Soil erosion monitoring indicators: An approach towards natural resource management in Kuresoi South, Kenya

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Abstract

Soil erosion is still one of the most important land problems and it is linked to land use and land cover changes. These have negative effects on land resource which ultimately affects agricultural productivity and water quality. Local monitoring systems constitute an almost compulsory component of any program or project dealing with sustainable management of natural resources. The purpose of this study was to identify soil erosion monitoring indicators in Kuresoi South, Kenya. The study was comprised of a total representative sample population of 68 respondents from Kuresoi south catchment which was achieved using Nassiuma coefficient of variation formulae. Our findings reveal a positive significant relationship between soil erosion monitoring indicators and natural resource management. Taken together, soil erosion monitoring indicators can be used in detecting change over time in soil resource.

Keywords: Soil erosion, Environment, Food Security,

1. Introduction

Soil erosion is a major problem confronting land and water resources. The rate of erosion is primarily determined by the erosive events (e.g., short duration and high-intensity rainfall events), soil type, and characteristics of the terrain (Wei et al., 2007). The impacts of accelerated soil erosion processes can be severe, not only through land degradation and fertility loss but through a conspicuous number of off-site effects such as sedimentation, siltation, and eutrophication of waterways or enhanced flooding (Borrelli et al., 2017).

Soil erosion rates are exacerbated for the arid and semi-arid regions due to barren mountains with scattered vegetation that provide direct exposure to heavy rainfall (Vijith et al., 2018). In Kenya, Soil erosion is one of the most important land problems and it is linked to land use and land cover changes. For instance, this problem has persisted in Kuresoi South where its negative effects on land resource, soil productivity, available agricultural land, and water resources due to sedimentation has been dominant.

Soil erosion monitoring indicators are strategies that are used in detecting change over time in soil resource. They help during natural resource decision making during environmental planning and management. Soil erosion is manifested in crop yield reduction. (Munodawafa, 2012), reduced quality of the water (Zhai, 2014), building up of rills and gullies (Blanco-Canqui and Lal 2008), exposure of roots and rocks (Stoffel et al., 2013) as well as Sediment deposition (Shen&Julien, 1993; Okoba, B. O., &Sterk, G., 2006).

Low vegetation covers and poorly developed soils intensify wind erosion (Jones et al. 2013; Blanco-Canqui and Lal 2008).

To date, various studies have been conducted to determine the strategies employed in monitoring soil erosion (Shen et al., 2009; Wang et al., 2009; Wu & Chen, 2012; Xu, Xu, Wu, & Tang, 2012). Nonetheless, less focus has been directed to Kuresoi South ward yet it is an agriculturally productive area which is experiencing high population growth. In fact, farmers in this area continue to experience soil erosion despite effort to conserve soil. This threatens agronomic productivity, the environment, food security, quality, and the well-being of many small-scale farmers. Therefore, the present study seeks to answer the question on whether there any soil erosion Monitoring Strategies in Kuresoi. Providing an answer to this question will immensely help the land use planners, environmental planners, and policy makers to identify and execute site specific best management practices to bring soil erosion rates within the permissible limits at the local environment.

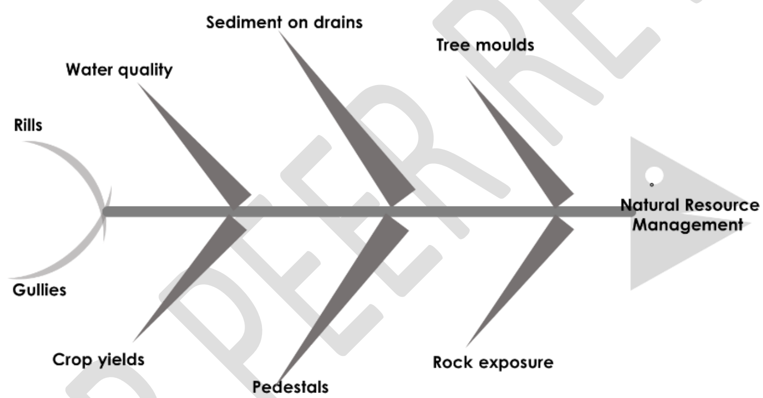

Figure 1: An illustration on the association between soil erosion monitoring indicators and natural resource management

2. Materials and methods

2.1 Study area

This study focuses on Kuresoi ward in Nakuru County, within a latitude of -0.3015° S and a longitude of 35.5307° E. Its elevation is 2551 meters feet. It is located next to the South West Mau Forest and is experiencing high population growth and people engage in wide range of agricultural activities such as farming, poultry and herd keeping for their livelihood. The area under study is under significant human pressure through encroachment to the remaining parts of the forest, charcoal burning, grazing, illegal tree logging, smallholder agriculture and subsistence farming. The area is therefore prone to soil erosion due to the many human activities taking place. It was therefore important to identify some soil erosion monitoring strategies to manage the problem of soil erosion.

2.2 Research Design

This study used descriptive research design to describe soil erosion monitoring strategies as indicators of soil erosion and natural resource degradation. This was deemed since it helped to provide answers to the raised questions (Bryman & Cramer.,1997) and how associated with soil erosion monitoring strategies.

2.3Target Population

Kothari (2004) defines target population as the total number of items that the study intends to investigate them. The target population in this study was the small holder farmers of Kuresoi South constituency, Kuresoi ward with specific focus to three villages; Mwaragania, Kibugat and South B within the affected regions. The total population of this area is 6,649 (2019 Census) and is distributed in the table below.

2.4 Sample and Sampling Procedures

Sampling is the selection of subset of units, people, or items, from the target population. This is for the purpose of collecting information which is used to draw deductions about the entire population (Kothari, 2014). A sample is the subset of units that are selected and they are used to represent the entire population (Mugenda & Mugenda, 2003). According to Abraham and Rusell (2008), a sample size should be greater than 30 for inferential statistics to be conducted. In this study, the sample was 68 households and was obtained using Nassiuma Coefficient of variation formula (Nassiuma, 2000).

$$S = \frac{N(Cv^2)}{Cv^2 + (N-1)e^2}$$

Where:

S = Sample size

N = Total size of the population (6,649)

Cv = the Coefficient of Variation (25%)

e = marginal error (3%)

2.5 Data Collection Instruments

Primary data collection was used in the collection of data where open and closed ended questionnaires adopted as well as the use of camera for capturing picture. Open ended questions gave deeper information about the soil erosion monitoring strategies while closed ended provided quantitative analysis for the study.

2.6 Validity of the Research Instrument

This is the adequate reporting of the objectives under study and the measure of accuracy (Cohen et al, 2000). Instrument’s validity is significant for logical premises and accuracy (Oso and Onen, 2008). The instruments were interrogated by the supervisors in the university together with the peers and the way forward was decided. The pre-testing of the instruments enabled for the evaluation of the content’s validity.

2.7 Reliability of the Research Instrument

A pilot study was conducted in order to ascertain the reliability of the research instruments, detect any ambiguities, identify the questions that are constructed poorly and cannot be understood together with those questions that are irrelevant. Mugenda and Mugenda (2003) recommended 10% of the sample size is appropriate for pilot study. A pilot of 7 respondents from the target population was selected randomly to test the questionnaires. Cronbach alpha with a set lower limit of Cronbach alpha 0.6 acceptability was used to analyze the results of the pilot test. The study found an overall Cronbach alpha results of 0.762 which is more than the recommended threshold of 0.6.

2.8 Data analysis

Descriptive statistics were used to analyze the data in this study. This describes and explains what the data shows about soil erosion monitoring strategies. After data collection, the researcher edited, coded, and presented the results in the form of frequency tables, graphs and pie-charts for easier understanding and interpretation. Descriptive statistics such as mean was used to summarize the data. Regression model was also used to establish the relationship between soil erosion indicators and soil management.

3. Results and discussion

3.1 demographic characteristics of respondents

The age and education level of the respondents were established and the results provided in figure 2 below

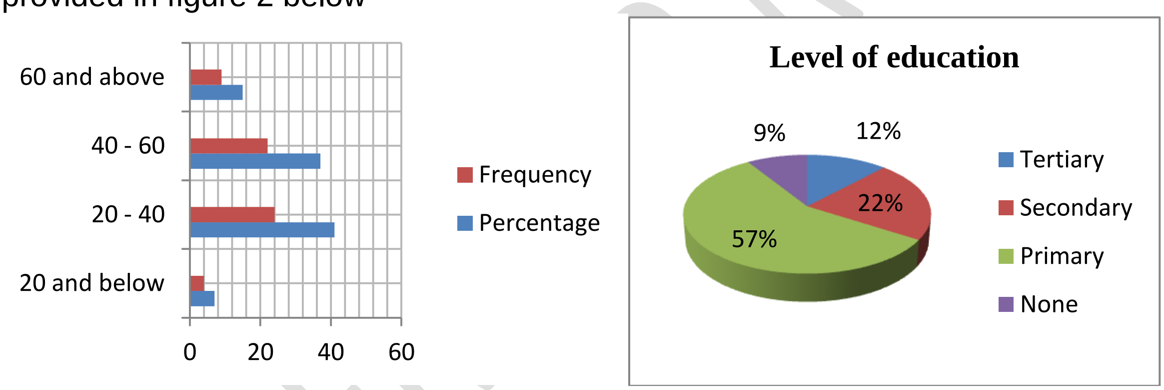

Figure 2: Age and education level of the respondents

The largest number came from age bracket of 20 – 40 years with 24(41%), followed by 40 – 60 years with 22(37%) then 60 and above with 9(15%) and finally 18 and below with 4(7%). It is evident that most of the respondents are youths in the society who are active and engage in economic activities like farming and animal rearing which are the major factors casing soil erosion. The highest percentage of respondents completed primary and secondary education with 57% and 22% respectively. This indicates that most respondents achieved basic education while a few advanced their studies.

3.2 Landscape characteristics

How the area was when the respondents first came was also assessed. It was provided in table1 below;

Table 1: The state of the area initially

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Forested	39	66.1	66.1	66.1
	Grassland	5	8.5	8.5	74.6
	Agricultural land	9	15.3	15.3	89.8
	Bare land	6	10.2	10.2	100.0
	Total	59	100.0	100.0	

The findings indicated that 39(66%) of the respondents indicated that the area was forested when they first came. 9(15%) indicated that it was an agricultural land while 6(10%) indicated that it was a bare land and 5(9%) indicated that it was a grassland.

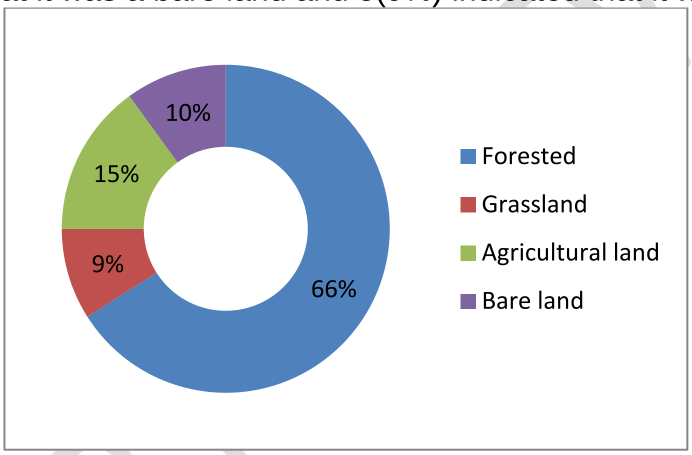

Figure 3: The state of the area initially

Most respondents (66%) indicated that the area was forested when they first came. This shows that soil erosion was not a serious environmental problem at that time. However, 15% responded that it was an agricultural land, to show that as time went by, there was massive migration of people to this land and the residents began to clear the forests in their land to create space for farming.

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Figure 4: Soil erosion monitoring indicators (a) Rills, (b) Gullies, (c) Tree root exposure, (d) Rock exposure, (e) Pedestal, and (f) Decolorized River water.

Decline in crop yield averagely indicated the presence of soil erosion (mean of 2.8136). Small channels greatly indicated the presence of rill erosion (mean of 3.4068 whereas deep channels indicated the occurrence of gully erosion (mean of 3.6102). The river water had been significantly decolorized and roots of plants exposed due to soil erosion (mean of 3.2203 and 4.2034 respectively). At the same significant rate, rocks located in the rivers had been exposed and sediments found along the drainages and river banks to indicate the presence of soil erosion (mean of 3.0169 and 4.2034 respectively). Change in soil color, tree mounds and pedestals indicated the presence of soil erosion at a low rate since they are observed after a long period of time (mean of 2.6271, 2.6102 and 2.0169 respectively).

Soil erosion monitoring indicators were therefore significant in assessing the effectiveness of natural resource management by a mean of 3.9492. Studies by Ypsilantis (2011) support these studies. He proposes that soil erosion monitoring indicators are important in providing qualitative assessment of erosion so that the sites that indicate potential erosion problems be red flagged and mitigating measures can be implemented to correct the problem. Rills and gullies were presented at a highly significant rate to show that rill erosion and gully erosion had taken place in most places and the necessary mitigation measures had to be put in place.

Table 2: Response on Soil erosion monitoring indicators

Soil erosion monitoring indicator	1(SD)	2(D)	3(N)	4(A)	5(SA)	Mean	STD

There is decline in crop yield in my farm due to soil erosion	0(0.00%)	12(20.3%)	11(18.6%)	12(20.3%)	24(40.7%)	2.8136	1.18139
There are small channels in my farm that indicate rill erosion	0(0.00%)	0(0.00%)	35(59.3%)	24(40.7%)	0(0.00%)	3.4068	.40545
There are deep channels in the fields and pathways which indicate the presence of gully erosion	0(0.00%)	0(0.00%)	35(59.3%)	12(20.3%)	12(20.3%)	3.6102	.80979
The river water have been decolorized due to soil erosion and thus not fit for human consumption	0(0.00%)	23(39.0%)	0(0.00%)	36(61.0%)	0(0.00%)	3.2203	.98380
The roots of plants and trees have been exposed due to soil erosion	0(0.00%)	0(0.00%)	0(0.00%)	47(79.7%)	12(20.3%)	4.2034	.40598
Rocks located in the fields and rivers have been exposed due to prolonged soil erosion	0(0.00%)	23(39.0%)	24(40.7%)	0(0.00%)	12(20.3%)	3.0169	1.10628
There are sediments on the drainages/river banks which shows that soil erosion has taken place	0(0.00%)	0(0.00%)	0(0.00%)	47(79.7%)	12(20.3%)	4.2034	.40598
The color of the soil in the farm has changed due to soil erosion	11(18.6%)	12(20.3%)	24(40.7%)	12(20.3%)	0(0.00%)	2.6271	1.01537
The soil under the trees in the field is at a higher level than the soil in the surrounding area which indicates prolonged soil erosion	0(0.00%)	0(0.00%)	36(61.0%)	23(39.0%)	0(0.00%)	2.6102	.49190
There is a column of soil that stands out from the general eroded surface on the fields as a result of prolonged soil erosion	23(39.0%)	12(20.3%)	24(40.7%)	0(0.00%)	0(0.00%)	2.0169	.90003
If soil erosion monitoring strategies are identified, it will help to manage soil erosion	0(0.00%)	0(0.00%)	19(32.2%)	24(40.7%)	16(27.1%)	3.9492	.77512

SD=Strongly disagree, D=Disagree, N=Neutral, A=Agree, SA= Strongly agree

Table 3: ANOVA soil erosion monitoring indicators

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	5.561	2	2.781	27.684	.000
Within Groups	5.625	56	.100		
Total	11.186	58			

The results of the findings above revealed that at the level of significance 0.05 soil erosion monitoring indicators identified by the community are significant in natural resource management ($F = 27.684$, $P<0.05$).

Discussion

The findings revealed that most respondents experienced decline in crop yield as result of soil erosion. Soil erosion on crop lands is manifested in the reduction of the yield potential (Munodawafa, 2012). Quantifying the effects of soil erosion on crop yields involves the evaluation of interactions between soil properties, crop characteristics and climate. The effects are also cumulative and not observed until long after accelerated erosion begins. The degree of soil erosion's effects on crop yield depends on soil profile characteristics and management systems (Lal, 1988).

The soil erosion has caused rills, gullies, tree root exposure, decolorisation of the river water, rock exposure and sedimentation as physical indicators of soil erosion in their farms and fields. Typically, rills occur where soil has been disturbed but the surface is left relatively smooth and unvegetated, e.g., after tillage, after building construction and on the sides of earth dams and road embankments (Gentile and Jones, 2013). Rock exposure describes the situation where underlying rock has been exposed at the ground surface because of erosion (Thrasher, 2005). The deposited sediment indicates the amount and type of material that has been eroded from the land above the drain. Sediment deposition occurs in most places where erosion occurs, as particles of soil dislodged are inevitably re-deposited elsewhere downslope - in this case in drains which act as sediment traps (Okoba, B. O., &Sterk, G., 2006).

Change in soil color, tree mounds and pedestals were experienced by few respondents. The presence of tree mounds indicates that there has been more erosion away from the tree than near it, since the surface of the mound represents an earlier soil level (Vanwalleghem, Laguna, Giráldez & Jiménez-Hornero, 2010). Pedestals are useful as an indicator of high sheet erosion rates. They are caused by differential rain splash erosion, which dislodges soil particles surrounding the pedestal but not under the resistant capping material (Mendonça, Bezerra, Gonçalves, Gonçalves, Guerra & Feitosa 2009). The soil particles in the pedestal itself are unaffected because they are protected by a material that harmlessly absorbs the power of raindrops. They give a ready indicator to monitor, especially on surfaces where erosion rates are very large due to high intensity rainfall (Vrieling, Sterk, & Vigiak, 2006). They occur on easily eroded soils, where random protection from erosion is afforded by stones or tree roots.

Therefore, in order to obtain high success rates in natural resource management, there is need to implement management techniques that will curb rill, gully, and sheet erosion since these types of erosion are responsible for decline in crop yield, decolorisation of the river water, sedimentation, tree/plant root exposure and rock exposure. Soil erosion monitoring indicators significantly affect natural resource management. It was also reflected in the regression model where soil erosion monitoring indicators was the second leading variable on predicting natural resource management

Conclusion

The study established that soil erosion monitoring indicators (rills, gullies, Tree root exposure, Rock exposure, Pedestal, and Decolorized River water) are important in natural resource management. These indicators are used in detecting change over time in soil resource. They help during natural resource decision making during environmental planning and management. Therefore, training needs and capacity building on the adoption of soil erosion monitoring indicators at a local scale

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