (Plate 1).

An understanding of the socio-economic factors that affect the adoption of soil and water conservation measures is an important input to support stakeholders in the management of soil erosion problems. Soil conservation measures have a direct bearing on soil fertility and land productivity. The Ministry of Agriculture [9] recognized that land degradation was a major culprit for increased run-off, flash flooding, reduced infiltration and serious soil erosion. The
Plate 1. Severe soil erosion on cultivated land, Kamelil, Nandi county, Kenya  
Source: Field capture April, 2020

degradation undermines sustainable water resource base. The MOA report [9] confirms that the degradation patterns observed in many parts of the country may be associated with poor farming methods and increased population which leads to cutting down forests to pave the way for agricultural production and to provide fuel-wood. The current study attempts to identify the socio-economic factors that may be related to poor farming methods that do not take into account sustainable land management practices.

In the many years of the past shifting cultivation was used to maintain soil cover and prevent soil erosion. The practice is no longer tenable due to high population densities. Stone-lines & trash-lines are no longer tenable too as they do not provide an adequate barrier to run-off water, particularly in steep slopes. The use of stone lines and trash lines in heavily cultivated steep land is no longer effective. Construction of terraces, cut-off drains, gabions and maintenance of biological strips are regarded as more effective in the conservation of soil & water [10]. These are the practices that have been promoted over the years in ecologically fragile environments by the Ministry of Agriculture [10].

Terraces are earth embankments built across a slope to reduce water run-off and increase water infiltration [1]. They can reduce soil loss by up to 95% [1]. Terracing is a labour-consuming technique, while biological strips involve sacrificing pieces of land which remain uncultivated [8]. Agro-forestry on the other hand also requires external inputs (seeds or seedlings) and is labour-consuming and takes up part of the land. To engage in these effective practices the farmer is required to have a clear perception of the benefits. Crop residues and manures are readily found on the farm while the rotation of crops and grazing does not require additional inputs. In agro-forestry, the trees incorporated into the crop/livestock systems cushion the impact of raindrops on the soil and interrupt the flow of water running off the surface while simultaneously filtering the run-off and trapping soil sediments. To what extent are these practices utilized? To what extent are they influenced by the socio-demographics of the farmers?

For purposes of the current study the decision to invest in soil conservation measures such as terraces, gabions, agro-forestry trees, retention ditches, cut-off drains and biological strips was treated as a decision to adopt soil conservation technologies. Similarly, a decision to reduce livestock numbers in order to reduce overgrazing is considered adoption since some income is forgone in the form of livestock produce. Trashes and stones which are simply arranged in the farm
to form trash-lines and stone-lines are not treated as an adoption process since in most cases they may be arranged simply to pave the way for cultivation and are ineffective in the hilly terrains.

Labour-demanding and costly measures requiring other inputs are less likely to be adopted since such inputs are not readily available. On the other hand productive and sustainable agricultural systems require efforts and additional external inputs [8]. Physical soil conservation measures such as *fanya-juu* terraces, gabions, retention ditches and cut-off drains are suitable soil and water conservation structures in steep, ecologically fragile environments as found in the study area. In an area where land sub-division goes on and farmers rely on fuel-wood from indigenous forests, such measures are imperative. Soils in the study area are covered with a lithic phase; prone to run-off and yet at the same time carry the burden of continuous cropping [11]. Prolonged droughts which are occasionally experienced remove vegetation cover and expose soils to severe run-off erosion at the onset of the next rains as observed in one catchment area (Plate 1). Erosion is particularly severe following the onset of long rains, usually after a 2-3 months drought [11] resulting in huge annual soil loss and compromising sustainable agriculture.

1.1 Conceptual Framework

In this study adoption is a dichotomous variable in which households are classified as either adopters or non-adopters. A household that has adopted any of the structural or biological barriers to run-off and soil erosion is an adopter, otherwise a non-adopter. The structural and biological barriers include diversion ditches, waterways, terraces, contour strips and agro-forestry trees. The decision to adopt is thought to be a complex process under the influence of several individual farmer-characteristics and socio-economic factors. Selected socio-demographic factors were investigated for their association with the adoption of soil conservation technologies. The socio-demographics of the farmer included; Age, education, gender, income, farm size and household size.

1.1.1 Age

This was a categorical variable that placed respondents into four categories; Youth, middle-aged and elderly representing age brackets; under 35years, 36-45years, 46-55 and 56 and above respectively. Some literature sources have suggested that younger farmers are more likely to adopt soil conservation technologies, while others suggest no relationship at all [12].

1.1.2 Household size

This was a categorical variable that placed households into three categories; small (3 or less), medium (4 to 6 household members) and large (7 and more household members). Large household size may be having adequate labour inputs to implement soil conservation measures as compared to small.

1.1.3 Education levels

This is a categorical measure of the household heads’ education based on the highest level of formal education attained and is categorized into none, primary, secondary and tertiary.

1.1.4 Gender of household head

This is a dummy variable (1 for female, 2 for male).

1.1.5 Farmers’ income

A continuous variable measured by earnings in Kenyan shillings per year. The data was later categorized into low, middle and high incomes.

1.1.6 Duration of residence

Number of years the respondent had lived in the farm. The duration was categorized into; 5 years and below, over 5-10 years and over 10 years.

1.1.7 Farm size

The total size of the farm occupied by the household in acres categorized into 2 acres and below, over 2-5 acres and over 5 acres and labeled small, medium and large respectively.

1.1.8 Level of awareness

A self-reported score by the farmer on his/her level of awareness on soil and water conservation technologies for farm level soil erosion control. The scale was on a 5-point scale; very low to very high.

1.2 Socio-demographics and Adoption

Socio-demographic characteristics have been studied for their effect on adoption by many researchers, but, their findings appear to give
conflicting results. In a study conducted in Tanzania, age and education had a positive significant influence on the adoption of soil conservation measures in Mbeya rural district as reported by [13]. Another author [6] also reported a positive influence of education on the adoption of conservation agriculture technology in South Africa, [14], however, reported that there was no association between education and adoption. In Keita valley, Niger a study reported that female-headed households were more likely to adopt soil and water technologies compared to male-headed [12]. On age, older farmers were less likely to adopt the practices; a report on a significant negative effect of age on adoption. The same study reported that off-farm income was positively correlated to adoption [12].

In a study conducted in Farta District of Ethiopia, [14] reported that adopters had slightly larger farm size than non-adopters, but, the adopters did not differ in household size, age and literacy with non-adopters. Off-farm employment had a significant negative effect on adoption. Authors [15] reported a significant positive influence of age, the slope of the land and membership to a group on the adoption of soil and water conservation practices.

Some authors have reported negative relationships between socio-demographics and the adoption of soil conservation technologies. Research that investigated gender, age, training, and access to credit observed that these attributes were not associated with the adoption of soil conservation practices [12]. Similarly, another study conducted by [16] in Iran reported that there was no association between the adoption of soil conservation practices and age, level of literacy, household size, annual income, and farm size. However, elsewhere in Ethiopia, a study conducted by [17] reported a positive association between the adoption of soil conservation practices and the age of the farmers, gender, education, household size, and land size. What is the influence of some of these socio-demographic factors on the adoption of soil conservation technologies in Nandi, Kenya?

1.3 Objectives of the Study

The objectives of the study were to examine the links between selected socio-demographic factors with adoption of soil and water conservation technologies. The socio-demographics included: age, education, gender, duration of residence, farm size, household size, level of awareness and income levels. These attributes were investigated for possible links with adoption of soil conservation technologies. The independent variables were measured on an ordinal scale. Adoption of soil conservation technologies was a dependent variable and was measured on a dichotomous scale; adopter or non-adopter.

2. METHODOLOGY

2.1 Study Site

A sample survey was carried out in the hilly terrains of Nandi County between November 2019 and April 2020 to gather information and data on soil conservation practices and adoption of soil conservation technologies. Nandi County is located in the Northern parts of Rift valley region. The County lies at latitude 0°34N and longitude 34°45E and reaches 35°25E [18]. The county covers an area of about 2884 km². The County is divided into six Sub counties (Fig. 1). It has five observable topographical features one of which is the Tinderet highlands. The other features include Kapsabet plateau, rolling hills to the west where there is minimal settlement, Nyando escarpment and King’wal swamp [18]. The current study focused on the settled areas of Tinderet highlands which are characterized by undulating slopes covered by rich volcanic soils. In the year 2019, Tinderet Sub County had a population density of 208 persons per km². This population density has implications on land utilization and degradation. For this reason it was of interest in the adoption of soil and water conservation survey.

To study the unknown relationships between the socio-demographics and soil conservation practices, a descriptive cross sectional survey design was used as suggested by [19]. The author suggests that surveys are appropriate in the case of establishing relationships between many types of behaviors that are of interest but cannot be rearranged realistically the way it can be done in an experiment. To achieve this, a sample is required where a census study is not possible.

2.2 Sampling Procedures

Purposive and multi-stage sampling procedures were used to select small-holder farmers to participate in the study. Nandi County has six sub-counties one of which is predominantly
covered by hilly terrain. The sub-county with the hilly terrains and catchment areas for the study was Tinderet Sub-county. Tinderet is occupied by three escarpments; Nandi hills escarpment, Ainapugetuny and Mbogo escarpment. From the three escarpments there were catchment areas all with human settlements. The settled catchment areas were the target of the study. From a total of twelve catchment areas, six of them spread across the three catchments were selected for the study. These gave two catchment areas from each escarpment to participate in the study. The total number of households from the six catchment areas was estimated at around 300 households [20]. Half of the households from these catchment areas were randomly selected to participate in the survey study.

2.3 Sample Characteristics

From a total target sample of 150 households, 138 households were accessed for information and data gathering. The remaining 12 households could not be accessed due to their unavailability during the survey period. This resulted in a response rate of 92%. An analysis of the sample showed that 13% were youth under 35 years of age, 23.2% were aged 36-45 years and 31.9% were aged over 55 years. Among them 5.8% had no formal education, 65.2% had primary level education, 18.8% had secondary level education while 10.1% had tertiary education (Table 1). 87% of the households were male-headed and 13% female-headed. The majority of the households had 4-6 members (40.6%) as depicted in Table 1. The respondents had resided in the same farms for varying durations. A majority had been settled in the same farms for over 10 years (84.1%), 5.8% had settled on the farms for between 5 and 10 years, while 10.1% had been resident on their current farms for periods less than 5 years as illustrated in the summary table (Table 1).

2.4 Data Analysis

Data were analyzed using SPSS version 20 to generate descriptive statistics. Descriptive measures of association were generated by running Kendall-Stuart Tau-c and Goodman-Kruskal’s gamma. The Kendall-Stuart Tau-c statistic is suitable for estimating correlations between ordinal data that are captured in rectangular cross-tabulations [21] such as in the current study. The Tau-c coefficient ($\tau_c$) is derived from the formula; $\tau_c = \frac{2(nc - nd)}{n^2 + m^2 - \frac{1}{2}}$, where $n_c = Number$ of concordant pairs, $n_d = Number$ of discordant pairs and $m$ is the minimum between the rows ($r$) and the columns ($c$).
Table 1. Socio-demographic characteristics of the sample

| Category          | Frequency | Percent |
|-------------------|-----------|---------|
| Age (years)       |           |         |
| Under 35          | 18        | 13.0    |
| 36-45             | 32        | 23.2    |
| 46-55             | 44        | 31.9    |
| Over 55           | 44        | 31.9    |
| Under 35          | 18        | 13.0    |
| Education Level   |           |         |
| No formal education| 8         | 5.8     |
| Primary           | 90        | 65.2    |
| Secondary         | 26        | 18.8    |
| Tertiary          | 14        | 10.1    |
| Household Head    |           |         |
| Male              | 120       | 87.0    |
| Female            | 18        | 13.0    |
| Total             | 138       | 100     |
| Household Size    |           |         |
| Less than 3       | 14        | 10.1    |
| 4-6               | 56        | 40.6    |
| 7-9               | 46        | 33.3    |
| 10 and above      | 22        | 15.9    |
| Years in the current farm |    |         |
| 5 and Below       | 14        | 10.1    |
| Over 5-10         | 8         | 5.8     |
| Over 10           | 116       | 84.1    |
| Total             | 138       | 100     |

Source: Survey data 2019-2020

Goodman and Kruskal’s gamma is recommended when the data has many tied ranks [22]. In the current study many tied ranks were expected since there were only two categories for the outcome variable of adoption; non-adoption and adoption. Goodman and Kruskal’s gamma was therefore an appropriate estimation for the association between farmers’ attributes and the adoption of soil and water conservation technologies. A test for monotonicity between variables was carried out using scatter plots before subjecting them to correlation analysis as recommended by [23]. The Gamma coefficient (G) is derived from the formula: $G = \frac{Ns-Nd}{Ns+Nd}$, where Ns is the number of pairs ranked in the same order (concordant) and Nd is the number of pairs of cases in reversed order (discordant pairs).

3. RESULTS AND DISCUSSION

3.1 Socio-demographics and Adoption

According to several authors the use of Kendall-Stuart tau-c with its coefficient $\tau_c$ as a measure of the strength of a relationship is recommended for analysis when the contingency tables are non-square [21]. This analysis was run on SPSS version 20 for purposes of screening the data sets for possible association between socio-demographic characteristics of the farmers with adoption of soil conservation technologies. Age, gender, duration of residence and farm size were found not to be significantly associated with adoption ($P > 0.05$).

The level of education of the farmer was found to be positively associated with adoption ($\tau_c = .201, P = .011$). Household size showed a weak relationship with adoption ($\tau_c = .156, P = .088$). The level of awareness of the farmer had a high association with adoption ($\tau_c = .318, P = .000$). There was also a significant association between household income levels and the adoption of soil conservation technologies ($\tau_c = .183, P = .042$).

The socio-demographics that showed significant association with the adoption of soil conservation technologies were further subjected to Goodman and Kruskal’s gamma analysis for measurement of association. The Gamma statistic has been suggested as the most robust statistic for calculating coefficient of correlation for ordinal data [22]. The analysis using Goodman and Kruskal’s gamma gave a similar pattern of outcome, but it suggested that there were stronger relationships between the variables (Table 2). There was a moderate strength relationship between education levels and adoption (Gamma = .359, $P = .034$). There was a weak relationship between household size and adoption (Gamma = .229, $P = .088$). The level of awareness of the farmer was strongly related to adoption (Gamma = .485, $P = .000$) as summarized in Table 2.
Table 2. Tau-c and Gamma coefficients between socio-demographics and adoption

| Attribute            | Kendall’s tau-c | P-value | Gamma  | P-value |
|----------------------|-----------------|---------|--------|---------|
| Education            | .201            | .011    | .359   | .034    |
| Household size       | .156            | .088    | .229   | .088    |
| Level of awareness   | .318            | .000    | .485   | .000    |
| Household income     | .183            | .042    | .282   | .042    |

Source: Survey data 2019-2020

3.2 Familiar Soil Conservation Technologies and Its Use

The enumerator-administered questionnaire had sought to establish the soil conservation methods that were most familiar to the respondents. The results revealed that a majority of the farmers were familiar with terrace construction (43.5%); others were more familiar with stone and thrash lines (33.5%), un-ploughed strips (14.5%), Agro-forestry (7.2%) and enterprise rotation (1.4%). An inquiry into what technology they put into use shows that 31.9% used terraces, 40.6% used stone-lines and thrash-lines, 20.3% used biological barriers, 4.3% Agro-forestry and 1.4% crop rotation and rotational grazing. Another 1.4% did not use any soil conservation technology (Table 3).

Construction of terraces that could sufficiently control water run-off in the hilly terrains was recommended by agricultural extension services in the locality, the use of biological barriers such as un-ploughed natural vegetation strips and the use of agro-forestry was also recommended [20]. Farmers who adopted these practices were classified as adopters in the current study. There were 56.5% adopters of the recommended soil and water conservation technologies. From the 56.5% adopters, 31.9% constructed terraces as their main soil conservation strategy, 20.3% predominantly used biological barriers, 4.3% Agro-forestry and 1.4% crop rotation and rotational grazing. Another 1.4% did not use any soil conservation technology (Table 3).

Although all the respondents reported being familiar with at least one type of soil conservation practice, there was discordance between what was familiar to the respondents and what they put into use. The cross-tabulation analysis showed that there was a contingency coefficient of 0.687 between the two variables. This measure suggests that about 31.3% of the study participants did not use the technology that they said they were most familiar with. This finding has implications for soil and water conservation Extension.

3.3 Discussion

3.3.1 Education levels

Education levels showed a moderately strong positive relationship with the adoption of soil conservation technologies as illustrated in Fig. 2. The sample category with no formal education was too small (8 respondents) to be considered on its own and was incorporated into none/primary level category in the analysis. The finding of a positive relationship between education and adoption is consistent with that reported by other authors elsewhere [13;6]. The finding, however, is at variance with others that have reported no influence from education [14;16]. The current finding suggests that formal education has a role to play in soil and water conservation practices. As argued by [8], this may mean that a more educated household-head has better perceptions about soil erosion problems and more knowledgeable on the soil conservation technologies. Better educated household-heads may be better placed in knowledge seeking and information seeking on soil conservation technologies compared to the less educated.

Table 3. Technology used as reported by respondents

|                          | Most familiar (%) | % Using the technology |
|--------------------------|-------------------|------------------------|
| None                     | 0                 | 1.4                    |
| Constructed terraces     | 43.5              | 31.9                   |
| Stone and thrash lines   | 33.3              | 40.6                   |
| Biological barriers (strips) | 14.5            | 20.3                   |
| Agro-forestry            | 7.2               | 4.3                    |
| Crop rotation/Rotational grazing | 1.4            | 1.4                    |

Source: Survey data 2019-2020
3.3.2 Household size

Household size showed some weak relationship with adoption. The relationship, however, was not negligible in terms of strength. The ratio of adopters to non-adopters was lower for smaller-sized households compared to larger households as depicted in Fig. 3. The positive relationship suggests that households of larger sizes may be having a better perception of soil erosion problems compared to small-sized. This probably may be attributed to intensive methods used by larger households to provide for the livelihoods of many individuals. Elsewhere, [17] reported a significant effect of household size on the adoption of soil and water conservation practices in the Ethiopian highlands. Author [8] argued that larger household sizes provided more labour for the labour-intensive soil conservation practices and therefore improved the adoption of the practices. On the contrary, [16] did not find any influence of household size on the adoption of soil conservation practices in a study conducted in Iran.
3.3.3 Level of awareness

There was a strong positive relationship between self-reported levels of awareness on soil conservation technologies with adoption as suggested by strong positive Tau-c and Gamma coefficients (Table 2). ‘Very low’ and ‘Low’ level categories on the awareness scale were more likely not to adopt compared to the ‘medium’, ‘high’ and ‘very high’ (Fig. 4). Authors [16] and [17] reported similar positive effects of awareness-enhancing training sessions on soil and water conservation practices in Iran and Ethiopia respectively. The current finding suggests that information and knowledge is an important driver in the adoption of soil conservation technologies. Training related to soil and water conservation in the catchment areas may have helped the smallholder farmers to raise their level of awareness. Farmers’ participation in training or seeking information on soil and water conservation practices has been associated with higher probabilities for adoption [17]. The current finding implies that raising the levels of awareness in a community increases the probability of adoption of best practices in soil conservation.

3.3.4 Farmers’ income

Household income revealed a moderate strength of association with the adoption of soil and water conservation technologies based on Tau-c and Gamma coefficients (Table 2). Non-adopters were proportionately higher than adopters for low-income category compared to the higher-income category as depicted in Fig. 5. This finding is inconsistent with that reported by [16] who reported no relationship between income and adoption of soil conservation practices in Iran. The finding by [6] who reported a positive association of income with adoption of conservation agriculture in South Africa is in agreement with the current observation. The author had argued that higher household incomes may have been associated with the availability of working capital that can be invested in conservation measures. The current findings may similarly imply that better-resourced farmers who have higher incomes may be better placed to invest in soil conservation structures compared to low-income farmers.

It has been argued by [7] that the issue of food security cannot be addressed without addressing soil erosion problems in Kenya. The current study has provided evidence of low awareness and low adoption of soil conservation measures resulting in soil erosion problems in the study area. The adoption of soil conservation technologies in the ecologically fragile hilly terrains of Nandi remains low particularly for low-income farmers. These observations suggest a need for investment in soil conservation extension as a public good.

![Fig. 4. Adoption in relation to level of awareness on soil conservation technologies](source: Survey data 2019-2020)
4. CONCLUSIONS AND RECOMMENDATIONS

Among the selected socio-demographic factors in the current study, age, gender, duration of residence and farm size were not associated with the adoption of soil and water conservation practices. Farmers adopted some form of soil conservation measures. The adoption of soil conservation technologies was positively influenced by the education level of the household head, household size and level of awareness as well as the annual income of the household head.

Deterioration in land quality in the study area continues due to severe soil erosion problems. There is low adoption of effective soil conservation measures particularly by low-income and lowly-educated households. Concerted efforts by the Government and other stakeholders are recommended to address the continued land degradation as it poses a threat to the environment and sustained food production in the study area.

Soil and water conservation efforts are imperative for sustainable food production in Kenya. Smallholder farmers in the study area acknowledged low levels of awareness on effective soil conservation technologies. Investment is needed to build the capacity of the farmers to adopt effective soil conservation measures, particularly terracing and agro-forestry measures in the ecologically fragile environments. Smallholder low-income farmers may need to be assisted by the County Government and other stakeholders to meet the initial investment costs of terrace construction in the already degraded farms on steep slopes. Awareness creation on the conservation of natural vegetation on the hill-tops is imperative for the sustenance of the natural resource base for agriculture.

CONSENT

Individual consent was sought from the respondents prior to administration of the data collection tools.

ACKNOWLEDGEMENTS

I acknowledge the good work that was done by my colleagues who volunteered to assist in data collection. Thank you for the great work.

COMPETING INTERESTS

Author has declared that no competing interests exist.
REFERENCES

1. Gachene CKK, Nyawade SO, Karanja NN. Soil and water conservation: An overview. College of Agriculture and Veterinary Sciences, University of Nairobi, Kenya; 2019.
2. Anderson D. Smallholder Agricultural in colonial Kenya: The official mind and the Swynnerton plan. In African Affairs. 1988;87(348). (Accessed 20 December 2019) Available:https://doi.org/10.1093/oxfordjournals.afraf.a098069
3. Tunstall B. The Economic Development of Kenya: International Bank for Reconstruction and Development Report. Management. 2010;1–12.
4. Karuku GN. Soil and water conservation measures and challenges in Kenya: A review. International Journal of Agronomy and Agricultural Research. 2018;12(6):116-145.
5. Ministry of Agriculture Livestock Development and Marketing, MOALD & M. Soil and water conservation manual for Kenya. Soil and water conservation Branch: MOALD & M, Kenya; 1997.
6. Ntshangase NL, Muroyiwa B, Sibanda M. Farmers’ perceptions and factors influencing the adoption of No-Till conservation agriculture by small-scale farmers in Zashuke, Kwa Zulu-Natal Province. Sustainability. 2018;1-16.
7. Mutisya TW, Zejiao L, Juma N. Soil and water conservation in Kenya-operations, achievements and challenges of the National Agriculture and Livestock Extension Programme (NALEP). Journal of American Science. 2010;6(3):7–15.
8. Atampugre G. Cost and benefit analysis of the adoption of soil and water conservation methods, Kenya. International Journal of Scientific and Research Publications. 2014;4(8):1–14.
9. Ministry of Agriculture, MOA. Agricultural Sector Development Strategy 2010-2020. Government of Kenya; 2010.
10. Ministry of Agriculture, MOA. County Annual Report 2013. Government of Kenya; 2014.
11. Ministry of Agriculture, MOA. Ministry of Agriculture: Farm Management Handbook. Government of Kenya/German Technical Cooperation, GTZ, Nairobi; 2015
12. Karido BY, Wang Z, Boubacar Y, Wei C. Factors influencing farmers’ adoption of soil and water control technology (SWCT) in Keita Valley: A semi-arid area of Niger. Sustainability. 2018;1-13.
13. Seenga R.B. Factors influencing adoption of soil conservation measures, sustainability and socio-economic impacts among small-holder farmers in Mbeya rural District, Tanzania (Msc. Thesis). Sokoine University of Agriculture, Morogoro, Tanzania; 2014.
14. Demeke AB. Factors influencing the adoption of introduced soil conservation practices in Northwestern Ethiopia: Discussion paper. Institute of Rural Development, University of Goettingen; 2003.
15. Alufah S, Shisanya CA, Obando JA. Analysis of factors influencing adoption of soil and water conservation technologies in Ngaciuma Sub-Catchment, Kenya. African Journal of Basic and Applied Sciences. 2012;4(5):172–185.
16. Rezvanfar A. Analysis of factors affecting adoption of sustainable soil conservation practices among wheat growers. World Applied Sciences Journal. 2014;6(5):644-651.
17. Belachew A, Mekuria W, Nachimuthu K. Factors influencing adoption of soil and water conservation practices in the Northwest Ethiopian highlands. International Soil and Water Conservation Research. 2020;8(1):80–89.
18. County Government of Nandi, CGN. County integrated development plan 2018-2023: Achieving sustainable and all inclusive social economic transformation. County Government of Nandi, Kenya; 2018.
19. Kothari CR. Research Methodology: Methods and Techniques (2nd Ed.). NEW AGE International Publishers, London; 2010.
20. Ministry of Agriculture, MOA. County Annual Report: Department of Agriculture. Republic of Kenya; 2018.
21. Berry KJ, Johnston JE, Zahran S, Mielke PW. Stuart’s tau measure of effect size for ordinal variables: Some methodological
considerations. Behavior Research Methods. 2009;41(4):1144–1148.

22. Igweze AH, Agbedeyi OD. Robust method for testing the significance of bivariate correlation of ordinal data. Mathematical Theory and Modeling. 2015;4(11):169-174.

23. Laerd Statistics. Goodman and Kruskal’s gamma using SPSS Statistics. Lund Research LTD; 2018. (Accessed January 15 2020)
Available: https://statistics.laerd.com/spss-tutorials

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/57396