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Effectiveness of Soil Erosion Monitoring Strategies 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. To mitigate against this, there has been an effort to transfer the management of natural resources to local communities especially in the tropics. Many of these initiatives incorporate the development of monitoring systems. 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 assess soil erosion monitoring indicators as effective management tools to be used to help in monitoring change in natural resources within the study area. 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. The study adopted a descriptive research design. Data and information was collected using questionnaires and interview schedules. Both quantitative and qualitative data was analyzed using Statistical Package for Social Sciences and presented in form of charts, tables of frequencies and percentages. The study results revealed the effectiveness of soil erosion monitoring indicators, degree of soil erosion and natural resource management. The study therefore recommends that it is important to introduce capacity building programs to the community and other stakeholders through creation of awareness and training so that they can have knowledge on these factors and thus implement the appropriate mitigation measures.

KEYWORDS: Environment, Kuresoi, management, Soil Erosion.

1. INTRODUCTION

At this era of increasing human population globally, there has been an unprecedented pressure on natural resources (FAO,2015). This has made it very urgent for Environmental Planning and Management to strive for better ways of natural resource management. In Africa, soil erosion as one of the most important land problems and most pronounced form of soil degradation (Thomas et al., 1995). Erosion is a natural geomorphic process occurring continually on the earth surface. However, the acceleration of this process due to anthropogenic activities such as considerable immigration of people into marginal dry areas and the growing population has had severe impacts on soil and environmental quality (Pimentel, 2000). According to Lal (1998), in many regions, unchecked soil erosion and associated land degradation have made vast areas economically unproductive. It is estimated that worldwide about 80% of the current degradation on agricultural is caused by soil.

In Kenya arid and semiarid lands occupy approximately 80%, leaving only 20% of the country ecologically advantaged in terms of agricultural productivity. With increase in population, land has become limited forcing populations to migrate to marginal areas despite their limitations. As these marginal areas are fragile ecosystems, the exerted pressure due to increased populations and land use and land cover changes has often resulted to severe degraded land, soil erosion and sedimentation of water bodies (Kithiia, 1997).

Soil erosion is a complex process that is related to soil properties, topography, land cover, and human activities. Efforts to reduce soil erosion need to be made in order to conserve the remaining soil and land resource. In addition to soil conservation measures, our natural environment should be monitored to provide data that can provide feedback for assessing the effectiveness of policies related to natural resource management, determining the success of land management systems and testing generally the health of landscapes erosion (Angima *et al.*, 2003).

Soil erosion monitoring strategies can contribute immensely in sustainable natural resource management. This can be by assessing the effectiveness of natural resource policies (Seymour, 1998), determining the success of land management practices (Enemark et al.,2005), diagnosing the general health of landscapes (Council of Europe, 2000), increasing community awareness on soil erosion (Forch, 2003), managing soil erosion (Ding, Chen,Cheng, & Wang, 2015), improving water quality (Liu, 2016; Sun, Shao, Liu, & Zhai, 2014) as well as increasing in farm productivity (Lal, 1998). Despite the existence of studies on soil erosion management techniques, there is no study that has been conducted in Kuresoi South. This are is an agriculturally productive land which is

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experiencing high population growth of 13.45% per year according to the 2009-2019 census results. It is an area characterized by intensive human activities such as overgrazing and poor farming methods which majorly contribute to soil erosion. Soil erosion is one of the most important land problems and it is linked to land use and land cover changes 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. This is continuously evident through sediments in river banks, exposure of plant root in some farms and also a layer of flowing water that forms and transport soil particles during rainy season. In addition, there has been a general decline in crop yield for example in plants such as maize where farmers have been experiencing low yields and have therefore opted for other alternatives such as planting leguminous plants, poultry and dairy keeping. In addition, there is decline in water quality in the adjacent rivers. This is witnessed by the decolonization of the river water over which suggests continuous loss of soil fertility that could be occasioned by the interference of their natural resources. There is therefore need to assess soil erosion monitoring strategies in Kuresoi South so as to establish the drivers of such changes and determine their role as indicators of natural resource degradation so that they could be incorporated into natural resource planning and management at both the micro (farm level) and macro (county and national levels). The present study therefore seeks to effectiveness of natural resource management in the area (Fig 1). This will help to manage soil erosion and help farmers in this area to gain positive outcomes form their land resource.

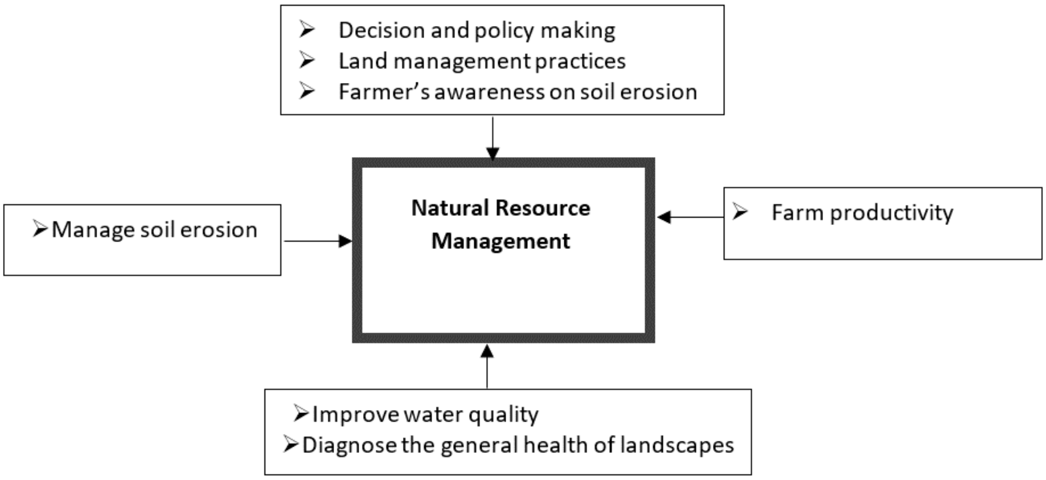

Fig 1: The association between the effectiveness of soil erosion monitoring strategies and natural resource management.

2. MATERIALS AND METHODS

2.1 Study area description

This study focuses on Kuresoi ward in Nakuru County (Fig 2), 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. Due to the wide range of human activities, there is a lot of pressure to the natural resources. This makes it necessary to identify soil erosion monitoring indicators that can be used to assess the effectiveness of natural resource management in this area.

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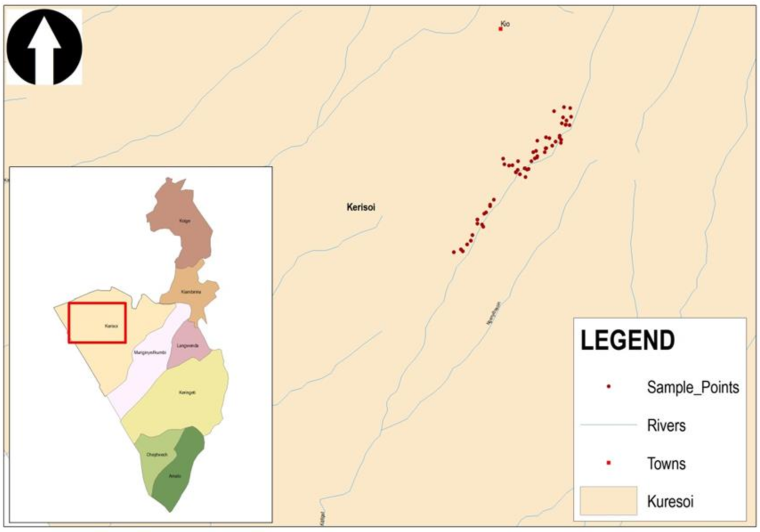

Fig 2: The map of the study area (Kuresoi South Ward)

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 on the questions of who, what, when, where and how (Bryman & Bell, 2015) associated with soil erosion monitoring strategies. This research design was used to obtain information concerning the current status of soil erosion and to describe what exists with respect to the variables or conditions in the situation. It was also used to measure the mean, mode, variance and central tendency. The survey method of data collection will also be utilized.

2.3 Target Population

Kothari (2004) defines target population as the total number of items that the study intends to investigate them. They are a well-defined set of people, a group of things, households, elements, services and events that are being discussed. Therefore, 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 1.

Table 1: Distribution of target population

Village	Population
Mwaragania	1206
Kibugat	2,465
South B	2,978
Total	**6 ,649**

Source: *2019 Census report*

2.4 Nature and sources of data

Primary data were utilized in this study. Primary data refers to data collected for the first time specifically for the issue under investigation (Sekaran, 2004). The primary data used questionnaires to source crucial information on soil erosion monitoring indicators on natural management from the residents of the area. The structured questionnaires which were administered consisted of both open ended and closed questions. Key government officials such as the agricultural extension officers, chiefs and farmers were given questionnaires to get accurate information on soil erosion monitoring strategies in the area. The data were both qualitative and quantitative where qualitative were collected using questionnaires while qualitative were collected using camera.

Secondary data obtained through already existing data such as census reports, relevant organizational records and information collected by the relevant departments of the government.

2.5 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). Nassiuma formulae considered the standard error of 3% which reduces the error made when calculating the sample size.

2.6 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. Closed question also allowed for both inferential and descriptive statistics. The picture was used to capture the extend of soil erosion. The table 2 below shows the distribution of questionnaires per target population.

Table 2: Distribution of questionnaires

Target population	No. of questionnaires
Mwaragania	16
Kibugat	23
South B	29

2.6.1 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. This was subjective since it focused on the framework of the research and the questions in the instruments covered the objectives of the study.

2.6.2 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.

2.7 Data Collection Procedures

The researcher used questionnaires to collect data from the respondents. Questionnaires were given out with the assistant of chiefs and government officers based in Kuresoi Constituency. This made it ease since chiefs and village elders new each house hold. The questionnaires were given and picked after one week to give them time for consideration. Questionnaires given to the respondents were collected after a few days to ensure high percentage of response rate. According to Taherdoost (2016) argued that questionnares should be picked within a short time to allow quick response and avoid loss of questionnaires. The researcher required maximum co-operation from the respondents to gain accurate information through the interviews. The information collected from the questionnaire included personal information such as age, gender and level of education together with how they experience soil erosion in their farms.

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2.9 Data analysis

Data analysis is a technique that investigates what has been collected in the research and make conclusions (Kombo, 2004). It seeks to fulfill each research objective and provide answers to the research questions (Bryman & Cramer, 1997). 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.

The regression model was given;

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + e$$

Where,

β_0 is a constant

β_1, β_2, β_{3} = Coefficients.

X_1 = Degree of soil erosion

X_2 = Soil erosion monitoring indicators

X_3 = Effectiveness of soil erosion monitoring indicators

Y = Natural resource management

3. RESULTS AND DISCUSSION

3.1 Degree of soil erosion

The findings on the degree of soil erosion in the farms of the residents indicated that when raindrops hit the soil surface and disperse soil particles into the air it had some slight contribution in causing splash erosion (mean of 2.7797). A large layer of flowing water that forms and transports particles of soil during rainfall causes sheet erosion at a great extent (mean of 3.1864). When it rains heavily, small channels that carry concentrated water flow develop significantly leading to rill erosion (mean of 3.2034). Rills which increase into deeper channels especially on steep slopes lead to the development gullies which bring about gully erosion at a great extent (mean of 3.4068)

Table 3: Degree of soil erosion

Degree of soil erosion	1(SD)	2(D)	3(N)	4(A)	5(SA)	Mean	STD
When raindrops hit the soil surface and disperse soil particles into the air it causes splash erosion	12(20.3%)	12(20.3%)	12(20.3%)	23(39.0%)	0(0.00%)	2.7797	1.17544
A large layer of flowing water that forms and transports particles of soil during rainfall causes sheet erosion	0(0.00%)	12(20.3%)	24(40.7%)	23(39.0%)	0(0.00%)	3.1864	.75372
When it rains heavily, small channels that carry concentrated water flow develop leading to rill erosion	12(20.3%)	0(0.00%)	11(18.6%)	36(61.0%)	0(0.00%)	3.2034	1.18583
Rills which increase into deeper channels especially on steep slopes lead to the development gullies which bring about gully erosion during rainfall	0(0.00%)	12(20.3%)	23(39.0%)	12(20.3%)	12(20.3%)	3.4068	1.03588

Understanding the degree of soil erosion in your farm can help to know the best technique to be adopted so as to manage soil erosion	0(0.00%)	0(0.00%)	0(0.00%)	47(79.7%)	12(20.3%)	4.2034	.40598

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

Understanding the degree of soil erosion in your farm will significantly help to know the best technique to be adopted to manage soil erosion (mean of 4.2034). Baldwin 2003 asserts that the effectiveness of any soil management system depends on the amount of erosive rainfall during that period. Erosive rainfall will therefore determine the degree of soil erosion and thus inform on the effective management technique to be adopted to manage it.

3.2 Types of soil erosion in the area

As depicted in Fig 3, the most dominant forms of soil erosion in this study were sheet, rill and gully erosion.

Figure 3: Type of soil erosion (a)Rill erosion (b) Gully erosion (c) Sheet erosion

Soil erosion monitoring indicators were significant in assessing the effectiveness of land management policies, finding out the general state of landscapes and determining the success of land management practices that had been put in place (mean of 3.2034, 3.8136 and 3.7966 respectively). It was greatly significant at a high rate in managing soil erosion and increasing farmer's awareness on soil erosion (4.4068 and 4. 3898 respectively). On a similar significant rate, they were effective in increasing farm productivity and improving the state of river water so that they can be fit for human consumption (3.4237 and 3.4237 respectively).

Table 4: Effectiveness of soil erosion monitoring indicators

Effectiveness of soil erosion monitoring strategies	**1(SD)**	**2(D)**	**3(N)**	**4(A)**	**5(SA)**	**Mean**	**STD**
Assess the effectiveness of the established land management policies	0(0.00%)	12(20.3%)	23(39.0%)	24(40.7%)	0(0.00%)	3.2034	.76066
Find out the general state of our farms and fields	0(0.00%)	0(0.00%)	11(18.6%)	48(81.4%)	0(0.00%)	3.8136	.39280
Determine the success of land management practices that have been put in place	0(0.00%)	0(0.00%)	12(20.3%)	47(79.7%)	0(0.00%)	3.7966	.40598
Manage soil erosion	0(0.00%)	0(0.00%)	0(0.00%)	35(59.3%)	24(40.7%)	4.4068	.49545
Increase land productivity/crop yield	0(0.00%)	23(39.0%)	12(20.3%)	0(0.00%)	24(40.7%)	3.4237	1.36714
Improve the state of river water so that they can be fit for human consumption	0(0.00%)	11(18.6%)	12(20.3%)	36(61.0%)	0(0.00%)	3.4237	.79228

Increase farmer's awareness on soil erosion	0(0.00%)	0(0.00%)	0(0.00%)	36(61.0%)	23(39.0%)	4.3898	.49190
Soil erosion monitoring indicators are effective since they will be used to manage natural resources.	0(0.00%)	0(0.00%)	23(39.0%)	24(40.7%)	12(20.3%)	3.8136	.75372

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

Soil erosion monitoring indicators were effective since they were used to manage natural resources at a significant rate (mean of 3.8136). This is in agreement with the research done by Pellant et al., 2005 who asserts that soil erosion monitoring indicators are used as rangeland health assessments. Identifying these monitoring indicators will help to identify how the environment has departed differently from its natural erosion rates so that corrective measures may be put in place.

DISCUSSION

The findings indicated that soil erosion monitoring indicators were effective since they will be used to manage soil erosion and increase communities' awareness on soil erosion at a high significant rate. They were also used to assess the effectiveness of land management policies, finding out the general state of landscapes and determining the success of land management practices that had been put in place. They were also significant in increasing farm productivity and improving the state of river water so that they can be fit for human consumption. Identifying effective soil erosion monitoring strategies will therefore have a positive influence in managing soil erosion. In the ANOVA analysis, it showed that effectiveness of soil erosion monitoring indicators was significant in natural resource management. The regression analysis also indicated that it was an important predictor. In the regression model, effectiveness of soil erosion monitoring indicators was the leading variable in predicting natural resource management.

CONCLUSION

The effectiveness of soil erosion monitoring indicators was more significant. This implies that for SEMI to be able to manage natural resources, they must be effective in terms of the community's ability to perceive them, understand and interpret. This will help to produce the desired results. Future studies should focus on assessing the impact of soil erosion and degradation on water quality.

Competing interest

The authors declare that is no conflict of interests.

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