Change Detection Analysis and Statistical Site Suitability Mapping for Edappadi Taluk Using GIS Techniques

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Abstract- *Change detection is the main understanding process of finding the differences in the land features by observing them at different times of periods. Change detection is such a kind of tool that we can compare satellite data from different times to assess the damages from natural disasters, understand the ways in which humans alter the land, and characterize climatic and seasonal changes to the landscape. The agricultural, urban built up land, water bodies and road networks are taken as the key features to mapping the changes in Edappadi taluk, Salem district, Tamil Nadu. The satellite images obtained in the three different periods such as LANDSAT 5(1991) and LANDSAT 7(2001) and LANDSAT 8(2015) are used in the present study along with the town and country planning map (1994) and survey of India Topo-sheets(1973,1974). Mapping of the built-up changes, agricultural land changes, waterbodies changes in the study area have been interpreted in view of developing with different classes. To identify the site suitable region for urban development and better suitable areas for urban dwelling in the Edappadi taluk, Salem using Multi Influencing factors (MIF) and Geoinformatics techniques (GIS). The site suitability mapping for urban development on the suitable areas along with suitable parameters has performed in the present study. The main aim of the study is to find out the growth and trend of future urbanization around study area, as well as to find out the suitable sites for further urban development around the Edappadi areas.*

Keywords- Change Detection, Land Use/Land Cover, Remote Sensing, GIS, Site Suitability

I. INTRODUCTION

The Remotely sensed data of different periods to provide the significant information about the changes occurred in the two or more time periods. Change detection is the process of determining the changes associated with land use land cover properties with reference to using the remotely sensed data. Land use and land cover is an important factor in understanding the connections of the human activities with the environment and thus it is necessary to be able to simulate the changes. Detection of changes are useful in many applications such as land use changes, habitat fragmentation, rate of deforestation, coastal change, urban sprawl, and other cumulative changes through spatial and temporal analysis techniques such as GIS (Geographic Information System) and Remote Sensing along with digital image processing techniques [14]. The land use land cover change detection map was prepared by [12] in Pathankot and Dhar Kalan Tehsils in Punjab. The author attempted to study the changes in land use and land cover in Kodaikanal Taluk, a part of Western Ghats located in Tamilnadu state over 40 years period of 1969-2008 [13]. The development of urban lands and the changes in the land use and land cover in Salem city, Tamil Nadu has been monitored by using IRS satellite data, Town and Country Planning map (1994) and Survey of India Topo-sheets (1972), in view of developing urban land with different classes [19]. Land use planning has been done by [10] using IRS-1A LISS-4 in southern part of Sonbhadra District, U.P., using Remote Sensing Techniques. The Ratnagiri mangrove maps of estuary was prepared by [9] using the unsupervised classification of principal components technique of Landsat-TM, Landsat-ETM, ASTER, IRS-P6 (LISS III) satellite data 1989, 1999, 2004 and 2009 respectively. Simly watershed landuse landcover map was prepared by using supervised classification-maximum likelihood algorithm in ERDAS imagine and the changes were observed in between the period of 1992 to 2012 through Landsat 5 and SPOT datasets [1].

A multisource classification approach applied to map the land cover in Himalayan region with High Mountain peaks by using the Remote sensing data of IRS LISS III image along with NDVI and DEM data layers [15]. The GIS is extensively accepted as a valuable decision support system that enables the determination of suitable spatial locations for a specific objective based on a group of criteria [3]. GIS and Multi Criteria Evaluation (MCE) are the most common techniques used to analyze the potential sites for urban development.

These techniques are very simple and flexible for the analysis process for the urban development [16]. Identification of suitable site for urban development in hilly area is one of the critical issues of planning. The statistical site suitability analysis has become inevitable for delineating appropriate site for various developing in enterprises and especially in the undulating terrain of the hills. The Geographic Information System (GIS) based Multicriteria Evaluation (MCE) technique was adopted to Mussoorie municipal area, Dehradun district, Uttarakhand study area urban development site suitable map has been done by [7]. The present study mainly aims to derive the land use land cover changes and site suitable regions for urban development of the Edappadi taluk, Salem district, Tamilnadu.

1.1 Study area

Edappadi Taluk is located at $77^0$45'56" and $77^0$57'25" and latitude of $11^0$31'25" to $11^0$43'27". It is situated at the nearby basin of the hill called 'Soorieya malai' (Mountain of Sun) and the Edappadi taluk has an average elevation of 288 m (945 ft.) in MSL. The study area is bounded by Sankari in the south, Jalakandapuram in the north, Konganapuram in the east and Poolampatti in the west. The river Cauvery flows on the west of the town from north to south at 8 Km from the town and taluk spreads over on area of 324 Sq. km. According to the 2011 census, the taluk of Edappadi had a population of 222,856 with 116,241 males and 106,615 females. There were 917 women for every 1000 men and they are mainly involved in Agriculture activities. Sankari – Edappadi route via Veerappam Palayem and Sunnambukkuttai is rocky terrain. It is really beautiful view of this town, while seen from 'Konamoori' (A Bridge with dangerous Turns in Kavadikaraoor) bus stop via. Sankari – Edappadi route. River Cauvery is 6 km away from Edappadi and near western side Mettur east bank canal and Edappadi in the western region of the study area. The river Sarabanka is passing through Edappadi and that is originating from Servarayan hills. It is now only carrying left outs and sewages of Edappadi residents. The Nanjudeshwarar temple is situated in the Centre of the town which is one of the rare Shiva temples in India. The Edappadi town near by the Periyar Eri is bigger lake in Edappadi taluk along with Sarabanka River. Along with the riverside there are number of natural and artificial tanks are located to increase the ground water level of the study area and fulfill the domestic and industrial water supply. The Edappadi study area base map is shown in the figure 1.

1.2 Climate

The temperature is moderate throughout the year except in summer where it will be very hot. The temperature varies from 22^0C to 40^0C. Heavy rainfall occurs between August and November in the northeast monsoon. The average rainfall is around 800mm.

1.3 Geology

The Edappadi Taluk mainly comprises of the rock type of fissile hornblende – biotite gneiss which are highly present in the study area. The study area has some different types of minerals, such as mica, quartz, feldspar, gypsum, beryl, tantalite, and columbite. The Poolampatti area is covered by mica, feldspar and quartz spreads area of Pakkanadu, Chittoor and samudram. Beryl occurrences found in Adiyur regions. The Geology map shown in the figure 2 and their aerial coverage shown in the table 1.

1.4 Geomorphology

Geomorphology map of the study area was prepared by demarcating geomorphic units from Survey of India (SOI). Geomorphological units were delineated based on image characteristics like shape, color, background etc. many tectonic land forms are present in the study area (figure 3). The majority of area are covered Pedi plan, and structural hill and linear ridges. The study area Geomorphology is mostly covered by shallow buried Pedi plan in 191.16 Km^2. The Geomorphology features aerial coverage shown in the table 6.

1.5 Soil

The study area comprises of distribution types of soil such as red soil, black soil, red sandy soil, and sandy alluvium. The study area is highly covered by red soil in 205.05 km^2. The soil map shown in the figure 4 and aerial coverage of the soil map is shown in table 6.

1.6 Objectives

- To understand the application of Remote sensing and Geoinformatics in change detection analysis.
- To analyze the changes of urban, water bodies, agricultural lands in Edappadi taluk in between 1991-2015.
- To generate data on land consumption by urbanization.
- To generate the site suitability region for future urban development.

II. METHODOLOGY

The selection of the study area in digital image processing and change detection analysis are involved to identifying the changes occurred in-between the different

periods of 1991-2015 and Multi Influencing Factor (MIF*)* analysis through overlay weighted method was used to delineate the urban site suitable zones. Figure 5 shows the methodology of the present study

III. DIGITAL IMAGE PROCESSING

ArcGIS and ENVI Image Processing software is utilized to digitally process the satellite data and extract the spectral characteristics. Landsat 5 (1991) and Landsat 7 (2001) and Landsat 8 (2015) were utilized for image analysis and generated various processed outputs. The image processing techniques involves contrast stretching, band ratios and band combinations. In band combinations, False Color Composite (FCC), True Color Composite (TCC) and Pseudo Color Composite (PCC) were generated.

3.1 Band Combinations

The range of image enhancement technique is broad but composite generation is one of the fundamental techniques used. For visual analysis colour composites make the fullest use of satellite imagery, which are applied to the RGB colour scheme to make the fullest use of capabilities of human eye. The true colour, false colour and pseudo colour composite images are useful to extract more information [20]. The table 2 describes various band combinations prepared using Landsat 5, Landsat 7, and Landsat 8 along with their applications. The False Color, True Color and Pseudo Color Composites are shown in the figure 6, 7 and 8 respectively.

3.2 Development of classification scheme

In the present study five features have been used to understand the change detection of the Edappadi taluk using by with the reference of the NRSC LULC Classification [6] which is given in the table 3.

The Land use Land cover maps of 1991, 2001 and 2015 are shown in the figure 9. The road networks have been drawn from the 1991, 2001, 2015 by using Landsat datas. The road networks are shown in the figure 10.

IV. RESULTS AND DISCUSSIONS

4.1 LULC and Change detection analysis

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes [5]. Different land use/land cover features have been identified using visual interpretation techniques [11]. Change detection using GIS is a process that measures how the attributes of a particular area have changed between two or more time periods. Change detection often involves comparing aerial photographs and satellite imagery of the area taken at different times. In the present study area it is focused to demarcate the changes occurred in the period from 1991- 2015 for the Edappadi taluk, Salem district, south India. The toposheets, Satellite data which are taken for the different period, NRSC Land use Land cover classification scheme, Envi, Arc GIS and Erdas software are used in the present study. The change detection analysis is performed using topo maps, Landsat 5(1991) and Landsat 7 (2001) and Landsat 8(2015) satellite images for the Edappadi taluk. The urban area of Edappadi has increased within the study period in-between 1991-2015. Since Edappadi is one of the most developing taluk in Salem District, Tamil Nadu, India most of the major education institutions, industries are situated in around the Edappadi taluk. The results of this study were obtained based on Image classification and its interpretation. The results obtained from the present study area is agriculture land is drastically reduced in the area about 21km^2 within 25 years period where as barren land is increased about 5.5km^2. The area covered by forest is more or less similar in the time period. The built up is increased nearby about 104% with an area covered of 25.4km^2. More than 50% of the water bodies are disappeared/or consumed for other purposes. The decrease of waterbody is an alarm in the current stage and necessary steps has to be taken to conserve the presently available waterbodies and barren land/waste land may be converted to build artificial recharge structures to improve the groundwater condition in the study area after necessary analysis. The road networks are developed in between 2001 and 2015 is shown the speedy urbanization process occurred in the study area. The changes occurred in between 1991, 2001 and 2015 is shown in the form of Graphical representation in figure 11 and the tabulated form given in Table 4.

4.2. Site Suitability Statistical Analysis for Urban Development

The site suitability for urban development in the study area to carried out by considering some of the parameters like soil media, land use land cover, settlement, proximity buffer road network, surface water body proximity, population density, geomorphology, and slope. These are the parameters used through integrated MIF method and GIS techniques. The MIF based weightage of the eight layers were assigned to develop the site suitable location for the urban development of the Edappadi Taluk. The eight classification is given in the table 6.

The Road network map was digitized from the recent Landsat satellite data and the proximity buffer region of this roads are prepared using multiple ring buffer tool of GIS. The road proximity buffer was created based on the transportation accessibility. So hereby the road network buffer zones have been generated by 50m interval based on the method adopted by [2]. The figure 12 showing the road proximity buffer of the study area. The urban settlement have been generated as 50m interval in the study area, which is shown in the figure 13. The population density is one of the more impact for the urban development and generally the area has high intensity of population will have more environment pollution. In the Edappadi taluk, Edappadi municipality and Chittoor, Konganapuram has huge population compare to other areas and the population density ranks are assigned based on [2]. The population density was created by using population data. Population density is shown in the figure 14. The slope ranks are done based on Manish Kumar and Biswas (2013). Figure 15 is showing slope map of the Edappadi taluk. The land use land cover map of Edappadi taluk consist of following classes of Agriculture land (160.5 km^2), Built-up land (49.3 km^2), Waste land (60.4 km^2), Forest (44.5 km^2), waterbody (9.3 km^2). The land use/land cover different classes are shown in the figure 16. The surface waterbody proximity is shown in the figure 17.

Urban development planning is a technical process concerned with the use of land and design of the urban environment, including transportation networks to guide and ensure the orderly development of urban suitable regions in process of remote sensing and GIS techniques. By using with the Multi Influence Factor (MIF) it is arrived the weights for thematic layers of study area is based on [8]. The integration key factors relationally together is necessary in order to obtain a site suitability map. The weighting approach was performed to obtain suitability map from the factors of influencing each layers [18]. The layers influencing factors is called cumulative index [4]. Using with this cumulative index to factors of the each layers are performed from as major effects and minor effects for the present study site suitable map. The major effects- 1 and minor effects- 0.5 relative factors values for site suitable proposed weighting for the study [17]. Table 5 describing the multi influencing factors technique to weights derived for the present study. The rank of each classes, all thematic layers weights and statistics for urban development suitability index are shown in the table 6 and 7. Table 8 shows Edappadi taluk site suitability criteria for urban development. The site suitable map of the Edappadi taluk shown in the figure 18.

V. CONCLUSION

The ingrated GIS method to statistical site suitability mapping results shown the better understanding to selection of the more suitable area comes under for urban dwelling in Edappadi taluk in 44 sq.km and suitable region 142 sq.km. The remaining parts are less suitable, not suitable have an aerial coverage of 123 sq.km and 15 sq.km respectively. The south part of near western side Konganapuram has most perfect place to urban dwelling. This study is more useful for administrative bodies to encourage the people's future. In future, this kind studies has to be using high spatial and spectral resolution satellite images to get the higher accuracy for planning and development projects.

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Figures:

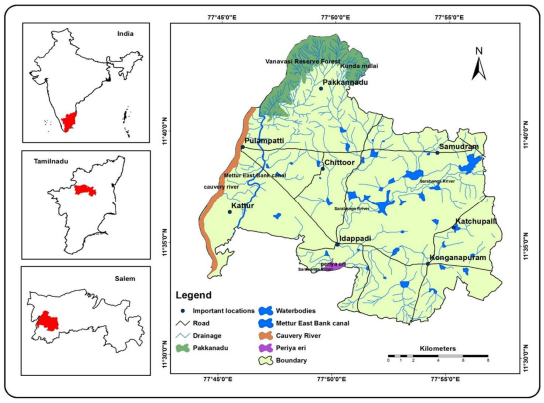

Fig. 1. The study area of Edappadi location map

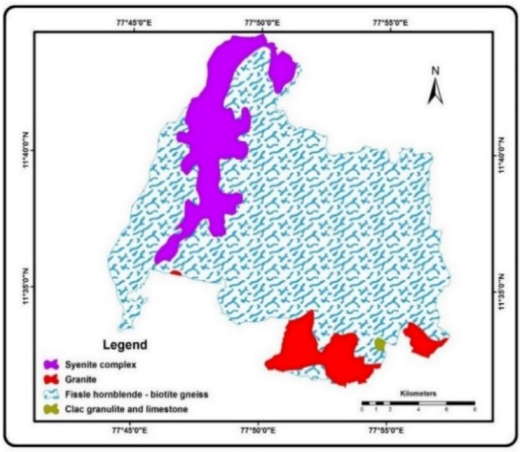

Fig. 2: The Geology map of the Study area

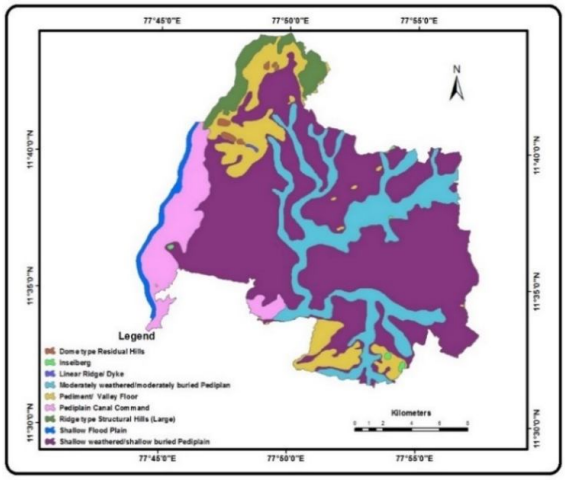

Fig. 3: The Geomorphology map of the study area

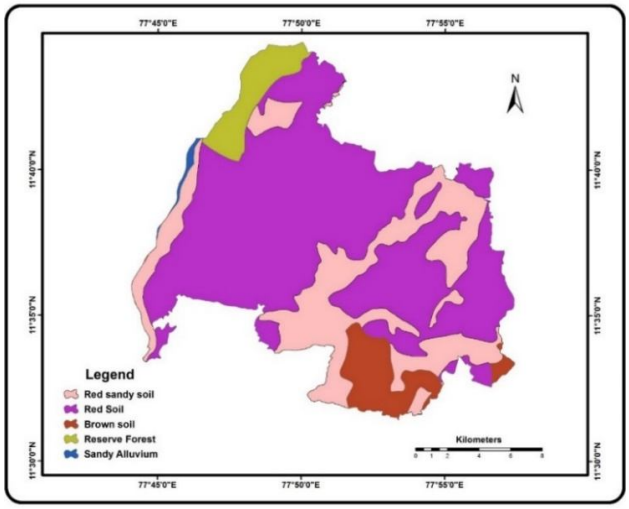

Fig. 4: The soil map of the study area

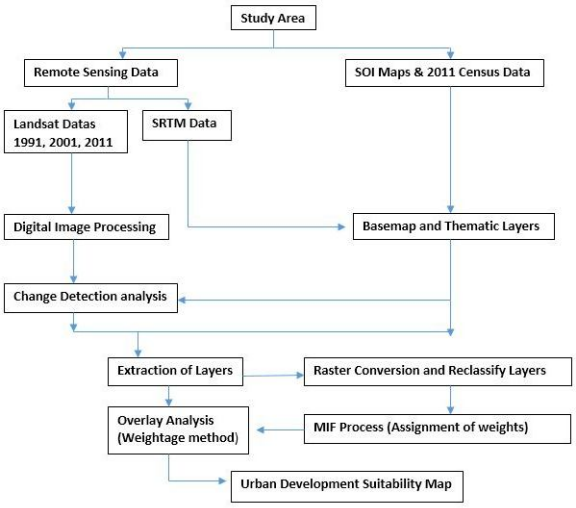

Figure. 5: The flow chart showing Methodology adopted in the present study

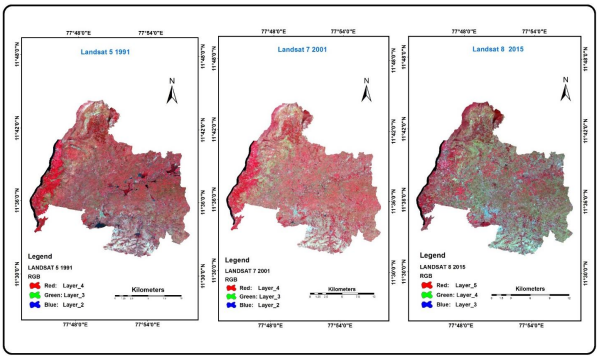

Fig. 6: False Colour Composite (FCC), generated using 4 3 2 in Landsat 5 and 4 3 2 in Landsat 7 and 5 4 3 in Landsat 8 bands were assigned as Red, Green and Blue colors which highlights the vegetation feature in Red.

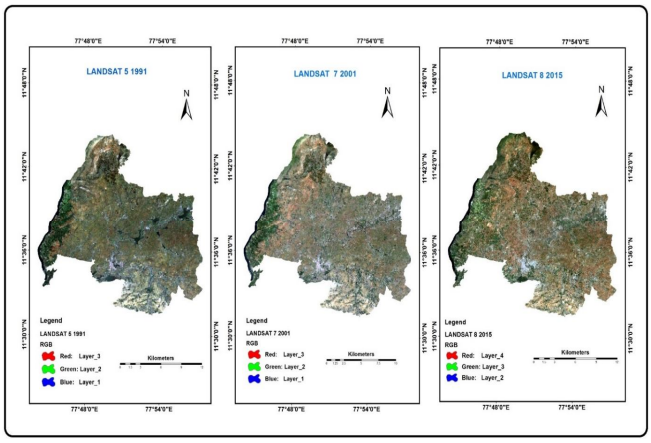

Fig. 7: True Colour Composite (TCC), generated using 3 2 1 in Landsat 5 and 3 2 1 in Landsat 7 and 4 3 2 in Landsat 8 bands were assigned as Red, Green and Blue colors. It highlights the urban in light blue.

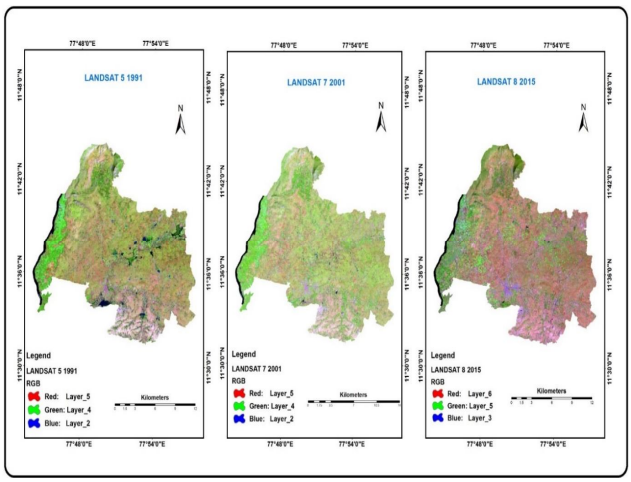

Fig. 8: Pseudo Colour Composite (PCC), generated using 5 4 2 in Landsat 5 and 5 4 2 in Landsat 7 and 6 5 3 in Landsat 8 bands were assigned as Red, Green and Blue colors. It highlights the road networks, water bodies in blue and dark blue.

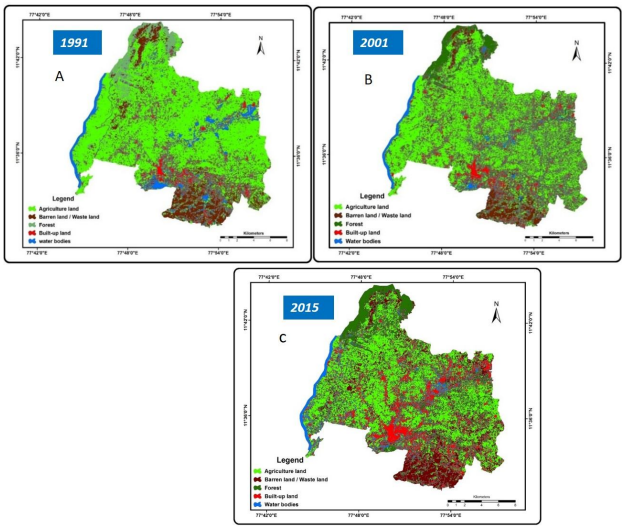

Fig. 9: The Study area Edappadi taluk Land Use Land Cover maps of 1991(A), 2001(B) and 2015(C).

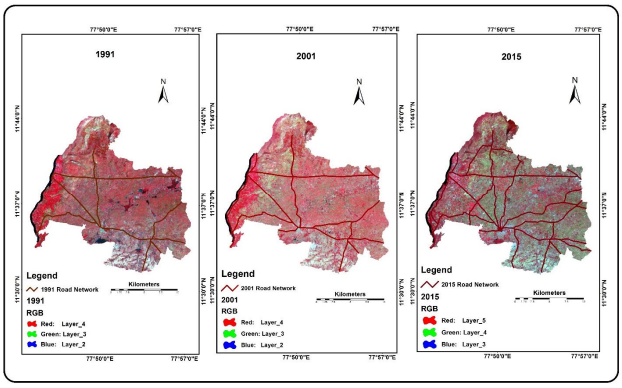

Fig. 10: The Road networks shows the changes occurred in between years of 1991, 2001, 2015

Fig. 11: Overall changes occurred in-between years of 1991, 2001, 2015

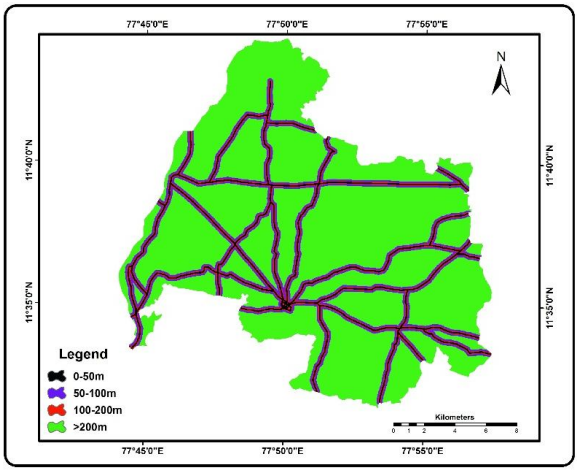

Fig. 12: The road proximity Study area

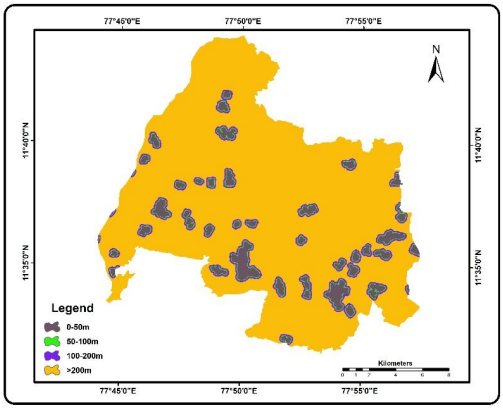

Fig. 13: The settlement proximity of study area

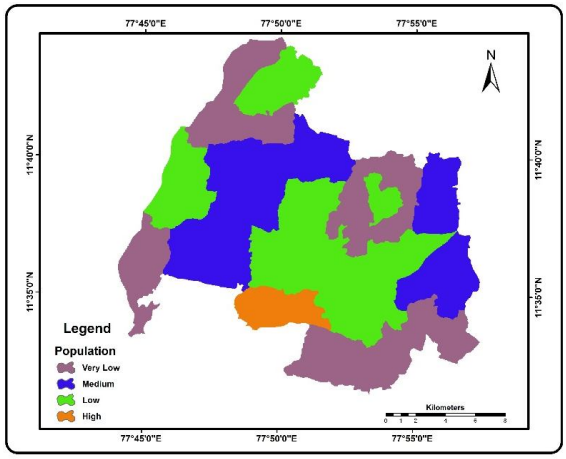

Fig.14: The Population density map

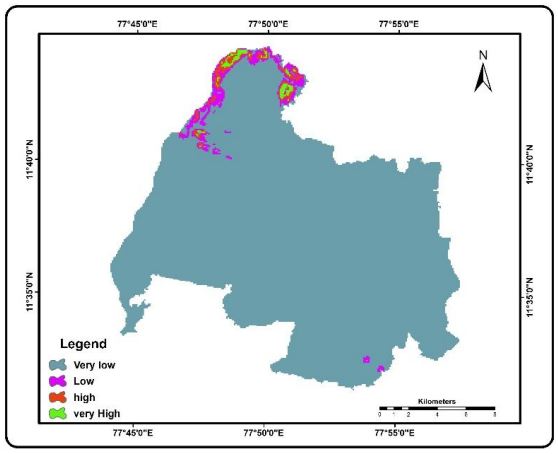

Fig. 15: The Slope map of study area

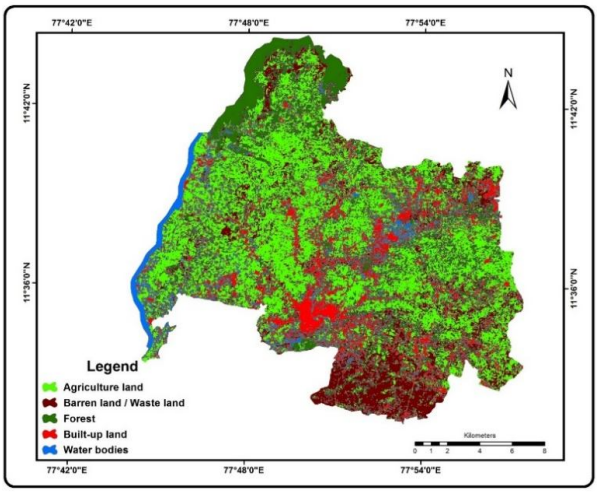

Fig. 16: The land use land cover map of study area

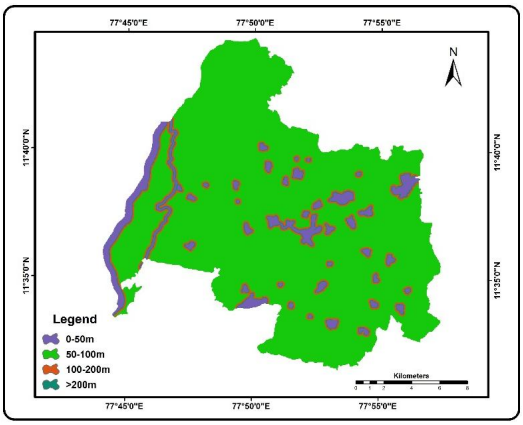

Fig. 17: The waterbody proximity of study area

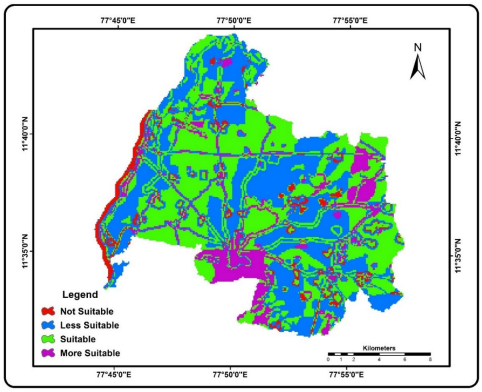

Fig.18: The site suitability map for study area

Tables:

Table 1: Various rock types and their aerial coverage in the study area

S.NO	Rock types	Area (Km^2)
1.	Syenite complex	45.33
2.	Granite	21.90
3.	Fissile hornblende – biotite gneiss	256.3
4.	Calc granulite and limestone	0.52

Table 2: Band combinations of LANDSAT 5 and LANDSAT 7 and LANDSAT 8 (USGS)

Composite Name	LANDSAT 5	LANDSAT 7	LANDSAT 8	Application
Colour infrared	4,3,2	4,3,2	5,4,3	Vegetation
True Colour	3,2,1	3,2,1	4,3,2	Urban ,water bodies
False Colour	5,4,3	5,4,3	6,5,4	Vegetation
False Colour	7,4,2	7,4,2	7,5,3	Vegetation
Pseudo Colour	5,4,2	5,4,2	6,5,3	Road networks and vegetation

Table 3: Classification scheme of Edappadi study area

S.No	Classification
1.	Built-up land
2.	Agriculture land
3.	Water bodies
4.	Barren land
5.	Forest

Table 4: The overall changes in between years of 1991, 2001 and 2015

S.No.	Classification	In 1991 (sq. km.)	In 2001 (sq. km.)	In 2015 (sq.km.)	Changes of 1991-2001 (%)	Changes of 2001-2015 (%)	Changes of 1991-2015 (%)
1.	Agriculture land	181.3	176.1	160.5	2.9	8.9	11
2.	Barren land/Waste land	55.4	51.5	60.4	7.1	11.7	10.9
3.	Forest	45.2	47.4	44.5	4.7	6.2	1.6
4.	Built-up land	24.3	34.4	49.7	29.4	30.8	104.4
5.	Water bodies	18.2	14.2	9.3	22	35.1	51
6.	Road networks	85.2(km)	112(km)	177.3(km)	24	36.8	108

Table 5: The multi influencing factors relative rates and weights scores for all the layers

Layers	Major Effects (A)	Minor Effects (B)	Proposed relative rates (A+B)	Proposed weight for each IF
Land use land cover	1+1+1+1+1+1+1	0	7	18
Geomorphology	1+1+1+1	0.5+0.5+0.5	5.5	14
Soil	1+1	0.5+0.5+0.5	3.5	9
Population density	1+1+1	0.5+0.5+0.5+0.5	5	13
Road proximity	1+1+1	0.5	3.5	9
Surface Water body	1+1+1	0.5+0.5+0.5	4.5	12
Slope	1+1+1	0.5+0.5	4	10
Proximity Settlements	1+1+1+1+1	0.5+0.5	6	15

Table 6: The Relative weights of thematic layers with their ranks and scores

Layers (factors)	Class	Area (Km^2)	Rank	Weight	Score
Land Use/ Land cover	Built up land	49.3	3	18	54
	Forest	44.5	2		36
	Waste land	60.4	4		72
	Agricultural land	160.5	1		18
	waterbody	9.3	1		18
Geomorphology	Pediplain	305.7	4	14	56
	Structural hills	11.8	2		28
	Denudational hills	1.7	1		14
	Flood plain	4.8	1		14
Proximity settlements	0-50m	18	1	15	15
	50-100m	6	2		30
	100-200m	13.5	3		45
	>200m	286.5	4		60
Population density	High	13.5	1	13	13
	Medium	97	2		26
	Low	108.4	3		39
	Very low	104.5	4		52
Slope	Very low	307.8	4	10	40
	Low	7.2	3		30
	High	6.7	2		20
	Very	2.3	1		10
Waterbody	0-50m	14.4	1	12	12
	50-100m	6.6	4		48
	100-200m	20	3		36
	>200m	283	2		24
Soil	Alfisols	80	2	9	18
	Entisols	205	4		36
	Inceptisols	21	4		36
	Vertisols	1.29	1		9
	Reserve forest	16.3	1		9
Road networks	0-50m	17	1	9	9
	50-100m	17	4		36
	100-200m	32	3		27
	>200m	258	2		18

Table 7: The statistics for urban development suitability index

Minimum	109
Maximum	451
Mean	228
Standard deviation	15.6

Table 8: Site Suitability criteria for urban development

S.No	Class name	Criteria	Suitability score	Area (km^2)
1.	More suitable	>($\mu+\sigma$)	247 to 452	44
2.	Suitable	μ to ($\mu+\sigma$)	225 to 247	142
3.	Less Suitable	($\mu-\sigma$) to > μ	200 to 225	123
4.	Not suitable	<($\mu+\sigma$)	109 to 200	15