SITE SUITABILITY ANALYSIS FOR INDUSTRIAL ZONE NEKEMTE TOWN, ETHIOPIA USING AHP AND GEOSPATIAL TECHNIQUES

[1]Dr.Santhi Swarup Manugula, [2] Dr. Surendra Pal Singh, [3] Dereje Sufa Kenea
[1]Professor, [2] Asst Professor, [3] HoD
[1,2,3] Department of Surveying Engineering,
[1,2,3] Wollega University, Nekemte, Ethiopia

Abstract: Construction of a new industrial zone is a major long-term investment, determining the suitable location is critical point to success or failure of industrial zone.

The significance of AHP and Geospatial technology presently in every aspect of human beings day to day activities initiated the project to conduct this study. Industry zone is important to enhance the economic level of a given country and GIS and remote sensing technologies would provide a variety of options during suitable site selection process. The main objective of the study is to identify suitable industrial zone with list these criteria based on parameters by using AHP and Geospatial techniques. Determining factors/parameters identified in this study to identify suitable site for the industrial establishment. Some of the main factors were slope, land use land cover, road network, drainage density, aspect, contour.

The findings revealed that land use land cover factors highly determine the selection for industrial sites; and slope determines minimum compared with other factors. Majority of the study area (20.5%)are high suitable (47.5%) is suitable to establish industries,15% moderately suitable and a small portion (9.5%)are less suitable and 7.5% unsuitable for industrial Conducting environmental impact assessment prior to establishing industries in the study area was not fully covered by the concerned government organization. Application of GIS and Remote Sensing technologies in the study area is partially employed.

In order to select suitable sites for the industry, the town administrators should focus on those important parameters by using Geospatial techniques. Analytical Hierarchy process (AHP) is one of the best additive decision analysis methods which is used in many of real world problems as well as non-spatial problems. segregating complex problems to simple and easy form by hierarchy or levels and then integrating with mathematical computation for pair wise comparison and normalization which results in priority vectors also known to be criteria weights.

IndexTerms **- LU/LC, Remote Sensing, Industry, industrial zone, Site Selection, Suitability Analysis..**

I. INTRODUCTION

Selecting a site is one of the vital decisions in the start-up process of all kinds of business for expansion or relocation Construction of a new industrial system is a major long-term investment, and in this sense determining the suitable location is critical point on the road to success or failure of industrial zone. In the process of a site selection, the analyst strives to determine the optimum location that would satisfy the final selection criteria. Almost the data used by experts and decision makers in industrial site selection are geographical which means that industrial process of site selection is a spatial decision problem. Such studies are becoming very common, due to the availability of the latest technology. Geographic information systems (GIS) are powerful tool for spatial analysis which provides functionality to capture the data, store the data in database, query the data as per user requirement, analyze, display for visualizing the model . GIS are used in conjunction with other systems and methods such as systems for decision making and the method for multi criteria decision making (MCDM) There are three main ways in which Analytical Hierarchy process (AHP) are complementary to each other

II. STUDY AREA AND DATA USED

➢ Location of the Study Area

Study Area Nekemte town, which was established as a town of municipality in 1942, is located between 9° 3’22’’- 9° 6’27’’ North latitude and 36° 30’31’’- 36° 35’ 11’’east longitude with an average altitude of 2,115 m above sea level. The town has a total area of about 53.8 km2 with a total population of over 122,000. Currently, it is divided into 7 administrative sub-towns: Bake Jama, Kaso, Bakanisa-Kase, Chalalaki, Burka Jato, Darge and Sorga

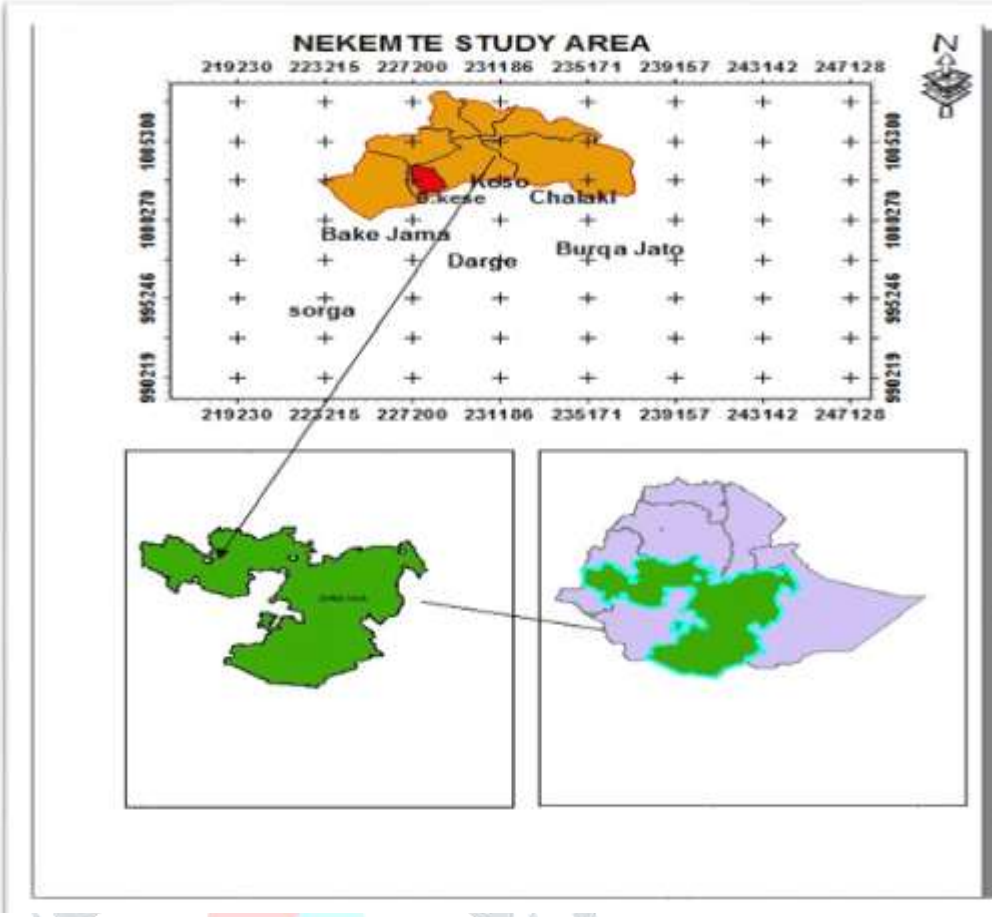


Figure 1 Study Area

➢ Data used

The input data used in this work is Google, Satellite Image, Nekemte base map, Landsat8, DEM, Hand GPS Instrument (Garmin Etrex)

Feature Dataset

A feature dataset is a collection of related feature classes that share a common coordinate system. Feature dataset works like a sub folder created inside the geo-database which can be used to store spatial data layers. Because of Nekemte Projected coordinate system is UTM Zone_37N.

Projected Coordinate System: WGS_ I 984_UTM_Zone_37N

Projection: Transverse-Mercator

False_ Easting: 500000.00000000

False Northing: 0.00000000

Central Meridian: 81 .00000000

Scale_ Factor: 0.99960000

Latitude Of_ Origin: 0.00000000

Linear Unit: Meter

Geographic Coordinate System: GCS_WGS_1 984

Datum: DWGS1984

Prime Meridian: Greenwich

Angular Unit: Degree

After creating the geo-database and the feature Dataset all required data layers were imported into the feature dataset. This was very important to prevent the projection errors of the layers and also keep all layers in same format.

III. OBJECTIVES & METHODOLOGY

1) General Objectives

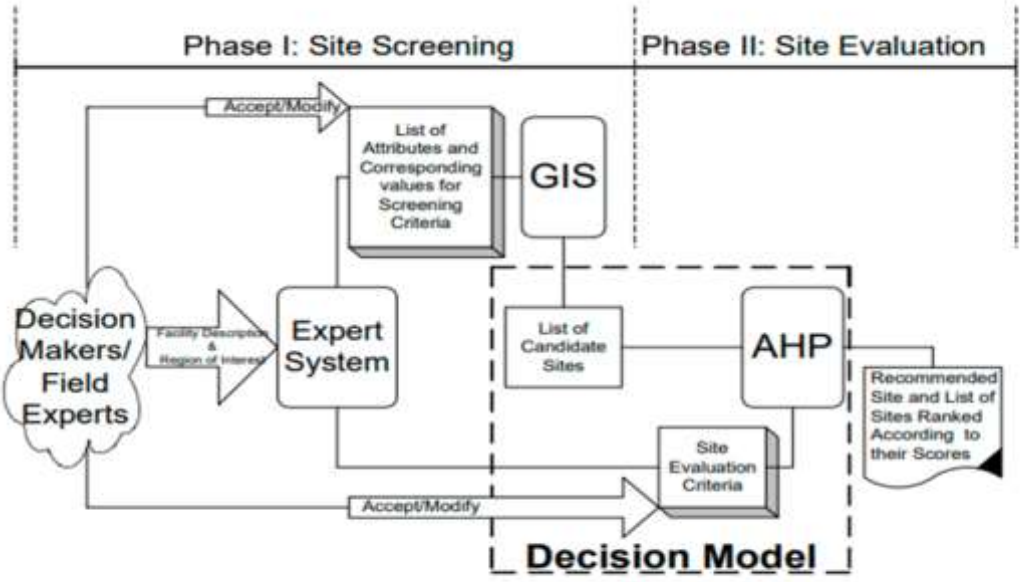
The general objective of the study is to identify suitable industrial site location by using AHP and Geospatial techniques in Nekemte town.

2) Specific Objectives

a) To determine the specific criteria for site selection of an Industrial site location in the study area.

b) To prepare the map of suitable site selection for Industrial Zone in case of Nekemte Town.

3) Methodology is explained in Flow chart



. Architecture of the Intelligent GIS Approach

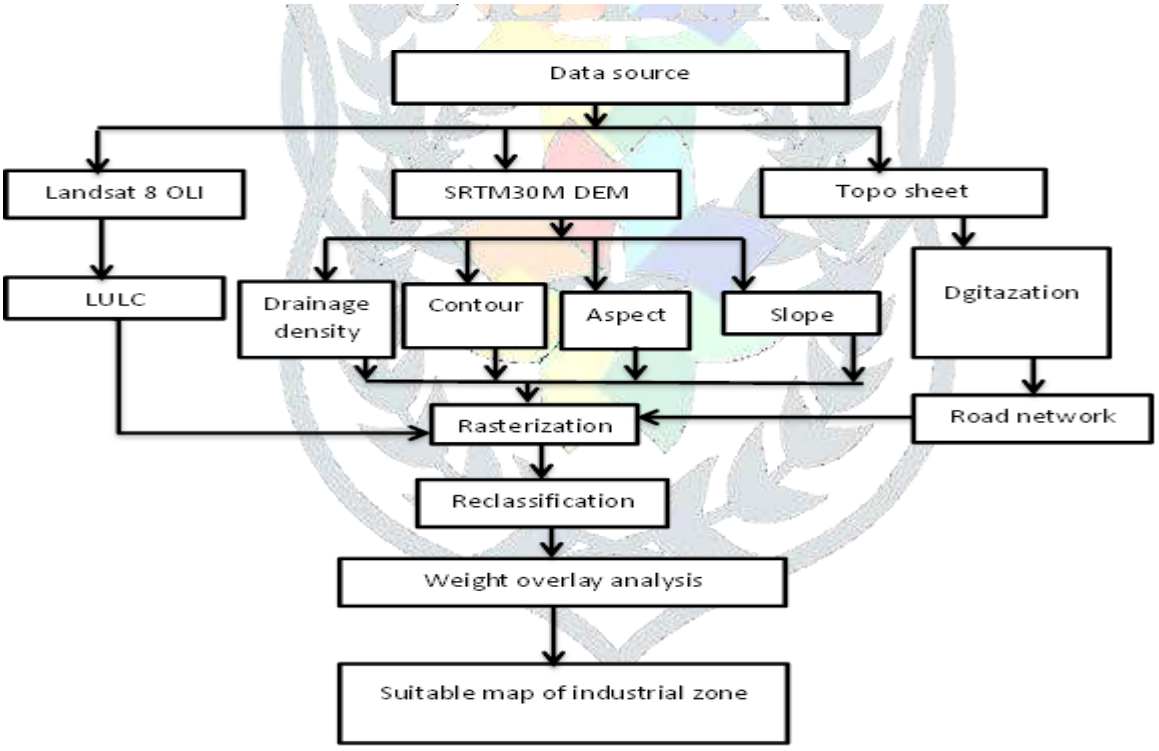


Figure 2 Process Flow Chart

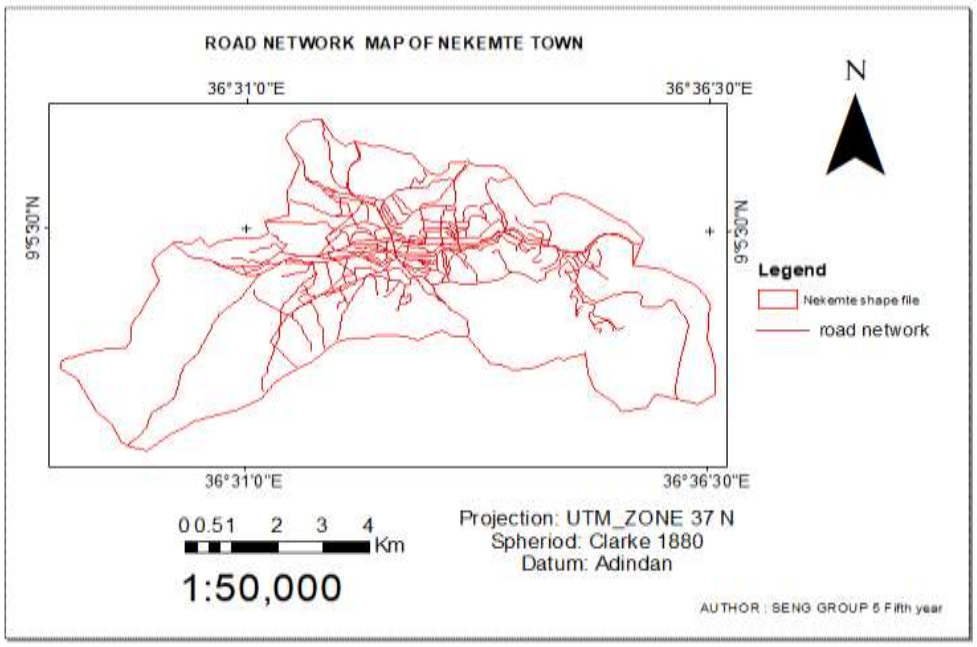
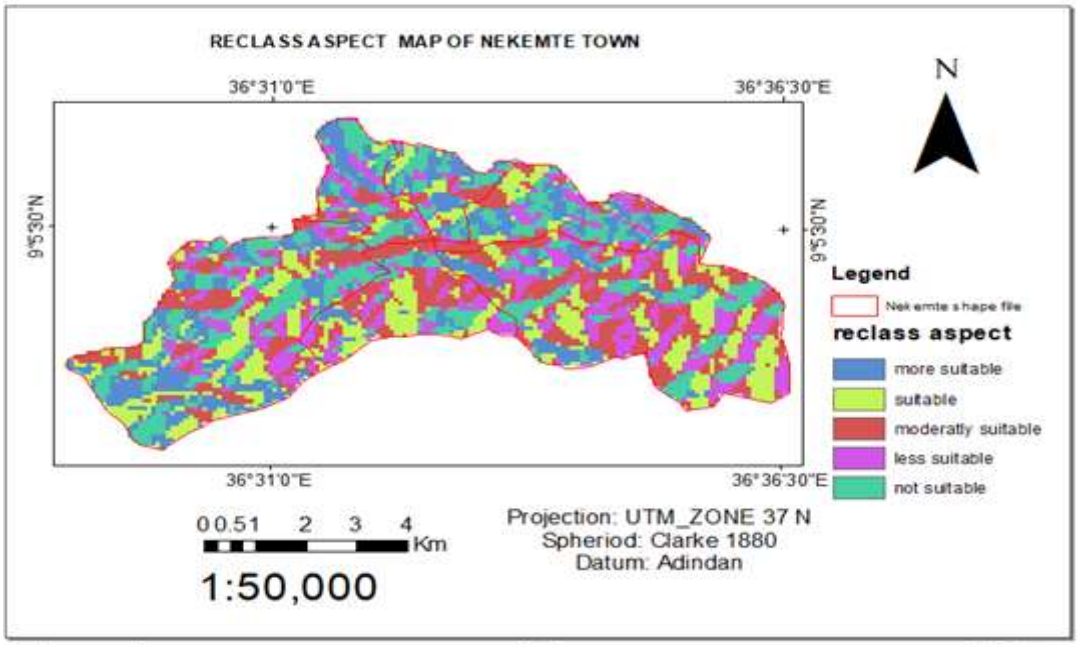


Table.1 Road and related scores

Roads Distance (meters)	***ranks***	***Suitability***
2639-3360	*1*	Not suitable
2016-2639	*2*	Less suitable
1344-2016	*3*	Moderately Suitable
672-1344	*4*	Suitable
0-672	*5*	High Suitable



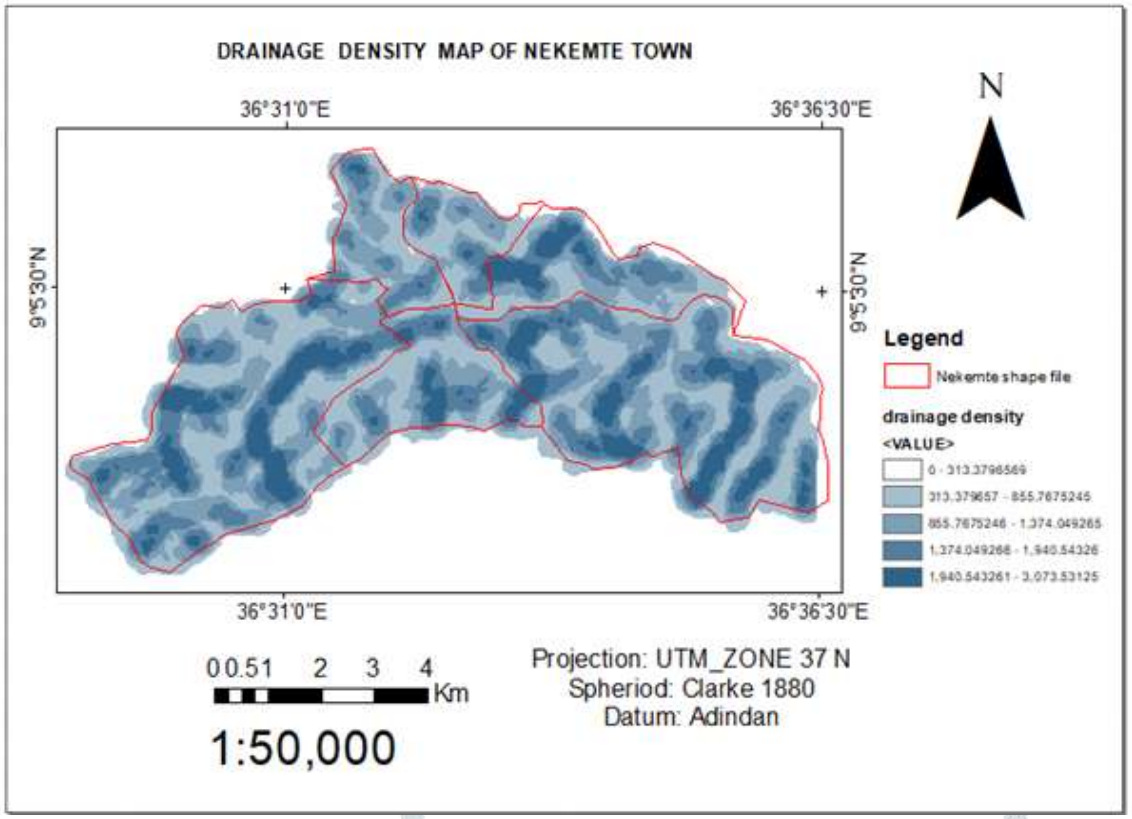
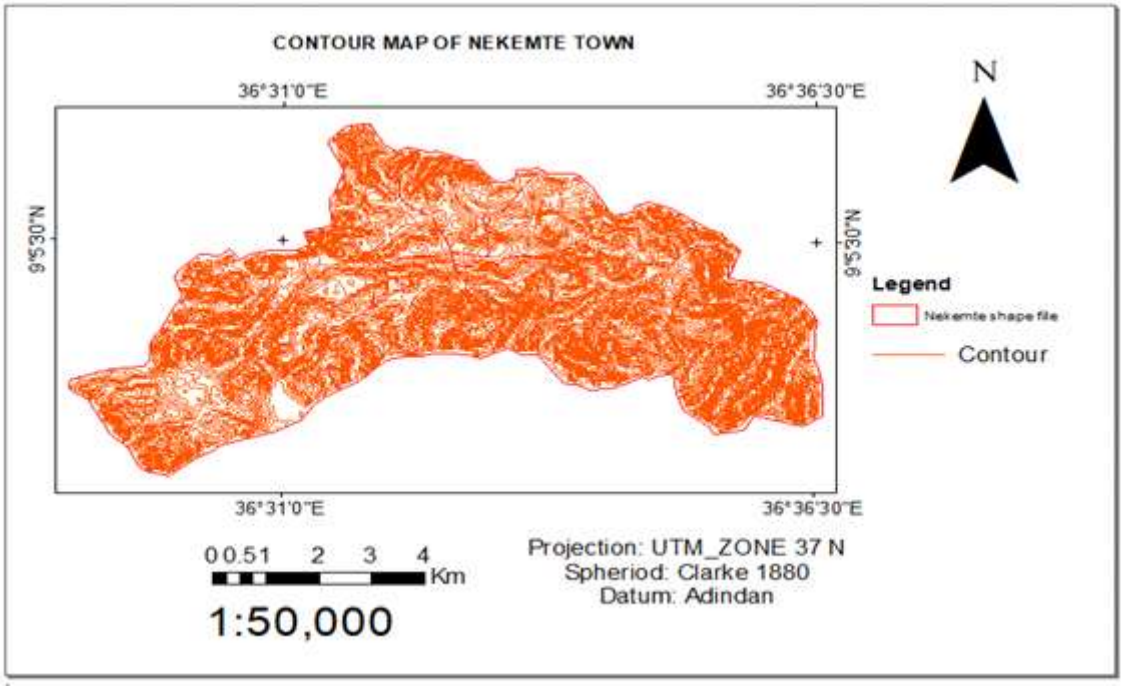
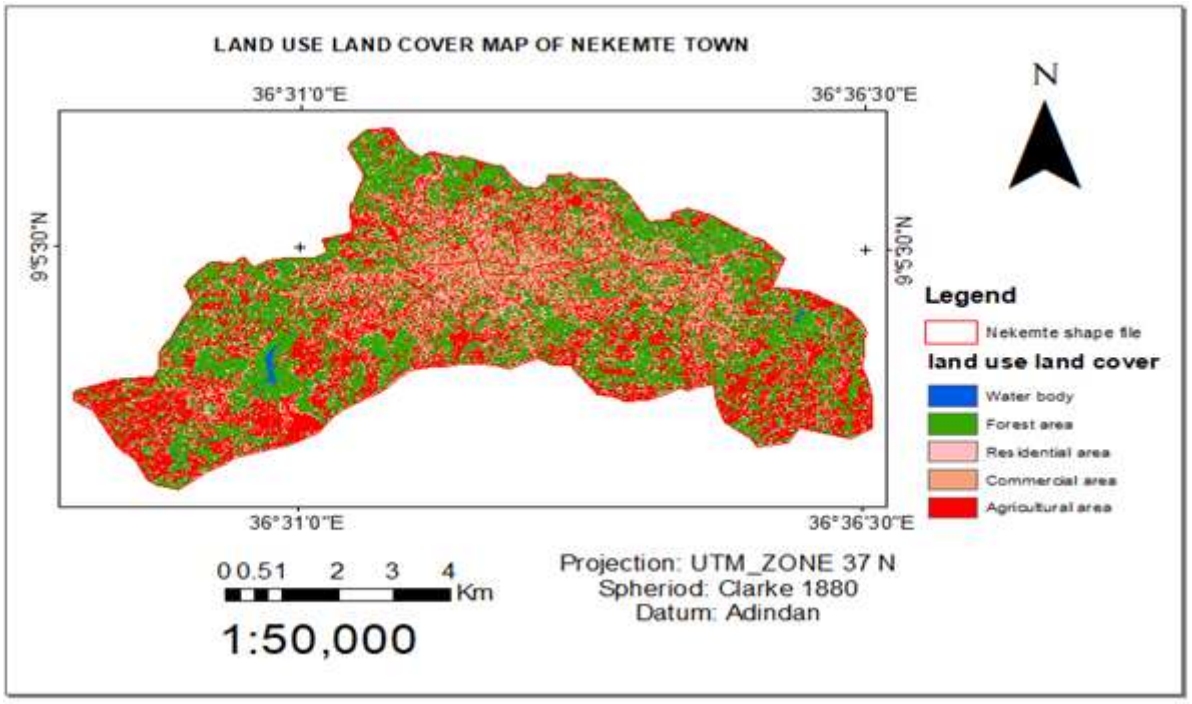
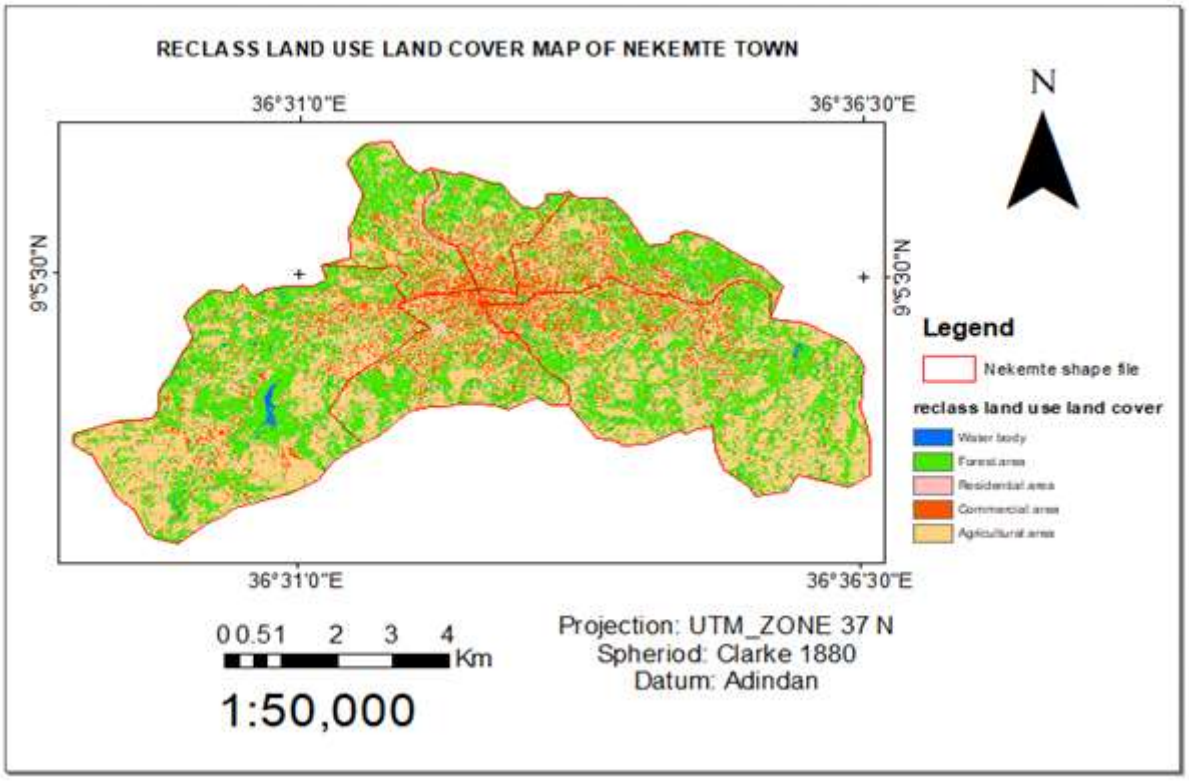


Table 2 Drainage amounts and related scores

Drainage r(m)	**Suitability**
0-250m	Not suitable
250-500m	Less suitable
500-750m	Moderately Suitable
750-1000m	Suitable
>1000m	High Suitable







IV. ACCURACY ASSESSMENT & RESULT ANALYSIS:

User Accuracy = Number of Correctly Classified Pixels in Each Category*100

Total Number of Classified Pixels in That Category (Row Total)

Producer Accuracy = Number of Correctly Classified Pixels in Each Category*100

Total Number of Reference Pixels in That Category (The Column Total)

Over All Accuracy = Total Number of Correctly Classified Pixels(Diagonals) *100

Total Number of Reference pixels

Kappa coefficient (T)=(TS*TCS)- ∑ (Column Total X Row Total) x100

TS^2 -∑ (Column Total X Row Total)

	Water body	**Forest area**	**Residential area**	**Commercial area**	**Agricultural area**	**Total(User)**
Water body	**3**	0	0	0	0	**4**
Forest area	1	**13**	0	0	0	**13**
Residential area	0	0	**5**	1	0	**6**
Commercial area	0	0	10	**3**	0	**13**
Agricultural area	0	0	0	0	**14**	**14**
Total (producer)	**4**	**13**	**15**	**4**	**14**	**50**

Table 4: Procedure Vs User

- Over All Accuracy = Total Number of Correctly Classified Pixels(Diagonals) *100

Total Number of Reference pixels

= 38/50*100 =76%

User Accuracy = Number of Correctly Classified Pixels in Each Category*100

Total Number of Classified Pixels in That Category (Row Total)

- **User accuracy calculation**

Water body =3/4*100 = 75%

Forest area =13/13*100= 1 00%

Residential area =5/6*100= 83.3%

Commercial area =3/13*100= 23.1%

Agricultural area =14/14*100= 100%

- Producer Accuracy = Number of Correctly Classified Pixels in Each Category*100

Total Number of Reference Pixels in That Category (The Column Total)

Producer accuracy calculation

Water body =3/4*100=75%

Forest area =13/13*100=100%

Residential area = 5/15*100=33.3%

Commercial area = 3/4*100=75%

Agricultural area =14/14*100=100%

Kappa coefficient (T)=(TS*TCS)- ∑ (Column Total X Row Total) x100

TS^2 -∑ (Column Total X Row Total)

= (50x38) -((4*4) +(13*13) +(15*6) +(4*13) +(14*14)) x100

$(50)^2$-((4*4) +(13*13) +(15*6) +(4*13) +(14*14))

= 1900-523*100

2500-523

=**69.65%**

Where, TS Total Sample , TCS Total Correctly Classified Sample

Analytical Hierarchical Process (AHP)

Spatial AHP is termed by Siddique et al., 1996 for the purpose of multi criteria decision analysis that integrates GIS and AHP. In this project Spatial AHP is used to spot suitable sites for industries and to quantify the levels through categorization and usage of knowledge, facts-based user preference and data contained in GIS maps. The most difficult assignment in carrying out land suitability analysis approach foran exacting land use type is to assign the relative weights of the entity criteria that are to be considered. Thus, the study limited the criteria to the nine most important aspects.

Saaty's Nine point scale

Intensity of importance on an absolute scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over the other	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	An activity is strongly favored and its dominance is demonstrated in practice
9	Extreme importance	Evidence that favor one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between two adjacent judgments	When compromise is needed

Reciprocals	If activity i is assigned to one of the above numbers compared to activity j, then j has the reciprocal value compared to i	
Rational	Ratios that arise from the scale	if consistency were to be forced by obtaining n numerical values to span the matrix

AHP is divided into three stages:

I) Decomposition - Identify and structure the criteria

II) Comparative judgment - through pair wise comparison

III) Aggregating the priorities - Calculate suitability indexThis fig depicts whole procedure of AHP for establishing industries. Structuring is comparatively subjective activity and depends on decision maker's skill and experience. Criteria are to be considered based on the importance of user's requirement

Sensitivity analysis:

This method used for evaluating how sensitive the spatial multicriteria model output is to small changes in the input values. This approach aims at analyzing the effects of introduced perturbations in the input values on the output (criterion outcomes).

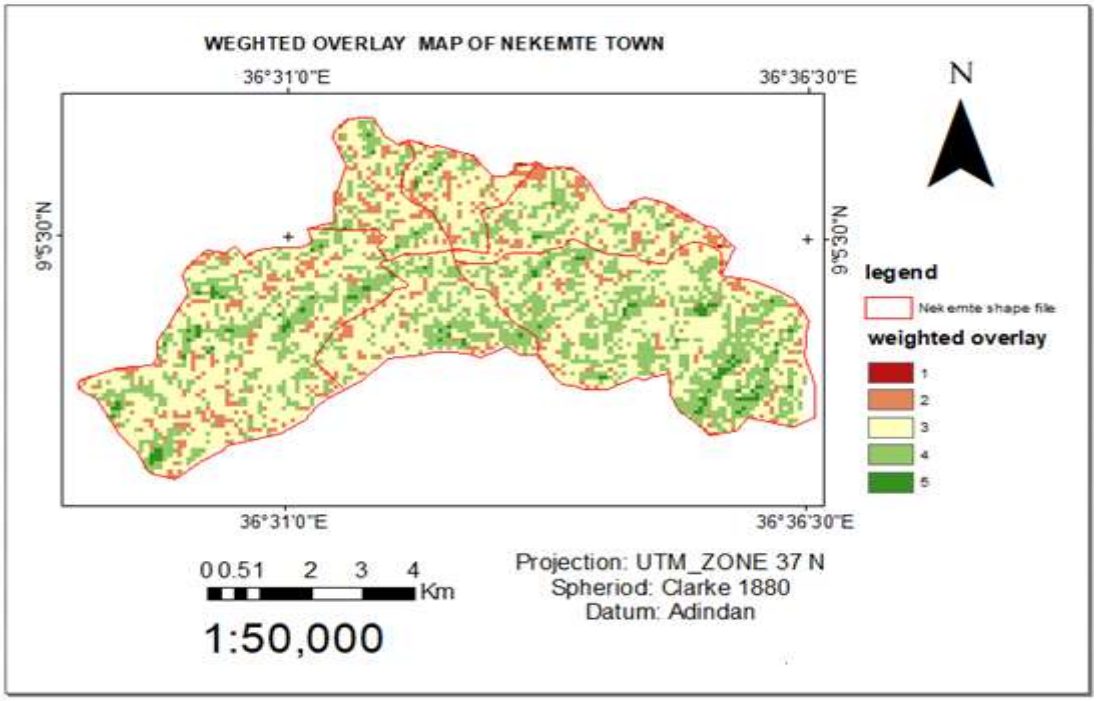
criterion weights and attribute values are the two most important essentials to consider in sensitivity analysis, out of these, sensitivity to attribute weights is perhaps more important. If the ranking of alternatives proves to be sensitive to one or more weights, the accuracy in estimating weights should be inspected carefully.

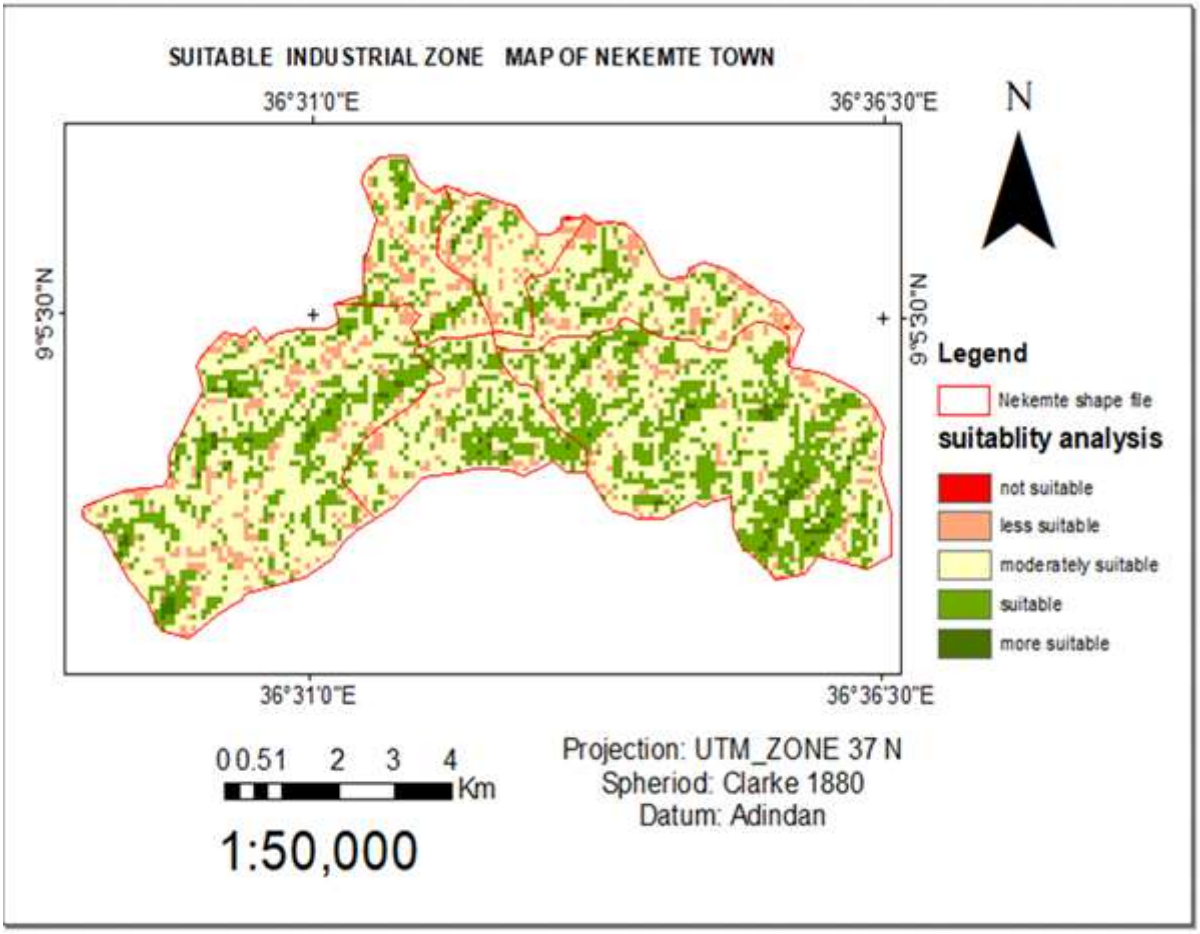
. The weights of criteria we have are changed at a certain percentage to find out the changing pattern of the suitability map within the classes of suitability fromoriginal weights of criteria.

Criteria	Weights
LU/LC	0.120196
Flood	0.276936
Geology	0.316898
Road Network	0.032038
Elevation	0.054213
Slope	0.135868

Table 4: Priority vectors from weighted decision matrix

The following result is from aggregate of all the criteria considered i.e., individual thematic layers are multiplied to the respective priority vectors obtained from pair wise comparison matrix of AHP. Suitability map of the region is classified to different classes from not suitable to highly suitable based on the cumulative evaluation of the criteria and weightages assigned to them at criterion level as well as attribute level





V CONCLUSION AND FUTURE SCOPE

Industries are important development endeavor that supports the economy for the towns and a given region. The ultimate purpose of establishing industry is to transform agricultural to industry, to ensure proper utilization of agricultural products, to establish and control standards, to generate income for the services rendered, and to alleviate impacts on the environment by controlling the environment and settlements from noise/pollution. Industries have some basic features that necessitate the search of unique location for them. Such location ought to satisfy some specific objectives including minimizing the undesirable impacts that the industry can pose on the surrounding environment and vice versa, ensuring the availability of basic facilities necessary for the proper functioning.

- Satellite remote sensing offers opportunity to obtain current information over large areas and GIS can be utilized to further analyze this information through simple models to answer the specific questions.
  - ✓ Remote sensing data analysis in this study has helped to derive quantitative information on spatial and temporal relationships of land use/land cover and its potential sites for industry development.
  - ✓ Geospatial technology with Analytical Hierarchy process AHP , as an information tool, has helped in the acquisition of recent land use information study aimed at solving problems. Information on different aspects for this study like land use land cover, slope, road, river etc. has been derived using this technique.
  - ✓ A multi criteria approach was employed in conjunction with GIS-based overlay analysis to identify the new industrial zone. A set of new industrial zone were identified after subsequent screening and refinement on the basis of analysis and field check.
    - ➢ Majority of the study area (20.5%) are high suitable (47.5%) is suitable to establish industries,15% moderately suitable and a small portion (9.5%) are less suitable and 7.5% unsuitable
    - ➢ Future scope the study results can be used for studying and implementing the Master Plan for suitable suggestions. The study can also be used for infrastructure development such as housing facilities developed by the government, institutional buildings etc.

REFERENCES

.
[2]. Ohri, A., Singh, P. K., & Singh, P. K. Spatial Multi Criteria Analysis For Siting Industries.
[3]. Congalton R. G., Green K. "Assessing the accuracy of classifications of remotely sensed data, Principles and practices", Lewis Publishers, New York, USA
[4]. John R. Jensen "Introductory Digital image, processing –A remote sensing perspective " ,second edition, practice hall, Englewood cliffs New Jersey.
[5]. Martinez J. A. & Stuiver H. J., Automated delineation of drainage networks and elementary catchments from digital elevation models. ITC Journal, No.3/4, pp. 198-208, 1998
[6]. Manugula S.S., Sagar M. "Digital classification of land use Land cover by using Remote sensing Techniques, International Journal of Innovations in Engineering and Technology (IJIET)", Vol 8 , Issue 2, pp. 149-156, 2017
[7]. Floyd, F.Sabins Jr, " Remote Sensing Principals And Interpretation" second edition, W.H. Freeman & company, New York 1987
[8]. Malczewski, J. (2004). GIS-based land-use suitability analysis: a critical overview. Progress in planning, 62(1), 3-65.
[9]. Berube, M. (2014). A GIS multi-criteria evaluation for identifying priority industrial land in five connecticut cities.
[10] Sarath Midatana, Saran, S., and Ramana, K. V.: SITE SUITABILITY ANALYSIS FOR INDUSTRIES USING GIS AND MULTI CRITERIA DECISION MAKING, ISPRS Ann. Photogrammetry. Remote Sens. Spatial Inf. Sci., IV-5, 447–454, https://doi.org/10.5194/isprs-annals-IV-5-447-2018, 2018
[11]. Fataei, E., & Mohammadian, A. (2015). Industrial state site selection using MCDM method and GIS in Germi, Ardabil, Iran. Journal of Industrial and Intelligent Information Vol, 3(4)