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Impacts of Land Cover Changes on Soil Erosion for Agricultural Sustainability in Maragua Sub-Watershed: Case Study in Murang'a County, Kenya.

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A B S T R A C T

Soil erosion affects the yield production becoming a major constraint to agriculture and environmental sustainability. In the last decade, Maragua watershed has undergone major environmental changes. This study explicates the detection of land cover change and how this has affected the amount of soil loss. Three epochs each spanning ten years from 1987 all though to 2017 was selected for this study. To prioritize conservation of predisposed areas, climatic conditions and topography factors that accelerate soil erosion were used in the RUSLE model to generate erosion risk maps and change analysis was carried out to show the trend in soil erosion. Land cover classification, was performed and a trend in the change was examined. To achieve the main objective; randomly created point sampled within the study area were used to demonstrate consistent trends in land cover changes that resulted in high erosion areas. The results of this study shows that bare land and cropland land covers were the major causes of increased soil erosion over the period of the study. The spatial and quantitative information on soil erosion this research provides can be used in managing resources and help implement practical approaches for agricultural sustainability.

1. Introduction

Land degradation is the temporary or permanent decline in the productive capacity of the land, and its value as an economic resource. It is a global problem but more specifically in developing countries in Africa with adverse effects on the functionality of the ecosystem (Kieti et al., 2016). In Kenya, the situation is intensified by rapid population growth, high poverty levels, land-use changes, poor land-use systems and deforestation leading to watershed degradation (Wani & Garg, 2009). Chen et al., (2011) indicates that watershed degradation decreases land productivity resulting in major downstream or off-site damage.

When caused by soil erosion and sedimentation, it poses major challenges in food security, water resources, biodiversity and environmental sustainability (Dabral et al., 2008). Sustainable agriculture majorly depends on how efficiently soil and water are utilized. In the quest to meet the rising food demand; land and water need to be conserved in order to maintain or increase crop yields. Although agricultural management, such as improved crop varieties or mineral fertilizer, has increased crop yields erosion rates have increased accordingly (Vanwalleghem et al.,2017). In developing countries with high poverty rates, access to these management practices is limited and as such, the most viable alternative would be to carry out soil management. Chen et al., (2011) maintain that to preserve the ecosystem, watershed management needs to be employed.

Watershed management is the development of appropriate land-use planning and management for rain-fed and irrigated lands to prevent soil erosion, increase biomass production, and improve the ecological balance (Bhuchar et al., 2011). It can be achieved through the implementation of water management and land-use practices (Wani & Garg, 2009).

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Shinde et al. (2010) points out that soil erosion depletes rich fertile soils, reduces reservoir capacity and degrades downstream water quality. In this case, soil conservation can be achieved through controlling erosion and maintaining soil fertility while focusing on the central role the soil resources play in ensuring sustainable agriculture.

To assess an erosion scenario, modelling is a useful tool that enables the adequate selection of erosion control measures. A wide range of models exists for use and the choice of a suitable model structure relies heavily on the scale of their intended use and the types of output information they provide (Merritt et al., 2003).

According to Merrit et al. (2003), depending on the physical processes simulated by the model and the data dependence, the model is classified as either empirical, conceptual or physically based models. Empirical models are the simplest of all models as they can be implemented in situations with limited data and parameter inputs, and are particularly useful as a first step in identifying sources of sediment. Examples of empirical models include the Universal Soil Loss Equation (USLE) and its derivate Revised Universal Soil Loss Equation (RUSLE) and the Modified Universal Soil Loss Equation (MUSLE) (Igwe, Onuigbo, Chinedu, Ezeaku & Muoneke 2017). The spatial and quantitative information of erosion on a sub-watershed scale contributes significantly to the planning for soil conservation, erosion control, and management of the watershed environment (Prasannakumar et al., 2012)..

In Kenya, the Tana Basin is one of the most important natural resource and plays a vital role in the country's economy. It is divided into two distinct ecosystems. The first is the Upper Tana Basin which receives more rainfall articulates as the main source of water (Braslow & Cordingley, 2016). The other is the drier and flatter lower Tana which is completely dependent on the Upper Tana basin.

The basins resources are used to produce hydroelectricity and supply irrigation water to some of the largest public schemes in Kenya. Intensive commercial and subsistence farming together with deforestation has caused the unpredictable flow of water despite the rising water demand (Hunink & Droogers 2015). Sediments and siltation have threatened the ecosystem resulting in reduced water supply, poor water quality, reduced hydropower generation and reduced agricultural yield.

The main causes of poverty within the area has a strong linkage to the environment. Change in environmental conditions has led to reduced agricultural production which supports a majority of the population in the catchment. This has in turn led to reduced incomes and as well as un-certainties in food security. The Upper Tana Natural Resources Management Project (UTaNRMP) was formed to help in conservation measures. It's main objectives, based on the challenges identified, is to increase sustainable food production and incomes for poor rural households living in the upper Tana and the sustainable management of natural resources for provision of environmental services.

In Maragua watershed, the hilly topography, soil disturbance through the removal of vegetation, deforestation on steep slopes and poorly executed terracing has significantly contributed to water controlled erosion and consequently to low agricultural returns. Due to these challenges, there is a need for watershed management to help to conserve the environment. This can only be achieved by monitoring soil erosion and reducing the effect of sediment yield.

The study aims at assessing soil erosion severity and identifying critical areas that need immediate and appropriate conservation measures for sustainable agriculture. The objective of the research is to evaluate how the changes in land cover impacts soil loss.

2. Research Objectives

The main objective of the study is to assess the impact of land cover changes on soil erosion to help in managing manmade and natural resources and assets, plan conservation measures and prioritize the erosion predisposed areas for agricultural sustainability in Maragua watershed, Murang'a County.

The specific objectives are;

- To perform watershed analysis for watershed delineation and stream feature extraction.
- To generate soil erosion risk map and land cover map for the year 1987, 1999, 2007 and 2017.
- Assessment of land cover changes on soil erosion.

3. Area of study

Murang'a County lies within the Upper Tana River Basin, which has three priority sub-watersheds namely Sagana-Gura, Maragua, and Thika-Chania (Water Resources Authority, 2018). Maragua sub-watershed covers an area of approximately 47000 Ha. The altitude ranges from 1191m to 3769m above sea level. Murang'a area has a bimodal rainfall pattern that includes long rains and short rains. The long rains occur between March and June while the short rains occur between October and December with an average annual rainfall of 700mm-1300mm (Muema, Kaluli, Gatheny018). Part of the watershed is covered by coffee plantations, subsistence farms and Aberdare forest. Study area map is in (Figure 1).

4. Materials and Methodology

To fulfil the objectives of the study, the data type, source and characteristics were required. To get the extent of the watershed, elevation data was required, the Shuttle Radar Topographical Mapper (SRTM) 30m digital elevation model was used. Rainfall data was sourced from CHIRPS website for monthly and annual precipitation data from the year 1982 to 2017. SOTER dataset from Food and Agriculture Organization of the United Nations was used to derive erodibility factors for the different soil types within the area. For temporal data on land covers, Landsat satellite imagery was obtained from the United States Geological Survey (USGS) website. The conceptual framework used to perform the study is as shown below (Figure 2):

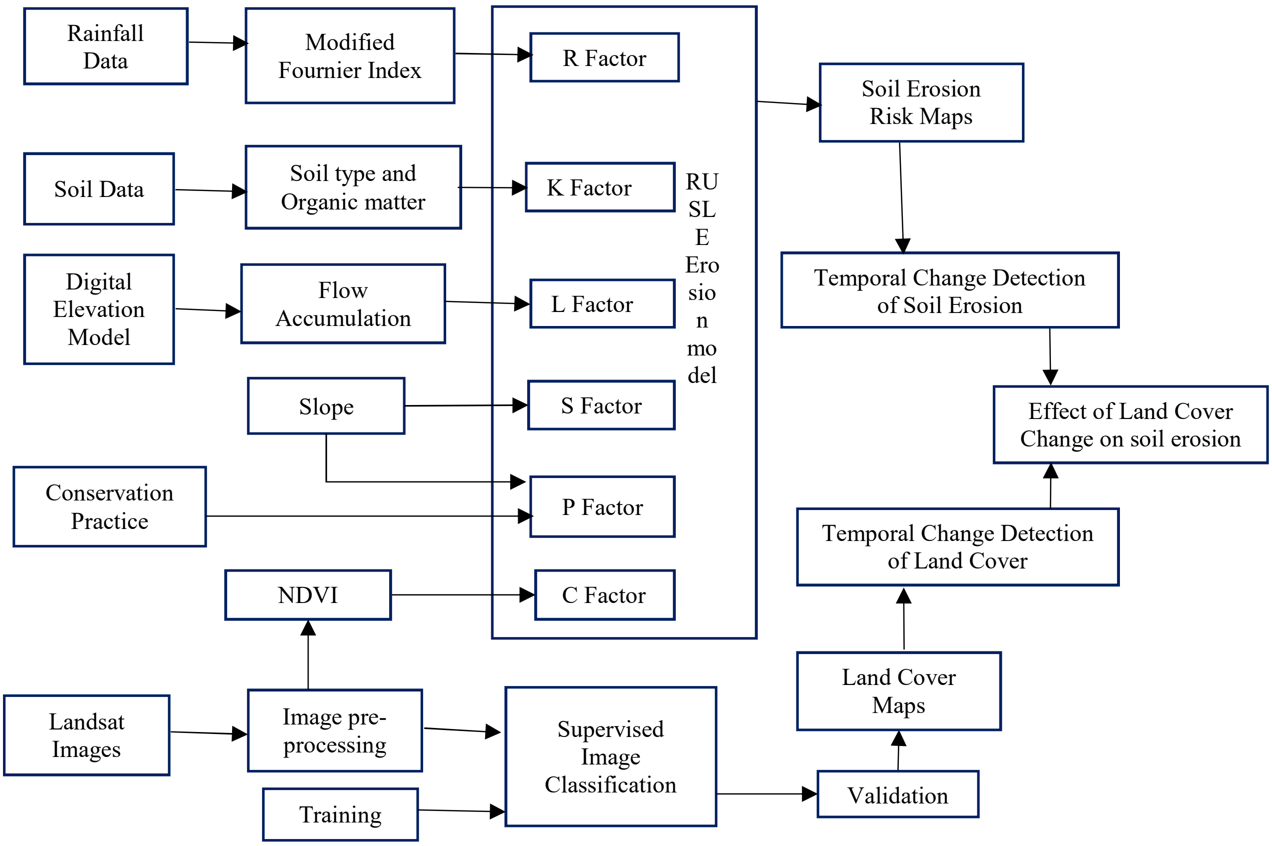

Figure 2: Conceptual Framework

Image Processing

Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) 1 arc-second, with a spatial resolution of 30 meters, were used to get the digital elevation model. The images were mosaicked, projection changed and clipped in ERDAS Imagine. The processed image was then used as an input, in ArcGIS, for watershed analysis to delineate Maragua watershed extent, slope and stream features as inputs for the study. See (Figure 3).

For the study, Landsat Mission images were selected for the period of February and March just before the heavy rains and with a cloud cover of less than 10%. The available images obtained from the USGS explorer for the year 1987 and 1999 was Landsat 5, 2007 was Landsat 7 and for 2017 was Landsat 8.

Image enhancement was carried out for all the images during pre-processing. For Landsat 7, de-stripping was done using the gap fill file available when the image is downloaded. Supervised classification, maximum likelihood classifier was used to classify the images into four major land cover classes. The classes identified were Forest, Crop Land, Bare land and Water. They were identified as being consistent in all the epoch and could be used in comparison during analysis

Accuracy assessment, for the 2017 image, was performed by comparing the classified image to reference data collected from the ground using GPS, 300 point were collected. As there was no ground data for the preceding years of 1987, 1999 and 2007, an image with a discernible features was used to extract the reference data for accuracy assessment. For each image consumers' accuracy, producers' accuracy, overall accuracy and the kappa coefficient were determined and proved to be sufficient for the study. This is to permit quantitative comparisons of different interpretations to determine the usefulness of the information. Post classification thematic change detection tool in ENVI was used to determine land cover changes and soil erosion changes over the years. Change detection was done for the years 1987-1999, 1999 – 2007 and 2007- 2017.

Soil Erosion model

They soil loss model applied for this study is the RUSLE model. The model estimates the value of soil erosion is derived from the production of six major soil erosion factors which are expressed numerically as follows (Bash, 2015):

$$(1)\quad A=R\times K\times LS\times C\times P$$

Where:

A is the Average soil loss per unit of area (t/ha/y)

R is the Rainfall erosivity factor (MJ mm/ha/h/y)

K is the Soil erodibility factor (t h/MJ/mm)

LS is the Topographic factor (dimensionless) including slope length (L) and steepness (S) factors

C is the Cover management factor (dimensionless)

P is the Support (or conservation) practice factor (dimensionless).

The rainfall erosivity factor was derived using the Fournier index due to the lack of detailed datasets on rainfall intensity. Rainfall data was acquired from CHIRPS and it constituted of monthly and annual precipitation from the year 1982 to 2017. The Modified Fournier Index for five years was then calculated using the formula (Hernando & Romana, 2016);

$$(2)\quad F_f = \frac{1}{N}\sum_{n=1}^{5}\left[\sum_{i=1}^{12}\frac{{p_i}^2}{p}\right]$$

Where:

F_f – Is the modified Fournier Index for N years, N is the five, for five years of precipitation used for this study. From the Modified Fournier Index the R factor was determined using (Benavidez, Jackson, Maxwell & Norton 2018):

$$(3)\quad R = 4.79 * F_f - 142$$

The soil erodibility factor that represents the ability of soil to detach, the potential of the soil to runoff and the capability of the eroded sediments to be transported was derived from the soil factors derived from the Food and Agriculture Organization of the United Nations (SOTER) dataset. The analytical relationship for the factor by Wischmeier is used expressed as (Ashiagbor 2012);

$$(4)\quad K = \frac{2.1*10^{-4}(12-OM)M^{1.14}+3.25(S-2)+2.5(P-3)}{7.59*100}$$

Where;

K is the erodibility (t ha h/ha/MJ/mm^{-1}); OM is the percentage of organic matter. The organic matter derived from the SOTER dataset using the expression;

$$(5)\quad OM = 1.72 * \%OC$$

S is the soil structure code; P is the soil permeability code; M is a function of particle size fraction of silt percentage and clay percentage given by;

$$(6)\quad M=(\%silt)*(100-\%clay)$$

Fine-textured soils have low K values of about 0.05 to 0.15 (Kim and David, 2014). Coarse textured soils have low K values of about 0.05 to 0.2. Medium textured soils have moderate K values of about 0.25 to 0.45. Silt size particles have high K values, which can exceed 0.45 and can be as large as 0.65 (Khare et al., 2017). From the SOTER data the following soil structures very fine, fine, medium fine, medium, and coarse was assigned indexes 1, 2,3,4,5 respectively. The permeability Indices and characteristics assigned to each soil drainage according to FAO and ISRIC is as shown in Table 1 below;

Table 1: Soil Drainage, Permeability Characteristic and Index

Soil Drainage	Permeability Characteristics	Permeability Index
Excessively drained (E)	Very rapid	1
Somewhat excessively (S)	Rapid	2
Well-drained (W)	Moderate to rapid	3
Moderately well-drained (M)	Moderate	4
Imperfectly drained (I)	Slow to moderate	5
Poorly drained (P)	Slow	6
Very poorly drained (V)	Very slow	7

The Slope length factor (L) was derived from the DEM to represents the effect of slope steepness on erosion. The formula used according to (Ghosh et al., 2013) is given as:

$$(7)\quad L = (\frac{\lambda}{22.13})^{m}$$

Where; L is the slope length factor; λ is the actual slope length in metres given by multiplying the Flow accumulation to the cell resolution of the Digital Elevation Model as 30m. The flow accumulation is derived from watershed analysis

$$(8)\quad \lambda = flow\ accumulation \times cell\ resolution$$

m is the slope length exponent that is the ratio of rill to interill erosion. It was derived by using the equation;

$$(9)\quad m = \frac{\beta}{\beta+1}$$

Where: β is given by;

$$(10)\quad \beta = \frac{(sin\,\theta/0.0896)}{0.56+3(sin\,\theta)^{0.8}}$$

$\boldsymbol{\theta}$ is the slope in degrees

The Slope steepness factor is the ratio of soil loss relative to a standard slope of 9%, which is the standard slope that modelled the RUSLE. The factor is calculated as (Kim & David, 2014);

$$(11)\quad S = 10.8\,sin\,\theta + 0.03, \textit{for a slope gradient less than or equal to 9\%}$$

$$(12)\quad S = 16.8\,sin\,\theta - 0.5, \textit{for slope gradient of more than 9\%}$$

Where; S is the slope factor; $\boldsymbol{\theta}$ is the slope gradient in radians

The cover management factor (C) represents the effect of plant cover on soil erosion. This factor was determined by use of Normalized Difference Vegetation Index (NDVI) using the Landsat satellite images. The equation used is expressed as:

$$(13)\ NDVI = \frac{NIR+RED}{NIR-RED}$$

Following the extracted NDVI the C factor was determined using the following equation (Kumar et al., 2014):

$$(14)\ C = e^{-\propto\left(\frac{NDVI}{\beta - ND}\right)}$$

Where; $\propto$ and β are unit parameters whose value are 2 and 1 respectively.

The support practice factor (P) is used to determine the effect of conservation practices on soil erosion. Within the region, the widely used soil conservation practice by the farmers is terrace Farming. In terracing, wide steps are cut around the slope to alter the shape of the slope to produce flat areas that provide a catchment for water and preventing soil erosion.

The P factor was estimated based on the slope and cultivation method. The table below was used to give the estimated values based on the relation between terracing and slope (Karamage et al., 2017).

Table 2: P Factor Values Based on Slope and Terracing

Slope	P Factor by Terracing
0.0 – 7.0	0.10
7.01 – 11.30	0.12
11.31 – 17.60	0.16
17.61 – 26.80	0.18
26.81 >	0.20

To get the soil erosion risk for the year 1987, 1999, 2007 and 2017, the product of the already generated model factors as expressed in the equation (1) above.

For the purpose of this study erosion values were classified into five main classes as shown in the table below;

Table 3: Soil Erosion Classification

Erosion Classification	Erosion Value (T/Ha/Year)
Very low erosion	0 - 50
Low erosion	51 - 100
Medium erosion	101 - 150
High erosion	151 - 300
Very high erosion	Above 300

Change detection was carried out to show how the land cover changes have affected the rate of soil erosion over the years. To show the trend, about 7000 random points within the area of study were created. The points were then populated with the land cover changes and their respective erosion changes. The points were then analysed to determine the prevailing land cover changes that had an effect of causing high and very high erosion.

5. Results and Discussion

Land Cover Change Analysis

The land-cover maps were classified into four classes, Forest, Cropland, bareland and water. The accuracy for the classified images was as follows; 1987 classified image had an overall accuracy of 87.50% and a kappa coefficient of 0.8102; 1999 classified image had an overall accuracy of 90.00% and a kappa coefficient of 0.8461; 2007 classified image had an overall accuracy of 94.01% and a kappa coefficient of 0.8980; 2017 classified image had an overall accuracy of 90.04% and a kappa coefficient of 0.8341.

(Figure 4 to 7) show the spatial distribution of the land covers over the years and the Table 4 below shows the area coverage of the land cover.

Table 4: Area Coverage and Percentage of Land Cover

Land Cover	***1987***		***1999***		***2007***		***2017***	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Forest	9362.52	19.62%	14069.16	29.48%	10435.05	21.87%	9560.34	20.03%
Cropland	19143.27	40.11%	17193.69	36.03%	9233.28	19.35%	12497.04	26.19%
Bareland	19188.63	40.21%	16347.6	34.26%	28045.35	58.77%	25665.03	53.78%
Water	27.99	0.06%	111.96	0.23%	8.73	0.02%	0.00	0.00%

Maps showing the land cover changes is shown in (Figure 8, 10 and 12) shows. Graphs as shown in (Figure 9, 11 and 13) show how the land cover changed. Water decreased continually from 8% to 2% and 0% with the area changing to bareland. Forest cover decreased form 89% to 65% and later increased to 76%. For the period 1987 to 1999, 5% of forest changed to cropland and bareland. Period of 1999 to 2007, 24% changed to cropland and 12% to bareland. The period 2007 to 2017, 16% changed to cropland and 8% into bareland. Cropland decreased drastically from 51% to 27% and increased to 80% from 2007 to 2017. In the period of 1987 to 1999, 25% and 23% changed to Forest and Bareland respectively. The period of 1999 to 2007, 5% changed to Forest and 67% into Bareland. 12% and 7% changed to Forest and Bareland respectively from 2007 to 2017. In the period of 1987 to 1999, 5% and 36% of bareland changed from forest and cropland respectively. 2% and 8% changed to forest and cropland respectively from 1999 to 2007. The period of 2007 to 2017, 2% of bareland changed to Forest and 12% into Bareland. It is predominantly noted that most part of bareland remained as bareland.

Soil Erosion Factors

The estimated R factor value ranges from 100.29 to 187.69 MJ mm/ha/h/year for the year 1987, 179.75 to 295.62 MJ mm/ha/h/year for the year 1999, 85.21 to 156.39 MJ mm/ha/h/year for the year 2007 and 183.04 to 324.69 MJ mm/ha/h/year for the year 2017. It is observed that the R factor was high for the years between 1987 and 1999 and there was a drop in the year 2007 as shown in (Figure 14 to 17). The factor then became very high for the period leading to 2017. The results are indicative of the results in the amount of rainfall within the region.

C factor was derived from land cover NDVI values and RUSLE model parameters. The values ranged from 0.00011 - 1 in 1987, 0.008 - 1 in 1999, 0.003 -1 in 2007 and 0.889- 1 in 2017 as shown in (Figure 18 to 21). The areas with high values are more susceptible to soil erosion than the areas with low values. In 2017 the area was highly susceptible to erosion mostly due to very little vegetation cover within the area.

The conservation practice factor represents the positive impacts any support practice has in preventing soil erosion. It accounts for the control practices that reduce the erosion potential of the runoff by their influence on drainage patterns, runoff concentration, runoff velocity, and hydraulic forces exerted by a runoff on the soil. The value of P factor ranges from 0 to 1, the value approaching 0 indicates good conservation practice and the value approaching 1 indicates poor conservation practice. For this study, the P-value is a factor of slope and terracing as a conservation practice the factor values is as shown in (Figure 22 to 25).

From the digital elevation model, the watershed analysis was carried out to get the flow accumulation and slope. The L factor which is the slope length was calculated from the flow accumulation and the slope steepness, the S factor, was determined from slope percentage as an input. The LS factor values ranged from 0 to 4.2588 refer to (Figure 26). With most of the area within the region having very low values it shows that the topography had very little impact on the erosion process.

The K factor lower value is associated with the soils having low permeability and higher values with soils having higher permeability. (Figure 27) show the factor values ranging from 0.001 to 0.046 ton/ha/MJ/mm.

The predicted annual soil loss for the year 1987 loss ranged from 9.521 - 662.753 t/ha/year with the mean annual soil loss for the entire watershed was estimated at 336.137 t/ha/year. For the year 1999, annual soil loss ranged from 1.259 - 446.068 t/ha/year with the mean annual soil loss for the entire watershed was estimated at 223.664 t/ha/year. For the year 2007, annual soil loss ranged from 7.571 - 420.038 t/ha/year with the mean annual soil loss for the entire watershed was estimated at 213.8045 t/ha/year. For the year 2007, annual soil loss ranged from 32.605 - 835.587 t/ha/year with the mean annual soil loss for the entire watershed was estimated at 434.096 t/ha/year. The erosion risk areas were classified into 5 classes; very low erosion, low erosion, medium erosion, high erosion and very high erosion. (Figure 28 to 31) show the erosion distribution on the watershed.

The results show decreased soil loss between the period of 1987 and 1999 this can be attributed to increased land cover even though there was a higher amount of rainfall. The amount of soil loss continues to drop for 2007 although there is a decrease in the amount of land cover, this can be attributed to the fact that there was less amount of precipitation around that period. There was a tremendous increase in soil loss to the period leading to the year 2017, this can be attributed to the fact that there was a complete increased amount of rainfall and tremendous decrease in the amount of land cover.

Soil Erosion Change Analysis

The results in (Figure 32, 34 and 36) illustrates the spatial distribution of erosion change and (Figure 33, 35 and 37) illustrates in percentages the temporal aspect of erosion change. Very low erosion continuously remained as areas of very low erosion with 95%, 53% and 85% over the three epochs. 45% and 46% of low erosion remained as low erosion in the period of 1987 – 1999 and 2007 – 2017 respectively.

Low erosion remained low at 45%, 38% very low, 13% medium and 4% high in the first epoch. In the second epoch it changed to medium at 58%, 28% remained low, 10% high and 2% very low and very high. The third epoch saw 46% remain low, 24% change to very low and 8% high erosion.

Areas of medium erosion changed 39% low, 33% remained medium, 16% high, 9%very low and 4% very high for the first epoch. The second epoch saw medium remain medium at 67%, change to high at 19%, low at 9% and 4% very high. 52% remained medium, 28% low and 19% at high erosion in the third epoch.

In the first epoch, 30% of high erosion remained high, 28% changed to medium, 24% changed to very high, 16% to low and 2% changed to very low. The second epoch, 57% changed to medium, 29% remained high, 12% changed to very high and 2% changed to low. In the period 2007 to 2017, 69% remained as high, 25% changed to medium, 4% to low and 3% to very high erosion.

Area of very high erosion changed mainly into 38% to high, 34% remained very high, 22% and 6% changed to medium and low erosion respectively in the period 1987 to 1999. 62% change to high erosion 24% remained as very high, 14% change to medium erosion for the second epoch of 1999 to 2007. The period of 2007 to 2017, 59% changed to high erosion and 33% remained as very high erosion.

Erosion trends illustrated by land cover variations are shown in (Figure 38, 40 and 42). During the all the epochs explored when bare land areas remained as bare land and cropland areas changed to bare land, it resulted in high and very high erosion scenarios. From change analysis maps shown in (Figure 39, 41 and 43), it is observed that the central and the eastern region were majorly covered by regions of high and very high erosion. With this information, conservation practices can be directed to areas that require urgent measures and ensure sustainable use of resources for this purpose.

6. Conclusion and Recommendation

The average amount of soil loss is 336.137 t/ha/year for 1987, there was a significant drop in erosion value to 223.664 t/ha/year in the year 1999. This can be attributed to the fact that there was increased amount of land cover around that period. In 2007, the value was 213.8045 t/ha/year this could be as a result of decreased amount of rainfall leading to that period. The value increased considerably to 434.096 t/ha/year in 2017 even though there was no significance increase in the amount of rainfall, this was attributed to the fact that there was significant decrease in the amount of land cover. The spatial information, in form of maps, display the critical areas where conservation measures should be directed with a lot of urgency. When cropland changed to bare land and bare land remained as bare land, there resulted in instances of high and very high erosion. Assessment of the impacts of land cover on soil loss showed that major changes that resulted in most of the soil loss were reflected in the loss of vegetation cover, poor conservation on agricultural land, and lack of rehabilitation of degraded lands. The improvement in vegetation cover could be attributed to better conservation practices.

To improve the accuracy of the results, the parameters can better be estimated by the use of detailed datasets. For instance, the R factor can be determined by using storm energy and 30 minutes of intensity, the use of high-resolution imagery for better mapping of the land cover. The model can also be improved by carrying out intensive research for areas with limited datasets

As soil erosion remains a challenge on watershed management, conservation practices are the only methodologies of mitigating the challenges. The practices include Contour ploughing, terrace farming, Keyline ploughing, perimeter runoff control, agroforestry and crop rotation (Bhuchar *et al.*, no date). Additionally, management of soil erosion should be concentrated to the affected areas and could be encouraged through grants and community education in developing adaptive measures that are desirable to the indigenous people (Wani & Garg, 2009). In order to protect and improve the soil's productivity and environment, there is need for commitment in all sectors of society. Understanding soil erosion is an essential step toward developing effective soil conservation strategies. By decreasing soil loss through conservation practices, the soil's fertility will allow for land to sustain higher crop yields that will have a positive impact on the economy.

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