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EVALUATING THE IMPACTS OF LAND USE/LANDCOVER CHANGE ON SOIL EROSION IN NGERENGERE CATCHMENT AREA

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EVALUATING THE IMPACTS OF LAND USE/LANDCOVER CHANGE ON SOIL EROSION IN NGERENGERE CATCHMENT AREA

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A Dissertation submitted in the department of Geospatial Science and Technology in partial fulfillment of the requirements for the award of Bachelor of Science degree in Geographical Information System and Remote Sensing (BSc. GIS&RS} at Ardhi University

CERTIFICATION

The Undersigned certify that they have proof read and hereby recommended for acceptance of a dissertation entitled "**EVALUATION OF THE IMPACT OF LANDUSE/COVER CHANGE ON SOIL EROSION**" in partial fulfillment of the requirement for award of degree of Bachelor of Science in Geographical Information Systems at Ardhi University

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Dr. Beatrice Tarimo	Ms. Beatrice Kaijage
(Main supervisor)	(Second Supervisor)
Date…………………………	Date…………………….

DECLARATION

I Msegu Esperance L. declare that this dissertation report is my own original work and that to the best of my knowledge, it has not been presented to any other University for a similar or any other degree award except where due acknowledgements have been made in the text.

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Msegu, Esperance L.

25487/T.2020

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DEDICATION

I dedicate this dissertation to my beloved family of Mr. and Mrs. Msegu whose love, support, prayers and belief in me have been the pillars of my success. You have all guided me to be a better person and influenced me to be the best version of myself every place I go. May you be blessed

ABSTRACT

Land Use Land Cover change (LULCC) is among the drivers of soil erosion. In the Ngerengere catchment area, LULCC has been occurring rapidly in recent decades, there has been a shift from forest to agricultural land. This shift has led to increased soil erosion, which is a serious threat to the sustainability of the catchment. Soil erosion has led to reduction in agriculture productivity, water quality and increase sedimentation. This dissertation evaluates the impacts of LULCC on soil erosion in the Ngerengere catchment area. The study uses remote sensing data which are A digital elevation model, land sat image (1991 and 2022), soil data and the rainfall data (1991 and 2022) of the Ngerengere catchment.

By the Use of the RULSE model it has been observed that there is an influence that the land cover change has over soil erosion that is because over the years 1991 and 2022 the annual average soil loss value obtained from the RUSLE model has been changing. Most of the areas of Ngerengere catchment area are observed to undergo erosion that ranges between 13.78 t/ha/year and48.22 t/ha/year in 1991 and in 2022 they range between 8.27 t/ha/year and 28.17 t/ha/year because most of the area in Morogoro is covered in cropland and forest these prevent erosion. From the year 1991 to the year 2022 there is seen to be increase in the built-up area from other classes, the change in the landcover has resulted to more erosion in the Ngerengere catchment.

Based on the results and conclusion provided further studies may be conducted that may involve stakeholders from the Ngerengere catchment area and make use of other methods such as the statistical analysis method and experts' opinion.

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ACRONYMS AND ABBREVIATIONS

A	Average annual soil loss
C	Cover management factor
DEM	Digital Elevation Model
GIS	Geographical Information Systems
K	Soil erodibility factor in RUSLE
LS	Slope length and steepness factor in RUSLE
LULC	Land use / Land cover
M.A.S.L	Meters above sea level
MAR	Mean Annual Rainfall
MFI	Modified Fournier Index
R	Rainfall erosivity factor in RUSLE
RUSLE	Reversed Universal Soil Loss Equation
USLE	Universal Soil Loss Equation

CHAPTER ONE

INTRODUCTION.

1.1 Background

Soil erosion is a major threat and serious concern for human sustainability (Lal, 1998) in numerous parts of Tanzania especially on the highlands of Uluguru found in Morogoro region whose landscapes are highly populated and transformed into farmland. Morogoro region has a number of natural resources such as Uluguru Mountains National Park, the Udzungwa Mountains National Park, the Kilombero Game Reserve, and the Ngerengere river, Morogoro is a mountainous and the surrounding area is good for agricultural activities as the land is fertile and the climate is conducive. These activities are also largely done in the Ngerengere catchment area in Morogoro

Ngerengere catchment is among the areas that are prone to soil erosion according to the study conducted by Yanda and Munishi (2007). The activities such as shifting cultivation, over grazing influences soil erosion. The river's steep slope has minimum conservation measures and presence of degradation of the upper part of Ngerengere river basin, all of this together contributes to erosion at the catchment.

In recent decades, there has been a major shift in the land use/cover of the Ngerengere catchment area. While agricultural land has increased by roughly 30%, forest cover has decreased by about 50% (P Yanda, 2007). Population growth, agricultural development, and deforestation for the manufacture of charcoal and lumber, have contributed to this change in land cover. For several decades tracing back to the 1990s, the catchments at the highlands has been experiencing increased rates of soil erosion problems, among the factors that influence in increase soil erosion are the land cover changes of Ngerengere (P Yanda, 2007).

The change in land cover in the Ngerengere catchment area has had a number of impacts on soil erosion. Among the land cover changes occurring is the change in the vegetation of Ngerengere, for instance reduction in the forest areas. Forests are important for mitigating soil erosion because they provide a protective cover for the soil. When forests are cleared, the soil is more exposed to the elements, which can lead to increased erosion. Agricultural land is also susceptible to soil erosion, especially if it is not properly managed. Poor agricultural practices such as overgrazing, tillage, and the use of heavy machinery can all increase soil erosion.

Studies of soil erosion are usually done by modelling of soil erosion by using the RUSLE model which accurately predicts the soil erosion in a certain area. Modeling of erosion brings an understanding of the extent to which alteration of the LULC has impacted the soil in Ngerengere catchment. Through soil erosion modeling, annual soil erosion's spatial pattern within the Ngerengere catchment will be determined. The result produces a spatial distribution of the LULC causing soil erosion at the Ngerengere catchment, which will be applied for conservation and water resource management planning processes, at the policy level, by land planners and decision-makers.

1.2 Problem statement

The Ngerengere catchment area is experiencing increased soil erosion due to changes in land use and land cover. As a result, agricultural production is declining, there are water quality issues, and rivers and streams are becoming more sedimented. There are studies conducted that give information of the land uses and land cover present at the area but information about the relationship between the LULC change and soil erosion of the Ngerengere catchment area is required as it is useful, in the management of the activities to reduce the rate of soil erosion. The aim of this study is to determine the land use/ land cover changes over the years and the relationship between LULC change and soil erosion of Ngerengere catchment area.

1.3 Research Objectives

1.3.1 Main Objective

- Evaluate the impacts land use/ land cover changes and soil erosion at the Ngerengere catchment area from 1991 to 2022

1.3.2 Specific Objectives

- To detect the land use land cover changes on areas at Ngerengere catchment area in the years (1991 and 2022).
- To Assess the relationship between land use/cover change and soil erosion

1.4 Research questions

- How does the land cover change at Ngerengere catchment area?
- How land use change impact soil erosion at Ngerengere catchment area?

1.5 Significance of the study

This study provides evidence that LULC change is a major driver of soil erosion in the catchment area. Also, results of the study will be used to develop recommendations for sustainable land management practices in the catchment area. The study will be helpful in decision making for future planning regarding the development and management of water resources and providing information in supplementing country policies on the change in land use/cover adaptive and mitigations capacities on prevention of future erosion risks in the catchment and /or another similar catchment in Tanzania.

1.6 Description of the study area

Ngerengere catchment (Figure 1) with an area of 2,913km^2 is located between latitude 6^0 27' 23"to 7^0 4'18" south of the equator, and longitude 37^0 28'18"to 38^0 21' 28" East of Greenwich. The catchment has the highest elevation of 2,276 meters above sea level (m.a.s.l), and the lowest point of 49 m.a.s.l. with the mean altitude of 415m. Ngerengere, Mgeta, Morogoro, Mlali, and Lukuga rivers are the major rivers draining the catchment. Morogoro, is a center of intense agricultural and industrial growth, and the Region is exemplary for environmental changes induced by this development.

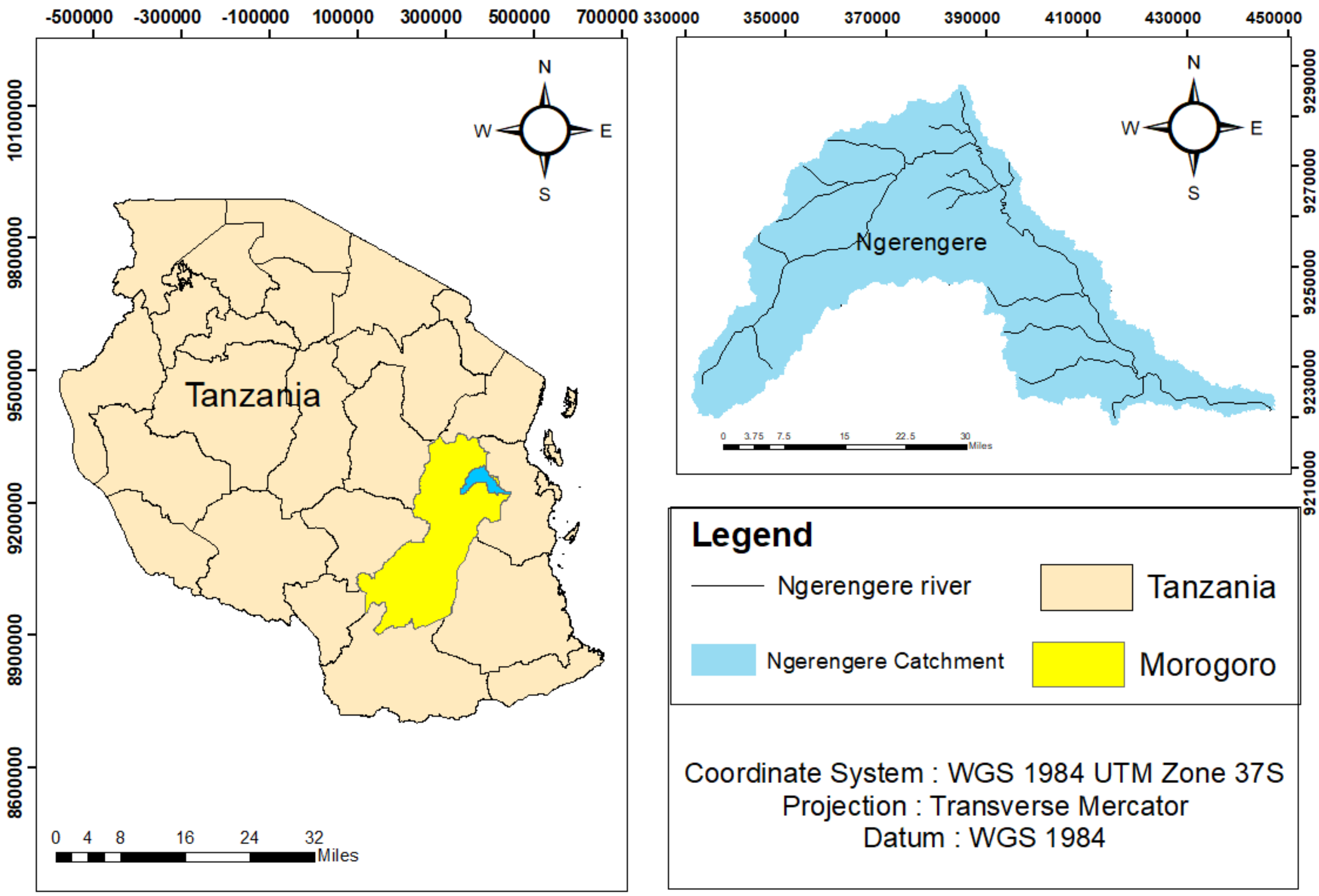

Figure 1.1: A Map showing the location of Ngerengere Catchment

CHAPTER TWO

LITERATURE REVIEW.

2.1 Overview

This chapter targets on the articles and research studies that have been published within the past decade on the soil erosion and land use / land cover and how they influence each other. some have consisted of the other factor that influence soil erosion such as rainfall, soil texture and slope of Ngerengere catchment area. For this study, further step will be taken to evaluate the impacts of LULC change on soil erosion in the Ngerengere catchment.

2.2 Soil Erosion

Soil erosion is a natural process that occurs when the topsoil is removed from the land surface. This can be caused by wind, water, or other factors. Soil erosion can have a number of negative impacts, including loss of nutrients and organic matter, Reduced crop yields, Increased flooding and Sedimentation in rivers and lakes. Despite all these soil erosions can be prevented Planting cover crops, reducing tillage, Contour farming, Building terraces and Planting trees and shrubs.

In Morogoro, Ngerengere, and Tanzania, soil erosion is a significant issue. It is brought on by a number of things, including as overgrazing, deforestation, and subpar agricultural methods (Dayoub, 2019). A key challenge to the long-term viability of the land is soil erosion, which is also affecting biodiversity, water quality, and agricultural output.

Soil erosion is a serious problem, but it is one that can be prevented. By taking steps to protect our soils, we can ensure that they continue to provide us with the many benefits they offer. The soil loss is measured by using the soil erosion models that combines the factors that influence soil erosion and provides the soil loss values.

2.3 Land Use/Land Cover Change

The term "Land Use/Land Cover Change" (LULCC) describes how land changes from one kind of use or cover to another. This could involve modifications to the vegetation's species, the existence of infrastructure, or the usage of the land for forestry, agriculture, or other activities. The land use/ land cover change may have a big effect on the ecosystem, affecting biodiversity, water quality, and air quality. Through the atmospheric release of greenhouse gases, it can also influence climate change. (Springer, 2004).

Land use and land cover change is a significant issue in Tanzania, Morogoro, and Ngerengere. Population growth, agricultural expansion, and climate change are the primary causes of LULCC in Tanzania. The LULCC situation in Morogoro and Ngerengere is especially critical because these regions are found in the Uluguru Mountains, a significant water source for Tanzania. The Uluguru Mountains' deforestation is a factor in both water scarcity and soil erosion.

The soil erosion rates in the Ngerengere catchment have increased significantly in recent decades, due to a shift from forest to agricultural land. Also soil erosion is a major threat to the sustainability of the catchment, and that it is causing a decline in agricultural productivity and water quality.In order to obtain the land cover change the following process need to be encountered

2.3.1 Image pre- processing

Preprocessing is crucial because it increases the quality of the image used as the foundation for further studies that will extract information from the image. Preprocessing includes fixing errors and removing faults. picture rectification and restoration are other names for picture pre-processing procedures (Lillisand, 2007). Pre-processing approaches focus on getting rid of unwanted or distracting parts of the image as well as data mistakes. There are numerous pre-processing methods, some of which include;

i. Inspecting characteristics and quality of data by displaying, summarizing, and presenting histograms and other statistical summaries
ii. Compensate for radiometric errors
iii. Geometric corrections.

2.3.2 Radiometric corrections

The Digital Number (DN) stored in an image is impacted by radiometric inaccuracy. Improved surface spectral reflectance, emittance, or backscattered measurements are achieved through radiometric corrections. They are brought on by sensors. mistakes brought on by sensor failures that are mechanical, electronic, or communication-related, as well as errors brought on by atmospheric interactions with EMR. A saved image's Digital Number (DN) is impacted by radiometric inaccuracies.

2.3.3 Image classification

According to (Mather, 2011)image classification is the process of categorizing pixels into nominal groups that lead to thematic classes. According to the idea of image classification, each pixel in an image is given a class based on its feature vector by comparing it to specified clusters in the feature space, and as a consequence, the entire image is classed. In this process, the computer is also given instructions by the (human) operator to carry out an interpretation under specific circumstances. image classification is based on the various spectral properties of various materials found on the earth's surface.

According to the classification principle, a Pixel is categorized based on its feature vector by contrasting it with predetermined clusters in the feature space. A categorized image is produced by doing this for each and every image pixel. Comparing an image to specified clusters is the essence of image classification, which calls for the definition of clusters and comparison techniques. During the training phase, cluster definition takes place in an interactive manner. Using classifier techniques, the clusters and individual pixels are compared. (Natya, 2016)

2.3.4 Classification methods

One of the classification approaches is computer assisted classification; manual and object-oriented methods are the other two (Natya, 2016**)**. There are two types of classification: supervised classification and unsupervised classification, depending on how the analyst and the machine interact during the process.

2.3.4.1 Supervised classifications

In supervised classification, the operator selects sample areas (training areas) to establish the spectral features of the classes. Operator familiarity with the area of interest is necessary for supervised categorization. The operator must be aware of where to look to locate the classes of interest in the image's coverage area. This knowledge can be gleaned through specialized fields of observations or from general area knowledge. Performing supervised categorization often involves the following stages:

2.3.5 Change detection

According to (Dengsheng, 2004), the process of detecting changes in an object's or phenomenon's state involves observing it at various intervals. Land use, land cover, forest or vegetation, landscape, urban, and environmental change are some examples of typical change detection. The output of change detection ought to offer details. Area changes and change rate.

a) Spatial distribution of changed types.
b) Change trajectories of land-cover types.
c) Accuracy assessment of change detection results.

Techniques used in change detection**.**

a) Image algebra methods which use a reference/threshold to detect change and involve some techniques such as image differencing, image regression, image rationing and vegetation index differencing.
b) Classification methods which based on the classified images and some of the techniques usedare post-classification comparison and artificial neural networks.
c) Advanced models which convert image reflectance values into physically based parameters or fractions which are easy to interpret and some of the techniques used is the spectral mixture analysis YYJK, T6.
d) Transformations method which reduces data redundancy and some of the techniques used are Principal component analysis (PCA) and tasseled cap transformation.

Image algebra methods use a reference or threshold to detect change, some techniques used in algebra are:

i. Image differencing, in this method the Digital Number (DN) value of two spatially registered imageries which are acquired at different times are subtracted pixel by pixel and band by band.
ii. Image regression, it involves on the establishment of the relationship between bi-temporal images and then estimates the pixel values of the second date image by use of regression function which involves the subtraction of the image from the first date image.
iii. Image rationing, this is for identifying the area of change and it is considered as a rapid mean.It is performed by calculating the ratio of Digital Number (DN) values of corresponding pixelsof two registered images at different dates with one band of more.
iv. Vegetation index differencing, it produces vegetation index separately the subtracts the second date vegetation index from the first date vegetation index (Dengsheng, 2004).

2.4 Impacts of Land Use/Cover Change on Soil Erosion

Land use and land cover change are some of the triggers that cause an environment shift in the world (Schosser B., 2010). The impact of the change in the land use and land cover begins slowly and eventually alters the rapid change in morphology, erosion production and deposition (MacArthur, 2008). Some of these activities are the root cause of environmental degradation while leading to erosion problems and impacting different engineering facilities. In the region scale, the effect of land use and land cover change can induce biodiversity loss, a decrease of land fertility, pollution to water sources, and lowering of the groundwater tables (Schosser B., 2010). However, apart from soil erosion changes in LULC subsidize to watershed destruction leading to water pollution, water shortage, and habitat destruction (Lambin EF, 2003).

2.5 Soil Erosion Modelling

Soil erosion modelling entails a mathematical description of the soil particles' detachment, transfer, and deposition on the land surface (Jain Manor Kumar et al, 2009). Upon modeling of Soil erosion there is quantification of the factors influencing soil erosion. Quantification of soil erosion is difficult due to the interchange of many factors related such as climate, soils, land cover, topography, and anthropogenic activities (Vrielling, 2006). The Reversed Universal Soil Erosion equation (RUSLE) has been among the best and appropriate tools in the estimation of average annual soil loss (Saleh, Yaghoub, Niazi, & Kalteh, 2012).
Researcher have successfully used the model and provided good estimates in predicting the impacts of climate change and LULC on soil erosion (Yang*etal*.,2003; Ito, 2007; Gupta, 2015). This study will apply the RUSLE model because the model is the best compared to other models used in measuring soil erosion and the most appropriate tool, it is mostly used in soil erosion modelling and requires a wide range of data thus providing more reliable results.
For a long time, the Universal Soil Loss Equation (USLE) and later the Revised Universal Soil

Loss Equation (RUSLE) has been the most widely used model in predicting soil erosion loss. The USLE was originally developed for soil erosion estimation in croplands on gently sloping topography. With the advent of the revised USLE, it has broadened its application to different situations, including forest, rangeland, and disturbed areas. Traditionally, these models were used for local conservation planning at an individual property level.
The factors used in these models were usually estimated or calculated from field measurements. The methods of quantifying soil loss based on erosion plots possess many limitations in terms of cost, representative-ness, and reliability of the resulting data. They cannot provide spatial distribution of soil erosion loss due to the constraint of limited samples in complex environments. Mapping soil erosion in large areas is often very difficult using these traditional methods. The use of remote sensing and geographical information system (GIS) techniques makes soil erosion

estimation and its spatial distribution feasible with reasonable costs and better accuracy in larger areas. For example, a combination of remote sensing, GIS, and RUSLE provides the potential to estimate soil erosion loss on a cell-by-cell basis.

2.5.1 Revised Universal Soil Loss Equation (RUSLE)

RUSLE is a universal Soil Loss Equation which was originally developed intentionally to predict soil erosion on croplands in the US. But with time became to be known that the equation can be used in many environments including agricultural site, mines sites, construction sites, forestry etc. RUSLE is simple and the parameters to feed are less and easy to obtain compared with other models. RUSLE model represent how Climate, Soil, Topography, Rainfall effect affects the soil erosion rate of an area. It has been used more to assess the soil erosion risk and It has been help to guide conservation plan for controlling soil erosion to different land cover.

Here

RUSLE stands for Revised Universal Soil Loss Equation

$$A= R\ K\ L\ S\ C$$

Where

A= average annual soil loss (tones/hectares)

R= rainfall-runoff erosivity factor (MJ/(ha * mm)

K= soil erodibility factor (t/ha * MJ * mm)

LS= slope length and steepness factor

C= cover management factor

Condition for the equation

- Used to estimate average annual soil loss
- Only considers sheet and rill erosion
- Does not consider gully erosion, stream bank erosion, mass wasting (landslides)
- Does not consider the unpredictable human element

2.5.2 RUSLE factors

An annual average loss over a site where losses at various parts of the site may differ greatly from one area to another. Because each area has its own characteristics or variables that makes soil erosion rate to differ Those variables are

Rainfall-Runoff Erosivity Factor with SI- unit (R-factor) MJ/ (ha * mm)

This factor is a measure of the energy in rainfall that can cause soil erosion. It is calculated based on the average annual rainfall, the intensity of the rainfall, and the length of the wet season. Is the kinetic energy of raindrop's impact and the rate of associated runoff (potential ability of rain to cause the erosion) It is dependent upon the physical characteristics of rainfall, which include

• Raindrop size

• drop size distribution

• Kinetic energy

• Terminal velocity

For a given soil condition, the potential of two storms can be compared quantitatively, regarding soil erosion to be caused by them. The power of overland runoff flow to erode soil material is partly a property of the rainfall, and partly of the soil surface but rainfall erosivity is highly related to soil loss. Increased rain erosivity indicates greater erosive capacity of the overland water flow. Soil erosion by running water occurs where the intensity and duration of rainstorms exceeds the capacity of the soil to infiltrate the rainfall

The R-factor is a multi-annual average index that measures rainfall's kinetic energy and intensity to describe the effect of rainfall on sheet and rill erosion for a specific location Is a measure of the total annual erosive rainfall, as well as the distribution of erosive rainfall throughout the year, is affected by

- storm energy and intensity
- amount of rainfall runoff that occurs during different seasons of the year,

The greater the intensity and duration of the rain fall, the higher the erosion potential. The values of R should be computed from rainfall records and probability statistics of a particular location.

The Soil Erodibility Factor (K) with SI-unit of t/ha * MJ * mm

Soil erodibility is an estimate of the ability of soils to resist erosion based on the physical characteristics of each soil. Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion. Sandy loam and loam textured soils tend to be less erodible than silt, very fine sand, and certain clay textured soils. The Soil Erodibility Factor (K) - Is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal factor affecting K, but structure, organic matter and permeability also contributes

Indicators

Tillage and cropping practices like seasonal bush fires, use of chemical fertilizers, use of tractor ploughing which lower soil organic matter levels, cause poor soil structure, and result in soil compactness contribute to increases in soil erodibility. Decreased infiltration and increased runoff can be a result of compacted subsurface soil layers. Again, a corresponding increase in the amount of runoff water can contribute to greater rill erosion problems

The Slope Factor (LS)

Is a measure of the effects of slope angle, length on soil erosion (LS is a slope length and steepness factor).The steeper and longer the slope, the higher the risk for erosion. It involves some calculations that will be discussed in the methodology. This is a very important factor in the overall erosion rate.

The Crop/Vegetation and Management Factor (C)

C-factor is used to reflect the effect of cropping and management practices on erosion rates. Soil management concerns all operations, practices, and treatments used to protect soil and enhance its performance (such as soil fertility or soil mechanics) .It is used most often to compare the relative impacts of management options on conservation plans. The C-factor indicates how the conservation plan will affect the average annual soil loss is obtained by taking the ratio of soil loss from land under specified crop or mulch conditions to the corresponding soil loss from tilled, bare soil (see mulch at preventing detachment and transport of soil particles (erosion control).

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter explains the methods, data, technologies, software and techniques used and applied in this research. This chapter explains the overall methodology and the figure 3.1 entails methods are to be used in land use evaluation in soil erosion

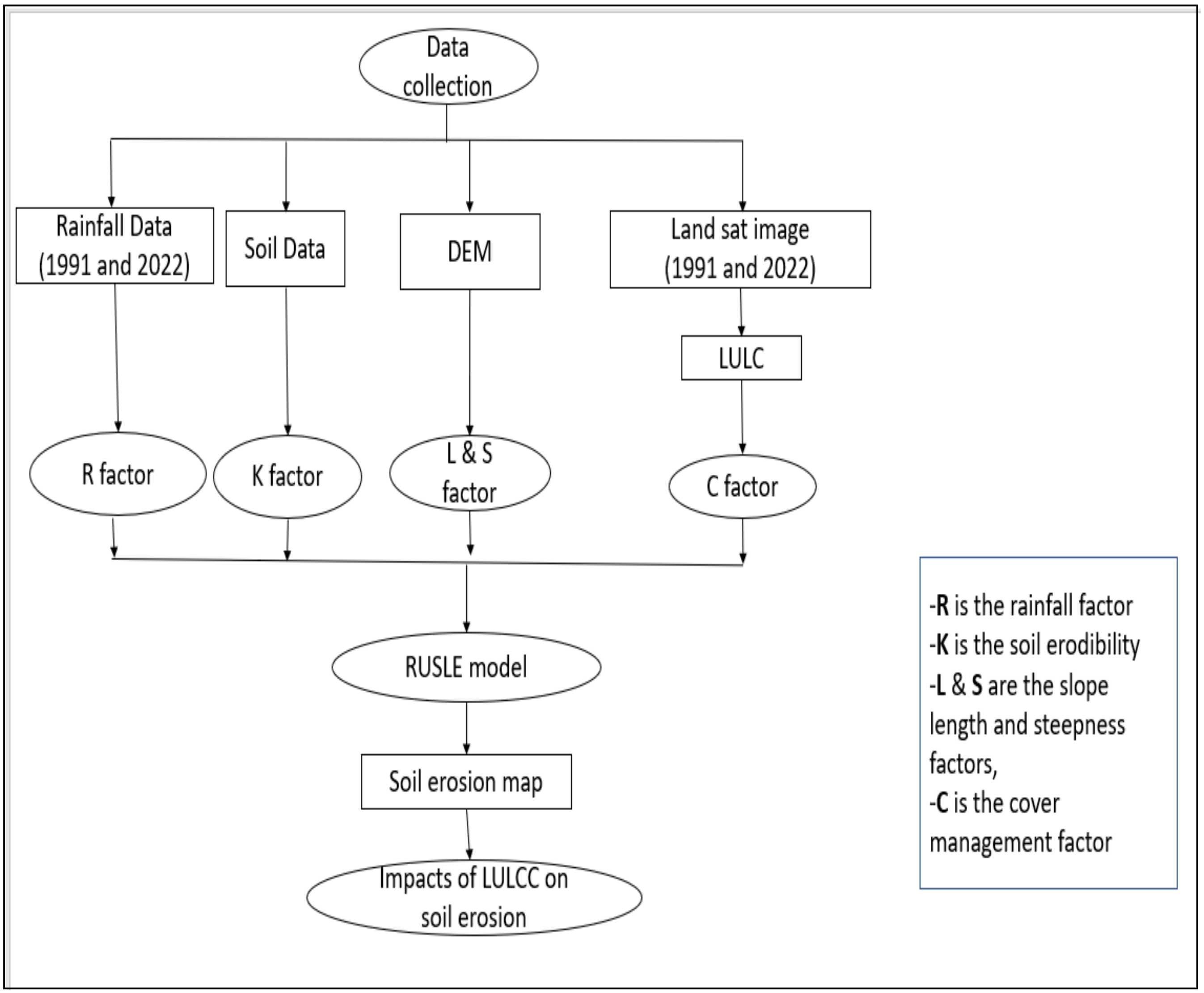

Figure 3.1: Methodology flow chart of the study

3.2 Data collection.

Below is the table that shows the list of data required and collected

Table 3.1: Showing the list of data used and their sources

Data Required	**Data source**	**Data info**
Landsat image	USGS in GeoTiff (.Tiff)	1991TM5 & 2022 landsat08, 30m resolution
Digital Elevation Model (DEM)	USGS in GeoTiff (.Tiff) SRTM	30m resolution
soil data	FAO-Harmonized World Soil Database	Digital Soil map of the world from FAO resolution 30m.
Precipitation	Tanzania Meteorological (TMA) Agency	Point data from 4 weather stations which are Morning side farm, Morogoro Hydromet, Luhungo and Mlali (1991 and 2022)

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3.3 Computation of the RUSLE model factors

3.3.1 Rainfall-runoff erosivity-R factor estimation

Rainfall and runoff are usually expressed as the R factor. To calculate the R factor, long-term precipitation data was needed with high temporal resolution, typically available for only few locations. The long-term average R-values was calculated with annual rainfall and the Modified Fournier's Index (MFI or F) (Arnoldus, 1980).

$R = 4.17F – 152$ as it is becoming the best model to estimate R factor of the Ngerengere catchment.

The R-factor was obtained in form of points, interpolation was done by using the IDW tool in raster interpolation tool. Then extraction by masking the area of interest was done and the raster image was obtained visualizing the R-factor which is an input in the RUSLE model.

3.3.2 Slope Length (L) Factor and Slope Steepness (S) Factor

The LS factor accounts for the effect of topography on erosion in RUSLE. The slope length factor (L) represents the effect of slope length on erosion, and the slope steepness factor (S) reflects the influence of slope gradient on erosion.

Using the DEM as the input data the flow direction was calculated in ArcGIS by using the flow direction tool. The flow direction image was obtained. Then Flow Accumulation was calculated with Flow Accumulation Tool using flow direction data as the input raster. Slope watershed in degrees was calculated using Slope Tool using Ngerengere DEM as the input layer, and then input the LS-factor formula below into Raster Calculator.

Calculation of the LS Factor

The effect of topographic factors, namely slope length L and percent slope S, on erosion was derived from slope length factor LS. The equation used to determine this parameter was that recommended by (Morgan and Davidson, 1991). The map algebra used to implement the LS factor is the following:

LS=Power (“flow accumulation” *[cell resolution]/22.1,0.4) *Power (Sin (“slope” *0.01745))/0.0 9, 1.4) *1.4

After computation of this equation the raster image showing the LS-factor was generated.

3.3.3 Soil erodibility Factor -K factor

Soil erodibility represents the susceptibility of soil to erosion. From the digital soil map of the world the catchment area was extracted and then the K factor was calculated by using the following formula

K = f (sand, silt, clay, OM, structure)

Where:

K = the erodibility factor

f = a function of the soil properties

sand = the percentage of sand in the soil

silt = the percentage of silt in the soil

clay = the percentage of clay in the soil

OM = the organic matter content of the soil

structure = the structure of the soil

These values are present in the digital soil map of the world. After the K-value was obtained the raster form of the K factor was created to be used in the RUSLE model.

3.3.4 Cover management (C-factor).

The cover management factor represents the effect of vegetation, management, and erosion control practices on soil loss

3.3.4.1 Generation of the land cover maps

The land cover maps of the year 1991,2000 and 2011 were generated in order to obtain the cover management factor of the respective years. Since cover management factor is among the factors for calculating the annual soil loss from the RUSLE model. The following procedures were undertaken in order to obtain the land cover maps

I. Image correction of the land sat images

Atmospheric correction was done to improve clarity of the image. Also radiometric correction was done to correct the differences in brightness and contrast across an image that is normally caused by the variations in the sensor "s sensitivity and atmospheric condition.

II. Image processing

After atmospheric correction layer stacking took place to combine bands to produce multi-band image. This type of multiband images is useful in visualizing and identifying the available land cover classes. The bands involved were band 1-7 because they would provide good results for classification with respect to the classes used. Then the images were mosaicked and the Ngerengere area was extracted for classification.

III. Classification stage.

Training samples are used to categorize each pixel in the image data into the land feature class it most closely resembles by employing Random Forest classification algorithm as it produces outputs with higher accuracy and it is simple to use and diverse and Anderson classification scheme was used because the land cover categories it had were also present in the area of interest.

IV. Output stage.

The outputs were classified images Ngerengere catchment area of the years 1991, 2000 and 2011. Accuracy assessment followed whereas the confusion matrix was used to calculate the overall accuracy, user and producer accuracy and also the kappa coefficient. Accuracy assessment determines the correctness of a classified image based on pixel groupings i.e. the categories of real-world features presented.

3.3.4.2 Change detection

The changes were by performing post-classification comparison. After the image has been classified, then the classified images were compared to identify changes in land cover. A confusion matrix method was used that is a table that shows the number of pixels that were correctly classified and the number of pixels that were incorrectly classified. The confusion matrix was used to identify the land cover classes that have changed between the two images.

3.3.4.3 Then to each land cover insert its C factor

Each cover type has its specific C-factor. The C-factors were added in the landcover raster of each year in order to obtain the C-factor that would be an input in the RUSLE model, the C-factor values were obtained from (Wisch, 1978).

Table 3.2:A table showing the land cover types with their respective C-factor

Land cover type	C-factor
Water	0.01
Cropland	0.25
Built-up	0.1
Forest	0.01
Bush land	0.05

3.3.5 Annual average soil loss.

After obtaining the estimation above of Rainfall erosivity, soil erodibility, slope length and steepness, and cover management, the multiplication of the results of the factors into estimated soil loss in the catchment was done whereas, the annual soil loss value was calculated of the years 1991and 2022. This was done in order to evaluate the impacts of land use/cover change on soil erosion.

3.3.6 Evaluating the impacts of Land use/ land cover change on soil erosion.

The evaluation of the impacts of land use/ land cover change was done by modelling the spatial relationship between the land use/ land cover change and the soil losses obtained. The geographically weighted regression tool was used to show each land cover change with their respective soiloss. From there it was possible to determine which land cover change has more impacts on soil erosion.

CHAPTER FOUR

RESULTS, ANALYSIS AND DISCUSSION.

4.1 Overview

This section consists of the output which were obtained and the explanation of each result, it involves data presentation, interpretation and analysis of the outputs. Contains output like maps which were obtained from the factors that influence soil erosion and from the RUSLE model.

4.2 Rainfall-runoff erosivity-R factor estimation

The rainfall erosivity factor (R-Factor) is among the primary factor that influence soil erosion. The R factor quantifies the impacts of rainfall on soil erosion. The results obtained on figure 4,1 show the rainfall erosivity factor of the year 1991 whereas the highest value is 775,27 MJ/ha*mm and the lowest value is 321.76 MJ/ha*mm. Figure 4.2 shows the rainfall erosivity value of 2022 which ranges from the highest value of 771.192 MJ/ha*mm and the lowest value of 327.98 MJ/ha*mm. The results are visualized in the figures below.

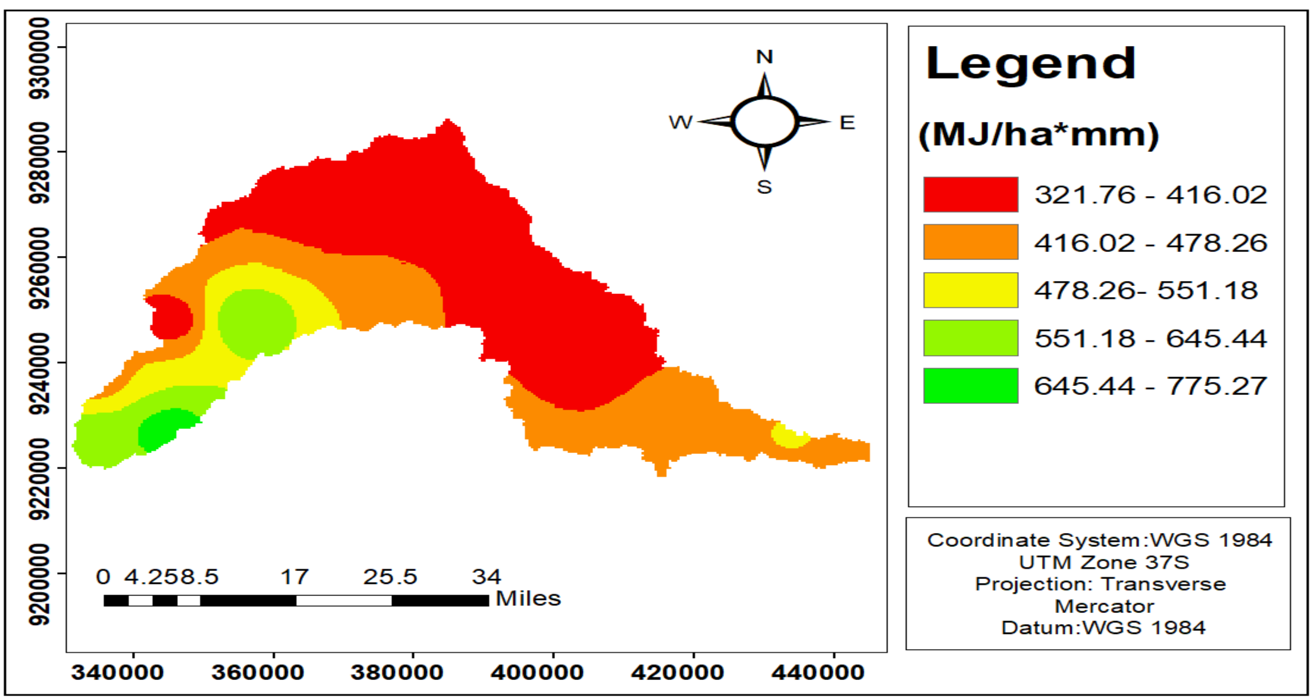

Figure 4.1:A Map showing the Rainfall-runoff erosivity (R-factor) of 1991 of Ngerengere catchment area.

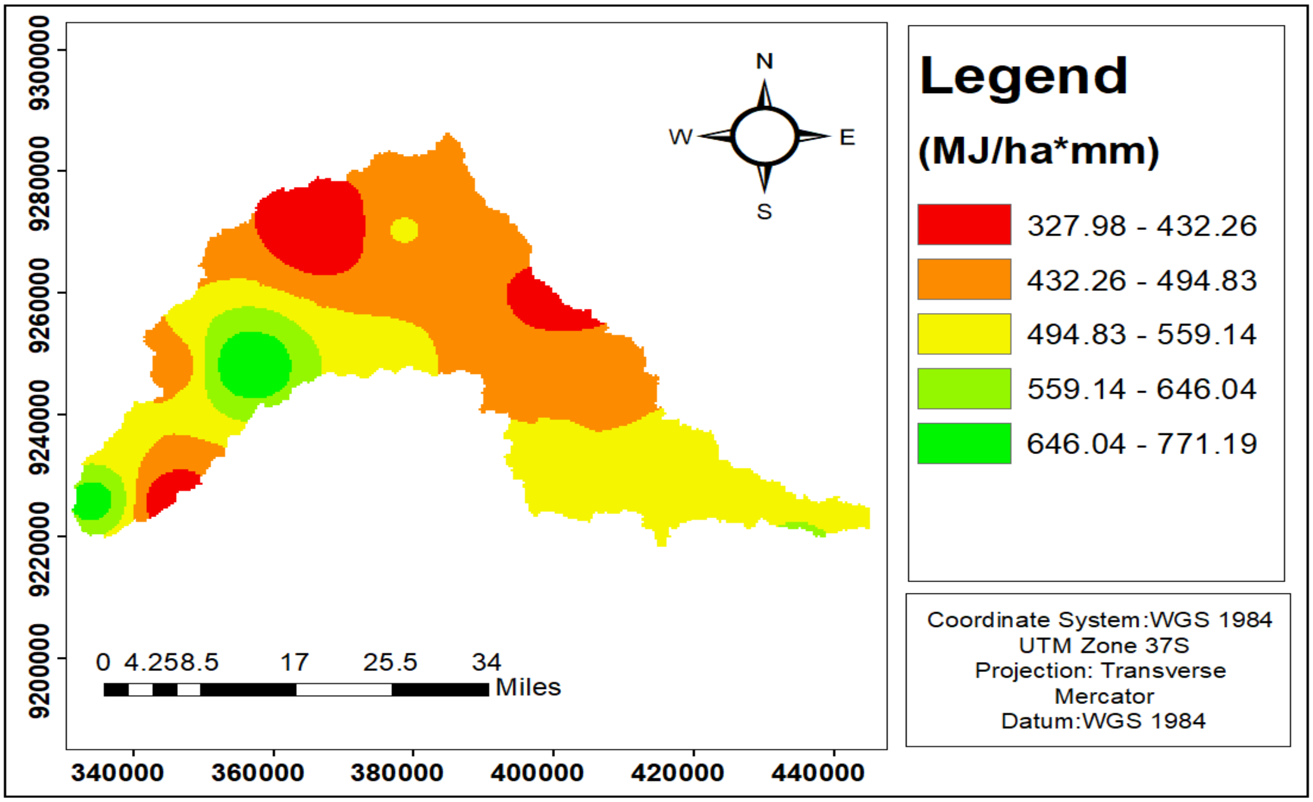

Figure 4.2:A Map showing the Rainfall-runoff erosivity (R-factor) 2022 of Ngerengere catchment area.

The rainfall erosivity factor is observed to decrease from the year 1991 to the year 2022. The decrease is caused by the decrease in the rainfall at Ngerengere. There have been studies conducted at Morogoro about precipitation and climate change that prove there has been a decrease in the amount of rainfall such as the study done by (Dayoub, 2019) show that in Morogoro there has been a decrease in rainfall by 4% per decade since the year 1991.

4.3 Soil erodibility K Factor

The soil types that are at Ngerengere catchment area were derived from the digital soil map of the world. The legend describes the distribution of these soil types at Ngerengere, The figure 4.3 that shows the soil types.

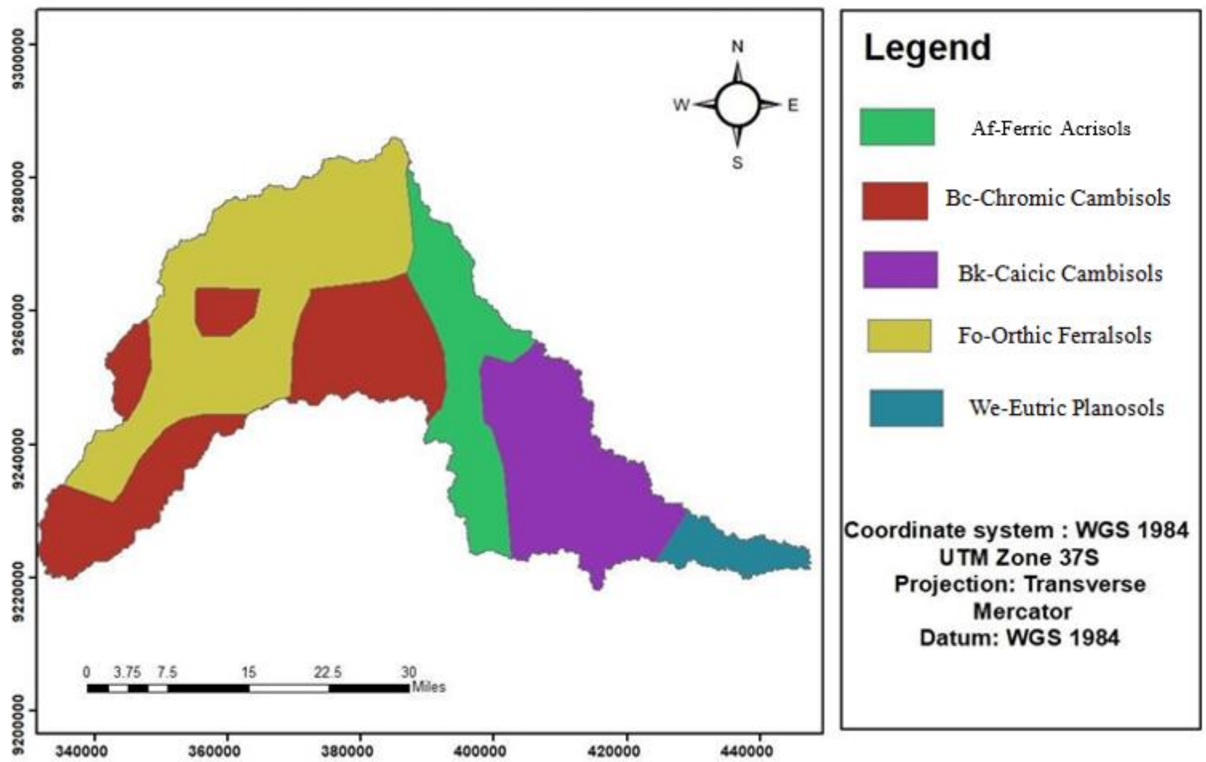

Figure 4.3:Soil type maps of Ngerengere catchment area

The soil erodibility factor (K-factor) was obtained after the calculation as explained in section 3.3.3, Each soil type found at Ngerengere has the K-factor value. With respect to the values obtained explains the extent to which the K-factor have influenced soil erosion at Ngerengere. The soil erodibility of Ngerengere catchment explains the susceptibility of soil erosion. The areas with high value of soil erodibility are more prone to soil erosion than areas with low erodibility. The values show that Ngerengere catchment has high erodibility. The study done by (Mlingwa, 2013) explains that Morogoro has high soil erodibility that makes the area vulnerable to soil erosion thus decreases the crop yields and agriculture products. Figure 4.4 below shows the soil erodibility factor value of each soil type.

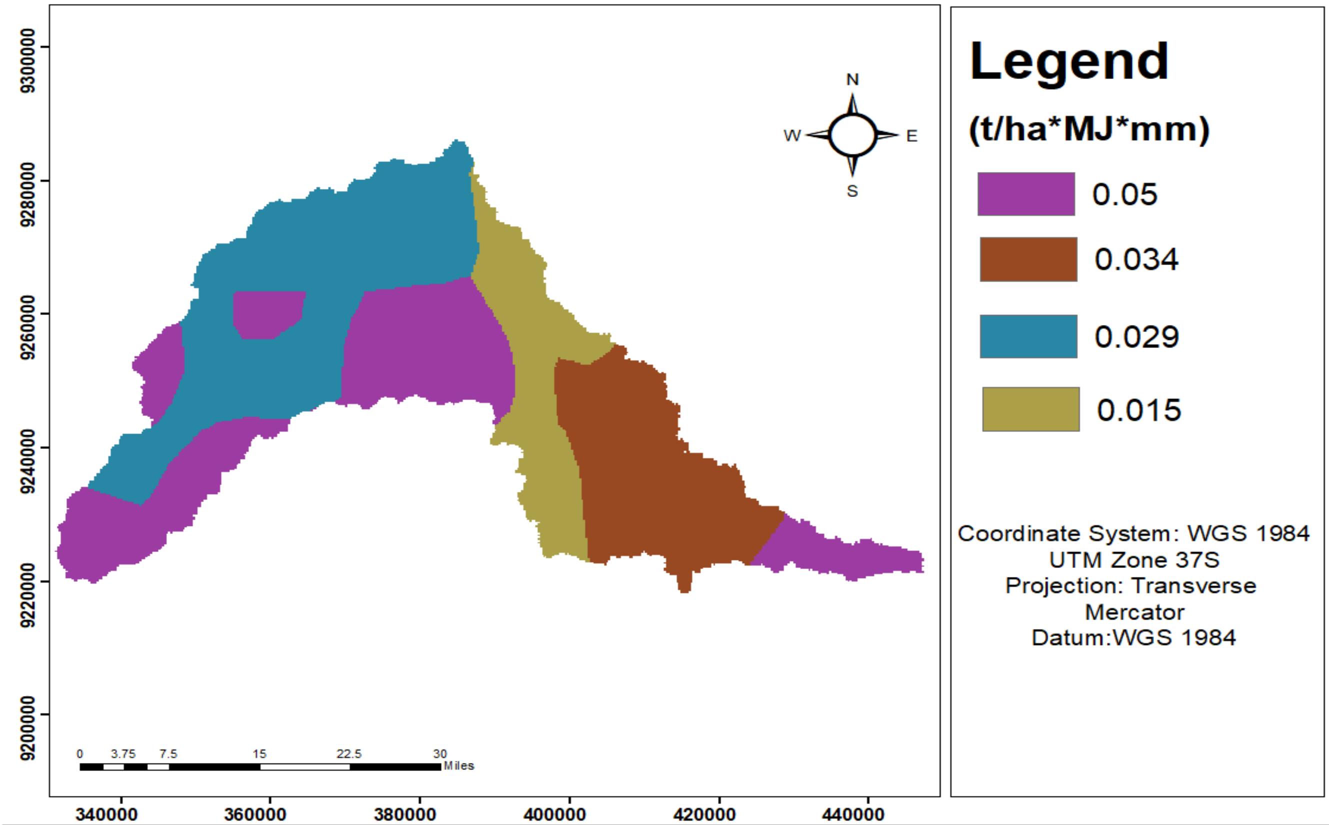

Figure 4.4: Soil erosivity (K-factor) map of Ngerengere catchment area

4.4 Slope Length and Steepness LS Factor,

The Slope length and slope steepness (LS-factor) is among the factors that influence soil erosion. The results obtained from the LS factor obtained show that the area has the variation of slope length and slope steepness as a result the amount of soil erosion occurring at Ngerengere varies with the LS-factor**.** The slope of Morogoro varies greatly. The city is located in a mountainous region, and the slopes can be very steep. The average slope of Morogoro is about 10%. However, there are some areas where the slope is much steeper, such as the Uluguru Mountains, where the slope can be up to 60% (Mlingwa S. P., 2013)The higher the LS factor the greater the potential for soil erosion, these results are shown in the figure 4.5 below.

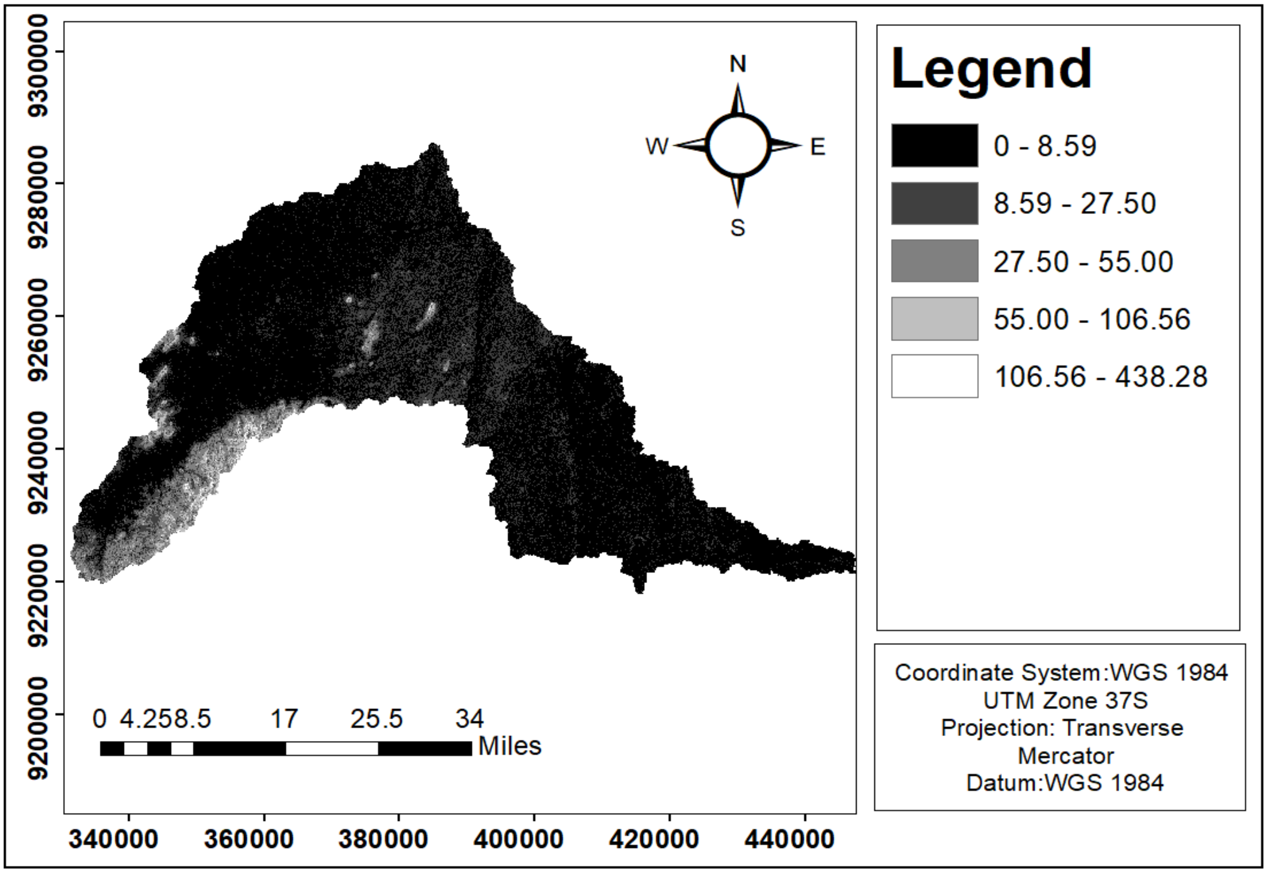

Figure 4.5:The Length and Steepness (LS factor) map of Ngerengere Catchment area

4.5 The landcover maps

The land cover maps of Ngerengere were of the year were generated from the Landsat images of the year 1991, and 2022 were generated, the land cover was distributed in five classes which are Water, Cropland, Built-up Area, Forest and Bushland. In the Year 1991 Ngerengere catchment area had more area covered in Forest that covers 99533.9 ha of the catchment and the lowest class area was water that covered 202.04 ha. In the year 2022 the class that covered more area was the bushland that covered 187205.8 ha and the lowest class was water instead there is an increase in the Built-up Area. The visualization of the distribution of these classes is seen in the figure 4.6 and figure 4.7 Moreover the spatial distribution of the classes is shown on table 4.3.

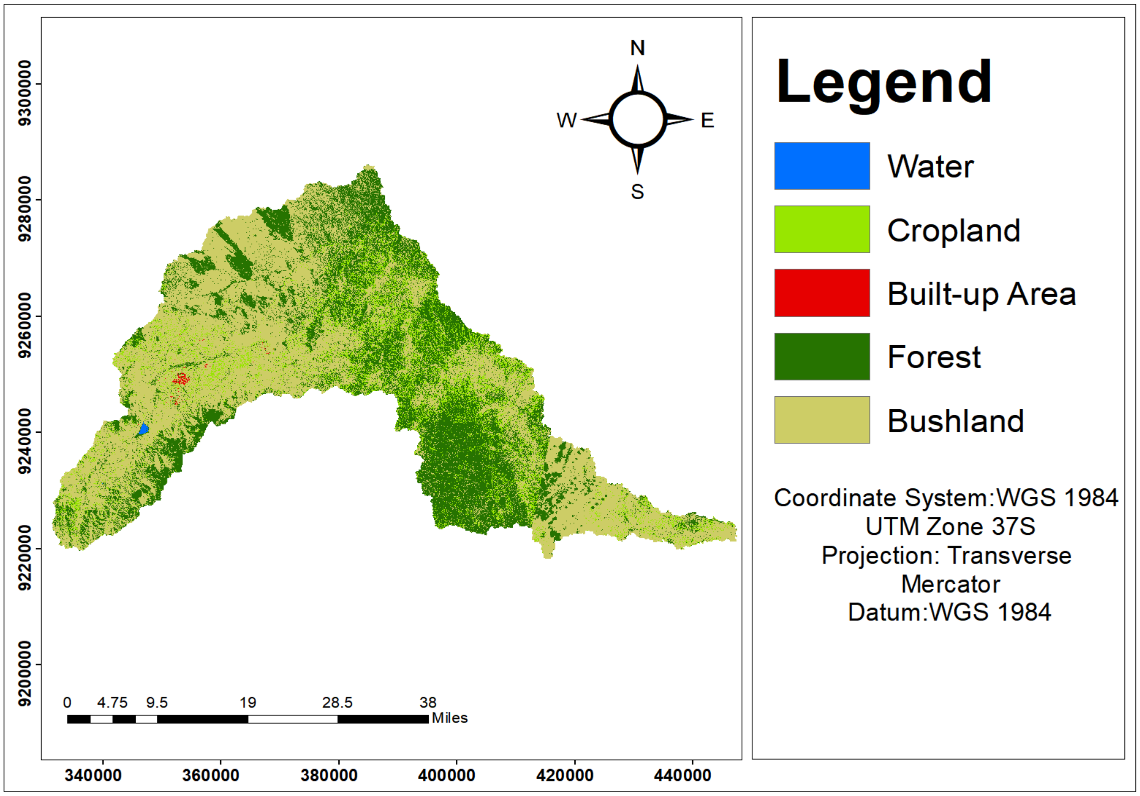

Figure 4.6:The Land cover maps (1991) of the Ngerengere catchment area.

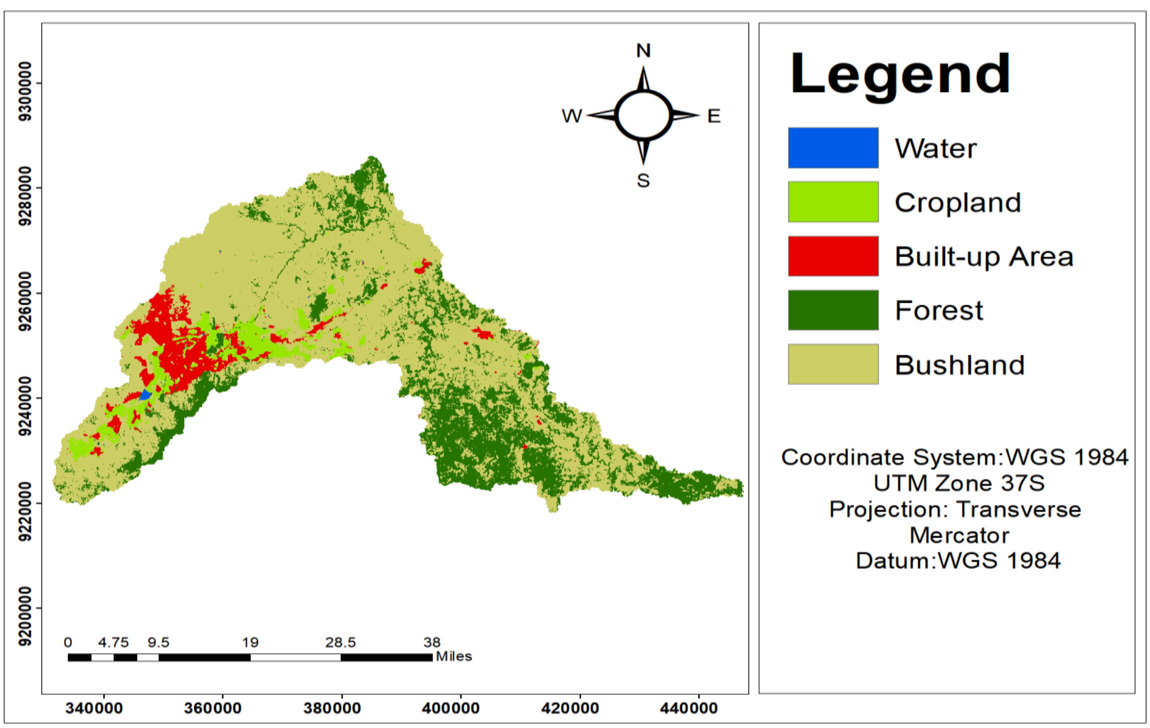

Figure 4.7:The Land cover maps (2022) of the Ngerengere catchment area.

Table 4.1:The change in the LULC area during 1991 and 2022

S/N	LULC Classes	Area in 1991 (ha)	Area in 2022 (ha)
1	Water	202.04	319.03
2	Cropland	32433.33	16284.51
3	Built-up Area	293.86	17561.56
4	Forest	99533.85	69930.11
5	Bushland	158851.97	187205.81
Total		291315.16	291301.04

4.6 The cover management C-Factor

The C-factor value was obtained from the land cover classified image of the year 1991and 2022. The C-factor varies from area depending with the land cover type of that particular area. The C-factor shows the effect of vegetation/crop cover and management practices on soil erosion rate. The C-factor value of Ngerengere vary from 0.01 to 0.1. Similar to C-values ranges from 0 to 1, whereby the value 0 indicates a good conservation practice and erosion resistance facility and the vale 1 indicates poor conservation practice and no manmade erosion resistance facility (Mlingwa S. P., 2013). Thus the areas that have value of 0.01 have a better cover management of the area compared to the areas that have the value of 0.1. Figure 4.9 below shows the cover management factor of Ngerengere catchment area.

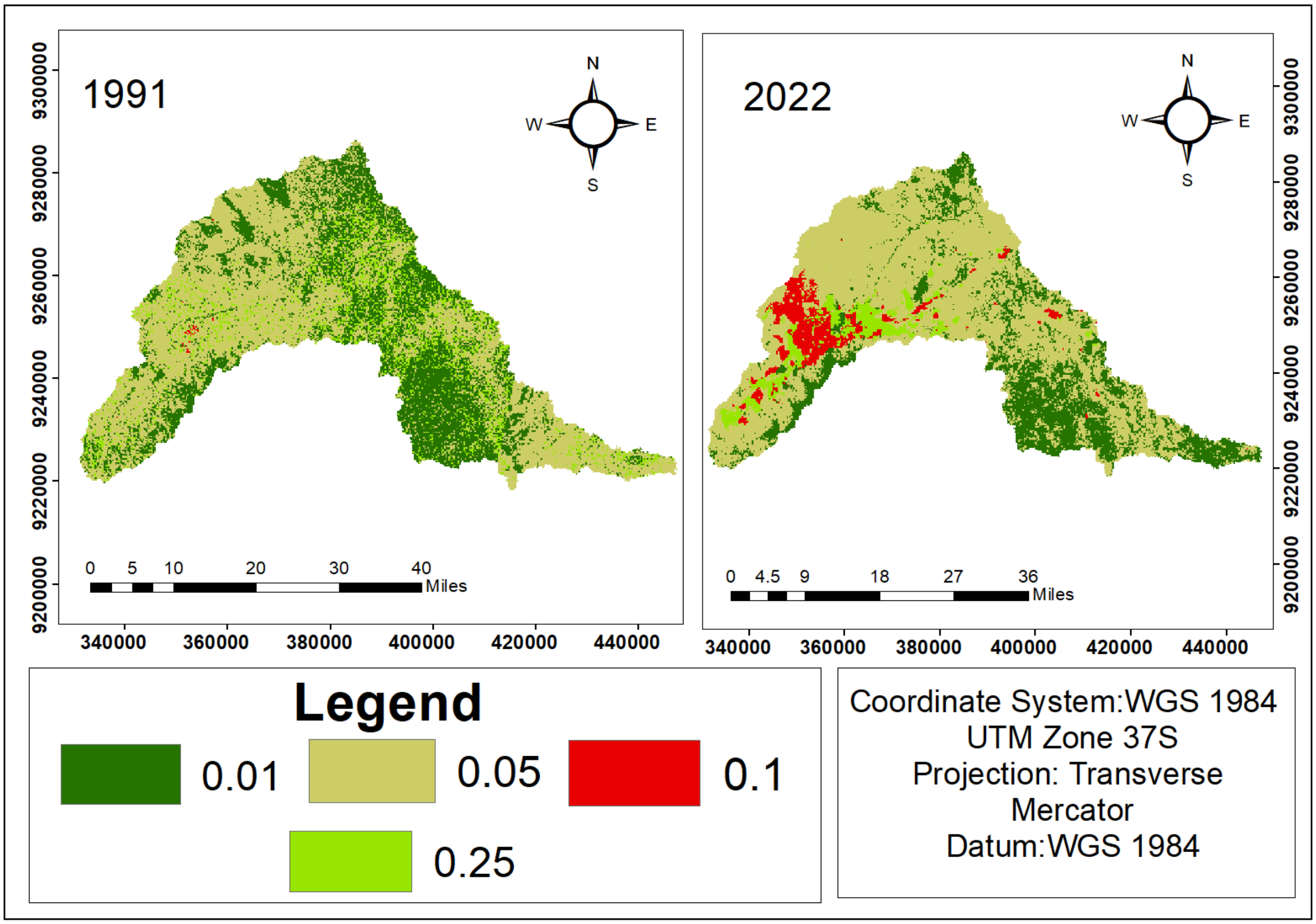

Figure 4.8:Cover management (C-Factor) of Ngerengere catchment area.

4.7 Change detection results

These maps show the change in the landcover of Ngerengere from 1991-2022. These maps tend to show the changes from the land cover maps in which look at two years and determine the changes and the classes that have not change at all within the two maps. This map obtains the change of the year 1991 to 2022. In the year 1991-2000 the changes were determined in which there were classes that did not change that is in some areas the classes remained the same and some areas shows that the classes changed. The declining trends of forest and cropland in the study resulted in predominantly soil erosion. Reduction of forest and grassland area resulted in an increase in surface runoff (Shang et al. 2019). Deforested lands are exposed to thepotential impacts of raindrops, which accelerate the detachment, removal and transportation of soil particles (Kidane et al. 2019).

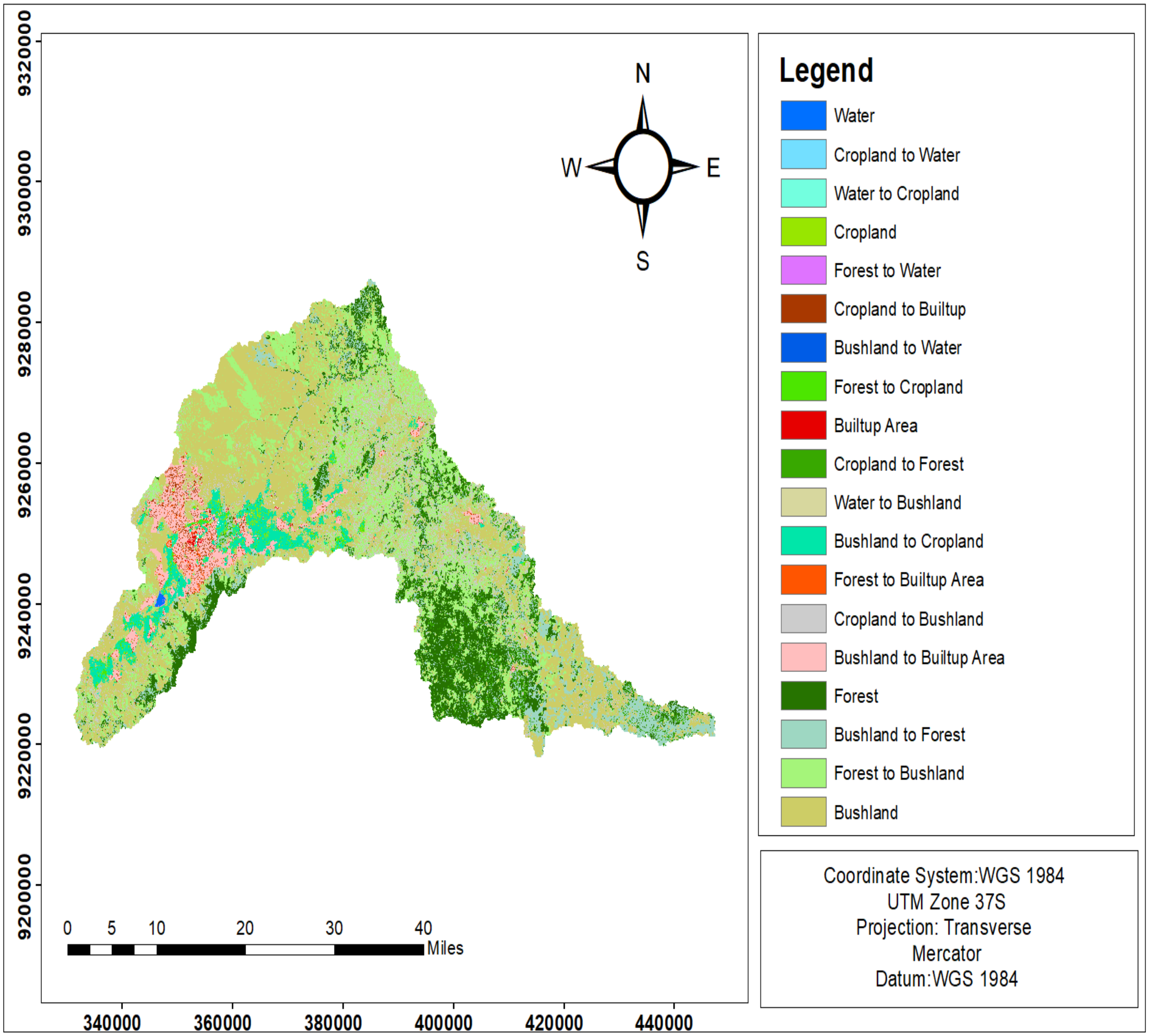

Figure 4.9:The 1991-2000 Change detection maps of Ngerengere catchment area

Table 4.2:LULC change and average annual soil loss

S/N	LULC Change 1991-2022	Mean Soiloss (t/ha/year)	S/N	LULC Change 1991-2022	Mean Soilloss (t/ha/year)
1	Water	7.9	12	Bushland to Cropland	10.3

2	Cropland to Water	4.6	13	Forest to Built-up Area	26.3
3	Water to cropland	6.7	14	Cropland to Bushland	5.0
4	Cropland	3.9	15	Bushland to Built-up Area	18.0
5	Forest to Water	6.2	16	Forest	7.5
6	Cropland to Built-up	0.2	17	Bushland to Forest	4.0
7	Bushland to Water	3.1	18	Forest to Bushland	0.1
8	Forest to Cropland	21.7	19	Bushland	7.7
9	Built-up Area	22.4			
10	Cropland to Forest	14.1			
11	Water to Bushland	9.3			

4.8 Analysis of annual Average Soil Loss

In this study evaluation of the impact of land cover change was done. The results of the soil erosion map of each LULC for the two years is presented in the figure 4.10 and figure 4.11. Most of the areas of Ngerengere catchment area are observed to undergo moderate erosion in 1991 and in 2022. But from the year 1991 to 2022 there has been a change from other land covers to built-up meaning deforestation has occurred. This study agrees with (zava, 2019) who discusses that removal of trees and shrubs reduces the amount of vegetation that protects the soil from erosion. This is one of the most significant factors contributing to soil erosion in Ngerengere. Due to the change in the year 2022 there is change in the soil loss pattern there is an increase in the high and very high values.

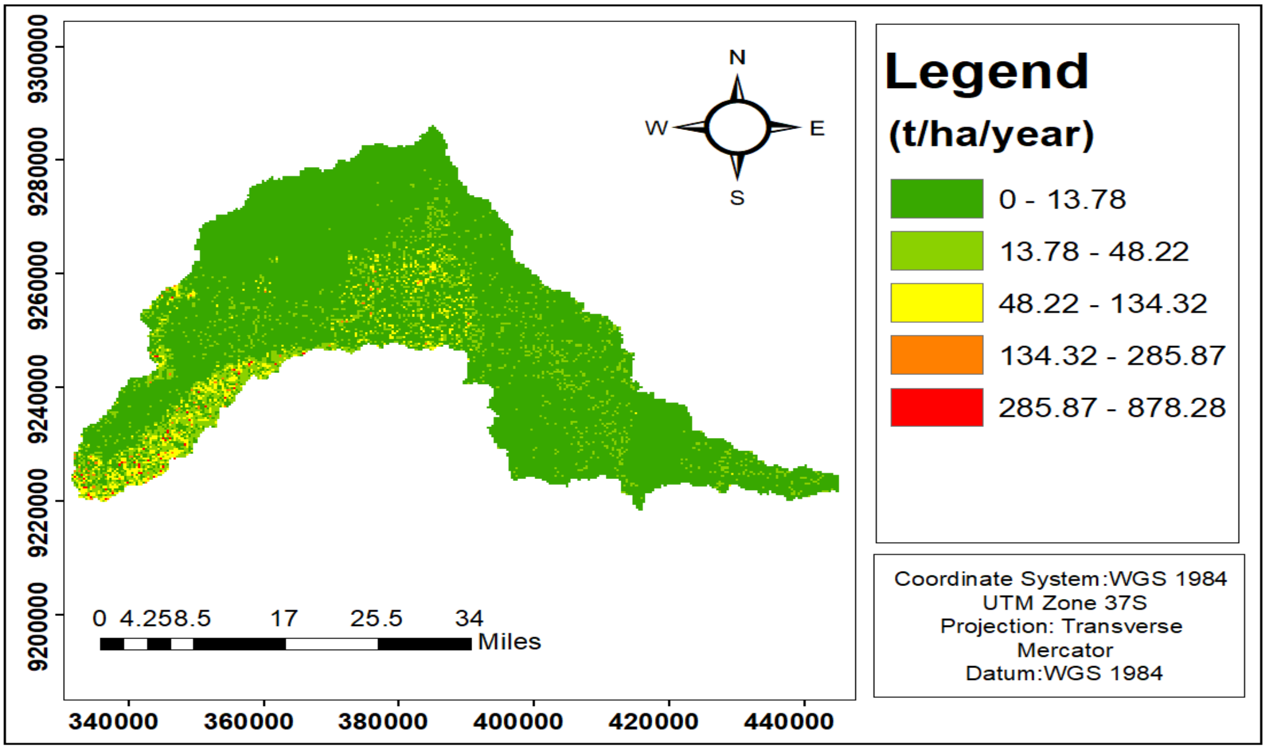

Figure 4.10:Soil loss map of 1991 at Ngerengere catchment area

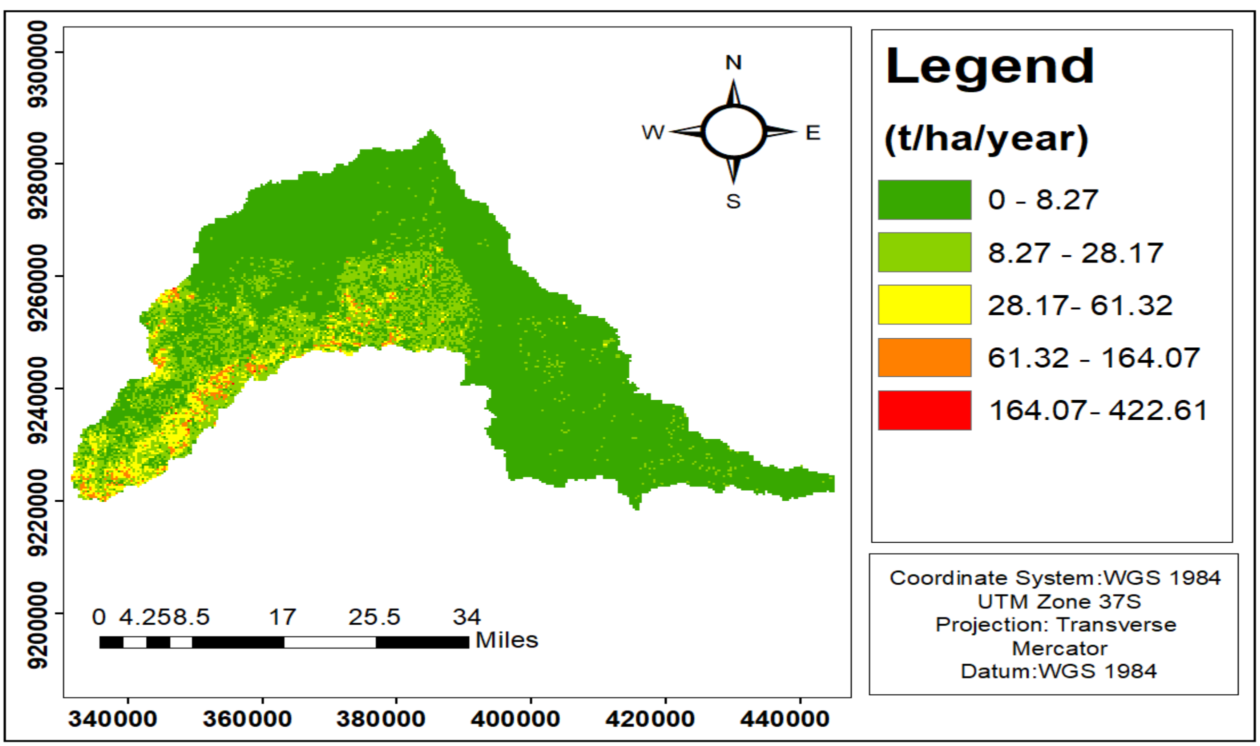

Figure 4.11:Soil loss map of 2022 at Ngerengere catchment area.

Table 4.3:Classes and soil loss range of Ngerengere catchment

S/N	Classes	1991 soil loss range (t/ha/year)	2022 Soil loss range (t/ha/year)
1	Low	0-13.78	0-8.27
2	Moderate	13.78-48.22	8.27-28.7
3	High	48.22-134.32	28.7-61.32
4	Very High	134.32-285.87	61.32-164.07
5	Severe	878.28-878.28	160.07-422.61

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Overview

The chapter based on the findings of the results and on how they have answered the research questions which are summarized in this chapter. The chapter contains conclusion of the research and recommendation which will help for the better results concerning the research.

5.2 CONCLUSION

From the study that has been conducted on the trend of the land cover change of the area of Ngerengere catchment area shows that there has been changes that have occur over the years 1991and 2022. The changes that have occurred have impacted soil loss of Ngerengere catchment area. The changes in the land cover are normally influenced by the activities taking place on the area. Also, there are areas that encounter minimum changes such as the water body area. It can be stated that the area has been experiencing the negative and the positive changes in the land cover.

The evaluation of the landcover change was a useful input in the assessment of the relationship between landcover change and soil erosion. By the Use of the RULSE model that used the rainfall erosivity, soil erodibility, length and steepness of the slope and the cover management factor, it has been observed that there is an influence that the land cover change has over soil erosion that is because over the years 1991 and 2022 the annual average soil loss value obtained from the RUSLE model has been changing with respect to the land cover changes.

5.3 RECOMMENDATION

Based on the results and conclusion provided further studies may be conducted that may involve stakeholders from the Ngerengere catchment area as they may provide with more feasible point of view from their area of expertise concerning soil erosion at Ngerengere catchment area. Also, the study can make use of other methods such as the statistical analysis method and experts' opinion that will ensure all the possible factors contributing to soil erosion are considered and the study is more comprehensive.

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