www.cafetinnova.org

Indexed in
Scopus Compendex and Geobase Elsevier,
Geo-Ref Information Services-USA, List B of Scientific Journals, Poland, Directory of Research Journals

ISSN 0974-5904, Volume 09, No. 04

International Journal of Earth Sciences and Engineering

August 2016, P.P.1465-1473

Detection of Urban Changes and Statistical Site Suitability Analysis in Tiruchencode Taluk using Geoinformatic Techniques

S ARIVAZHAGAN[1] AND M KIRUBAKARAN[2]

[1]*Centre for Applied Geology, Gandhigram Rural Institute–Deemed University, Gandhigram, Dindigul District, Tamil Nadu, India 624 302.*

[2]*Department of Civil Engineering, Dhirajlal Gandhi College of Technology, Salem, Tamilnadu, India-636309*

Email: *arivusv@gmail.com, kirubakaranvm@gmail.com*

Abstract: Unplanned city growth is an indicator of rapid industrialization, which usually reduces the quality of the environmental health of a region - sometimes disastrously. Monitoring provides the planners and decision - makers with required information about the current state of development and the nature of changes that have occurred. The vegetation, urban sprawl, water bodies and road networks are taken as the key features to map the changes in Tiruchengode taluk, Namakkal, Tamil Nadu. The satellite images obtained in the two different periods such as LANDSAT 7 (1999) and LANDSAT 8 (2013) were used in the present study along with the town and country planning map (1994) and topo-sheets (1972) as ancillary data. Change detection is an important tool in many remote sensing applications. Using such tools we can compare satellite data from different times to assess damage from natural disasters, understand the ways in which humans alter the land, and characterize climatic and seasonal changes to the landscape. Mapping of the urban changes in the study area have been interpreted in view of developing urban land with different classes. The identification of suitable region for urban development is also quite important for planners to do sustainable development. So current study attempts to identify the suitable site for urban development in Tiruchengode taluk, Namakkal using integrated GIS and multi influence factor (MIF) techniques.

Keywords: *LANDSAT, GIS, Multi IF technique, Tiruchengode*

1. Introduction

Change detection is the measure of the distinct data framework and thematic change information that can guide to more tangible insights into underlying process involving land cover and land use changes than the information obtained from continuous change. Digital change detection is the process of determining the changes associated with land use and land cover properties with reference to geo-registered multi-temporal remote sensing data. The change detection is to identify the changes between two or more periods which are uncharacterized of normal variation. 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 (Ramachandra and Uttam kumar, 2004). Various thematic maps like land use/land cover, geomorphic units, soils, ground water potential, and environmental degradation have been generated using a IRS-1A (LISS-II) satellite data coupled with ground truth for the overall development of the Sonbhadra District, U.P (Narayan Chopra, 2012). The Ratnagiri mangrove maps of estuary was prepared by Nakhawa et al., (2012) 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. Through this study it is understand that mangrove coverage of Sakhartar estuary in 2009 was about 297.36 ha, while mangrove coverage in 1989, 1999 and 2004 were 109.13, 188.62 and 203.45 hectare respectively. 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 (Tamilenthi and Baskaran, 2011). Studies have shown that there are only few landscapes remain on the Earth that is still in their natural state. Due to anthropogenic activities, the Earth surface is being significantly altered in some manner and man's presence on the Earth and his use of land has had a profound effect upon the natural environment and thus resulting into an observable pattern in the land use/land cover over time. The present study focused on development of urban land and the changes in the land use and land cover in Tiruchengode taluk, Namakkal, Tamil Nadu has been monitored by using Landsat 7 (1999) and Landsat 8 (2013) satellite data, Town and Country Planning map (1994) and Survey of India topo-sheets (1972) with limited field checks. This study highlights the changes in urban development, vegetation and water bodies in the study area. Mapping of the urban changes in the study area have been interpreted in

#02090418 Copyright ©2016 CAFET-INNOVA TECHNICAL SOCIETY. All rights reserved.

view of developing urban land with different classes. The objective of the study consists of two major part one is the satellite image processing technique based urban change detection analysis and another one is selection of suitable region of future urban development using integrated GIS and multi influence factor techniques.

2. Study Area

Tiruchengode taluk is located in Namakkal District, Tamilnadu, India. It is Located south west of Salem at a distance of 45 km, 20 km from the city of Erode, and 36 km from Namakkal. The river Cauvery flows on the west of the town from north to south at 16 Km from the town. It spreads over on area of 818.16 Sq Km. The population of this town is 80,187 as per 2001 census and 96,431 as per 2011 census. The study area lies between the northern latitude of $11^{o}14'09"$ to $11^{o}31'00"$ and eastern longitude of $77^{o}40'23"$ to $78^{o}07'11"$. Tiruchengode has the elevation of 230m above the mean sea level. The town derives its name from the hill within the town with a temple at top. There is a Siva temple known as "Arthanareeswarar Temple" situated on a hill at a height of 550m from mean sea level. The people are mainly employed in Agriculture Activities, Power Loom Factory and Bore well Rig machineries. The study area location map is shown in the Figure 1. Rasipuram, Bhavani, Sankagiri are the adjacent taluks of the study area. The Tiruchengode taluk has nearly about 126 villages.

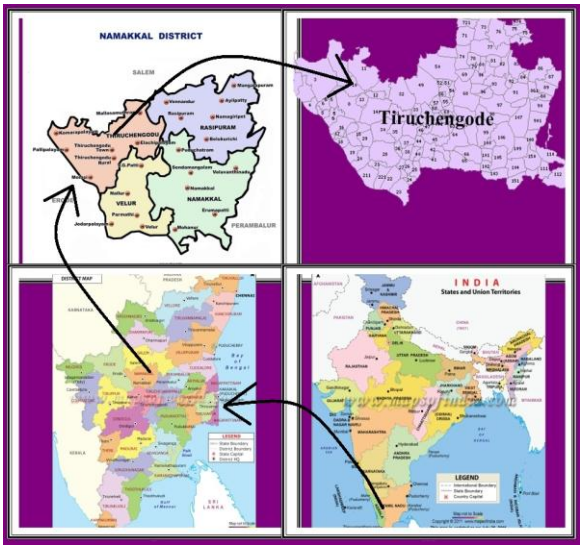

Figure 1: *The Study area location map*

2.1 Climate

The temperature is moderate throughout the year except in summer where it will be very hot. Heavy rainfall occurs between August and November. The average annual rainfall is around 950mm.

2.2 Geology and Geomorphology

The Tiruchengode taluk mainly comprises of semi consolidated sediments, intrusive and crystalline rocks. The area broadly covers dome type denudational hills, pediment/valley floor, shallow flood plain near to Cauvery River and linear ridges and dykes.

2.3 Physiographic of the Study Area

There are two rivers flown in the Tiruchengode taluk named as Cauvery in the western side and Tiruchengode in the Eastern region of the study area. 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.

3. Methodology

The methodology of the study consists of two main process are image processing based change detection study and GIS based site selection. The detailed methodology adopted in this study is given in the Figure 2.

3.1 Digital Image processing and Layers preparation

The range of image enhancement technique is broad but in the present study composite generation technique is adopted to detect the various changes in between two data sets of Landsat 7 and Landsat 8. Composite generation is one of the fundamental techniques used. For visual analysis color composites make the fullest use of satellite imagery, which are applied to the RGB color scheme to make use of capabilities of human eye. The true color, false color and pseudo color composite images are useful to extract more information. Making composite images in different sequences generates different results. This color variation occurs due to interaction of the particular bands with the ground surface objects and placement of the bands during composition. Band combinations in RGB comparisons for Landsat 7 and Landsat 8 are given in the Table.1.

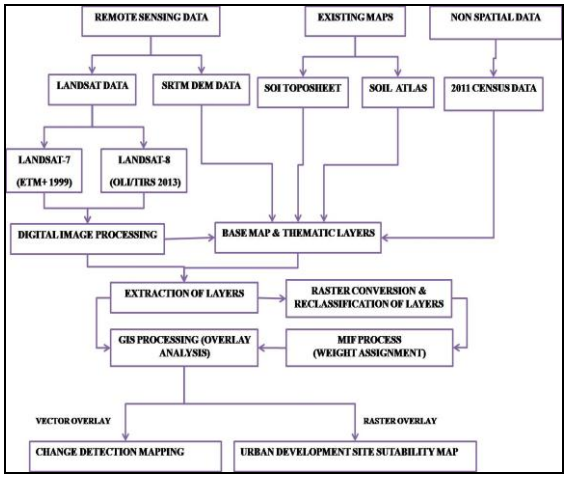

Figure 2: *Methodology adopted in the present study*

The thematic layers utilized for this study are land use map, road map, settlement map, population density

map, soil map, surface water body and slope. Based on the band combinations output images the vegetation index, urban sprawl, road networks and water bodies area changes are calculated using Landsat 7 and Landsat 8 in the years of 1999 and 2013 respectively. The different band combinations applied in the present study is shown in the figures 3, 4 and 5. The slope map of Tiruchengode taluk was generated from SRTM digital elevation model data which was downloaded from USGS web portal. The village wise population density map was prepared using 2011 census data of Tiruchengode taluk which was collected from Namakkal district census department. The soil map of the study area was digitized from the published soil map of European digital archive.

Table 1: *Band combinations in RGB comparisons for Landsat 7 and Landsat 8*

Color Composite	Landsat7 (1999)	Landsat8 (2013)
Colour Infrared	4,3,2	5,4,3
Natural Colour	3,2,1	4,3,2
Pseudo Colour	5,4,3	6,5,4

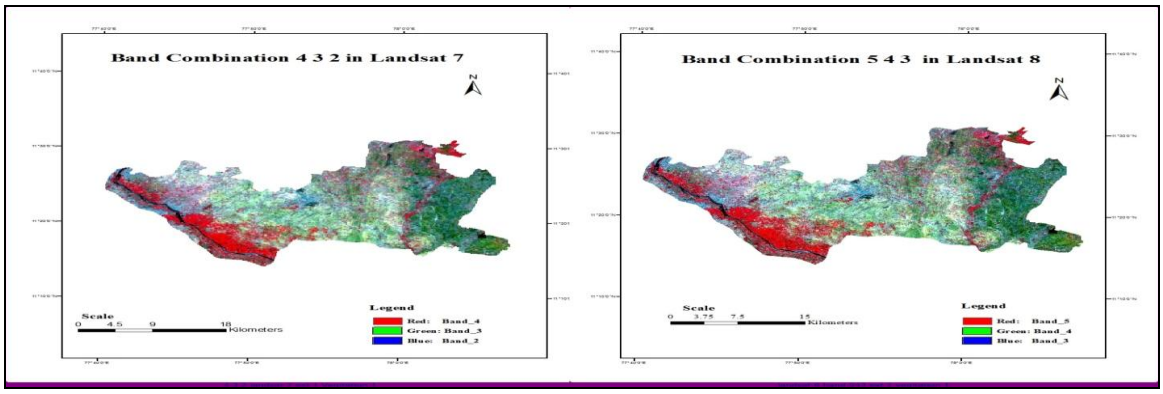

Figure 3: *False Color Composite (FCC), generated using 4, 3, 2 in Landsat 7 and 5 4 3 in Landsat 8 bands were assigned as Red, Green and Blue colors. It highlights the vegetation feature which shows in the red colour*

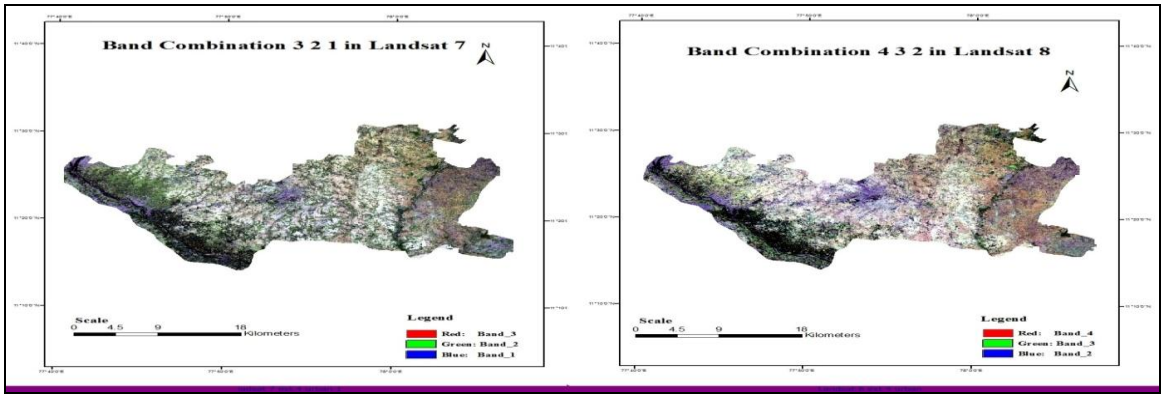

Figure 4: *True Color Composite (TCC), generated using 3 2 1 in Landsat 7 and 4 3 2 in Landsat 8 bands were assigned as Red, Green and Blue colors. It highlights the urban sprawl which shows in the blue colour*

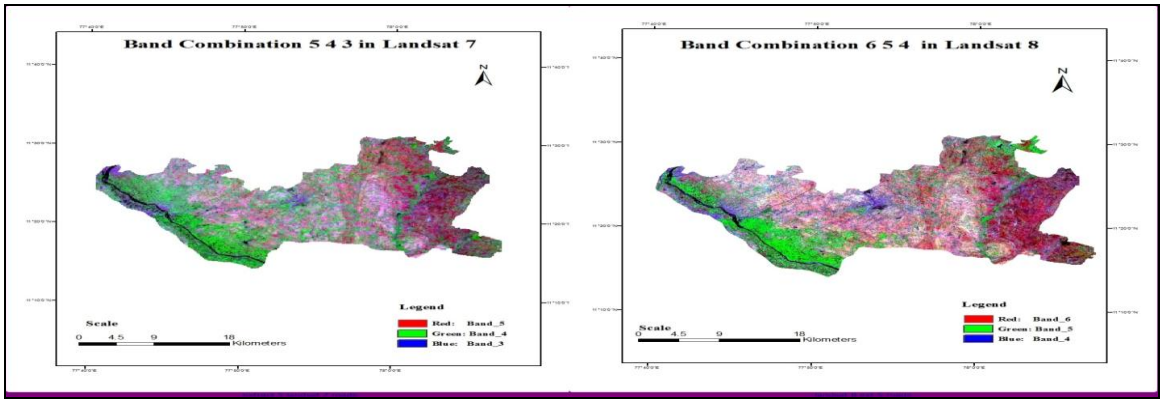

Figure 5: *Pseudo Color Composite (PCC), generated using 5 4 3 in Landsat 7 and 6 5 4 in Landsat 8 bands were assigned as Red, Green and Blue colors. It highlights the road networks, water bodies in black colour*

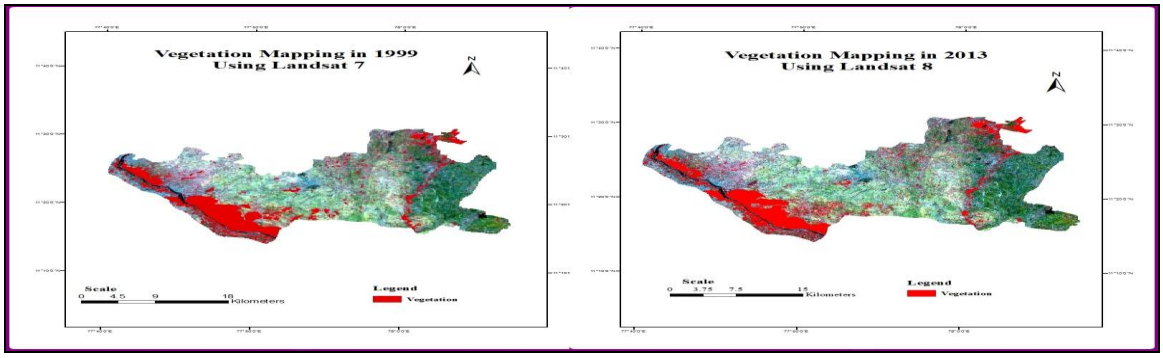

Figure 6: *Change detection analysis of Vegetation cover from 1999-2013*

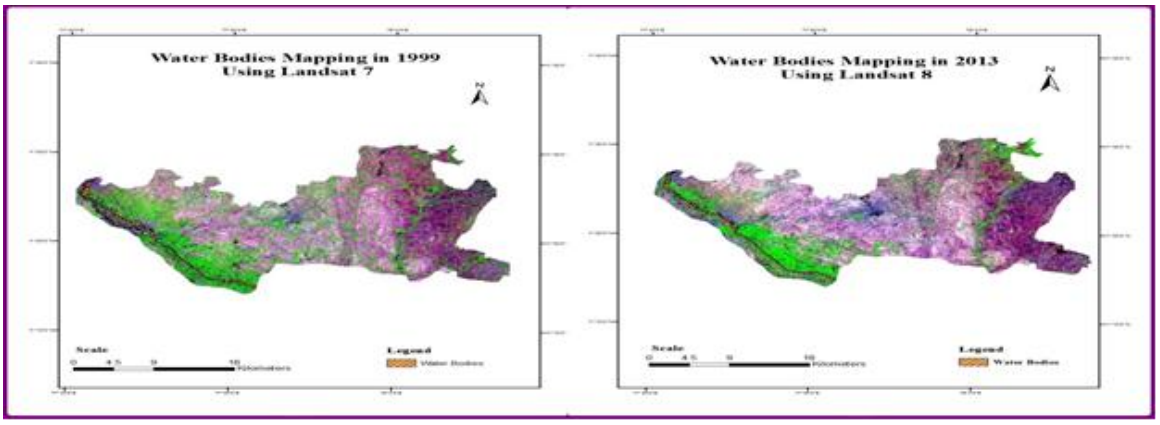

Figure 7: *Change detection analysis of Water bodies from 1999-2013*

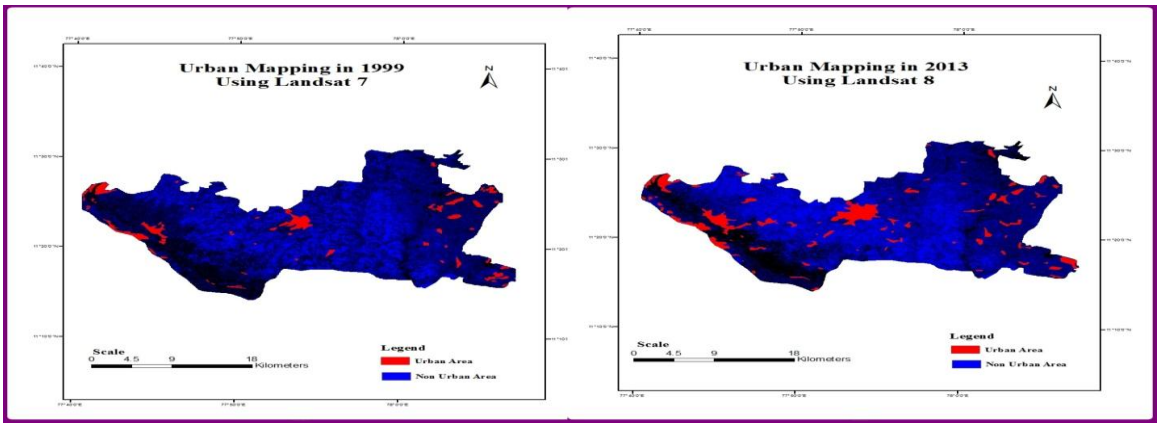

Figure 8: *Change detection analysis of Urban area from 1999-2013*

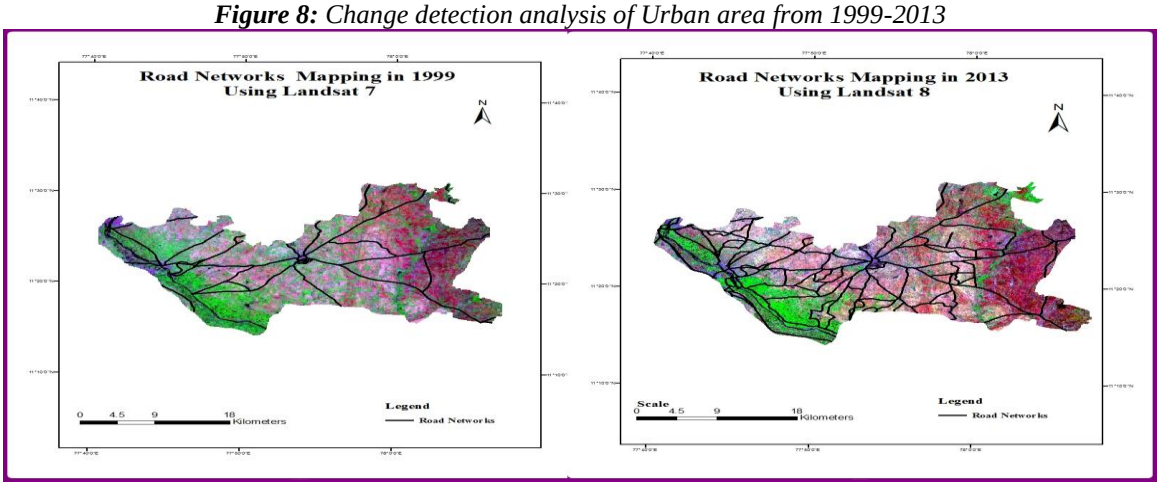

Figure 9: *Change detection analysis in Road networks from 1999-2013*

3.2 Land suitability for Urban

The identification process of suitable land for urban development involving the GIS based raster overlay analysis (Kumar and Shaikh, 2012). The methodology adopted here is to determine suitable region for urban development which consist of four steps. The first and foremost step is the identification of thematic maps which are relevant to urban development. The second step is the preprocessing of these layers for maintaining uniform scale, resolution and projections. The third step is layer integration in GIS environment and the final step is the classification of prepared resultant layer in four classes. The weights for the overlay analysis were obtained using the multi influence factor technique . This method of site identification is useful for understanding of the urban development's influencing factors. Finally, the prepared thematic layers for urban suitability are reclassified and applied for weighted overlaid in GIS environment to develop the index suitability map (Senes and Toccolini (1998). These index map was further classified using statistical approach called cumulative score index Jain and Subbaiah,(2007). Figure 10 illustrates the Schematic sketch of the interactive influence of factors concerning urban suitability.

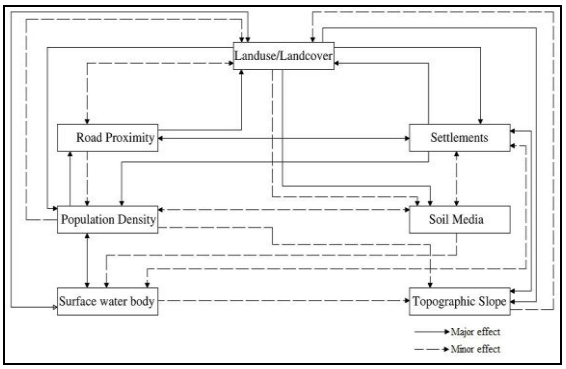

Figure 10: *Schematic sketch showing the interactive influence of factors concerning urban suitability*

4. Results and Discussions

4.1 Change Detection

In the present study the change detection analysis is performed using topographic maps, Landsat 7 and Landsat 8 satellite images for the Tiruchengode taluk. The urban area of Tiruchengode has increase gradually within the study period. This resulted from rural-urban migration. Tiruchengode is one of the most developing taluk in Namakkal, Tamil Nadu, India and most of the major education institutions, industries and factories etc are situated and upcoming here. The results of this study were based on Image classification and its interpretation. The results obtained from the present study are;

The mapping of the urban development of Tiruchengode taluk shows the development of urban lands had brought changes in other part of the district as well. The interpretation of multi-date satellite and other data helped in the preparation of urban sprawl map of the study area (Figure 6). The study of the spatial growth of the taluk over the years has revealed that the built-up area has spread along main transportation corridors in a radial pattern viz. Namakkal, Salem, Rasipuram and Erode. The decrease in agricultural area is due to conversion of urban land use or discontinuation of agricultural lands. The Barren land has been reduced considerably.

The rural-urban migration has been characterized for Tiruchengode urban area. The overall percentage increase within the decade is about 28.04% in urban area. The major urban sprawl has come across in Pallipalayam, which is located in the western Region. Due to the urban sprawl, there has been decrease in vegetation index of 14.05% in 2013 in the part of settlements compared to 1999. The major decrease of vegetation index has come across in Mettupalayam, which is located in the Eastern region (Figure 7). The water bodies are also decrease 73.61% in 2013. The rapid decrease water bodies have come across in Kilapalayam, which is located in the region of Eastern direction (Figure 8). There has been the tremendous increase in road network as 62.25 % in 2013 which implies that the developmental activities and rapid urban sprawl. The major road development has come across in Thokkavadi, which is located in the region of Western direction (Figure 9). The different Land use, land cover categories generated by visual interpretation techniques of various satellite imageries with different years. The final area results in sq.km as mentioned in Table 2.

Table 2: *Results derived from Land use / Land cover mapping of different year data*

S. No.	Classification	In 1999 (sq. km)	In 2013 (sq.km)	Changes (sq.km)	Changes (%)
1.	Vegetation	27.89	23.97	3.92(-)	14.05
2.	Urban Area	14.7	20.43	5.73(+)	28.04
3.	Water Bodies	12.62	3.33	9.29(-)	73.61
4.	Road Networks	191.87(km)	508.29(km)	316.42(km)(+)	62.25

4.2 Land suitability for Urban

The land suitability analysis for urban development in the study region are carried by analyzing the different parameters, particularly land use / land cover, settlement, Proximity buffer of road network, surface water bodies, population density, soil media and

topographic slopes throughout integrated MIF method and GIS techniques. The synopsis classification of seven categories with ratings and weights are displayed in Table 4. Soil media is an important factor for suitability of land use parameters.

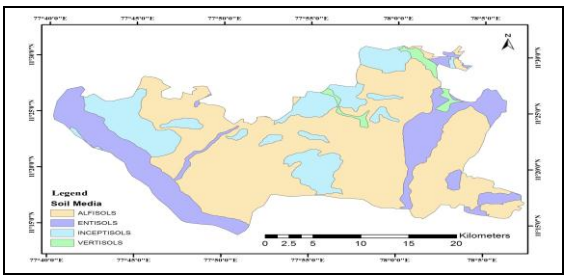

Figure 11: *Soil media in the study area*

The Tiruchengode taulk consists of the following soil class of USDA soil taxonomy that is alfisols (61.2 km^2), entisols (19.79 km^2), vertisols (1.63 km^2) and inceptisols (17.36 km^2). The soil map of this taluk is shown in figure 11.

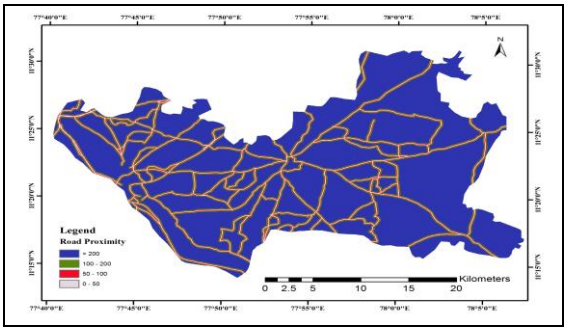

Figure 12: *Road proximity map*

The road network maps are digitized from the Landsat 8 satellite data and proximity buffer region of this roads are prepared using multiple ring buffer tool of GIS environment. Moreover in order to discover better accessibility to the existing transportation networks, buffer zones have been created by taking 50 m distance from the road based on Manish kumar and Vivekananda Biswas (2013). The figure 12 shows the proximity layer of road network of the study region. The population density is also an important criterion in urban site selection because of people like to migrate their dwelling to surroundings of high dense population areas. Generally the area has high intensity of population will have more environmental pollution.

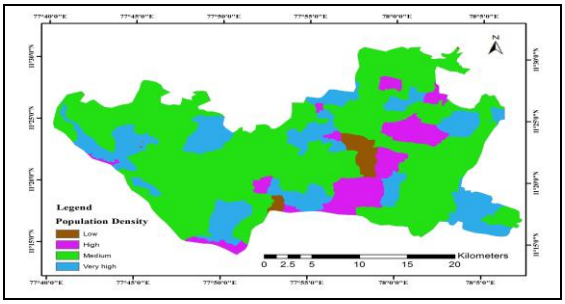

Figure 13: *Population density map*

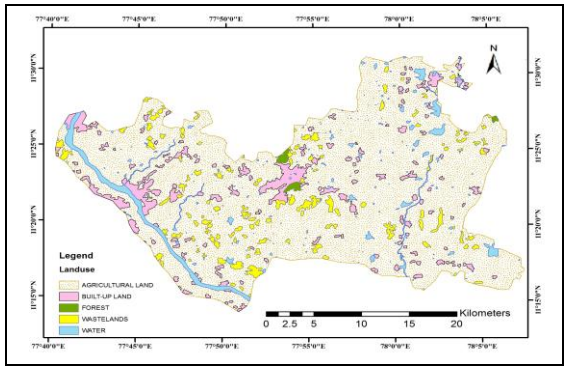

Figure 14: *Land use / Land cover map*

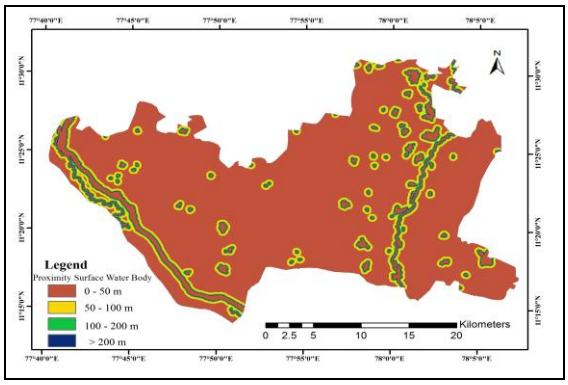

Figure 15: *Surface water body proximity map*

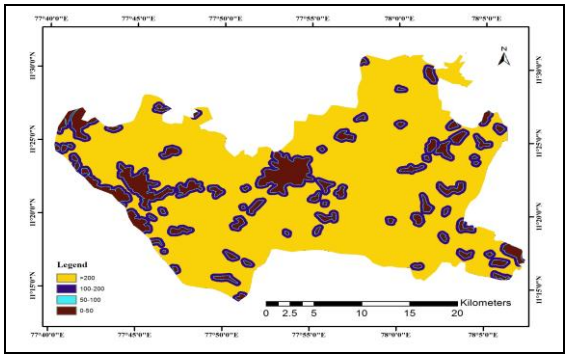

Figure 16: *Settlement proximity map*

The 2011 census data of Tiruchengode taulk shows that the local administration units like Tiruchengode municipality, Kumarapalayam municipality, Pallipalayam municipality etc has huge population density values compared to other places of the study region. The population density is expressed in population (in numbers) per square kilometers. The ranks for the population density classes are assigned based on the expert's opinion. The figure 13 shows the reclassified population density map of the study region. The discussion about the land use related layers like land use/ land cover, proximity of surface water body and settlements are shown in figures 14, 15 and 16 respectively. Slope is one of the major key aspect for urban development which is directly proportional for urban growth. The topographic elevation in the study region ranges from 125 – 547 amsl.

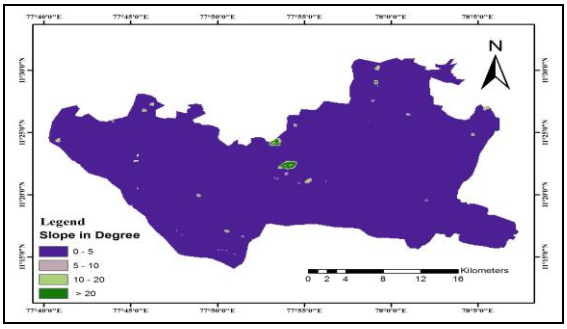

Figure 17: *Slope in degree*

The classification and assignment of ranks for slope layer (figure 17) are done based on the researcher Manishkumar and Vivekananda Biswas (2013) recommendation.

4.3 Statistical Analysis

In this study the multi influence factor (MIF) technique was used to arrive the weightages of the each thematic layers of this analysis based on the method followed by Martine Nyeko (2012). The integration of all urban development key factors together is necessary in order to obtain a site suitability map. The weighting approach was performed to obtain suitability map meantime the thematic layers do not have the same degree of influence. So the multi IF decision making technique is applied for thematic layers to obtain the relative weights for each layer. The Figure 10 shows that the effects of each influencing factors (IF) may contribute to identify the suitable site for urban, these factors comes at a relative values of 1 or 0.5 (1 for major effects and 0.5 for minor effect) based on the minor and major effects between different thematic layers (Selvam et al., 2014). The relative weight is arrived based on the cumulative value of both major and minor effects. This rate will be utilized to generate suitability index value of each factor. The Table 3 shows the weight arriving methodology of Multi IF technique. The rank of each classes, weight and site suitability scores of each and individual thematic layers are shown in Table 4. The overlay resultant index map shows that the site suitability scores of urban development for this area are ranges from 108 to 370.

Table 3: *Effect of factor influencing, relative rates and scores for each factors*

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	0.5	6.5	22
Road Proximity Buffer	1+1	0.5+0.5	3	10
Proximity Settlements	1+1+1+1+1	0.5+0.5	6	20
Population density	1+1+1	0.5+0.5+0.5+0.5	5	17
Soil media	1	0.5+0.5+0.5	2.5	8
Topographic slope	1+1	0.5+0.5	3	10
Surface water body	1+1+1	0.5+0.5	4	13

The statistical information about the resultant map is given in table 5. The cumulative score index methodology was applied for the suitability map to generate classified map. The resultant suitability map consists of four classes namely more suitable, suitable, less suitable and not suitable. The urban suitability map of the study area is shown in figure 18. The Table 6 shows the Suitability criteria for urban development and area occupied by each class.

5. Conclusion

In the present study, it is understand that, Geoinformatics is a promising tool for the change detection and urban sprawl mapping studies. The integrated geospatial technique and statistical methodologies will reduce the working complexity and has reduced the total work expanse of a conventional method.The site selection phase of this study reveals that the 109.89 km2 area of the study region comes under more suitable for urban dwelling. The remaining part of the study area covered by three classes namely suitable, less suitable and not suitable with the areal coverage of 202.58 km2, 454.58 km2 and 51.10 km2 respectively.

From the Geoinformatic analysis of Tiruchengode taulk it is suggested that, the further improvement can be done in the Morur area (i.e) in Norhtern region, because from the past 2 decades, there has been no improvement in that region.

The results of the remote sensing images should be compared with the field checks along with the high end GPS measurements which are having higher accuracy. So that it can be easily discriminate if any deviations are there in the boundaries of the features calculated in the present study.

This study results are most useful for planners and local administrative bodies to facilitate people's future needs. Similar studies can be under taken for other cities also to estimate the urban sprawl and quantum of damage caused to the environment by urbanization. In future, this kind of studies should be made with the high spatial and spectral resolution satellite images to obtain the higher accuracy for planning and development projects.

Table 4: *Relative weights of thematic layers with their corresponding rank and scores*

Factor	Class	Area (km^2)	Rank	Weight	Score
Land use/ Land cover	Built up land	55.11	4	22	88
	Forest	3.07	2		44
	Surface Water	29.82	1		22
	Waste land	35.63	3		66
	Agricultural land	694.53	1		22
Road Proximity Buffer (in meter)	0 -50 m	48.95	4	10	40
	50 – 100 m	46.32	3		30
	100 – 200 m	86.29	2		20
	>200 m	636.59	1		10
Proximity Settlements (in meter)	0-50 m	72.19	4	20	80
	50 – 100 m	15.38	3		60
	100 – 200 m	102.62	2		40
	>200 m	627.92	1		20
Population density (persons per km^2)	>500	78.96	3	17	51
	500 – 300	542.84	4		68
	300 – 200	80.41	3		51
	200 – 100	17.79	2		34
	<100	98.16	1		17
Soil media	Alfisols	500.29	2	8	16
	Entisols	161.81	4		32
	Inceptisols	141.92	4		32
	Vertisols	13.39	1		8
Topographic slope (in degree)	Medium (0 - 5)	811.71	4	10	40
	Medium – Steep slope (5 - 10)	2.73	3		30
	Steep slope (10 - 20)	2.17	2		20
	Very steep slope (>20)	1.56	1		10
Surface water body (in meter)	0-50 m	712.38	1	13	13
	50 – 100 m	15.41	4		52
	100 – 200 m	31.73	3		39
	>200 m	65.68	2		26

Table 5: *Statistics for urban development suitability index map*

Minimum	108
Maximum	370
Mean	170.92
Standard deviation	38.27

Table 6: *Suitability criteria for urban development*

S.No	Class Name	Criteria	Suitability Score range	Area (km^2)
1	More Suitable for urban development	>(μ+σ)	209.19 to 370.00	109.89
2	Suitable for urban development	μ to (μ+σ)	170.92 to 209.19	202.58
3	Less Suitable for urban development	(μ-σ) to > μ	132.65 to 170.92	454.58
4	Not Suitable for urban development	<(μ+σ)	108.00 to 132.65	51.10

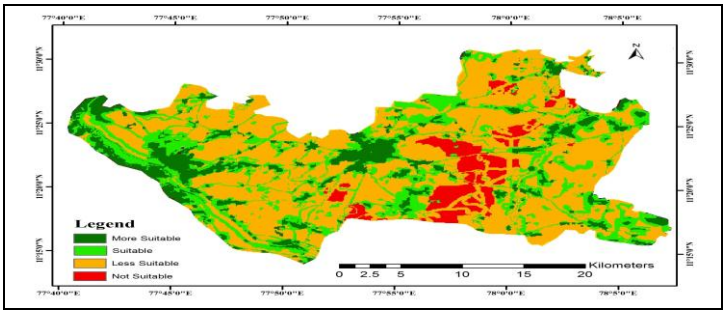

Figure 18: *Site suitability map for the study area*

Acknowledgement

I hereby acknowledge my project students S.Mohamed Ibrahim, V.Manikandan, M.Settu and A.Mythili for their help to complete this article successfully.

References

[1] Nakhawa, A.D., Markad, S., Priyanka, S., Vichare and Shirdhankar, M ., (2012) 'Mapping and change detection of mangrove forest in Sakhartar estuary of Ratnagiri district, Maharashtra'.International Multidisciplinary Research Journal, Vol. 2(8),pp 04-08.

[2] Narayan Chopra, (2012) Land use planning of southern part of Sonbhadra District, U.P., using Remote Sensing Techniques', International Journal of Geomatics and Geosciences, Vol. 2(4), pp.924-938.

[3] Ramachandra, T. V., Uttam Kumar (2004) Geographic Resources Decision Support System for land use, land cover dynamics analysis, Proceedings of the FOSS/GRASS Users Conference - Bangkok, Thailand, 12-14 September 2004, pp.1-15.

[4] Tamilenthi.S, Baskaran.R ,(2011) 'Vegetal cover change detection based on remote sensing and GIS study of Salem revenue division, Salem district, Tamil Nadu, India', Department of Earth science, Elixir Remote Sensing 40, pp 5376-5379.

[5] Selvam S, Magesh NS, Rajamanickam M, Chidambaram S, Sashikkumar MC (2014) A GIS based identification of groundwater recharge potential zones using RS and IF technique: a case study in Ottapidaram taluk, Tuticorin district, Tamil Nadu, Environ Earth Sci, DOI 10.1007/s12665-014-3664-0

[6] Manish Kumar and Vivekananda Biswas (2013) Identification of Potential Sites for Urban Development Using GIS Based Multi Criteria Evaluation Technique. A Case Study of Shimla Municipal Area, Shimla District, Himachal Pradesh, India, Journal of Settlements and Spatial Planning, vol. 4, no. 1, 45-51.

[7] Martine Nyeko (2012) GIS and Multi-Criteria Decision Analysis for Land Use Resource Planning, Journal of Geographic Information System, 4, 341-348.

[8] Kumar, M., and Shaikh, V. R. (2012), Site Suitability Analysis for Urban Development Using GIS Based Multicriteria Evaluation Technique: A Case Study of Mussoorie Municipal Area, Dehradun District, Uttarakhand, India, Journal of Indian Society Remote Sensing, DOI 10.1007/s12524-012-0221-8.

[9] Senes, G., and Toccolini, A. (1998), Sustainable land-use planning in protected rural areas in Italy, Landscape and Urban Planning, 41, pp. 107–117.

[10] Jain, K., and Subbaiah, V. Y. (2007), Site suitability analysis for urban development using GIS, Journal of Applied Sciences, 7(18), pp. 2576-2583.

[11] http://landsat.usgs.gov