KATHMANDU UNIVERSITY SCHOOL OF ENGINEERING

DEPARTMENT OF GEOMATICS ENGINEERING

FINAL REPORT ON

LANDFILL SITE SELECTION IN BHAKTAPUR DISTRICT USING GIS BASED ANALYTICAL HIERARCHIAL PROCEDURE

Submitted by

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Acknowledgement

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Abstract

Landfills work by layering the waste with soil and other materials to create a barrier between the waste and the environment. Landfill sites are home to both household and commercial waste. This may include packaging, organic waste, WEEE equipment, industrial materials, and more. There is need of proper landfill site in the Bhaktapur District. Different factors like road, river, slope, land use land cover (LULC) built-up were determined according to past literatures and existing data availability. Each data were classified into five class highly suitable, suitable, less suitable, moderately suitable and unsuitable. Each criterion was identified and weighted. . Then each criterion was mapped using the GIS technique and then a suitable landfill site was identified using overlay analysis.

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1. Introduction

1.1 Background

A landfill site is an area of land where a huge amount of waste is deposited that cannot be recycled. Landfills work by layering the waste with soil and other materials to create a barrier between the waste and the environment. Landfill sites are home to both household and commercial waste. This may include packaging, organic waste, WEEE equipment, industrial materials, and more. Rapid urbanization in the majority of Nepal's urban centers has made SWM a significant challenge that needs immediate attention. About 500,000 tons of municipal waste are produced annually in Nepal's 58 municipalities, according to estimates. Less than half of this is collected, and nearly all of the waste that is is disposed of in an neglected and unprofessional way. A survey conducted by the Solid Waste Management and Resource Mobilization Center found that 10 municipalities have some kind of dumping site, 19 municipalities dump waste in open piles, and 21 municipalities dump waste along riverbanks (Bank, n.d.). Sanitary landfills are considered as the most common E-waste disposal technique which aims to reduce or mitigate the potential risks associated with the environment and human health.

The selection of suitable site of landfill would reduce the impacts on environment and also would form a basis for proper management. The selection of suitable landfill sites can be done by the integration of GIS and Multi-criteria Decision Analysis (MCDA).For this study five data criteria were chosen. Factors such as river, land use, road, settlement, slope and airport were considered. GIS-MCDA is a method for solving spatial problems by combining and transforming geographical data with value judgments. It does so by taking into account geographic data models, the spatial dimension of the evaluation criteria, and choice alternatives while evaluating the criteria. In simple words, it is a process that transforms & combines geographical data & value judgments (the preferences of the decision-maker) to obtain information for decision making.

1.2 Problem Statement

Bhaktapur's fast urbanization presents a serious waste management challenge that calls for the selection of suitable landfill locations. There is currently a risk of inadequate waste disposal and environmental degradation due to the lack of an organized system for site selection. Integrating Geographic Information Systems (GIS) with the Analytic Hierarchy Process (AHP) offers a potential solution. However, there's a need to develop a tailored GIS-based AHP approach specific to Bhaktapur, considering its unique geographic and social characteristics. The objective of this approach is to guarantee environmental sustainability and community well-being by methodically assessing criteria and prioritizing landfill sites..

1.3 Objectives

1.3.1 Primary Objectives

To determine the landfill site in the bhakatpur district.

1.3.2 Secondary Objective

To determine the factors that influence the landfill site.

To use MCDA and GIS for analysis purposes.

2. Literature Review

Improper solid waste disposal has remained the major bottleneck for the socio-economic development particularly in urban and peri-urban areas of Ethiopia. This study was conducted with the prime aim of identifying an optimum municipal solid waste management option subsequently selecting the best landfill site in Hossana town using integrated geographical information systems (GIS) and multicriteria decision analysis (MCDA) techniques. Accordingly, GIS integrated with MCDA was used to analyze the relative weight of each criterion and the overall suitability map where ten criteria were considered within their respective constraints. To create a landfill suitability index, environmental and

socioeconomic factors such as distance from settlement, land use and land cover, lineament, slope, road, and wind direction/aspect were weighted (Wanore, 2023).

Geographic Information Systems (GIS), which offer a spatially clear platform for decision-making, have become essential in the field of waste management. A thorough examination of the variables affecting the suitability of a landfill site can be conducted because of to the integration of multiple spatial data layers made possible by GIS (Pijanowski, 2002). When choosing a landfill site, the partnership between AHP and GIS guarantees a thorough and well-informed decision-making process.

Successful landfill site selection necessitates exact compliance to regulatory frameworks and extensive environmental impact assessments. The literature emphasizes the importance of incorporating these considerations into the decision-making process to ensure that selected sites meet legal requirements while minimizing negative environmental effects (Kumar, 2013).

AHP is a powerful tool for solving complicated problems that may have interactions and correlations among multiple objectives. This technique provides a means of decomposing the problem into a hierarchy of sub-problems that can be more easily comprehended and subjectively evaluated. The subjective evaluations are converted into numerical values that are ranked on a numerical scale. This present study examined the applicability of the GIS techniques in combination with a multi-criteria approach for analyzing the land suitability for landfill. (Debishree KHAN, 2015).

3. Materials and Methodology

3.1 Study Area

As part of this project, the Bhaktapur district was chosen as the study location for selecting suitable dumping sites. The district is located between the coordinates of latitude 27° 40' 22.6848" N and

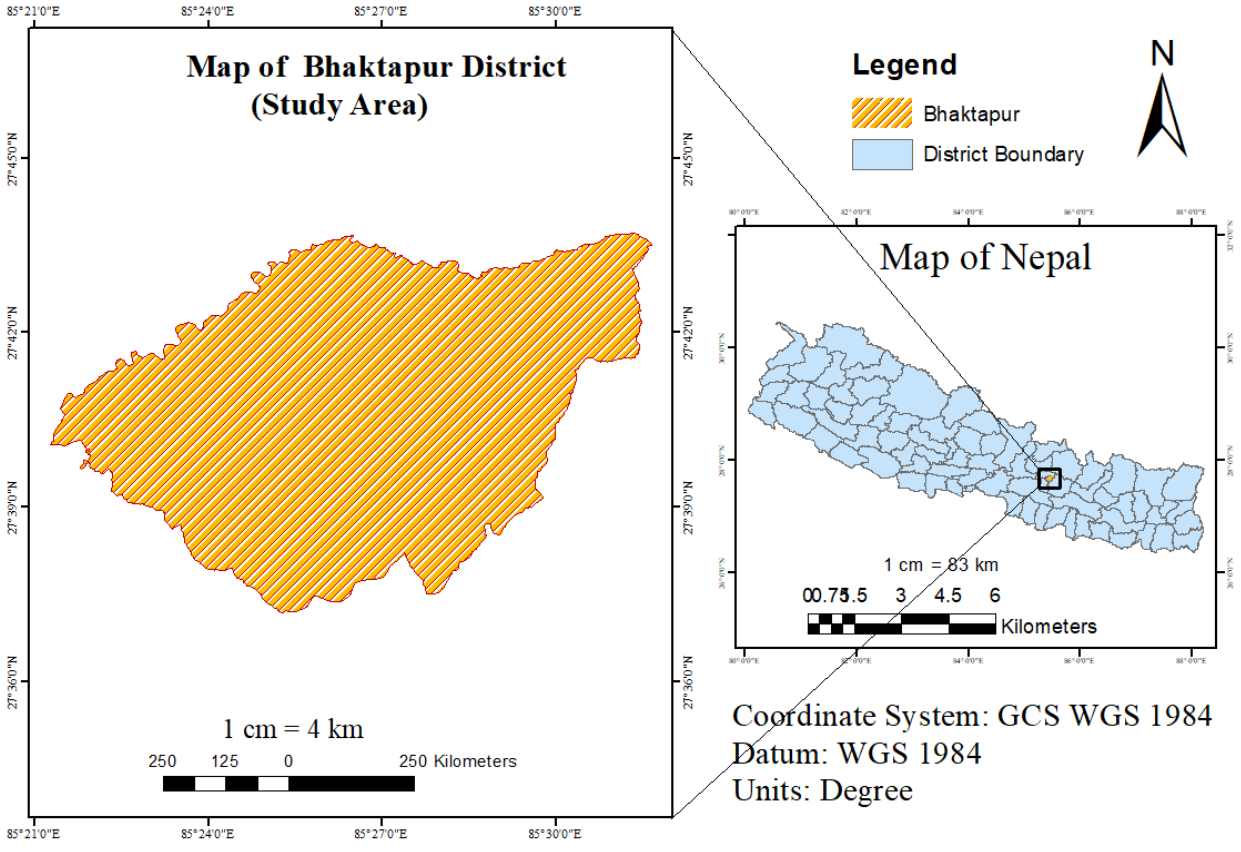


Figure 1:Study area for landfill site

longitude 85° 25' 45.4476" E. This district is located in Bagmati Province, with Hetauda serving as the district headquarters. It has a total size of 119 km². It is surrounded by Kavrepalanchwok District in the east, Kathmandu and Lalitpur District in the west, Kathmandu and Kavrepalanchwok District in the north and Lalitpur District in the south. The average elevation is 1,401 m (4,596 ft) above sea level.

3.2 Methodology

3.2.1 Data Preparation

Data were projected into the same projection system, unnecessary data was removed. The area of interest was kept into account. For this project data of LULC, river, slope, road, settlement, airport was taken. The data was collected through different websites.

S.N	Types of Data	Authority
1	Road networks	ICIMOD (https://rds.icimod.org/)
2	Elevation	The Humanitarian Data Exchange (https://data.humdata.org/)
3	River	ICIMOD (https://rds.icimod.org/)
4	Settlements	The Humanitarian Data Exchange (https://data.humdata.org/)
5	LULC	ICIMOD (https://rds.icimod.org/)

Table 1:Data Source

3.2.2 Multi-Criteria Evaluation

Spatial multi-criteria decision making (MCDM) is a process where geographical data are combined and transformed into a decision. It involves input data, the decision makers' performances and manipulation of both information using specified decision rules. The actual process of applying the decision rule is evaluation. In order to meet the objective, several criteria need to be evaluated and is termed as Multi-Criteria Evaluation. Standardization was done by assigning a numeric value between 1 and 5, where 5 signified the maximum suitability rate and 1 as the not suitable for each criterion. Each of the criteria was standardized based on expert opinions considering the potentiality of the land for landfill site and then each of the prepared layers was evaluated in GIS platform.

3.2.3 Description of Criteria Used

First, the evaluation criteria for selecting a landfill site at the Bhaktapur District were determined. Only six parameters were taken into account for this study namely, slope, roads, land use, settlement, river. The following things were assumed while taking these factors into account:-

3.2.3.1 Suitability of the slope

For this study areas with high slopes were considered less suitable while area with lesser slope were considered highly suitable. Slope was obtained from DEM in Arc GIS. Reclassification of slope was done and categorized into five classes with slope ranging from 0-5, 5-10, 10-15, 15-20 and 20> as highly suitable, suitable, moderately suitable, less suitable and unsuitable respectively.

3.2.3.2 Road

The landfill must not be located within 200 m of any major highways and city streets (Debishree KHAN, 2015). On the other hand, the landfill site should not be placed too far from the existing road networks for reducing the cost of new road construction, transportation and collection costs of solid wastes.

3.2.3.3 River

The river water quality is affected by the presence of landfill surface runoff. Its impact can be seen in the region where the drains are meeting the river. This is one of the causes of river pollution apart from other major municipal and industrial source. Hence, landfill site must be as far as possible from river sites.

3.2.3.4 Settlement

In close proximity to settlement areas, a landfill site is not advised. Settlement areas are defined as developed areas that include commercial areas, governmental and private institutions, schools, health facilities, religious institutions, educational institutions, dwellings, and other social services. To avoid disputes, landfills should not be located too close to densely populated.

3.2.3.5 Land Use and Land Cover

The land-use describes the level of economic activity and population density present in the research region. Various weights were allocated to the various land-use types based on the population density and their related economic activity. Water, Forest, built-up, Grassland, Riverbed were classified into grades. Grade 5 being the most suitable whereas the grade 1 denotes unsuitable.

Criteria	**Class**	**Rating**
LULC	Water	1
	Settlement	2
	Cropland	3
	Grassland	4
	Forest	5
Slope	0-5	5
	5-10	4
	10-15	3
	15-20	2
	>20	1
River	0-500	1
	500-1000	2
	1000-1500	3
	1500-2000	4
	>2000	5
Settlement	0-300	1
	300-500	2
	500-1000	3
	1000-1500	4
	>1500	5
Roads	0-100	1
	100-500	2
	500-1000	3
	1000-1500	4
	>1500	5

Table 2: Criterion Table

3.2.3.6 Overlay Influence Percentage

Influence Percentage was determined using the AHP calculator. The comparison matrix was done on the basis of the importance of the overall criteria. LULC was taken as the top priority so the influence percentage of LULC is high. The table is given below:

Resulting Priorities

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	LULC	40.9%	1	4.7%	4.7%
2	River	24.3%	2	12.0%	12.0%
3	Settelment	16.1%	3	9.2%	9.2%
4	Road	11.4%	4	5.7%	5.7%
5	Slope	7.3%	5	2.8%	2.8%

Number of comparisons = 10
Consistency Ratio CR = 8.4%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4	5
1	1	2.00	3.00	4.00	5.00
2	0.50	1	3.00	2.00	2.00
3	0.33	0.33	1	3.00	2.00
4	0.25	0.50	0.33	1	3.00
5	0.20	0.50	0.50	0.33	1

Principal eigen value = 5.377
Eigenvector solution: 6 iterations, delta = 1.2E-8

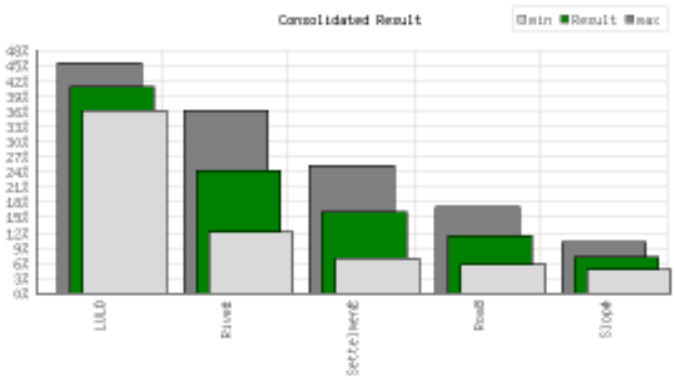


Table 3: Resulting Weight of the Criteria

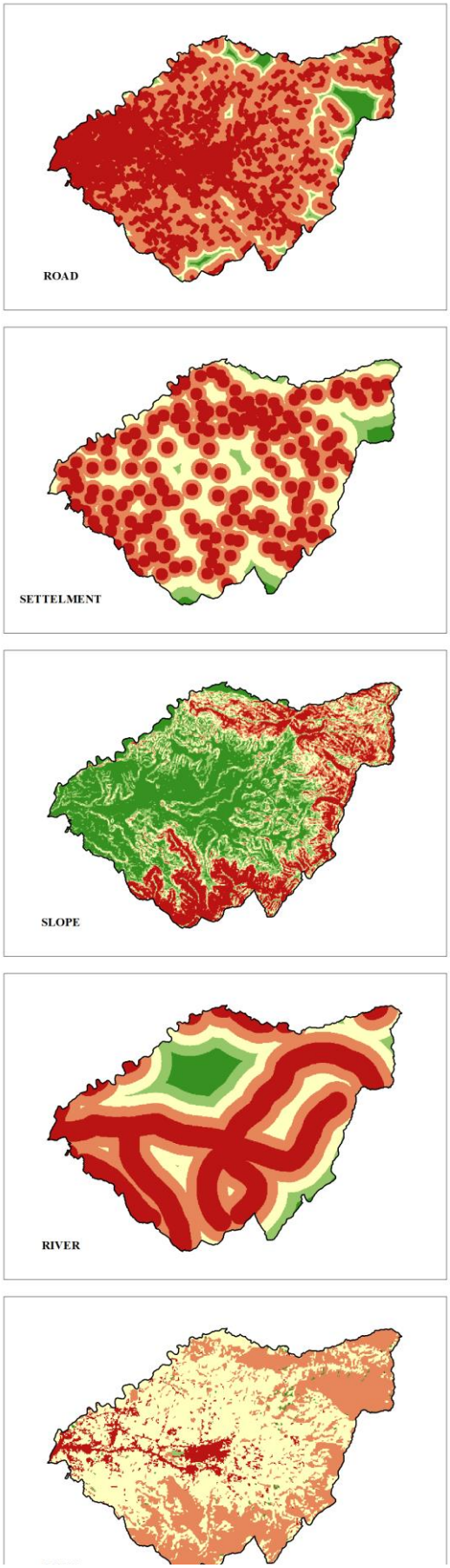


Figure 2:Overall Map Of all five Criteria

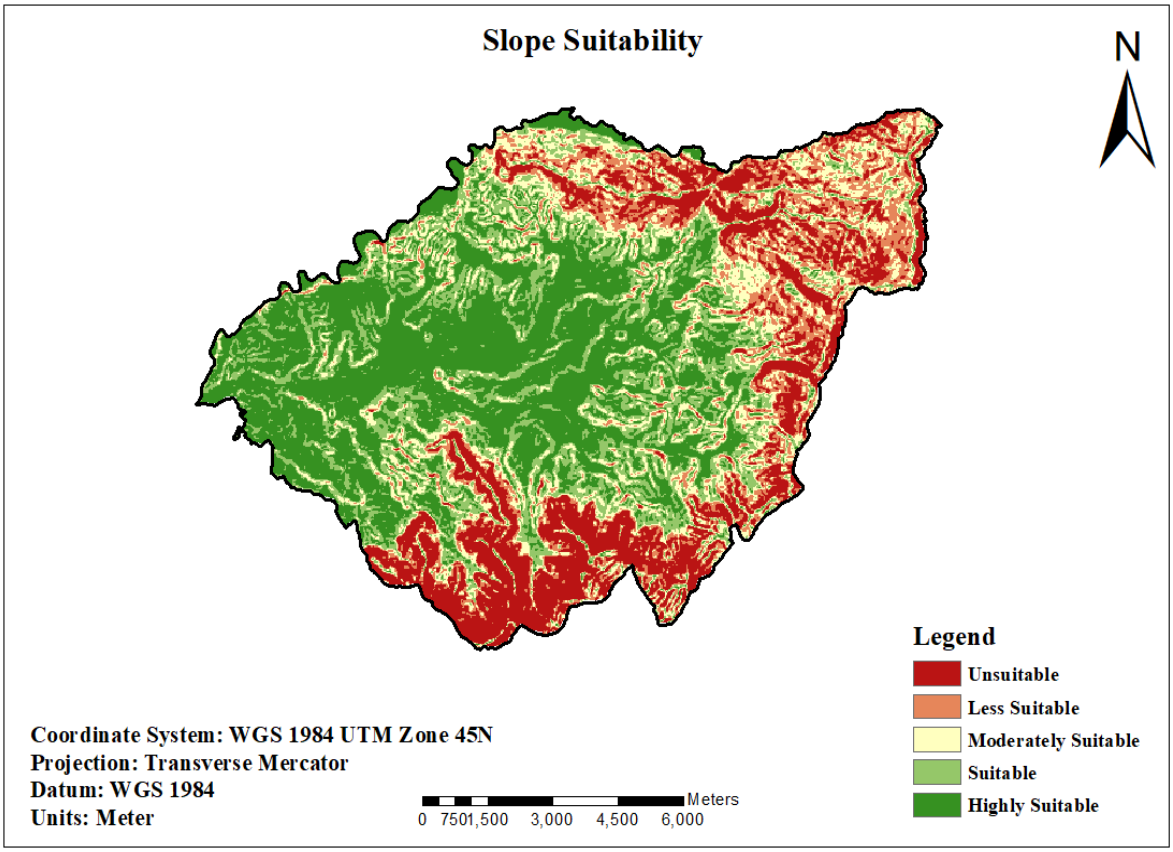


Figure 3: Showing Suitable Areas of Landfill Site According To Slope Suitability

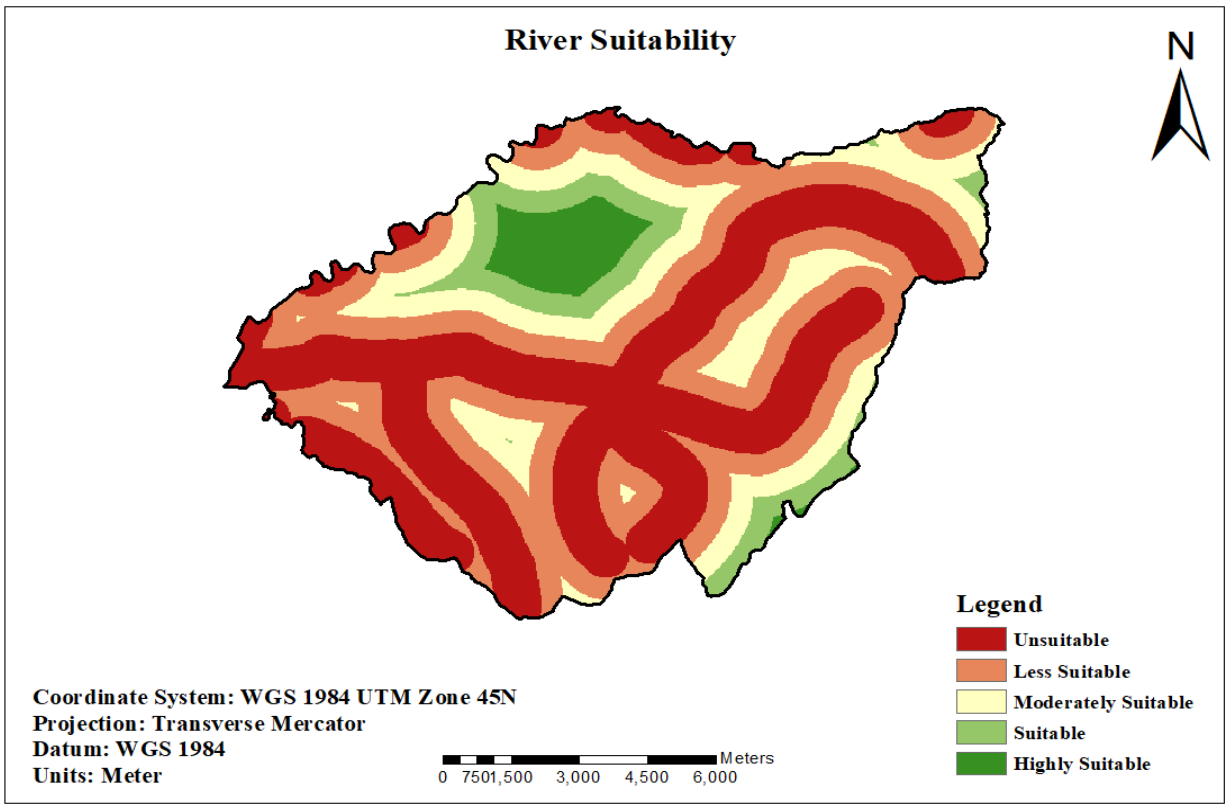


Figure 4: Showing Suitable Areas for Landfill Site According To River Criteria

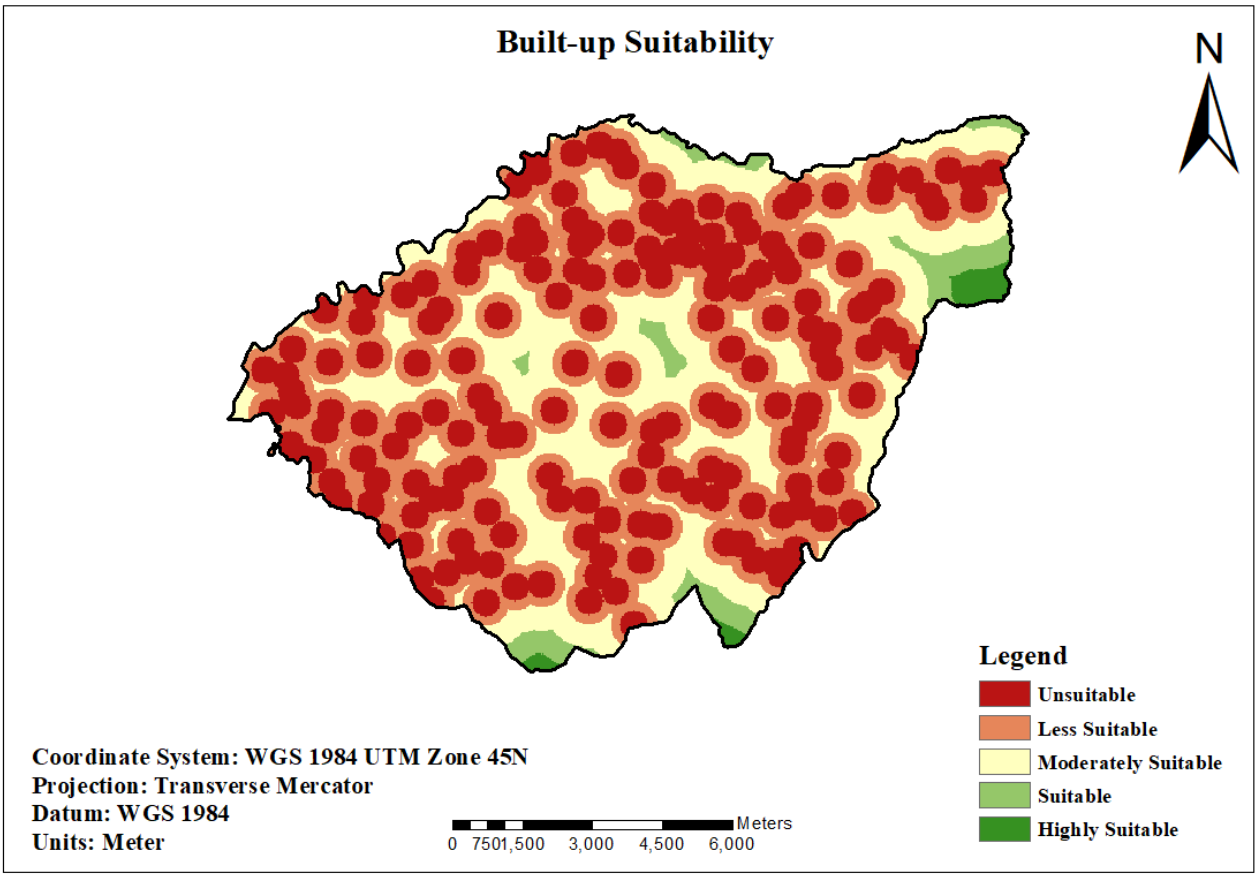


Figure 5: Showing Suitable Areas of Landfill Site According To Settlement Criteria

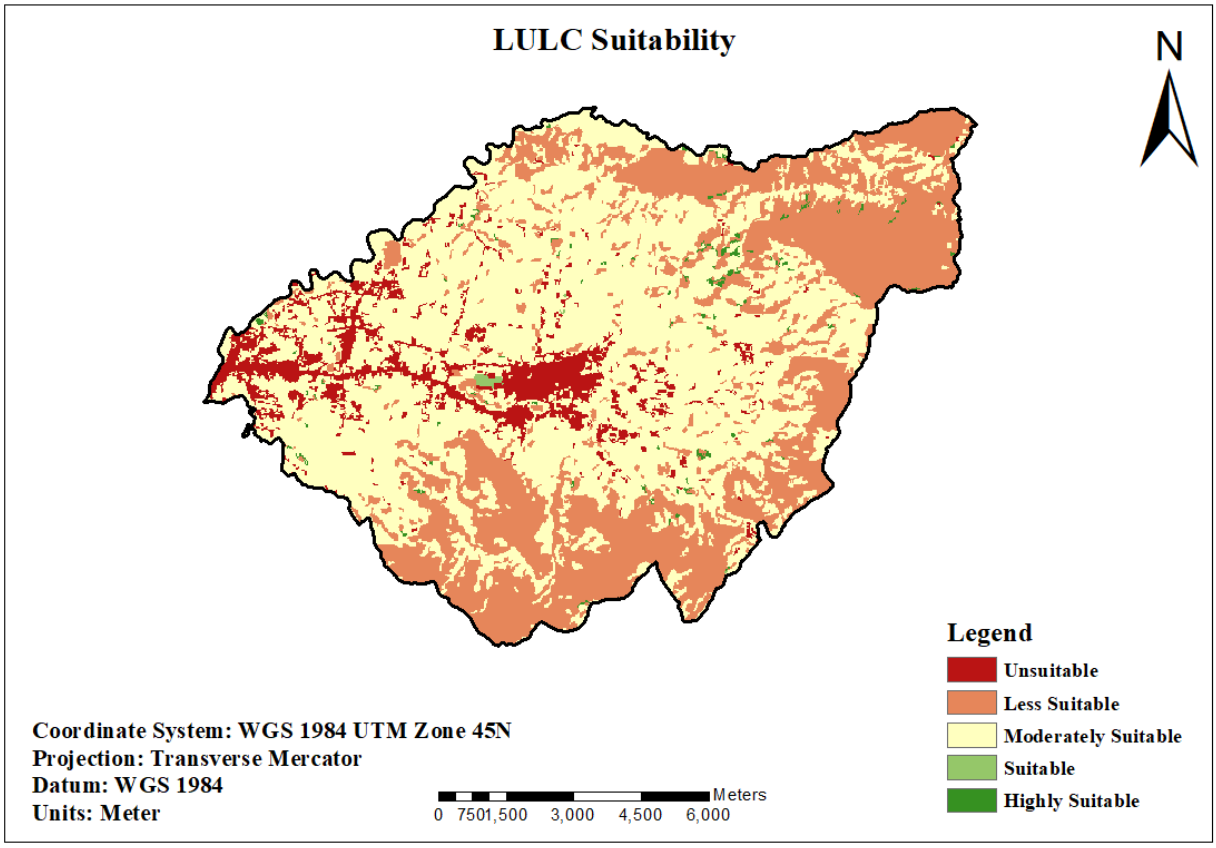


Figure 6:: Showing Suitable Areas of Landfill Site According To LULC Criteria

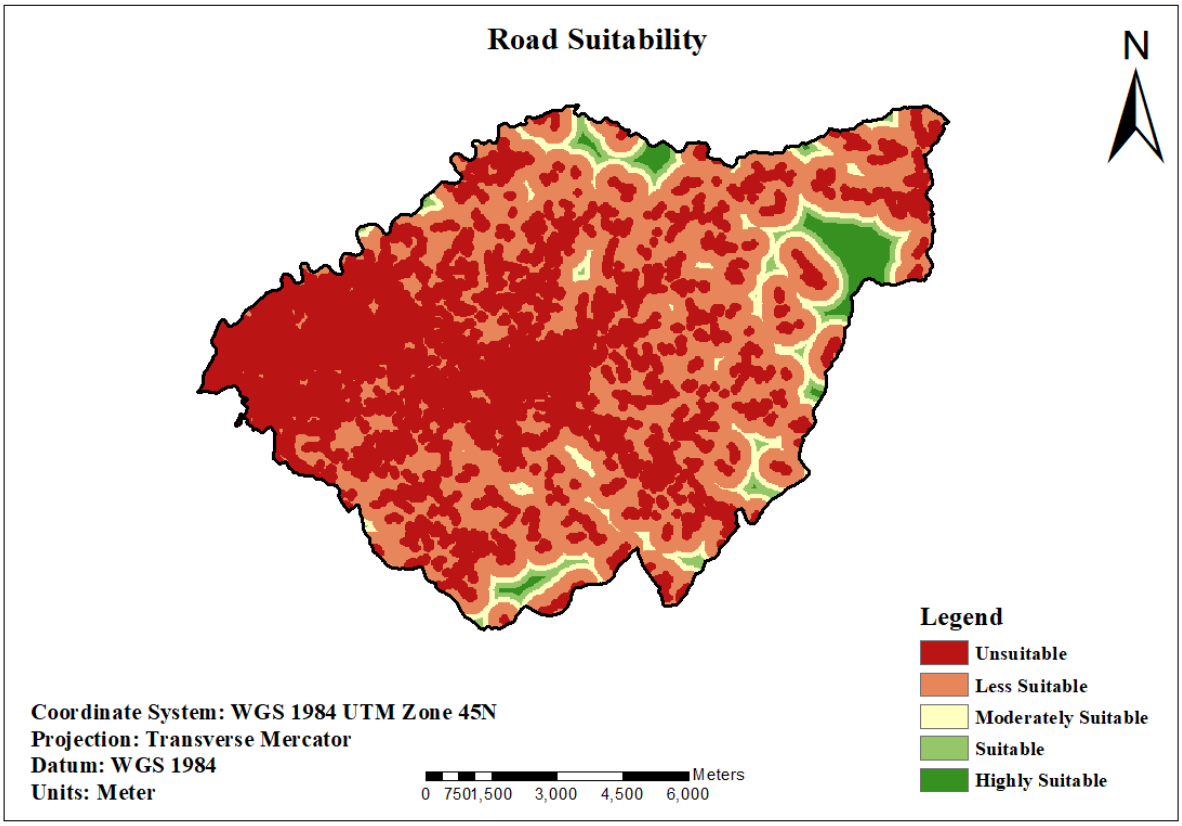
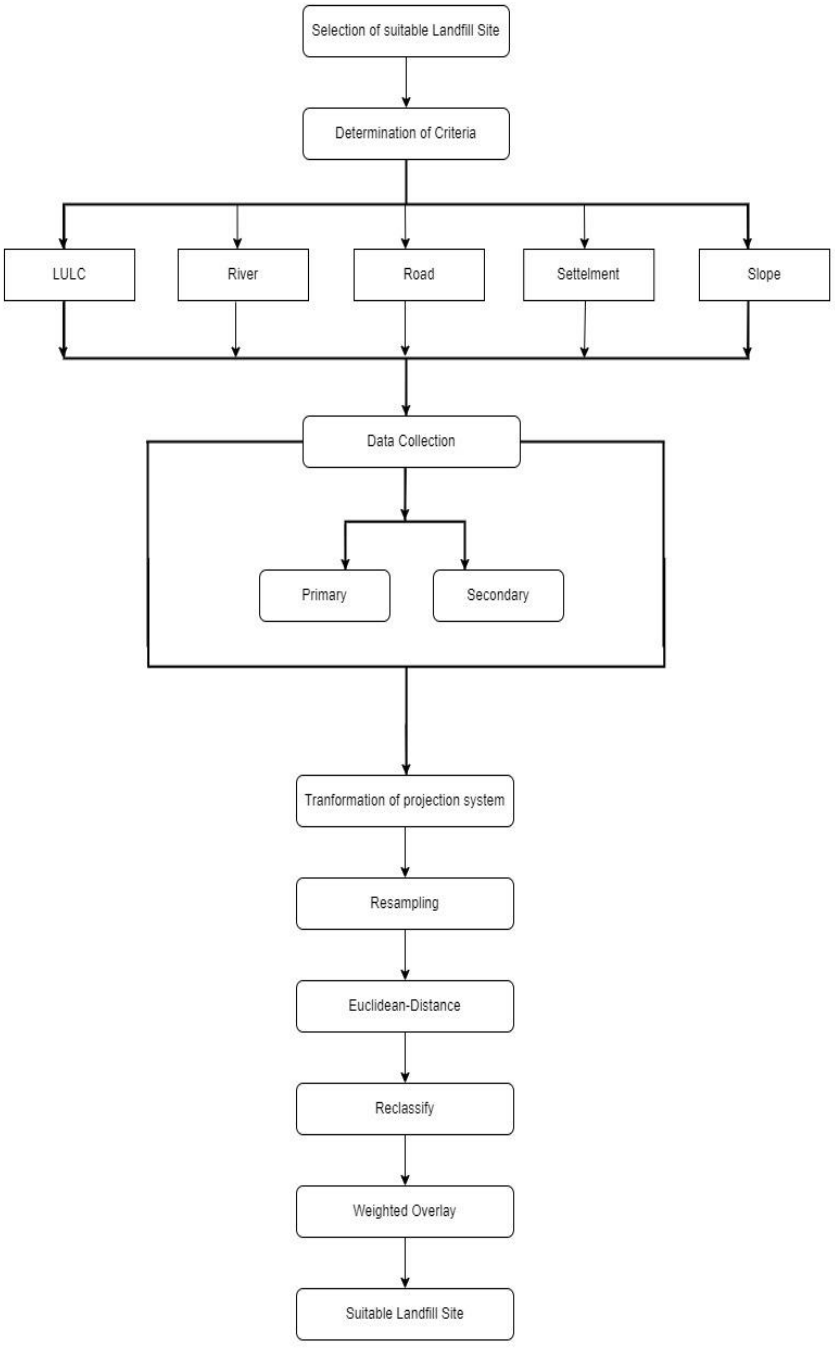


Figure 7: Showing Suitable Areas of Landfill Site According To Road Criteria

3.3 Workflow


Selection of suitable Landfill Site
Determination of Criteria
LULC
River
Road
Settelment
Slope
Data Collection
Primary
Secondary
Tranformation of projection system
Resampling
Euclidean-Distance
Reclassify
Weighted Overlay
Suitable Landfill Site

4. Result

Suitable Landfill Site was selected using GIS based Multi-Criteria Analysis. Each reclassified map was generated and overlaid to generate final suitable landfill site map. The results from this study are:

1. 7.55% of the area was highly suitable for the landfill site selection.

2. 51.66% of the area was suitable and 0.47 % of the area was unsuitable for the selection of landfill site.

3. 9223200m^2 of the land was highly suitable for the landfill site selection.

4. 63047700m^2 of land was suitable for the landfill site.

5. 2826000m^2 of land was less suitable and 576000m^2 of land was unsuitable.

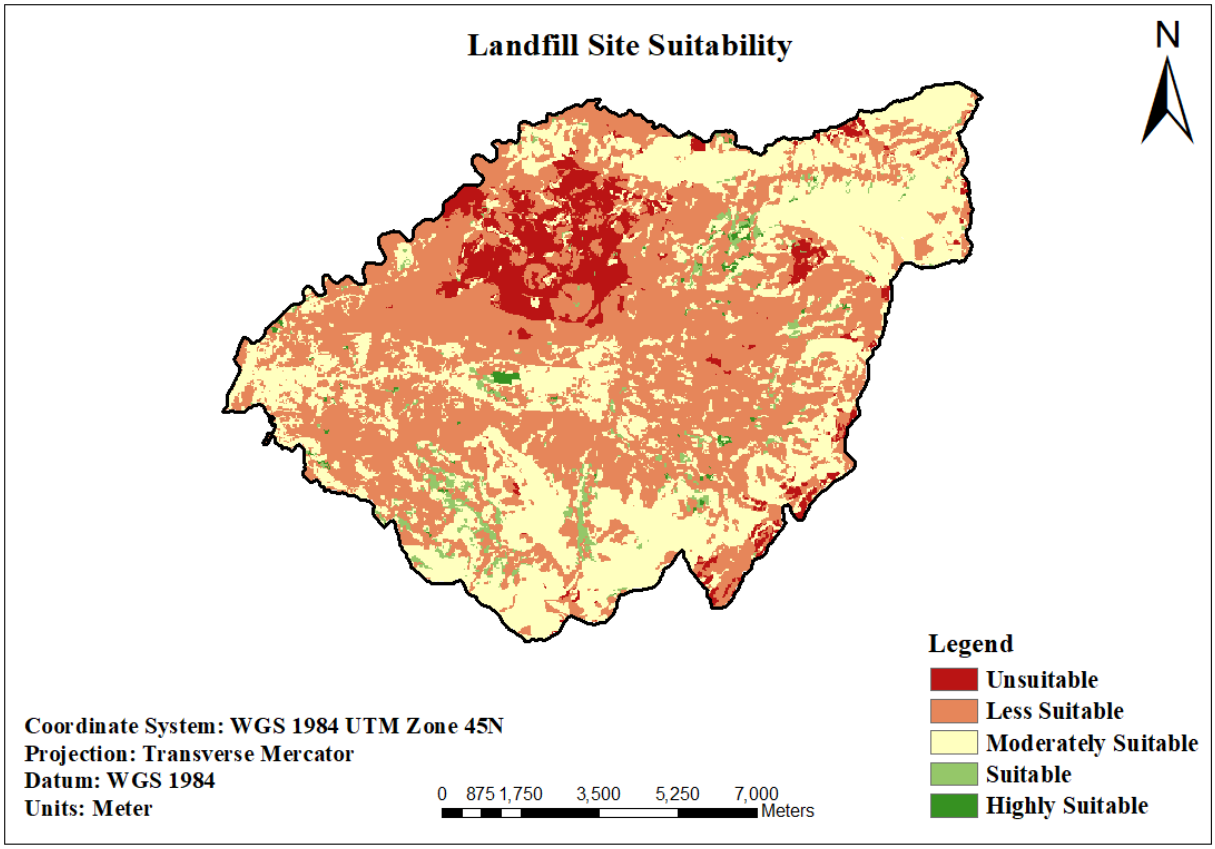


Figure 8:: Showing Suitable Areas of Landfill Site

5. Limitation

- Data used in this project are from secondary sources.
- Data used in this project may not be valid and reliable since , all data was taken from the internet.
- Suitable landfill site may differ in reality.

6. Conclusion

Landfill site selection is one of the most important components of any MSWM system and needs to be planned scientifically using recent advancements in the spatial sciences. In conclusion, the application of the Analytic Hierarchy Process (AHP) within ArcGIS has facilitated an organized and thorough plan to landfill site selection in Bhaktapur District. There needs to be proper selection of the landfill site which meets all the criteria. An unscientific siting of a landfill may result in adversely affected surrounding environment. Generally more criteria give more precise results, but selecting less important criteria which have negligible impact, make the system very complex. So, the evaluation criteria must be selected based on their impact on the suitability analysis. In this project, we have taken the consideration of only five factors. For the accurate and better result we can take account of more primary data sources.

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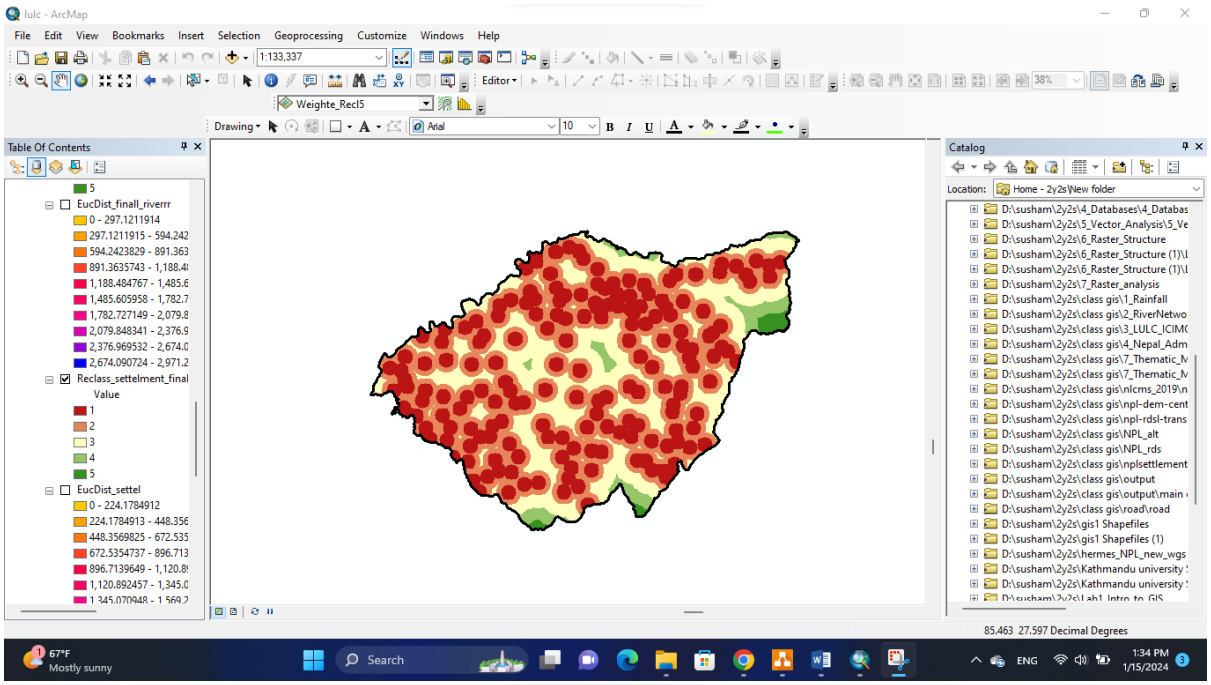
8. Annex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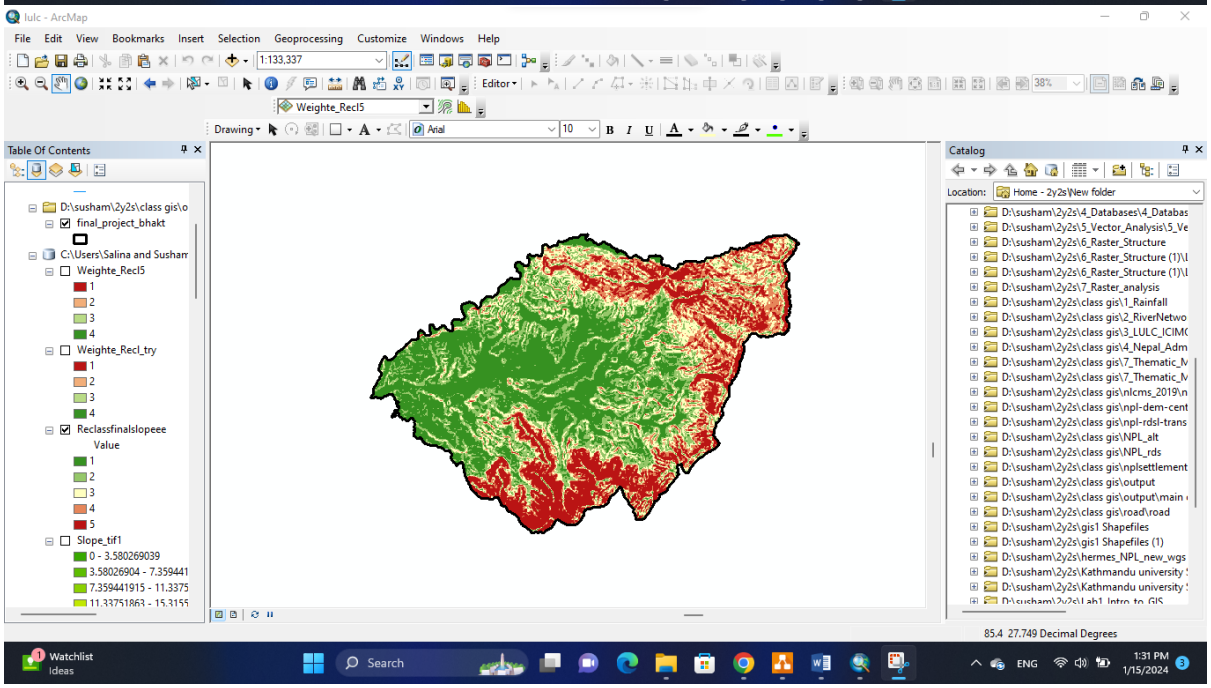
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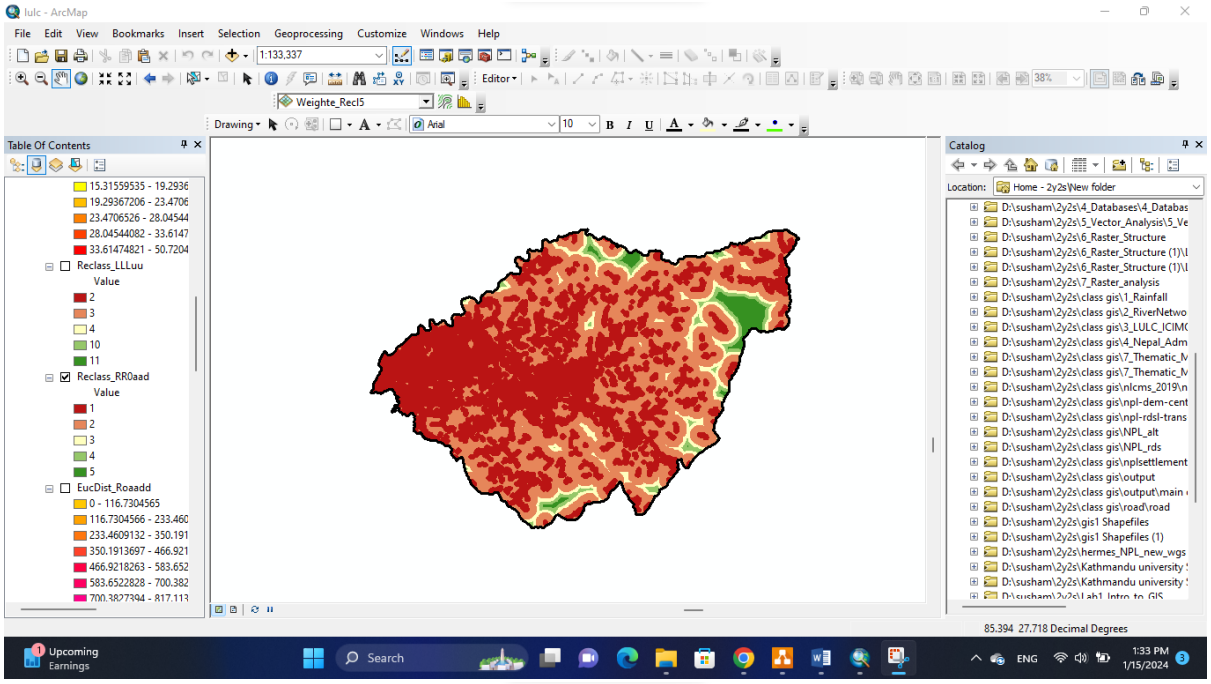
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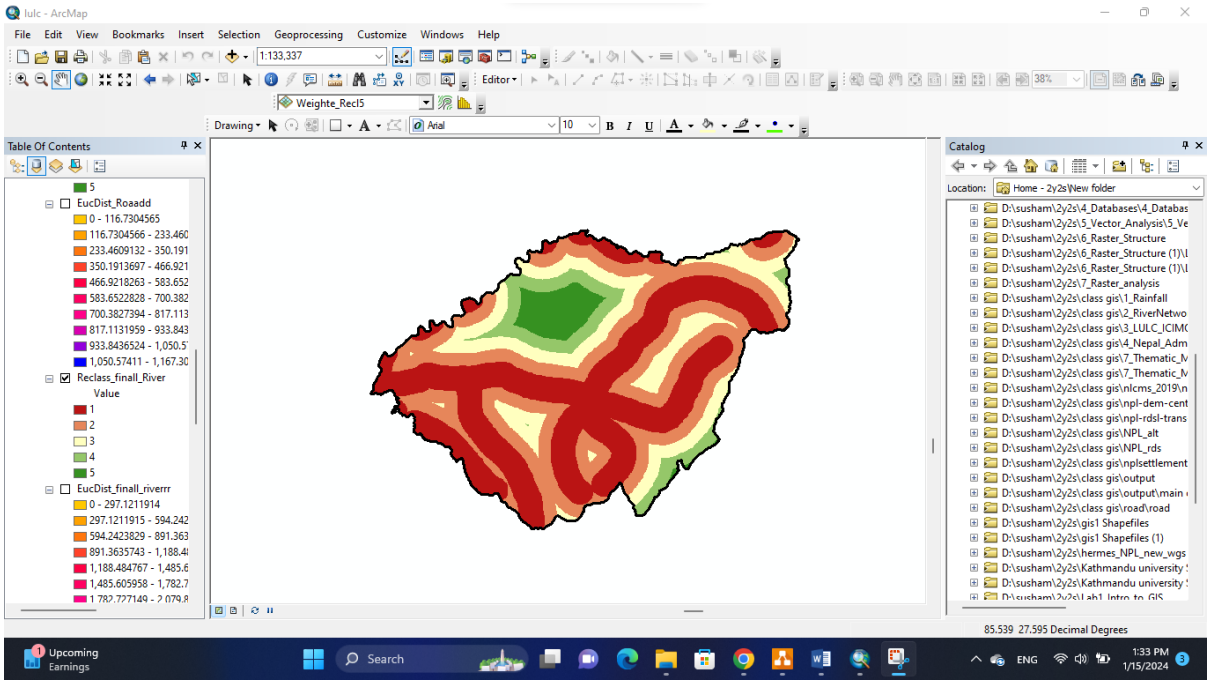
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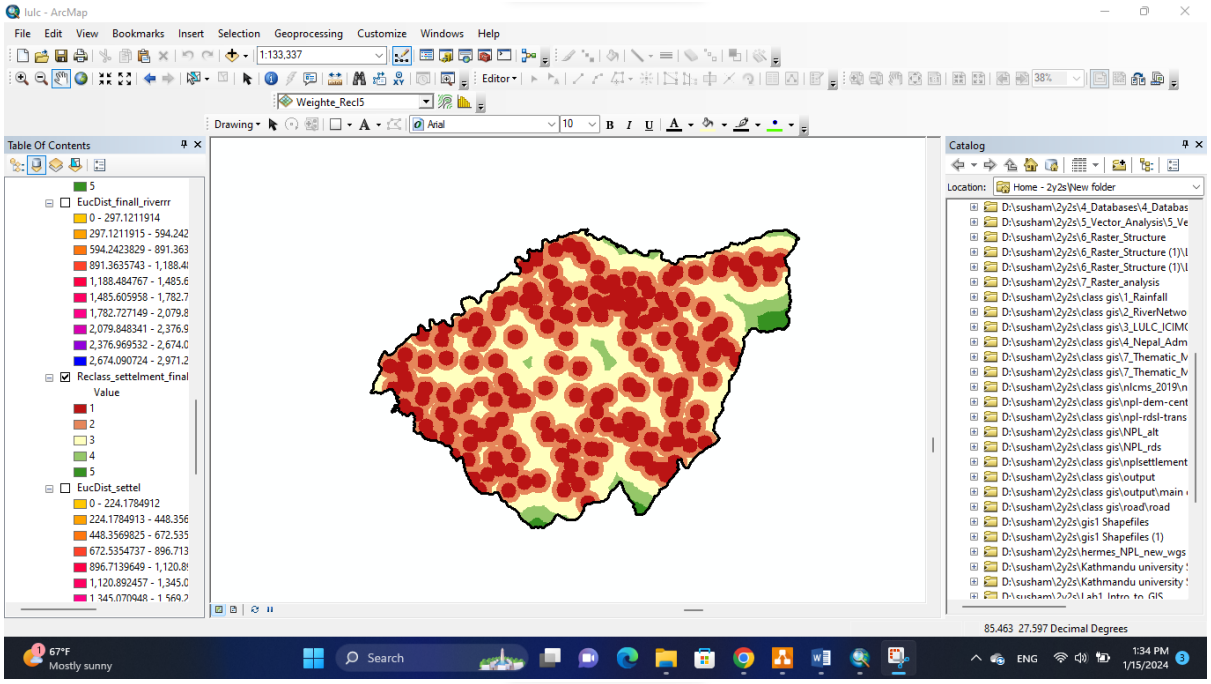
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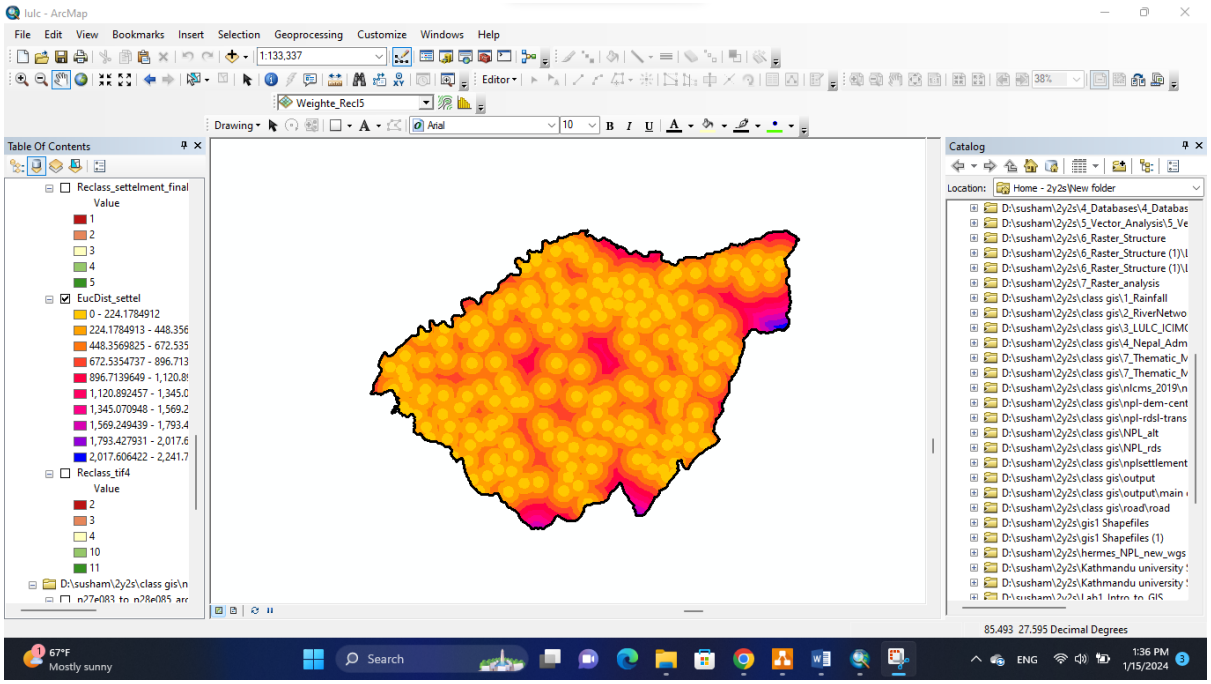
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