DETERMINATION OF SUITABLE SITES FOR AIRPORT USING MULTI CRITERIA DECISION ANALYSIS.

Case study of Iringa Urban Municipal

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A Dissertation Submitted in the department of Geospatial Science and Technology in Partial Fulfilment 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 been read and hereby recommend for acceptance by Ardhi University as dissertation titled: “Determination of suitable sites for Airports by using multi criteria analysis a case of Iringa Urban’’ in fulfillment of the requirements for the Bachelor of science degree in Geographical Information System and Remote Sensing.

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DECLARATION AND COPYRIGHT

I, Catherine Aspedito Mfugale the undersigned, hereby declare that the contents of this dissertation are the results of my own findings, obtained through studies and investigations. To be the best of my knowledge, similar work has never been presented anywhere as the thesis for an award of diploma, degree or any other profession in higher learning institution.

Signature.....

Catherine Aspedito Mfugale

(25467/T.2020)

Date.....

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DEDICATION

I would love to dedicate this work to my lovely parents ,my father Mr.Aspedito S Mfugale and my mother Mrs. Adelia P Msasa by the almighty grant them long living life. My Father and my mother who have been my motivation and inspiration in undertaking any responsibility. My sibling's sister Neema , Brother Dennis and Brother Mohammed have had much contribution in my education journey that has led me through the way to achieving what I intended to do may the almighty bless them.

ABSTRACT

Suitability analysis is type of analysis used in GIS to determine the best sites for something like school, Airports, GPP, markets, ranch, dams as to mention a few. Suitable areas or sites can be determined by using different methods, AHP is one of the methods of MCDA by quantifying a complex problem into different hierarchical levels. This research aims on determination of suitable sites for the Airports. Air Transportation is one of fastest means of transportation and believed to be safe thus Airport needs to be placed in areas without causing any damages to human beings. The process of finding the best location for Airport by conventional method is very expensive and time consuming, therefore the use of MCDA can help in finding the best locations which supports in deriving good decision making to authorities for various applications.

The data used for this research are Digital elevation model (DEM), Sentinel 2 image, accessibility data (Road) from the DEM I was able to generate slope and delineate drainage as among of criteria for site selection. Each criterion has its own influence weight based on the comparison pairwise matrix from AHP approach. Followed by the use of GIS based on MCDA and given criterion were able to determine suitable sites for Airport at Iringa Urban.

The result was obtained by overlaying all the criteria layers and their calculated weights by using weighted overlay analysis (WOA) tool within ArcGIS software. Therefore, the suitable sites obtained were of three categories which are low suitable, moderate suitable and high suitable areas for Airport.

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ACRONYMS AND ABBREVIATIONS

ICAO	International Civil Aviation Authority
TCAA	Tanzania Civil Aviation Authority
TMA	Tanzania Meteorological Authority
DEM	Digital Elevation Model
USGS	United States Geological Survey
DTM	Digital Terrain Model
MCDA	Multi-Criteria Decision Analysis
GIS	Geographic Information System
MCDM	Multi-criteria Decision Making
PP	Pre-Processing
SG	Slope Generation
DE	Drainage Extraction
R	Rasterization
WOA	Weighted Overlay Analysis
DN	Digital Number
RI	Random Index
CI	Consistency Index
CR	Consistency Ratio

CHAPTER ONE

INTRODUCTION

1.0 Background of the study

An airport can be defined as area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft (aerodome design and operation, 2018) .An aerodrome can also be called as an airport ,air terminal or air field.

In Tanzania the air transportation regulator is Tanzania civil Aviation Authority (TCAA) the authority deals to ensure safety ,security and regularity of civil aviation in Tanzania through effective oversight ,provision of efficient air navigation services and training while maintaining quality, protection the environment and safeguarding the interest of stakeholders.

According to "Airport site suitability and development based on multicriteria in Egypt" (Essam M. Fawaz, december 2022) many countries were suffering from the problem which is how to select the best location for constructing airports. The substantial population growth in developing countries, especially in Tanzania ,the existing way was a through collecting data from TMA and survey team of the area they want thus lead me to propose for alternative methods or innovative ways to provide the best site locations for establishing national projects, as airports. In the past few years many airports were built for the purpose of security protecting themselves from the enemies. According to standardizations, several of these structures are actual obstacles for air navigation to International Civil Aviation Authority (ICAO) standardization. These obstacles are also affecting the development plans and future expansions of some airports . This condition affects aviation traffic and makes some runways or even airports unusable, resulting in the airport being downgraded from international to national airport in some cases or rendering some runways unusable. Some airports encountered numerous issues as a result of poor site selection planning, resulting in serious problems with airport operation systems, result. Due to the airport's location within an urbanization region, this has an impact on air traffic and aviation navigational aids during take-off and landing.

In another case when airports lie nearby lakes for an example Bukoba affects the aviation movement regarding the climate change(mostly wind) and other factors it brings difficulty on landing and taking off of the airplanes since the plane flies against the direction of the wind . The main goal of this research is to improve this situation and choose the best airport locations.

According to "Airport" by (Ashford) The requirements for aerodromes have increased in complexity and scale since the earliest days of flying. Before World War II the landing and taking off distance of most passenger's transport was at most 600 meters (2000 feet).Additional clear areas were provided for blind landing or bad weather runs, but total area involved rarely exceeded 500acres

More than 100 aerodromes around the world can handle 5million and more passengers per year. In order to meet the increasing demand for air travel large transport aircraft powered by multiple jet and turboprop engines have been built such aircraft requires extensive ground facilities, runways, taxiways, fire-fighting and rescue services, passenger and cargo handling facilities, access to parking and public transport, lighting, navigational and approach aids and various support facilities such as catering, meteorology and governmental inspection.in order to be attractively convenient ,the complex of activities and facilities that make up a modern aerodrome must be located sufficiently close to the main centers of world population at the same time they must be adequately distant so that the environmental problems associated with the noise of large aircraft and the activities of large passenger, workers and visitors do not become intolerable to the cities that are served.

Geographic Information system has been applied to many disciplines including geography, forestry, urban planning, tourism planning, land use, site suitability analysis ((GIS Applicationto Determine suitable sites for Atomatic rice mills in Joypurhat,Bangladesh, 2015) by Ahesan and Marson) but nowadays GIS is recognized widely as a valuable software for managing, analyzing, and displaying large volumes of diverse data related to many local and regional planning activities ((Pareta, 2013)). GIS can be considered as a tool box of techniques and technologies which is widely applicable to analyses site suitability. ((Site Suitability Analysis For Local Airport Using Geographic Information System, 2018) by Pushpakumara and Rodrigo.)

In site selection the we use GIS to carry out suitability analysis and sit selection process because it can handle large amount of data and information. Also, its powerful to visualize new and existing

data , can help produce new maps while avoiding human errors made during decision making in "Geothermal power plant site selection using GIS" (Yousefi & Ehara,2007) spatial multi-criteria analysis can be thought of as process that combines and transforms geographical data (input) into a resultant (output).

The site selection process is divided into many stages, with the first involving geospatial analysis of previously gathered data and features relating to the location that are more easily handled. GIS may integrate spatial, attribute data, and some modules in GIS propose the integration of a powerful decision support system with analytical tools such as multi-criteria optimization methods, spatial analysis, and statistical tools.

Multi-Criteria Decision Analysis (MCDA) is a general framework for supporting complex decision-making situations with multiple and often conflicting objectives that stakeholders' groups and/or decision-makers value differently. A typical example of a decision-making situation assisted by MCDA methods is determination of an appropriate water regulation policy, which has a variety of economic, ecological and social consequences regarded as desirable by some stakeholders and undesirable by others.

It provides significant support for the comparison of alternatives in getting best suitable sites. Multiple criteria considered for GIS modelling in order to achieve sustainable developments in many regions. A successful site selection process may reduce operational cost. The optimum location for new airports sites were identified by defining the criteria, these criteria are topography, urban areas, and geological characteristics, climatological data. The relative significance weighting for each criterion will be calculated using MCDA method. (Morenike, 2016)

Each map layer will be built by overlaying assessments of each criterion map to form the final appropriate map. To assess the correctness and suitability of the candidate locations, a field reconnaissance will be conducted. In this research, an innovative methodology for locating the best site in Iringa that could be used as airport new suggestions is proposed. The suggested methodology aims to create a GIS-based model based on the multi-criteria decision analysis (MCDA) in Iringa.

1.2 Research problem

In Tanzania there are many aerodromes built from the early years, which they were able to accommodate small aircraft but due to technological development in air transportations, there is a

need of accommodating large aircrafts that needs longer runways. Therefore, extension of runways is required or new areas for new aerodromes has to be located. When selecting a suitable area for longer runways or new aerodromes, the authority uses visualization method by locating suitable locations on google earth and later confirms by conducting site visit. With the use of various information from various sources such as climatic data/information from Tanzania meteorological data (TMA) and topographical data/information from google earth, they manage to choose suitable location for the new aerodrome sites. The method in use is neither efficient nor effective.

Thus, proposing an effective and efficient method, which is multi-criteria, decision analysis. This method will perform suitability analysis for aerodrome site using the same criteria used by the authority when selecting a suitable location for aerodrome whereby this process will provide effective and efficient results.

1.3 Research Objectives

1.3.1 Main objectives

The main objective of this study is to determine suitable sites for airports by using multi-criteria decision analysis.

1.3.2 Specific objectives

The specific objectives of the research are:

i. To determine appropriate criteria and data useful for locating Airport
ii. To produce a land cover map
iii. To produce a suitable area for locating airport in Iringa

1.4 Research questions

The following are the research questions which govern this research:

i. Which are criteria needed for selection of the best location of Airports?
ii. Which data can be used in identifying the best location for Airports?
iii. Where are the most suitable sites for location of Airports ?

1.5 Scope and limitation

The scope of this research is to assess suitable areas for aerodromes by using multi-criteria decision analysis based on the criteria used to locate suitable areas for aerodromes. The research also intends to show suitable site of aerodrome in Iringa.

1.6 Significance of the research

The purpose of the research is to determine from all identifiable the most suitable site option for an aerodrome in a particular location given all listed criterions mentioned , this research is therefore aimed at determining better locations for aerodromes.

1.7 Beneficiaries

The following are the expected beneficiaries of this research:

i. Government especially ministry of transportation
ii. Institute which deals with aviation authority like Tanzania Civil Aviation Authority (TCAA)

1.8 Software used

During the research the software utilized was:

- Arc GIS

The Software was used in creating location map , generating slope and drainage from Digital Elevation Model , Image Classification and performing AHP process.

1.9 Organization of the report

Chapter one of this report entails the introduction to the research, statement the problem gives main and the specific objectives of the study, as well as the study area which is Iringa Urban. Furthermore, it gives the research questions, significance, beneficiaries and scope of the research along with the software utilized.

Chapter two gives the conceptual to empirical framework of the research, basing on the objectives of the research and the related terms and phenomena that are necessary to understand to undertake the research.

Chapter three comprise the methodology utilized to conduct the key tasks and give the required deliverables. Some of these methods being Slope layer , Drainage layer ,Road layer and land cover mapping.

Chapter four is all about the results that have been acquired through integration of GIS & RS. The outputs such as classified images, slope map , drainage map and road map covering study area.

Chapter five discusses the results of the study; the implications of the results are brought into focus. Ensuring that the data collected were sufficient, the outputs are later presented and analyzed to meet the requirements

CHAPTER TWO

LITERATURE REVIEW

2.0 Airports

An airport is a location where airplanes take off and land, and where passengers and cargo are loaded and unloaded. It is a complex of runways, taxiways, aprons, and buildings that are designed to facilitate the movement of aircraft and passengers. Airports are typically owned and operated by government or private entities, and they serve as important transportation hubs for both domestic and international travel. Airports are essential for the aviation industry, as they provide the infrastructure necessary for safe and efficient air travel. They are also important for the economy, as they facilitate the movement of people and goods across long distances, which is essential for trade and commerce. Additionally, airports create jobs and generate revenue for local communities.

2.0 Airport characteristics , their uses and effects

2.1.1 Characteristics and uses of An Airport

Airports are transportation hubs that serve as the entry and exit points for air travel. They are designed to accommodate the needs of passengers, aircraft, and cargo. Here are some of the characteristics of airports:

- Location: Airports are typically located outside of urban areas to minimize noise pollution and safety concerns. They are often situated near major highways or public transportation systems to provide easy access for passengers.
- Runways: Airports have long, flat runways that are designed to accommodate the takeoff and landing of aircraft. The length and width of the runway depend on the size of the airport and the types of aircraft that will be using it.
- Terminals: Airports have terminals that serve as the main point of entry and exit for passengers. Terminals are equipped with amenities such as restaurants, shops, and lounges to provide comfort and convenience for travelers.
- Parking: Airports have parking facilities for passengers who need to leave their vehicles while they travel. These facilities may include short-term and long-term parking options.

- Security: Airports have strict security measures in place to ensure the safety of passengers and crew. These measures may include metal detectors, X-ray machines, and security personnel.
- Air Traffic Control: Airports have air traffic control towers that monitor the movement of aircraft in and around the airport. Air traffic controllers communicate with pilots to ensure safe takeoffs and landings.
- Cargo Facilities: Airports have facilities for the handling and storage of cargo. These facilities may include warehouses, loading docks, and refrigeration units.

2.1.2 Airport uses

Airports are essential transportation hubs that serve a variety of purposes. Here are some of the most common uses of airports:

- Commercial air travel: The primary use of airports is to facilitate commercial air travel. Airports serve as the starting and ending points for millions of passengers every day, connecting people to destinations all over the world.
- Cargo transportation: Airports also serve as hubs for the transportation of goods and cargo. Air freight is a fast and efficient way to transport goods over long distances, and airports play a critical role in facilitating this process.
- Military operations: Many airports are also used for military purposes, such as transporting troops and equipment, conducting training exercises, and supporting military operations.
- Emergency response: In times of crisis, airports can be used as staging areas for emergency response efforts. For example, during natural disasters or other emergencies, airports can be used to transport supplies, equipment, and personnel to affected areas.
- General aviation: Finally, airports also serve as hubs for general aviation, including private and corporate aircraft. Many airports have facilities for private planes, including hangars, fueling stations, and maintenance services.

2.1.3 Effects of airports

Airports have both positive and negative effects on the surrounding areas and the wider society. Positive effects of airports include:

- Economic benefits

Airports can generate significant economic benefits for the surrounding areas and the wider society. They create jobs, attract businesses, and stimulate tourism, which can boost local economies. be the ordinary airport is not such a revenue-producer that it alone would support even a medium-sized shopping center nearby. Like food, relaxing and shopping facilities are being incorporated in the grounds of the airport, itself and are being let out as concessions in order to take advantage of all income-producing possibilities; primarily, these include lunch rooms, news-stands, novelty shops, drug counters, and gasoline service stations.

- Improved connectivity

Airports provide a means of transportation that connects people and goods across the world. This can facilitate trade, cultural exchange, and international cooperation.

- Innovation and technology

Airports are hubs of innovation and technology, driving advancements in aviation, logistics, and transportation.

Negative effects of airports include:

- Noise pollution

Airports generate significant noise pollution, which can have negative impacts on the health and well-being of nearby residents. The airplane noise so far, has been an inevitable heritage of every area near an airport is the most objectionable of the three nuisances. The principal source of airplane noise are the propellers, engine exhausts, the engines themselves, airstream, and vibrating parts. The noise level is greatest around large commercial fields since the air traffic is heavier, and large planes are used. Because of the noise factor, people do not want to live near the airport and it is a definite problem to airport planners. It has also been claimed that it is dangerous to live near an airport because of the possibility of a plane crashing. According to ((Effects of exposure to

road,railay airports and recreational noise on blood pressure and hypertension, 2021) by Petri ,Licitra and Fredinelli), exposure to noise pollution from transportation sources such as roads, railways, and airports can have negative impacts on human health, particularly on blood pressure and hypertension. The study found that individuals living near airports and major roads had significantly higher systolic and diastolic blood pressure levels than those living in quieter areas. Furthermore, exposure to recreational noise, such as loud music at concerts or sporting events, can also increase blood pressure levels. These findings are consistent with previous research, which has demonstrated a link between noise pollution and cardiovascular disease. The mechanism underlying this association is thought to involve the activation of the sympathetic nervous system and the release of stress hormones, which can lead to vasoconstriction and increased blood pressure. The study highlights the importance of reducing noise pollution in urban areas to safeguard public health. Policymakers can consider implementing noise barriers, traffic management measures, and promoting the use of public transportation to mitigate the negative effects of noise pollution on cardiovascular health. In conclusion, exposure to transportation and recreational noise can have detrimental effects on blood pressure and hypertension. It is crucial to address this issue through effective noise reduction strategies to promote healthier living environments.

- Air pollution

Airports contribute to air pollution through emissions from aircraft and ground vehicles, which can have negative impacts on the environment and public health.

- Land use and displacement

Airports require large amounts of land, which can displace communities and disrupt ecosystems.

In conclusion, airports have both positive and negative effects on society. While they provide economic benefits and improved connectivity, they also generate noise and air pollution and can displace communities. It is important to carefully consider the impacts of airports and work to mitigate their negative effects while maximizing their positive contributions.

2.2 Suitability Analysis

“Suitability Analysis written by (P.Laube & Rodger's) ,Suitability analysis describes the suitable area for certain phenomenon ,where people need to decide the potential sites. Decision maker’s

needs to consider the following questions: which areas are well suited for dam construction, which areas and human activities will interfere the activities of dam and what are the attributes to consider during dam construction .to answer these questions and others the implementation of decision support techniques with combination to GIS is widely applied .in decision with GIS ,area can be found that meet the multi criteria for one purpose. This is more used when there is more than one criterion but only single objective example in identifying the best location of sites for dam construction different literature says it should be located away from dense settlement and slope of a range 1.5% to 2% .in this case it is called Multi criteria evaluation where in this case of MCE there are several approaches such as:

- Boolean Overlays
- Weighted Linear Combination
- Ordered Weighted Approach
- Analytical Hierarchy Process

2.3 Geographical Information System(GIS)

GIS is defined by several definition which focus on spatial data, users, hardware, software and methods "What is Geographical Information System" by (Westminster, 2000) defines GIS as a computerized based tool for mapping and analyzing spatial data. GIS as the one that allows us to view, understand, question, interpret and visualize data in many ways that reveal relationships, pattern, and trends in the form of maps, globes, reports and charts as illustrated in the figure 2.1 below :

Figure 2.1:Components of GIS

(Esri, 2012) in "What is GIS?" it was defined as a computer software that links geographic information(where things are) with descriptive information(what things are).Unlike a flat paper map, where what you see is what you get ,GIS can present many layers of different information and " (Geographical Information Systems, 2002) by Prakash" defined GIS as a computer system capable of assembling , storing , manipulating and displaying geographically referenced information.

2.3.1 How GIS works

According to (Westminster,2002) a GIS stores information about the world as a collection of thematic layers that can be linked together by geography. This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems from modelling global atmospheric circulation, to predicting rural land use and monitoring changes in rainforest ecosystem.

2.3.2 Importance of GIS

The effective and efficiency ability of GIS to search databases and perform geographic queries has revolutionized many areas of science and business.it can be beneficial during a decision-making process. The information derived from GIS can be presented successfully and clearly in the form of a map and accompanying report, allowing decision makers to focus on the real issues rather

than trying to understand the data. Because GIS products can be produced quickly ,multiple scenarios can be evaluated efficiently and effectively .For this reason , in today's world, the ability to use GIS is increasingly important(Westminster,2000).

GIS application in site selection is applicable in determining the best site or area for something including the location of the best sites. When conducting site selection analysis , analysis must set various criteria from that GIS software can rate the best sites or ideal sites. Site selection analysis can also be conducted with raster and vector data but commonly raster data is mostly used in WSA and BSA whereby the weighted site selection analysis allows users to rank raster cells and assign the relative intensity of importance value to each layer to be used and BSA does not consider the ranking ,it involves the assigning of binary number as 0and 1 to all layers to be used.

2.3.3 Geographic Information System (GIS) based on multiple complex criteria

Geographic information system (GIS) offers a wide variety of tools to manipulate and analyses data however the addition of MCDM analytical techniques provided a powerful means to handle the limitations of GIS when multiple complex criteria and objectives are involved (2003).

Accordingly, the use GIS evolved into a "decision support system" (Eastman.R , Jin.W , P.A.K. , & Toledano.J, 1995)) Since early 1990s, the integration of GIS and multi-criteria decision analysis (MCDA) has gained a growing interest for researchers. The field of land management, for example, has incorporated such methods as: land-use suitability analysis using fuzzy quantifiers via ordered weighted averaging ((Malczewski, 2006)), land-use planning using OWA, multi-objective multicriteria for land allocation using raster analysis , spatial optimization techniques, and mapping landslide hazard zones (Othman.N, Naim., M.W & N.S,, 2012).

In the field of integrated water resources management, the MCDA was well documented by ((Bogardi.J, Dudgeon.D,Lawford.R, Flinkerbusch.E,Meyn.A,Pahl-Wostl.C, Vielhauer.K & Vorosmarty.C, 2012)) also (Collins, 2007) reviewed 113 published papers and concluded that the multiple criteria analysis has been frequently used in water strategic planning and evaluation as well as in selection of infrastructure. For example, to prioritize the protection of drinking water facilities according to their vulnerability to contamination, to select potential areas for groundwater utilization and to satisfy water demand with limited financial capabilities by prioritizing the execution of projects (Machiwal.D,Jha.M, K.M., & Mal.C,, 2011)

2.4 Remote Sensing

By definition (Remote Sensing Environment,2007) defined Remote sensing as the acquisition of information of some property of an object ,by a recording device that is not physical contact with an object (Sensung,2002) defined Remote Sensing as the science of gathering information from a location that is distant from the data source. Image analysis is the science of interpreting specific criteria from a Remote Sensed image. An individual may visually or with assistance of computer enhancement ,extract information from an image ,whether its furnished in the form of an aerial photograph, a multispectral satellite scene ,a radar image , a base of Lidar data ,or a thermal scan.((Aggarwal.S)) Defined Remote sensing as to obtaining information about objects or areas at the Earth's surface without being in direct contact with the object .Remote sensing techniques allow taking images of the earth surface in various wavelength region of the electromagnetic spectrum.

2.4.1 Remote Sensing Process

According to Remote Sensing Environment,2007states that the remote sensing process is referred to as the remote sensing data collection and analysis procedures used for earth resources applications are always implemented in a systematic way as shown in the figure 2.2 below**:**

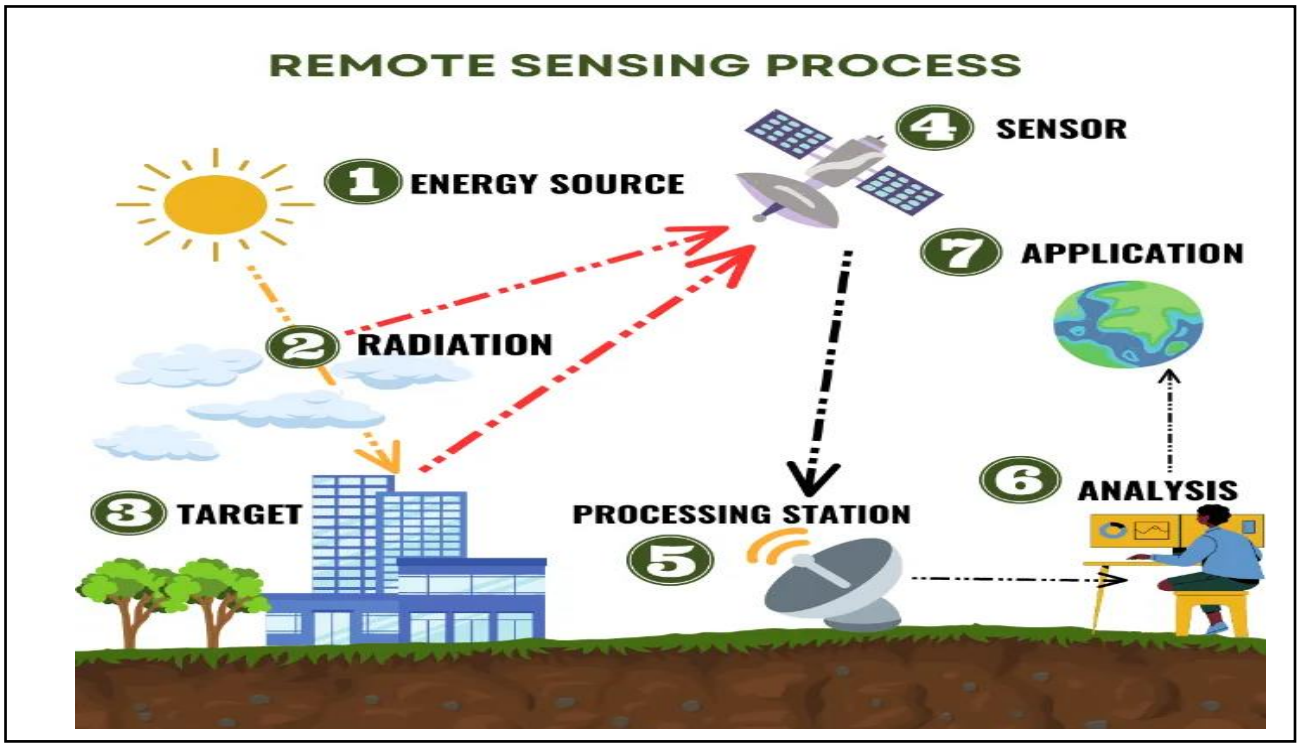
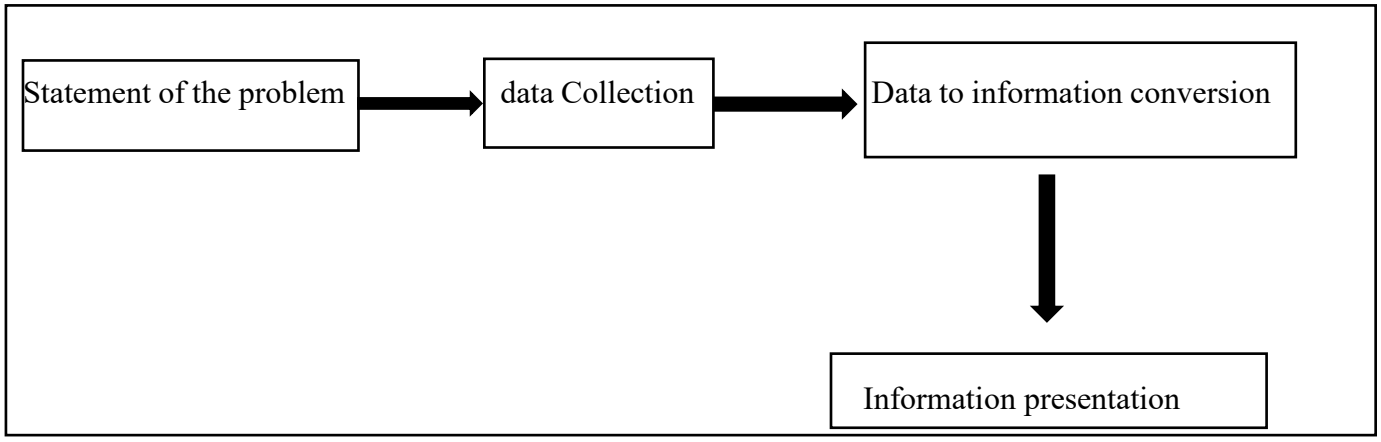


Figure 2.2 :RS Process

Where Remote Sensing Environment process can be summarized the whole process of remote sensing as below



Also ((Aggarwal.S))Described the stages in Remote sensing as follows:

- Emission of electromagnetic radiation ,or EMR (sun/self-emission)
- Transmission of energy from the source to the surface of the surface of the earth, as well as absorption and scattering
- Interaction of EMR with the earth's surface :reflection and emission.
- Transmission of energy from the surface to the remote sensor
- Sensor data output

2.4.2 Importance of Remote Sensing

According to Remote sensing can facilitate the fundamentals biophysical information ,including the x, y and z location , biomass, moisture content and temperature under controlled condition, it provide derived information which is now critical to the successful modelling of numerous natural example non-point source pollution ,eutrophic studies and water supply estimation ,the passive remote sensing is potential that it cannot disturb the object or area of interest and lastly remote sensing devices can be programmed to perform collection of data in systematic way example within 9*9 in frame of the vertical photography

Remote sensing data and techniques is applicable to solve problems ,address policy implications and to improve the making decision process focusing on the land cover and land use change where by the Sentinel image will be used for the purpose of assessment of land cover changes.

2.5 Image pre-processing

Image pre-processing operations which are also referred to as image restoration and rectification. The pre-processing techniques are concerned with the removal of data errors and of un-wanted or distracting elements of the image (Pal & Mather, 2003). There are two image pre-processing which are:

- Radiometric corrections.
- Geometric corrections.

Radiometric corrections

Radiometric corrections involve improving the surface spectral reflectance, emittance, or backscattered measurements obtained using remote sensing system. They are caused by sensor Errors which are due to mechanical, electronic or communication failures of sensors and due to atmospheric errors, which are caused due to atmospheric constituents' interaction with EMR. Radiometric errors affect the digital number (DN) stored in an image.

Geometric corrections

Geometric errors change the position of a DN value and it involves placing the corrected pixels in their proper locations or reference system. Two approaches are used which are:

- Geo-referencing which relates the image coordinates to map coordinates by a set of transformation.
- Geocoding which is a process of changing the pixel size value of a given raster map (image) by resampling the raster map such that the resolution of a given picture element (pixel) is changed to any desired size to suit a particular use.

2.6 Image classification

Image classification is the process of assigning pixels to nominal which results to the thematic classes. The principle of image classification is that a pixel is assigned to a class based on its feature vector by comparing it to the predefined clusters in the feature space where by doing so all image pixels results in a classified image. The process of image classifications typically involves five steps which are:

i. Selection and preparation of the image data depending on the cover types to be classified, the most appropriate sensor, the most appropriate dates of acquisition and the most appropriate wavelength bands should be selected.
ii. Definition of the clusters in the feature space where two approaches are used which are supervised and unsupervised classification.
iii. Selection of classification algorithms where the operators need to decide on how the pixels (based on their DN) are assigned to the classes.
iv. Running the actual classification which is done once the training data have been established and the classifier algorithm is selected. This means that based on its DN values, each pixel in the image is assigned to one of the predefined classes.
v. Validation of the result which is done once the classified image has been produced its quality is assessed by comparing it to reference data (ground truth). This requires selection of sampling technique of a sampling technique, generation of an error matrix and the calculation of error parameters.

2.6.1 Principle of Image Classification

Pixel is assigned to a class based on its feature vector, by comparing it to predefined clusters in the feature space. Doing this for all image pixels results in a classified image. The crux of image classification in comparing it to predefined clusters, which require definition of clusters and methods of comparison. Definition of clusters is an interactive process and is carried out during the training process. Comparison of individual pixels with the clusters take place using classifier algorithms.

2.6.2 Classification scheme

This shows how the classes will be chosen during the process of image classification. There are several classification schemes and one of them is Anderson's classification scheme. This was developed for the use with remote sensing data both aircraft and satellite based. The advantages of this classification scheme are can be used for many applications by selecting the level of the detail desired and many of the classes are not separable over large areas using remote sensing observations.

There are four levels of Anderson Classification scheme;

- Level one, general classification that is it explains in general about a certain feature for example built up area
- Level two, this level describes more about level one for example a residential area
- Level three, this level gives more description on level two for example government office
- Level four, this level represents the most detailed of classification.

Classes chosen during the process of image classification. The classes can be chosen;

- Based on pixel information.

Based on pixel information and are classified as pre-pixel classification, sub pixel classification, profiled classification, contextual classification, knowledge-based classification and combination of multiple classifications.

- Based on training samples.

Based on use of training samples and are classified as supervised classification and unsupervised classification.

Supervised classification methods require input from an analyst. The input from analyst is known as training set. All the supervised classifications usually have a sequence of operations that must be followed:

- Defining of the Training Sites.
- Extraction of Signatures.
- Classification of the Image

2.6.3 Computer assisted classification

Computer assisted classification is one among the classification methods, the other ones be manual and object-oriented method. Depending on the interaction between the analyst and the computer during the classification, there are two types of classification which are:

i. Supervised classification
ii. Unsupervised classification

Supervised Classifications

In supervised classification the operator defines the spectral characteristics of the classes by identifying sample areas (training areas). Supervised classification requires that the operator to be familiar with the area of interest. The operator needs to know where to find the classes of interest in the area covered by the image. This information can be derived from the general area knowledge of from dedicated fields observations (Pal & Mather, 2003).

Unsupervised classifications

In supervised classification, clustering algorithms are used to partition the feature space into a number of clusters. The algorithms examine the unknown pixels in an image and aggregate them into a number of classes based on the natural grouping or clusters present in an image. In performing classifications, image values within a given class are close together while image values in different classes are comparatively well separated

2.6.4 General stages in performing supervised classification

i. Training stage.

The analyst identifies representative training sites and develops a numerical description of the spectral attributes of each feature imaged (Rehna & Natya, 2016). The training effort is both an art and a science. It requires close interaction between the image analyst and the image data. It requires substantial reference data and a thorough knowledge of the geographic area represented by the data. The training stage is important as it determines the quality of the information generated through classification. It helps to yield quality classification results; training data must be representative and complete but also to include all spectral classes and to include all information classes to be discriminated. In the training stage is were the

- The number of classes are identified
- The Training sample per each class
- The selecting and identifying validation samples and training samples. The validation samples are the samples that are used to qualify the performance. The training samples are the samples used to create the model. Training samples are always 70% of all samples while the validation samples are 30% of all samples.

- Class separability. This is the statistical measure between two signatures and can be calculated by Euclidean distance, Divergence, Transform divergence and Jeffries (Rehna & Natya, 2016).

ii. Classification stage.

Training sites are used to categorize each pixel in the image data into the land feature class it most closely resembles. A number of mathematical approaches exist for this purpose that is spectral pattern recognition. Select appropriate classification algorithm Example Minimum Distance to means classifier, Parallelepiped classifier, and Maximum Likelihood classifier, Support vector machine. The actual classification is done here. Classifiers, it's a computer program that implements a set of procedures for image classification. There are different methods/strategies to image classification ((Lillesand.T , Chiemeri & Kiefer.R, 2007)). Example ML classification, composed of various sets of procedures. A proper selection of a classifier is required for good accurate results. The classifier selected was; Support Vector Machine.

iii. Output stage

In this stage Presentation of the results of the categorization process. The output must effectively convey the interpreted information to its end user. The output might be in the form of Graphic files, Tabular data, and Digital information file. It is in this place where Accuracy assessment is done. Accuracy assessment determines the correctness of a classified image based on pixel groupings. Example the categories of real-world features presented. The results of classification are assessed using a confusion matrix.

- User accuracy

Probability that a certain reference class has also been labelled as that class. In other words, it tells us the likelihood that pixel classified as a certain class actually represents that class.

- Producer accuracy.

Probability that a sample point on a map is that particular class. It indicates how well the training pixels for that class have been classified (Rehna.V & Natya,J, 2016).

2.7 Land use and land cover mapping

The term land use and land cover are often used interchangeably, but each term has its own unique meaning, land covers refer to the surface cover on the ground like vegetation, urban infrastructure, water, bare soil etc. Identification of land cover establishes the baseline information for activities like thematic mapping and change detection. On the other side land use refers to the purpose the land serves for example recreation, wildlife habitat or agriculture.

Land use and land cover map play a significant and prime role in planning, management and monitoring programs at local, regional and national levels. This type of information, on one hand provides a better understanding of land utilization aspects and other hand, it plays an important role in the formation of policies and programs required for development planning.

2.8 Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) developed by Saaty in the late 1970s, is one of the methods for multi- criteria decision making. The AHP disaggregates a complex decision problem into different hierarchical levels. The weight for each criterion and alternative is judged in pairwise comparisons and priorities are calculated by the Eigenvector method. The slowly increasing application of the AHP was the motivation for this study to explore the current state of its methodology in the site selection of geothermal power plant.

The standard method to calculate values for the weights from an AHP matrix is to take the Eigen vector corresponding to the largest Eigen value of the matrix and then normalized the sum of the components to one. The process involves creation of the pairwise matrix that would define number of comparisons to be performed based on the number of factors involved. From the pairwise matrix the normalized scores are also obtained. The Eigen vectors for each factor are obtained from the normalized scores. Judgment on the weights assigned is performed through computation of Consistency Ratio (CR). The CR is obtained from the Consistency Index (CI) and the Random Index (RI).

$$CR = CI/RI$$

The consistency index defined by CI, defined by ($\lambda max - n$)/ (n -1), defined information about logical consistency among the pairwise matrix. When CI=0, it means the judgment is considered 100% consistent. As the value of CI grows, it also indicates the growth of logical inconsistence in

the pair wise comparison judgment. Also, RI is delivered from Saaty as seen in table 2.2 in which upper row is the number of criteria and the lower row is the RI. Consistency ratio (CR) is used to determine whether the inconsistency is acceptable or not. The condition of CR says that, if CR<0.10, then pairwise comparisons are acceptable; if, however CR≥0.10, the values of ratio are indicative of unreliable decisions.

Table 2 1: Saaty's pairwise comparison

Intensity of Importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience and judgment slightly favor one over the other
5	Much more important	Experience and judgment strongly favor one over the other
7	Very much more important	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice.
9	Absolutely more important	The evidence favoring one over the other is of highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed

Table 2 2: Random indices by Saaty

n	3	4	5	6	7	8	9	10
R1	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

CHAPTER THREE

METHODOLOGY

This chapter describes the data used, methods, approaches and the procedures followed to the datasets, methods to obtain results.

3.1 Description of the study area

The study area encompasses the Iringa Urban district found in southern highlands in Iringa with a total area approximately 176.987 square kilometers. The districts lie between 35°E to 36°E and 7°S to 8°S with an average elevation in range of 900m to 2300m and altitude is between 1560 and 2000 meters above mean sea level. Its population is about 111,820 people(census 2022). The Iringa urban district has almost 18 wards. Iringa has a fairly dry subtropical highland climate bordering on a tropical savannah climate with wet season from December to April also its average rainfall is approximately 740millimeters per year. The figure 3.1 below shows the area of the study:

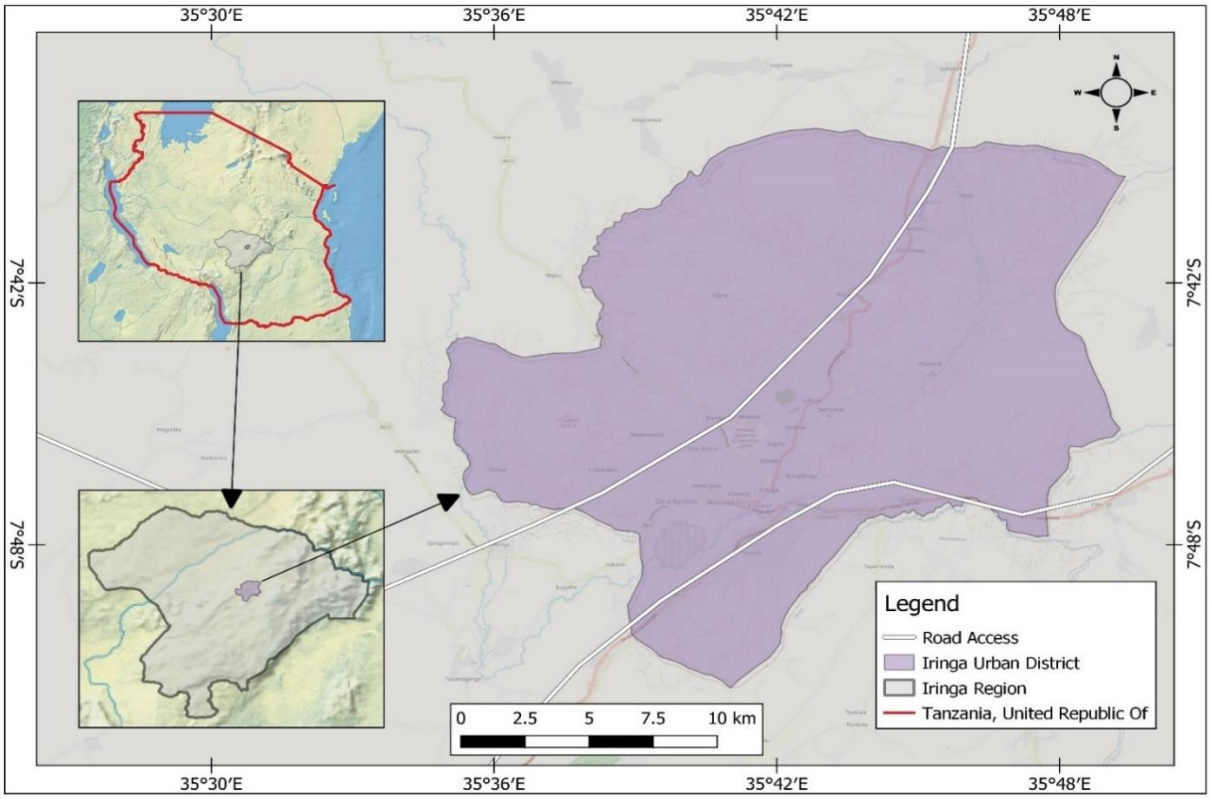


Figure 3.1: Study area map

3.2 Flow chart methodology

This research is expected to follow the steps as shown in figure 3.2

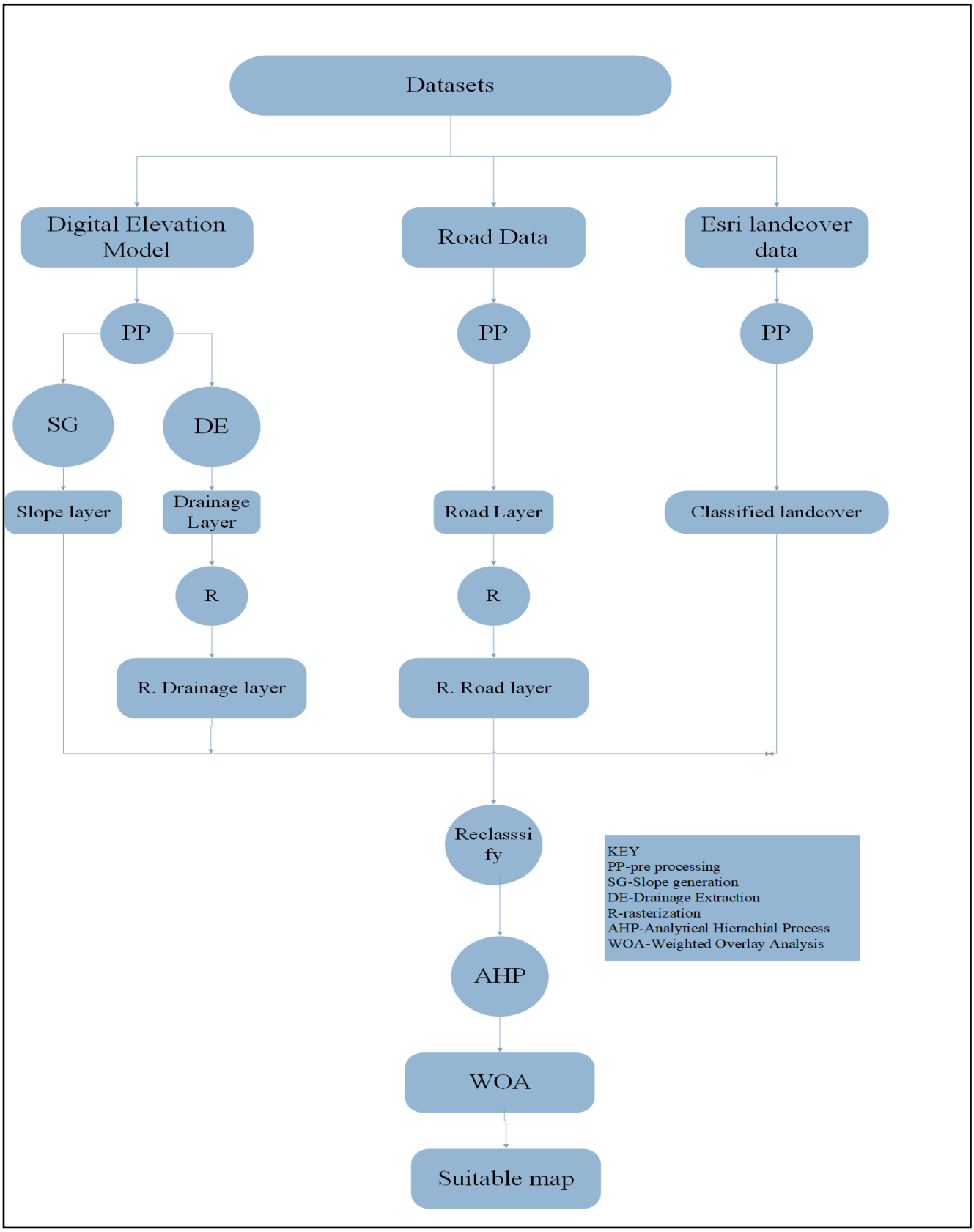


Figure 3.2:Flowchart

3.3 Criteria for site selection

Criteria can change with the purpose and the type of the airport. Although they can be changeable, there are certain criteria which are important for the authority. (BAHÇELİOĞLU, 2014);

i. Topography

Topographical considerations that should be taken into account are: (1) the grading that will be required to meet the standards for maximum runway grades, which vary from 1.5 percent to 3.0 percent depending upon the class of the airport; (2) selection of a site which departs sufficiently from the dead level to allow adequate natural drainage, but does not have portions so steep that serious erosion may result in drainage the vector form result was buffered to 60M that is underthat distance it is not suitable for airport selection; and (3) selecting an location where the soil is pervious, yet has a suitable amount of natural binder, and where the water table (ground water table) does not come too close to the surface.

ii. Population Centre

The site must be far from population center, and to avoid of selection or affect these areas, eleven-kilometer buffer size must be applied around these features to make the population center limited data layer. This factor examines the magnitude of property to be acquired for each candidate site. The airfield layout, the size and shape of existing parcel ownership, and other impacts to neighboring parcels can affect the amount of property necessary to be acquired. Also included for consideration under this category will be residence acquisition.

iii. Accessibility (roads)

One of the most important factors influencing the selection of an airport site is its accessibility to the destination and source of the passengers and cargo. This is a particularly vital consideration for commercial airports since one of the great advantages of air travel is its advantage of shorter travel time over other means of transportation. To provide maximum service to an area, an airport should be located in reasonable proximity to the population center it is to serve. The location in relation to business and industry should also receive attention. Preferably, the airport should be located adjacent to and visible from a major highway route. In Road data buffering was done under

60m on both sides of the roads It is easy to access by using local and transient roadways. Driving time and distance to the center should be maximum sixty minutes

iv. Obstruction and Airspace

An analysis of the relationship with the airspace requirements of the existing airport system is essential. It is also necessary to review the envelope area of each site for the presence or absence of potential obstructions to aircraft activity. Certain obstructions may be considered immovable or too expensive to move when other options are available (e.g., large land forms, tall communication towers, major power lines, water towers, etc.). under the height of 121M no object is allowed to be above that height such as smaller power lines, trees, buildings, and roads, impose a cost of removal or relocation that must be considered.

3.4 Data and their sources

- Digital Elevation Model

This data was downloaded from United State Geological Survey (USGS) Earth explorer (Https:earthexplorer.usgs.gov).it was downloaded as Shuttle Radar Topographical Mission with a resolution of 30m in Geo Tiff format. The figure 3.3 below shows the topography of Iringa Urban

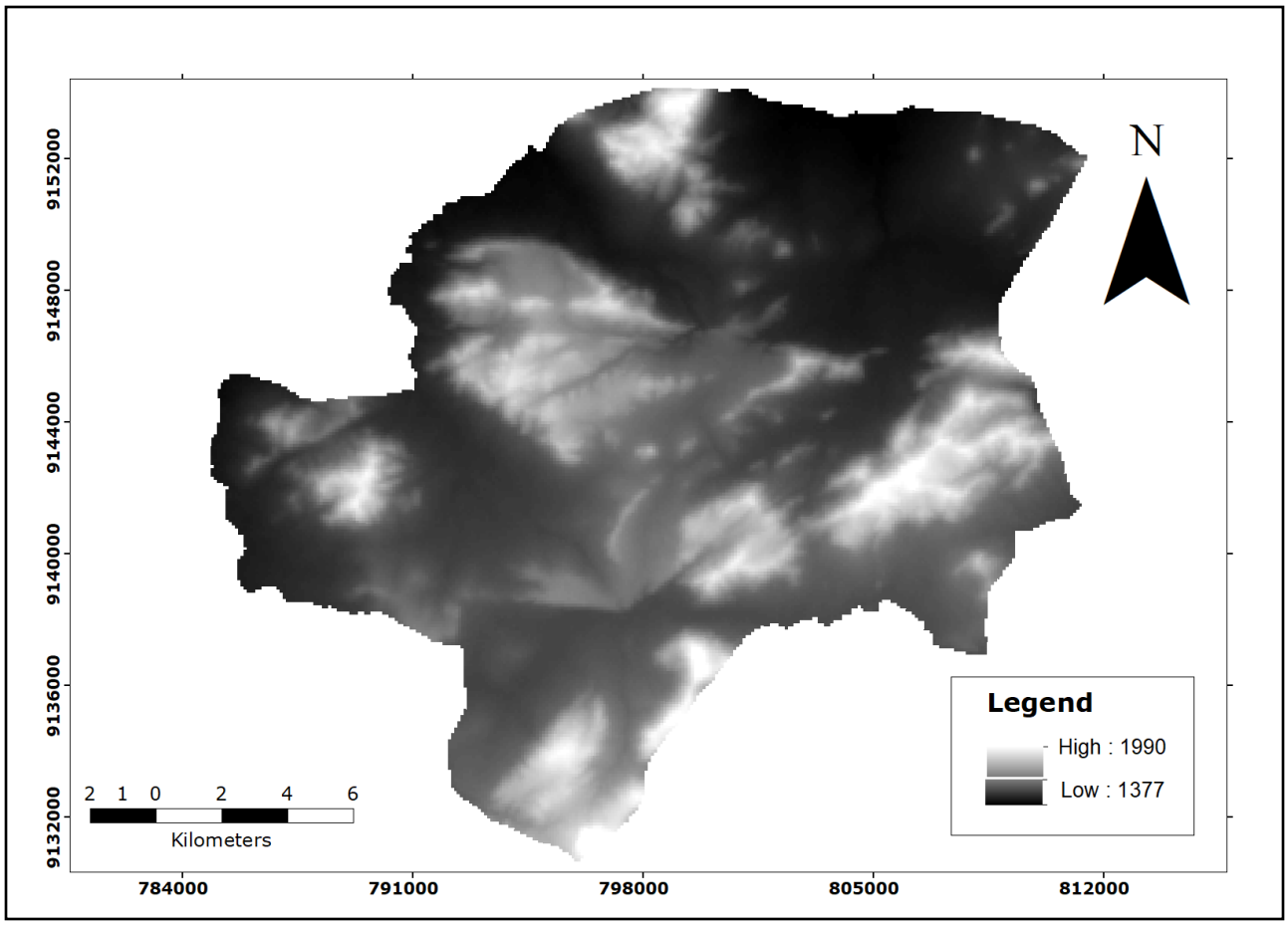


Figure 3.3:Iringa Urban DEM

- Road data

The road data was downloaded from DIVA GIS with shapefile format the road data shows all the main roads of the Iringa Urban district.the figure 3.4 below shows roads in Iringa Urban

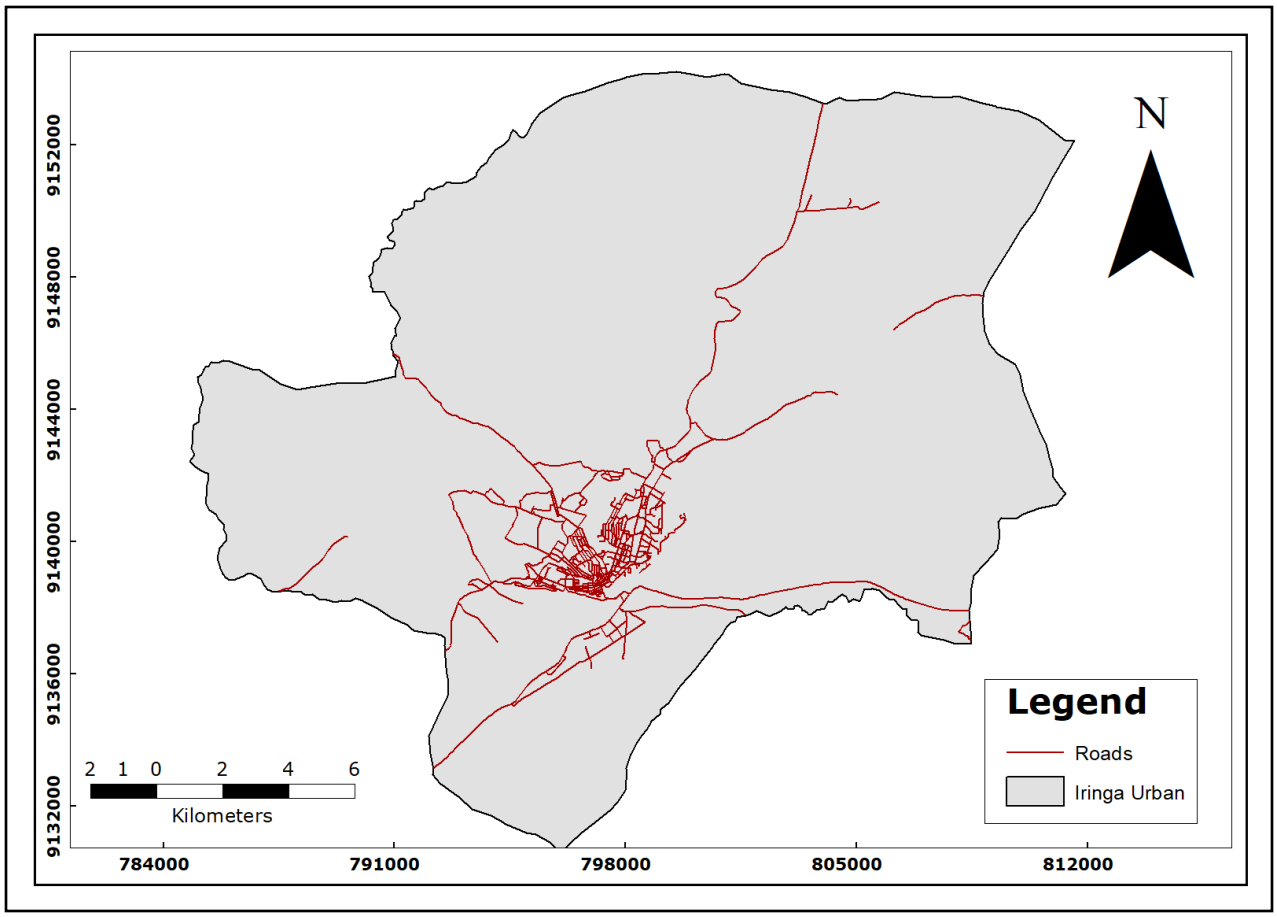


Figure 3.4:Road Data

- Sentinel Image

In this part data was download from Copernicus as our source of data, i downloaded Sentinel 2 images of three years which are 2022

After obtaining the criteria helped to know the type of data to use as shown in table 3.1. Table

Table 3.1: Data and their sources

S/N	DATASET	RESOLUTION	FORMAT	SOURCE
01	Sentinel 2 image	10m	Tiff	Copernicus
02	SRTM DEM	30m	Tiff	United State Geological Survey (USGS) Earth explorer (Https:earthexplorer.usgs.gov)
04	Road data		Shape file	DIVA GIS (https: www.divagis.org)
05	Administrative boundary		Shape file	DIVA GIS (https: www.divagis.org)

3.5 Data Pre-Processing

3.5.1 Projection and Reshape

Most of the data used in this study have original projection of GCS_WGS_1984 that is Geographical Coordinate system which uses degree described angular unit. Geographical Coordinate system which contains spherical coordinates system was projected to match the mapping system used in my study that is ProjectedWGS_1984Zone 36S.

3.5.2 Image Sub setting.

The re-projected images were subset to represent the area of our interest. This was accomplished with ARC GIS software using the extraction spatial analyst tool specifically extracting by mask whereby the shape file of Iringa urban was the input feature mask data and the re-projected image was our input raster. Consider the figure 3.5 below shows Sub-setted image

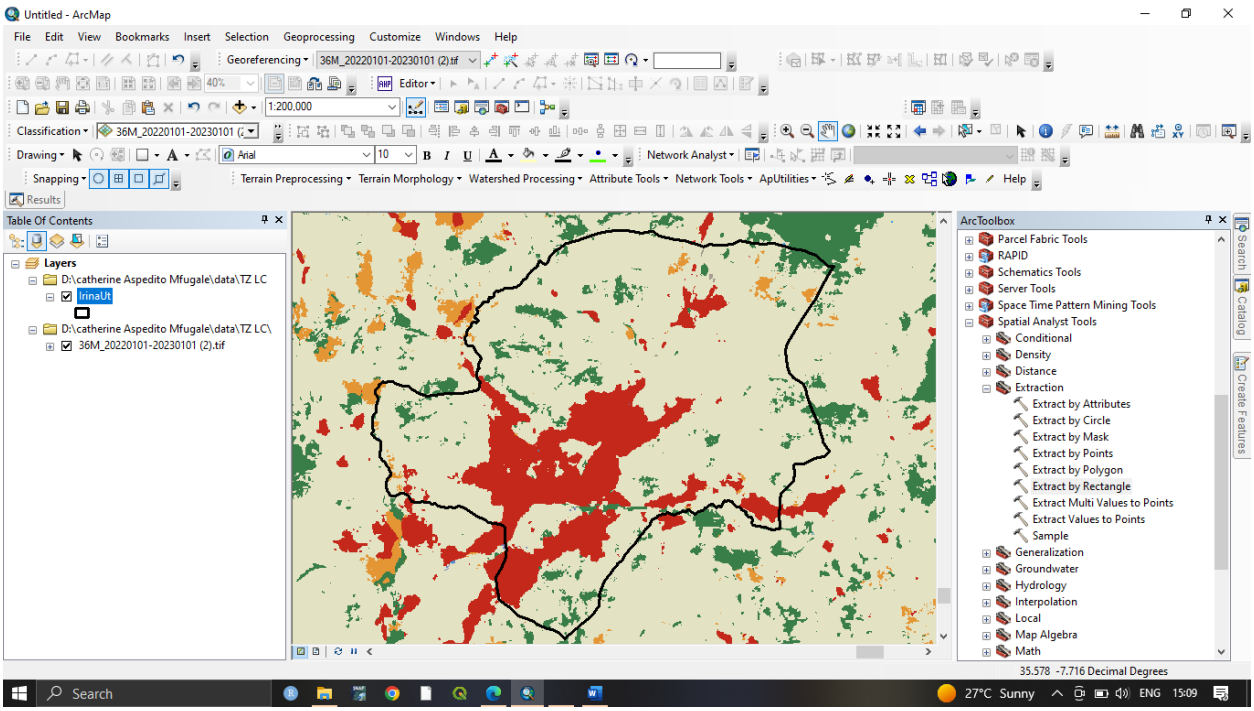


Figure 3.5:A picture showing screen dump of clipped image

3.6 Data Processing

The layers consisting Slope, Drainage, Roads and Population (land cover) layers were created by ArcGIS software in which each layer was created separately in GIS environment through uploading data.

3.6.1 Slope Generation

According to (Dai,2018) slope can be expressed in terms of degree slope and percentage slope, Slope in degree which is applied in this study describe angle between ground surface and horizontal and slope in percentage describe the percentage ratio of elevation change on the horizontal distance change.

Digital Elevation Model (DEM) of 30M resolution was added in the Arc Map environment with the shapefile of case study, by using extraction by mask tool the DEM of area of interest was extracted. After obtaining the DEM of area of interest, slope was generated by using surface tool in Arc GIS toolbox. The figure below shows the slope of Iringa urban

3.6.2 Road Layer

Road layer was added into ArcMap and the main roads were selected and by using Clip tool within Arc GIS software the roads at the area of interest were obtained. Then the road network as the one of the criteria were buffered to 60m so as to have the suitable site.

Since the buffered road layer obtained was in vector dataset then by using **conversion tool → to raster from → from polygon,** I converted the buffered road layers into raster.

3.6.3 Delineation of Drainage network

The drainage was delineated from the DEM and was carried out by using the Arc Hydro extension plug-in within Arc GIS software (https://downloads.esri.com/archydro). The main steps in DEM processing are sequential as identified in the figure 3.6 below:

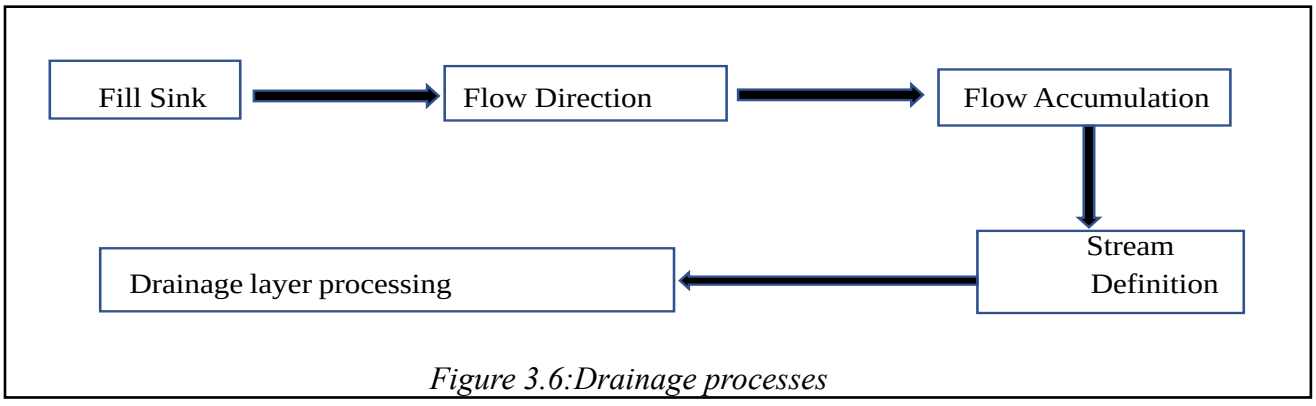


Figure 3.6:Drainage processes

- sink fill

This function fill Sinks in a grid. If a cell is surrounded by higher elevation cells, the water is trapped in that cell and cannot flow. The Fill sink's function modifies the elevation value to eliminate these problems, in which the Dem was input.

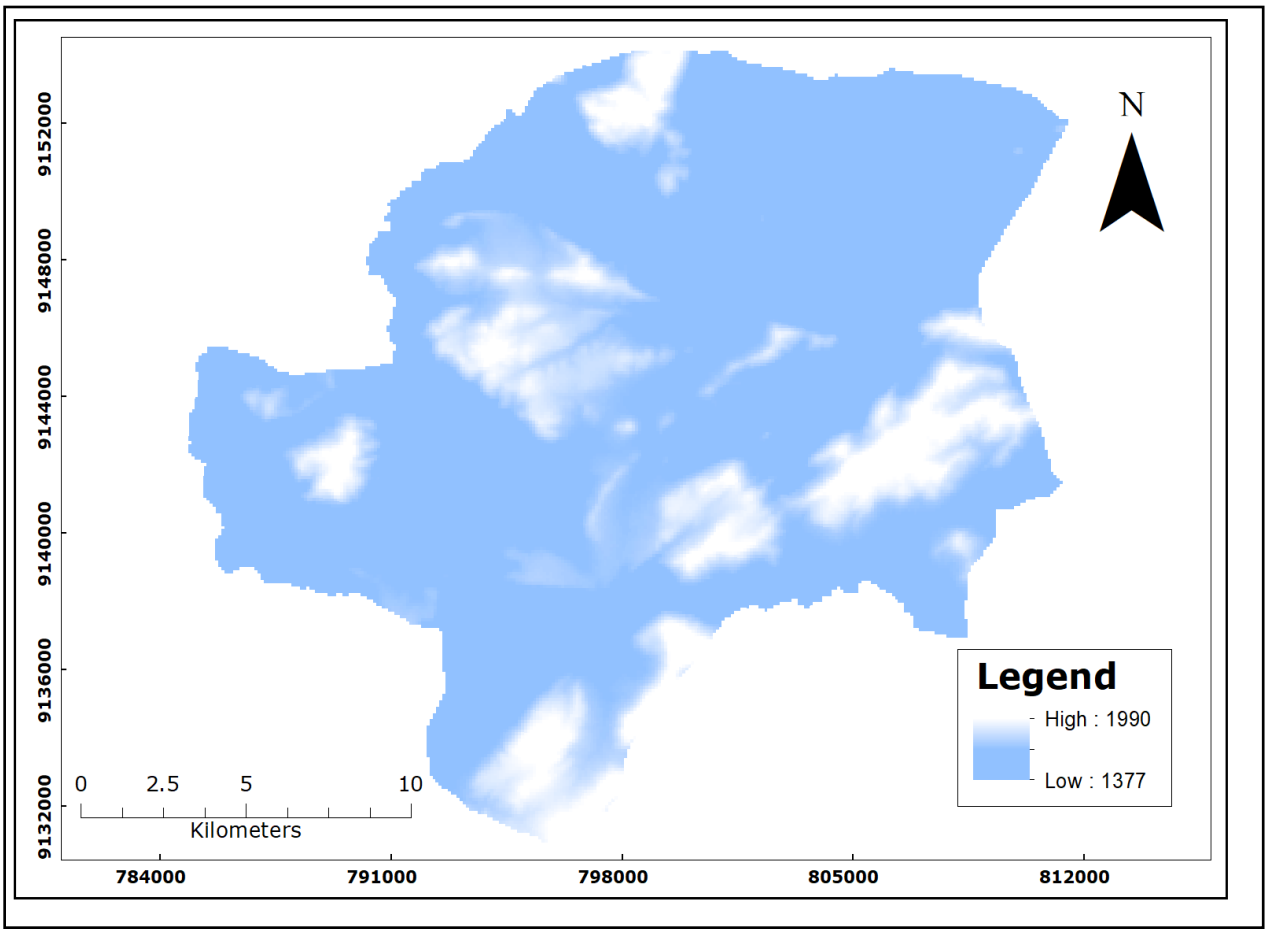


Figure 3.7:Fill sinks

- flow direction

the function computes the flow direction for a given grid. The values 1,2,3,4,5,16,32,64 and 128 in the cells of the flow direction grid indicated the steepness descent from that cell as show in the figure below.in this function of the identification of flow direction by using the flow direction tool and the input was the fill sink result.

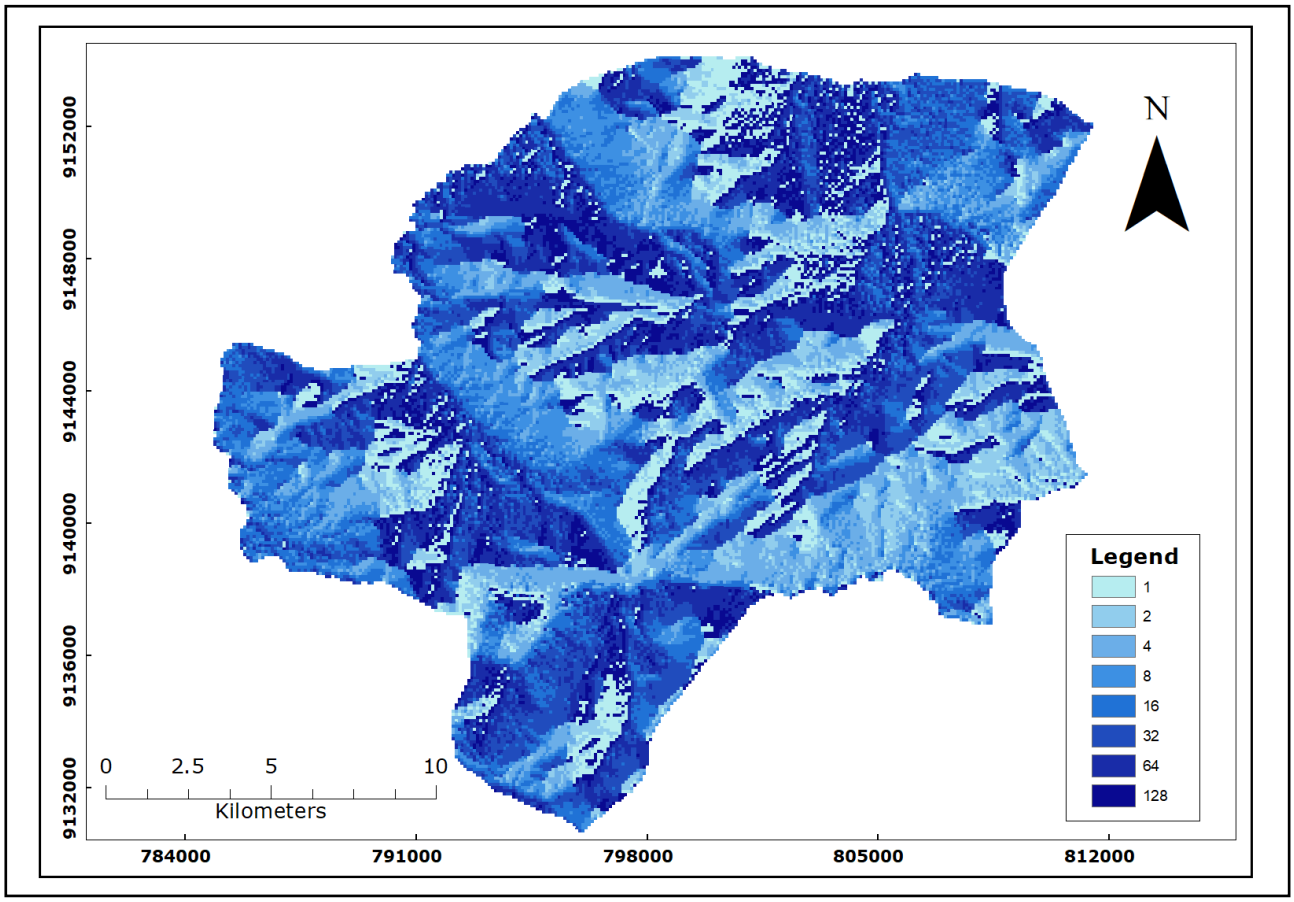


Figure 3.8:Flow Direction

- flow accumulation

After flow direction the next step was calculation of flow accumulation which used input of flow direction result. This function the flow accumulation grid that contains number of cells upstream of a cell upstream of a cell, for each cell in the input grid. According to (Dai,2016)resulting grid illustrated the increase flow accumulations as it goes downhill into the flow network.

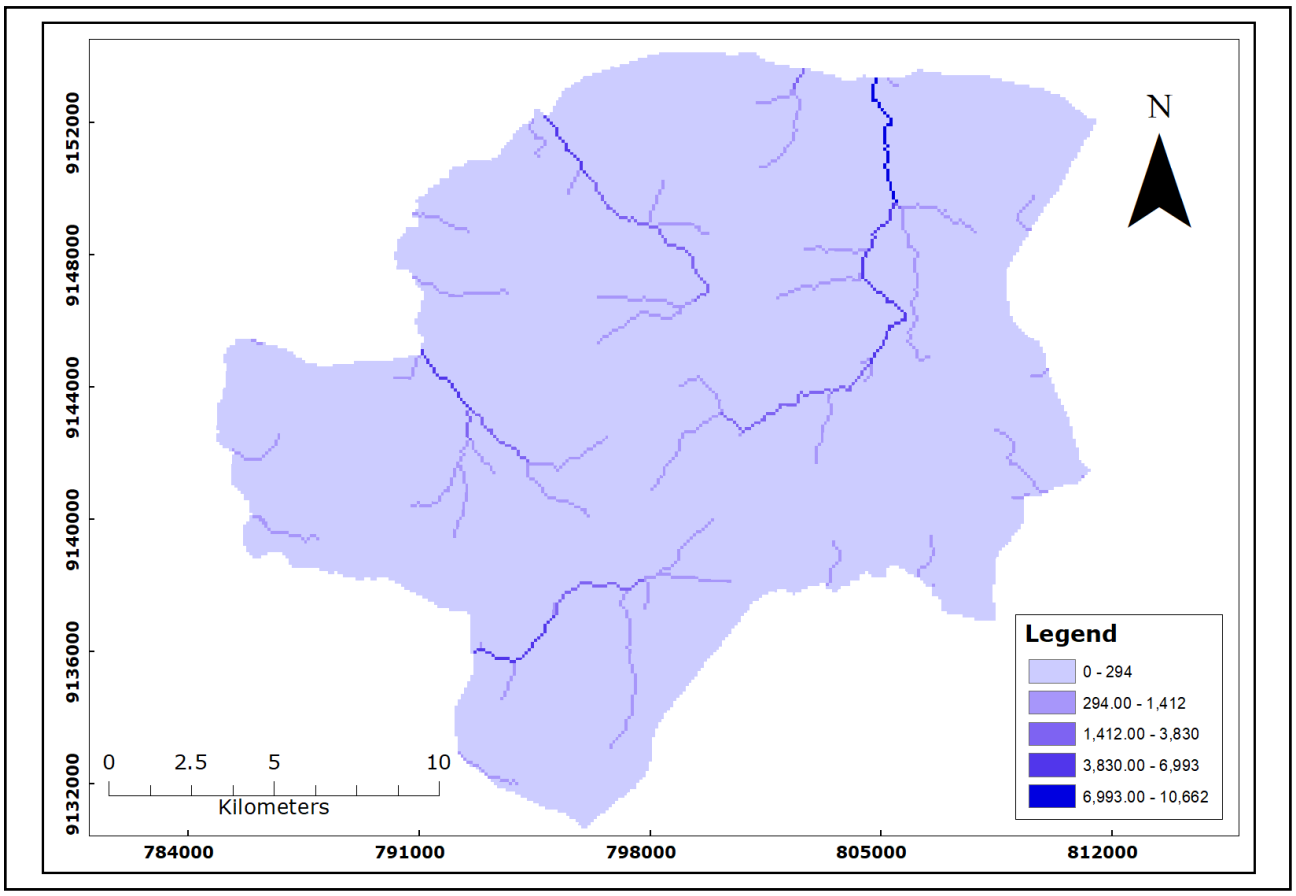


Figure 3.9:Flow Accumulation

- stream definition

and lastly stream definition were done by combining the result of flow direction and reclassified result of flow accumulation by using stream definition in Arc Hydro extension which result to raster drainage map.

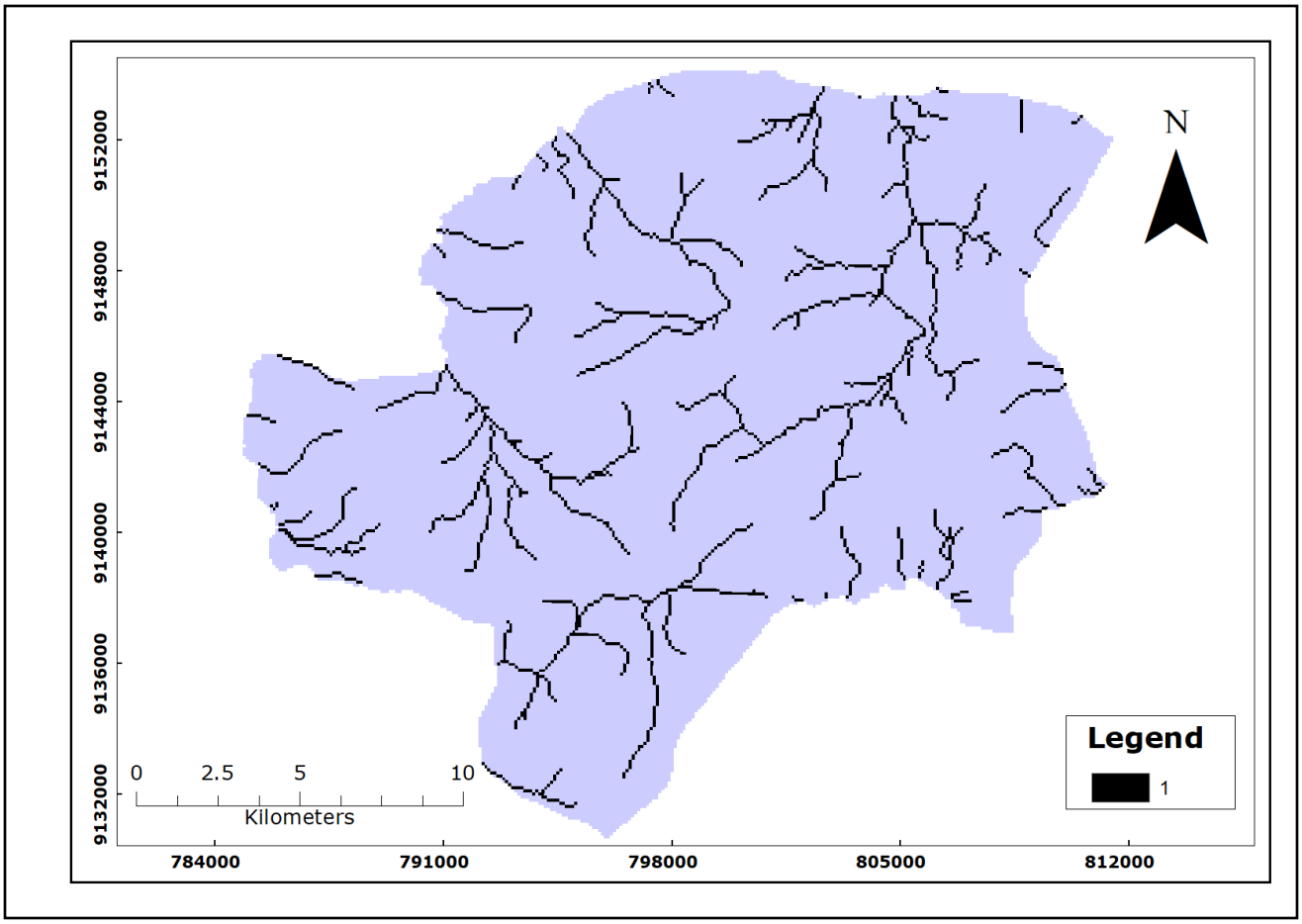


Figure 3.10 :Stream Definition

So, to obtain the vector of drainage I used **conversion tool → from raster to → to polyline** then the drainage appeared as vector. After obtaining the drainage as the layer which is among of the criterion, I had to buffer the drainage to 60m as the standard of proximity to reach the suitable site by using **Geoprocessing tool → buffer** within Arc GIS software. Then by using **conversion tool → to raster from → from polygon** I converted the buffered drainage from vector to raster layer.

3.7 Image Classification

Multiband image from sentinel was added in Arc GIS software and supervised approach was used. There are several image classification techniques used but for I opted to use supervised classification which involves controlling the process by the selection of classes based on the nature of the area, collecting training samples for ground truthing data. It involved the following steps:

i. Classification classes

The following classes were used:

- Built-up area
- Bare land
- Shrubs
- Vegetation
- Water bodies

ii. Selection of training set:

In Arc GIS software training set from ground truthing data were imported in the form of shapefile to the raster satellite image in order to define various classes in the area of interest.

iii. Editing Signature

In signature file various classes were selected to train the software to assign the class to the pixels, then all matching classes were merged together and renamed according to the class that represents.

iv. Classifying the image

The image was classified by the use of supervised classification approach in Arc GIS software by applying the maximum likelihood algorithm based on the decision rule and the probability that a pixel belongs to a particular class for sentinel image.

3.8 Analytical Hierarchy Process (AHP)

Table 3. 2: Pairwise comparison matrix

	PAIR WISE COMPARISON MATRIX			
CRITERIA	SLOPE	DRAINAGE	LC	ROAD
SLOPE	1	3	5	5
DRAINAGE	0.333333333	1	3	3
LC	0.2	0.333333333	1	3
ROAD	0.2	0.333333333	0.33333	1
Σ	1.733333333	4.666666667	9.33333	12

Table 3. 3: Normalized scores

	NORMALIZED SCORES					
	SLOPE	DRAINAGE	LC	ROAD	EIGEN VECTOR	EIGEN VECTOR (%)
SLOPE	0.576923077	0.642857143	0.53571	0.416667	0.543040293	54.3040293
DRAINAGE	0.192307692	0.214285714	0.32143	0.25	0.244505495	24.45054945
LC	0.115384615	0.071428571	0.10714	0.250000	0.135989011	13.5989011
ROAD	0.115384615	0.071428571	0.03571	0.083333	0.076465201	7.646520147

Table 3. 4: Principle Eigen value

	PRINCIPLE EIGEN VALUE TABLE		
Thematic Map	Σ of Column(x)	Eigen vector(y)	x*y
SLOPE	1.733333333	0.543040293	0.94127
DRAINAGE	4.666666667	0.244505495	1.14103
LC	9.333333333	0.135989011	1.26923
ROAD	12	0.076465201	0.91758
		λ max	4.26911

Table 3. 5: Consistency Index

CI	0.0897

Table 3. 6: Consistency Ratio

CR	0.09967

The condition of CR says that, if CR<0.10, then pairwise comparisons are acceptable; if, however CR≥0.10, the values of ratio are indicative of unreliable decisions.

Then since the pairwise comparison was acceptable, the value of weights was.

Table 3. 7: Weighted value

	EIGEN VECTOR (%)
SLOPE	54
DRAINAGE	24
LC	14
ROAD	8

3.9 Determination of suitable sites

The final suitability obtained by using reclassified selected criteria layers and their weights. This was done by using the weighted overlay tool from spatial analyst within ArcGIS software.

- Weighted Overlay

  This is a multiplication overlay between layers. All weighted suitability criteria layers multiplied together in the weighted overlay operation. Scale values for each criterion were assigned by weights of the input raster as were determined using AHP method.

CHAPTER FOUR

RESULTS AND ANALYSIS

This chapter depicts the results which were obtained from the methodology. It aims at reviewing whether the objectives of the study have been attained or not. The following are the results obtained;

4.1 Slope map

The slope generated was obtained by using percentage rise and results to have range of degree from 0 to 37.511 as shown in figure 4.1.In the figure below it is a slope map which shows areas with high gentle and steep slope.

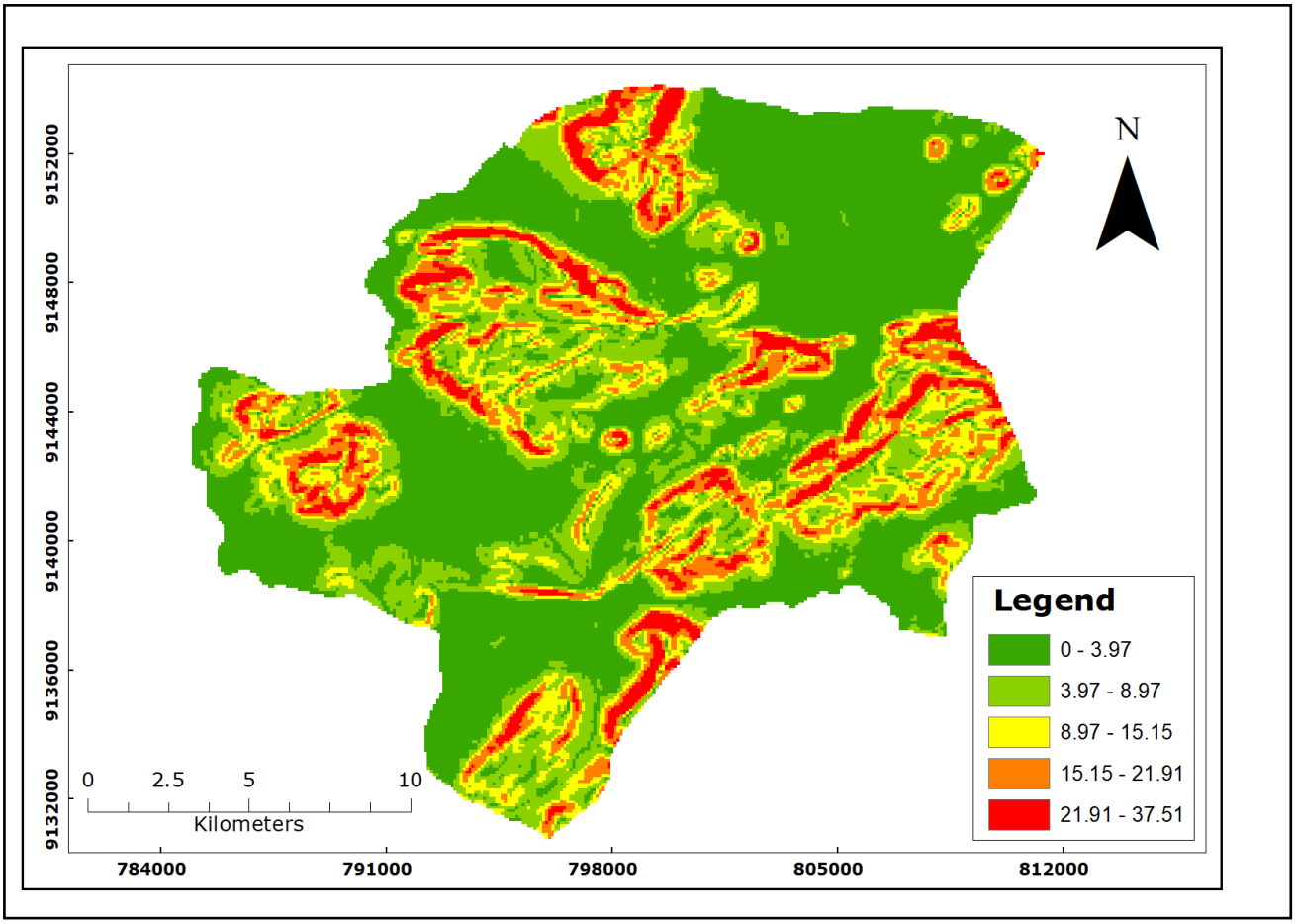


Figure 4.1:Slope map

But the suitable slope for the site selection should not exceed 3.5 degrees of the values, so I had to reclassify the slope so as to get the reclassified slope which show the high suitable, moderate suitable and low suitable sites as shown in figure 4.2

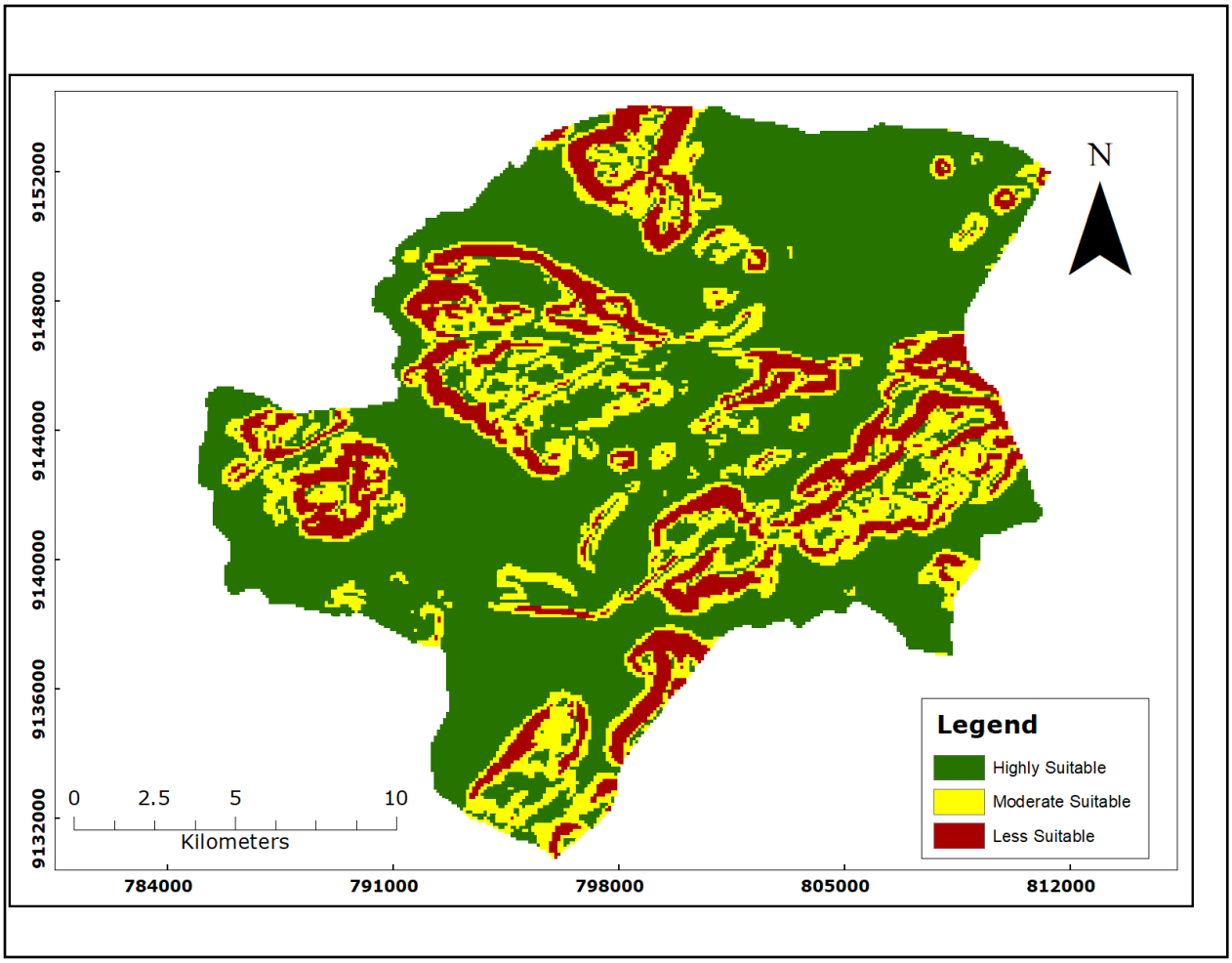


Figure 4.2:Reclassified slope map

4.2 Drainage map

Delineated drainage patterns obtained show the potential areas for flooding since the tributes of drainage have the character to store water (which flows or from rain) and when the rain is heavy can lead to floods. So, the figure 4.3 shows the drainage pattern.

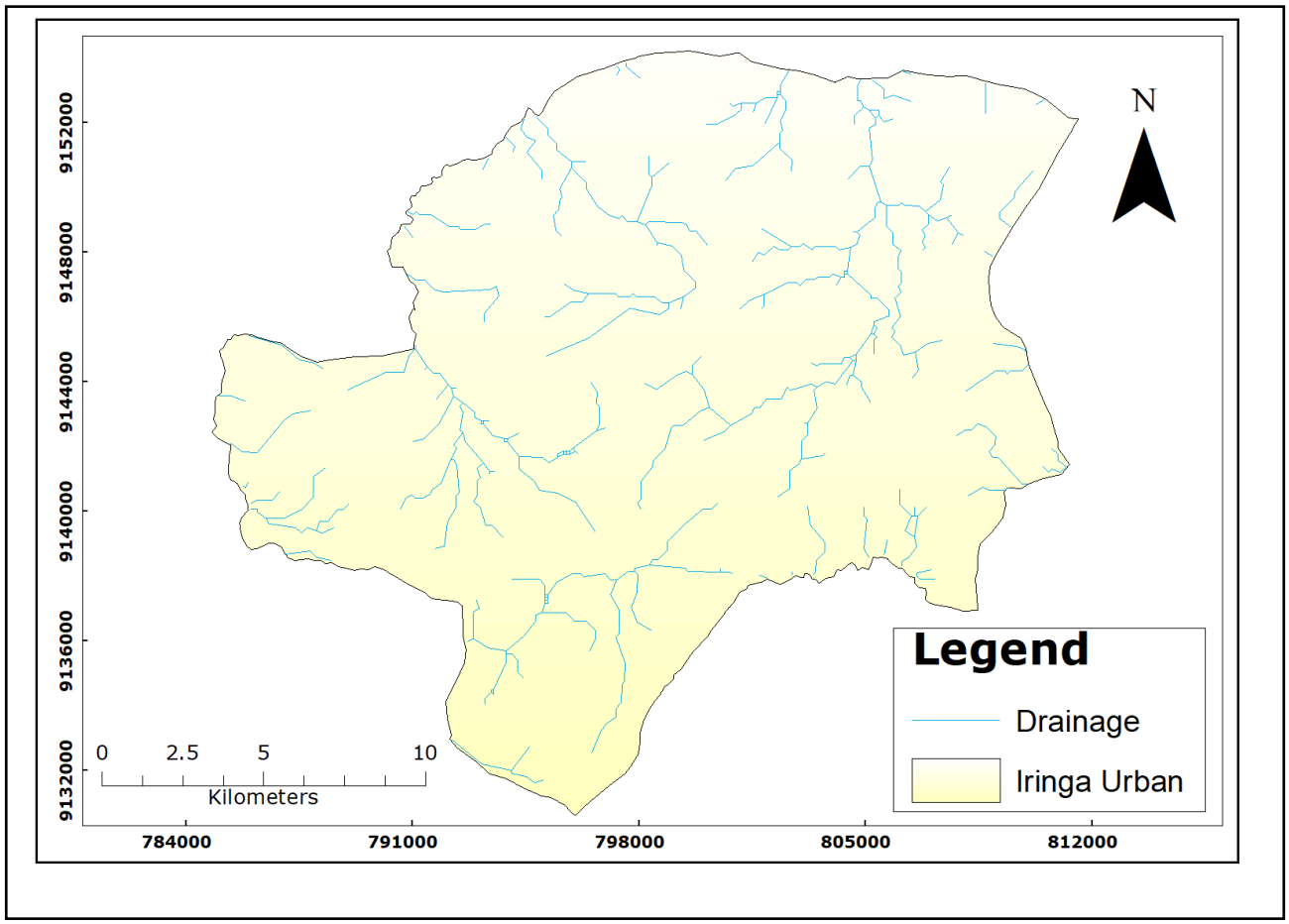


Figure 4.3:Drainage map

But so as to have the airport in the area must consider the drainage pattern, then I buffered drainage pattern to 60m and converted to raster layer and lastly reclassify to have the area which is suitable and not suitable for Airport as shown in figure 4.4

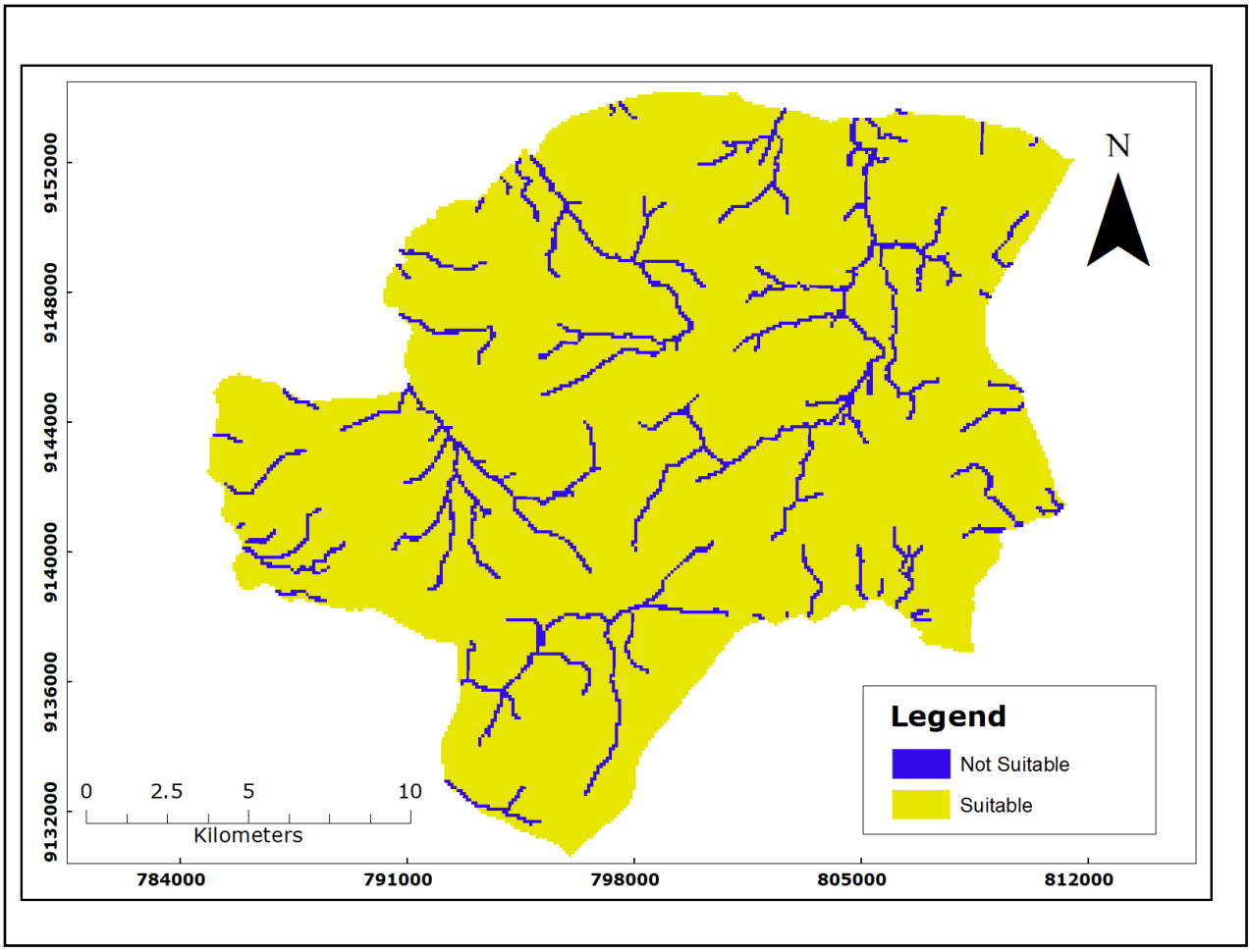


Figure 4.4:Reclassified drainage map

4.3 Road access map

After obtaining road access layer from the methodology chapter three above for a better Airport location the road access is very necessary since the road can be accessed by different land users then I buffered road to 60m both sides as shown on the figure 4.5

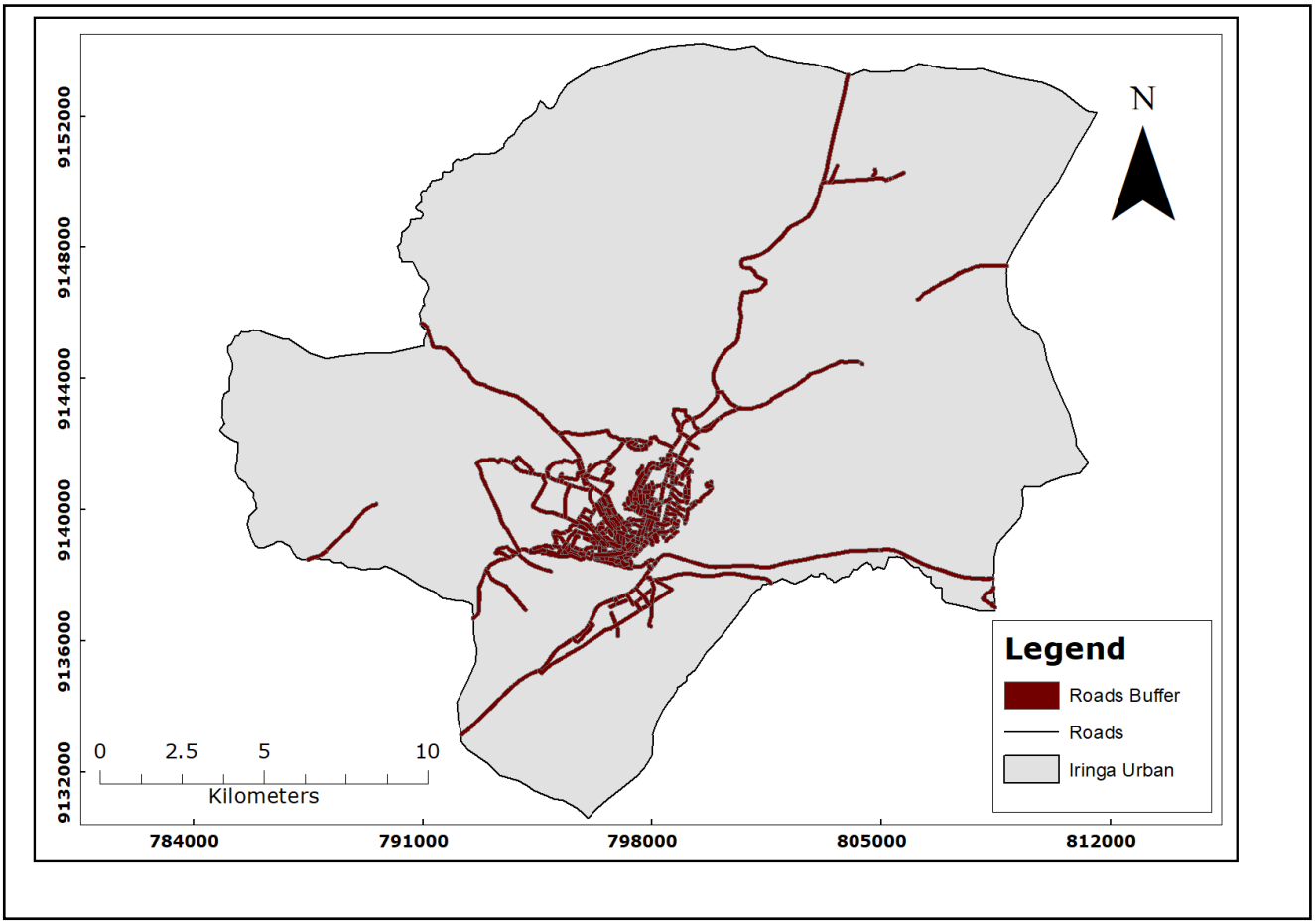


Figure 4.5:Road map

Then I converted the buffered road zone to raster layer by using a using **conversion tool → to raster from → from polygon** getting a buffered road map which was reclassified so as to show the suitable and not suitable location for Airport as road access considered as shown in figure 4.6

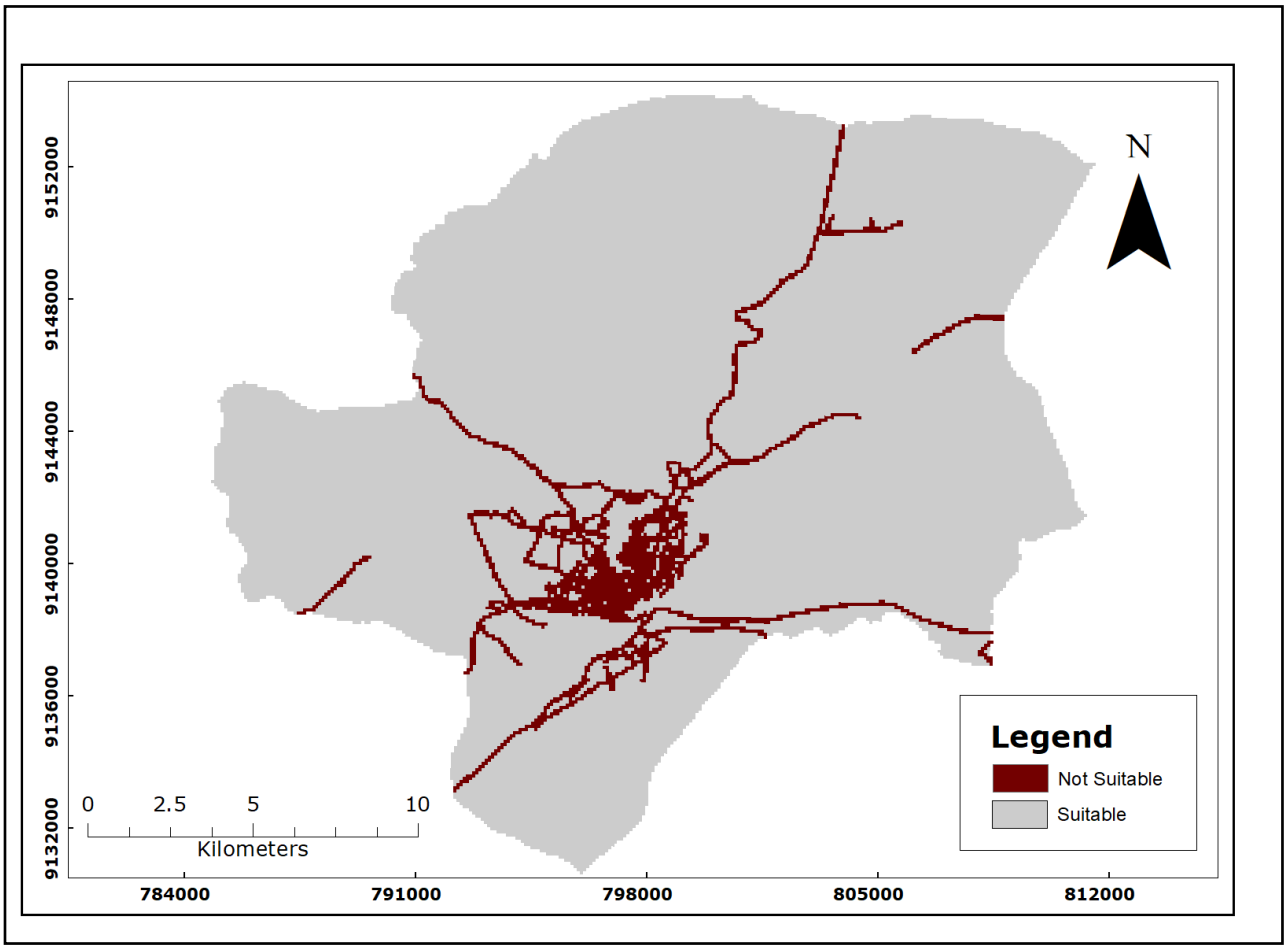


Figure 4.6:reclassified road map

4.4 Land cover map

After the process of image classification, the land cover map consisting 6 classes which are class of built area (area of population for people having permanent settlement), forest, grass land, bare land, bush land and water bodies was obtained. as shown in figure 4.7

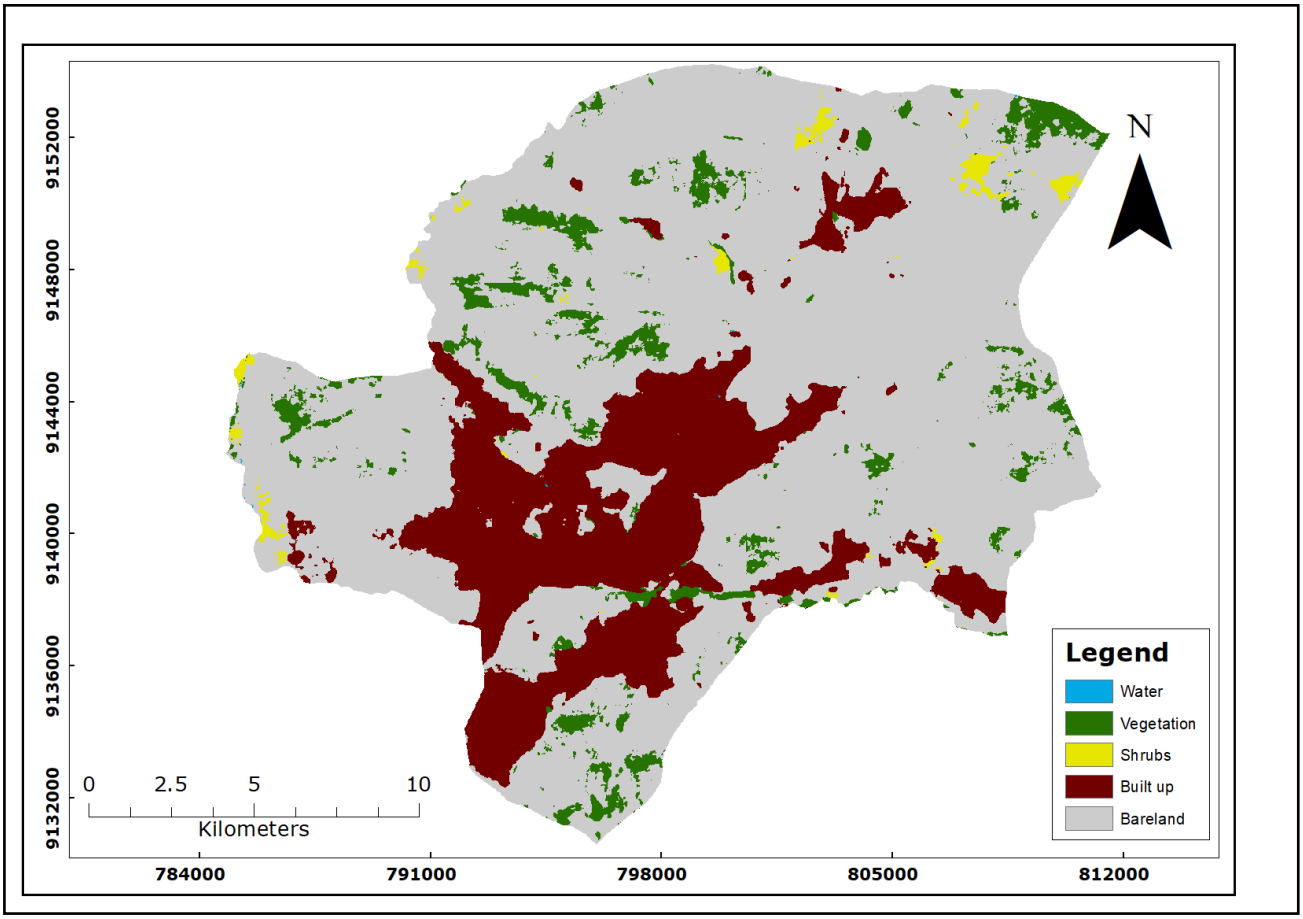


Figure 4.7:landcover map

But the Airport sites must not be around the location where people live, then I had to reclassify the land cover layers into three classes of high suitable, moderate suitable and low suitable as shown in figure 4.8

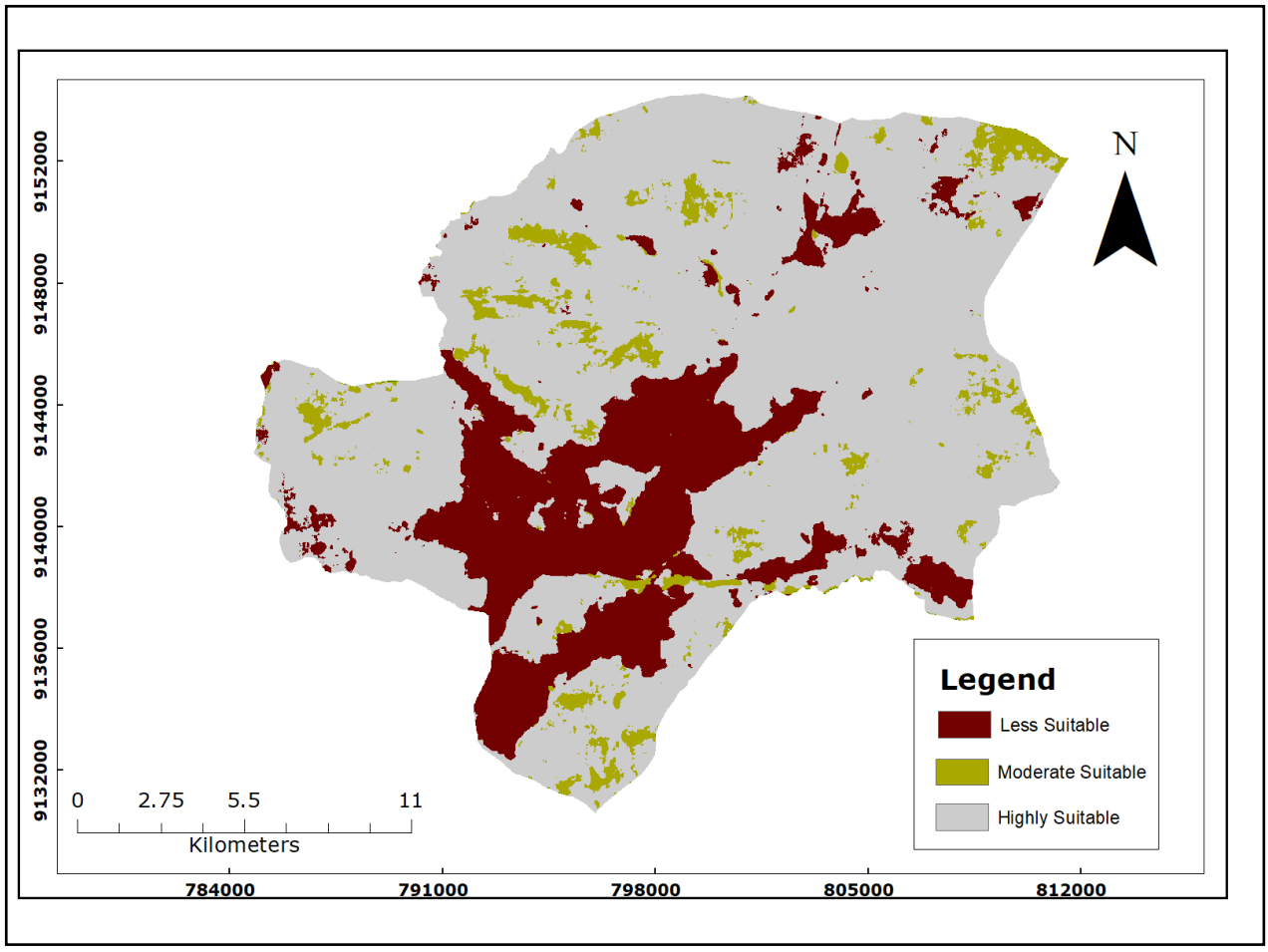


Figure 4.8:Reclassified landcover map

4.5 Suitability map

As explained in the chapter 3 of methodology that weighted overlay tool in Arc GIS software was used to obtain the suitable sites for Airport by multiplying the criteria layer with their weights obtained by AHP. The results of suitable sites were obtained as shown in figure 4.9 below:

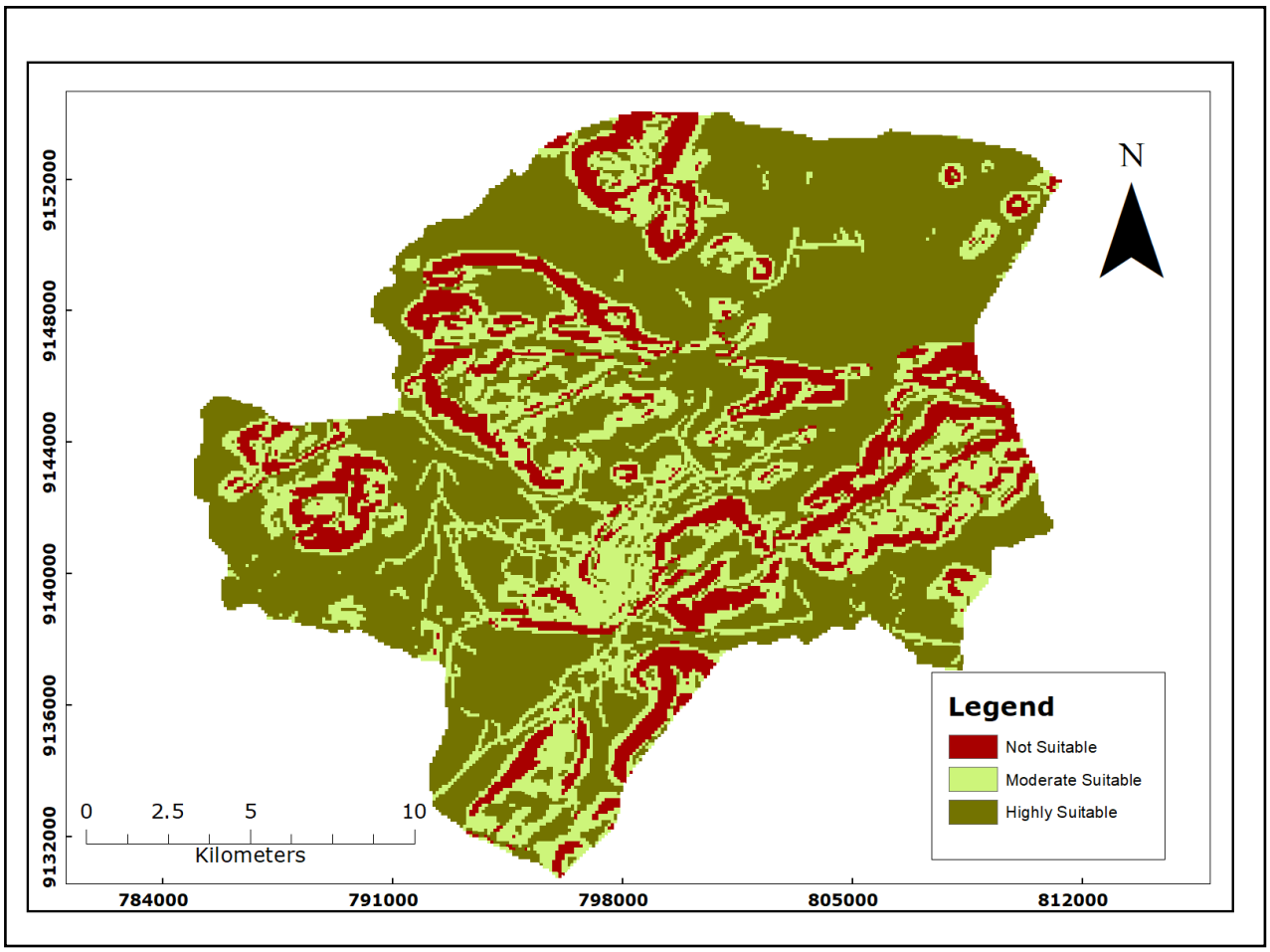


Figure 4.9:suitability map

The results of suitable sites were influenced most by the slope since the slope had the more weight which is also made the final result to resemble much of the slope as criterion. This gives the meaning that slope is the criteria which should be considered in the Airport much

4.6 Discussion

From the figure 4.21 it shows areas which are Suitable areas divided into three classes which are:

- Suitable are areas mostly with high elevation of mounted features such as mountains thus near these features we cannot site an airport since the slope of that area won't be gentle

- Moderate Suitable are areas which are moderate that is the slope of the area its gentle but presence of households and roads can lead an area to be moderate suitable since slope has high importance compared to road and drainage
- High suitable are the areas mostly with the gentle slope according to the criterions slope has a heavy weight compared to landcover, drainage and roads thus the areas located with highly suitable are the areas with gentle slope.

4.7 Accuracy Assessment

Below are the tables showing the error matrices and total accuracy of all classified image. Table show the error matrices and total accuracies for accuracy assessment of respective year.

Table 4. 1Accuracy assessment of 2022

Classifiedresult							
		Water bodies	Built - up	Vegetation	Shrubs	Bare land	Total
	Water bodies	4	0	0	3	1	6
	Built - up	0	5	1	4	6	9
	Vegetation	1	0	15	3	10	24
	Shrubs	0	2	4	9	7	5
	Bare land	1	6	6	5	44	56
	Total	6	18	26	24	68	100

	Land cover	Reference Total	Classified Total	Number correct	Producer accuracy	User accuracy
Classification	Water bodies	6	5	4	67%	80%
	Built - up	18	19	12	67%	63%
	Vegetation	27	31	20	74%	65%
	Shrubs	13	34	10	70%	60%
	Bare land	61	57	44	72%	77%
	Total	112	112	80		

Overall accuracy = 70%

In my research I preferred to use classified sentinel image data of 2022 from ESA which they have higher accuracy assessment compared to the one I classified ; the Sentinel image data were classified using Google Earth Engine.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Geospatial technology plays a crucial role in developing effective decision support systems for sustainable development and management of vital resources such as airport. Integrating RS and GIS for spatial decision-making purposes is important as it expands the opportunity for using GIS based technology as the base of decision support systems. The present study shows that GIS and RS play a crucial role in mapping suitable sites for Airport. In addition, AHP used for solving complex problems of management and expert choice software make mapping of Airport areas easier. In this study GIS and RS were used to determine suitable sites for Airport and four (4) different criteria including slope, drainage, accessibility (road), and land cover were used. Each criterion was assigned weights respectively. Integration of the 4 criteria through Weight Overlay Analysis led to suitability map of Airport which was divided into three categories which were low suitable, moderate suitable and high suitable sites for Airport.

This research is potential in managing airport prospect areas also the effective utilization of resources can be achieved more.

5.2. Recommendation

Further studies should be conducted to gather information on Airport by including more criteria so as to improve the accuracy of the final result which is specific to a certain location as the conventional method result. The ministry of Transportation together with TCAA should use the generated information to conduct explorations. Also, local authorities and agencies should preserve the over exploited areas for restriction of people to live so as to avoid accidents like explosion which can damage their properties.

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