

Land Use and Land Cover Change Detection Using Geospatial Techniques in the Theni District, Tamil Nadu, India

Dr.M. Sakthivel¹, H. Krishnamoorthi², S.Murugesan S³, Santhi⁴

¹*Professor, Department of Geography*

^{3,4,5}*Research Scholar Department of Geography*

Abstract— Mapping, analysis, and monitoring of land use and land cover (LULC) are essential for sustainable land resource management and regional planning. This study evaluates the spatial and temporal changes in LULC patterns in Theni District over a period of 21 years (1997–2018). Geo-rectified multi-temporal satellite data at a scale of 1:50,000 were utilized, including Landsat 5 imagery for the years 1997 and 2007, and Landsat 8 imagery for 2018, obtained from United States Geological Survey. Eleven LULC classes were identified following the Indian LULC classification scheme, namely Dense Forest with Plantations, Mixed Forest, Plantation, Water Bodies, Rock Outcrop, Barren Land, Built-up Land, Dense Forest, Fallow Land, Scrub Land, and Agricultural Land. Supervised classification using the Maximum Likelihood Classifier (MLC) was applied to delineate LULC categories, and accuracy assessment was performed using a stratified random sampling method. The results reveal significant changes in land use patterns during the study period. Built-up land exhibited a substantial increase of 2.19% (62.85 km²), indicating rapid urban expansion. In contrast, Plantation, Water Bodies, Fallow Land, Scrub Land, and Agricultural Land showed declining trends of -0.55% (-15.82 km²), -1.14% (-21.13 km²), -0.37% (-10.64 km²), -0.55% (-15.58 km²), and -0.19% (-5.44 km²), respectively. Forest-related classes such as Dense Forest, Dense Forest with Plantations, and Mixed Forest experienced only marginal variations, reflecting relative stability due to conservation measures. The study indicates that the reduction in water bodies and scrub/fallow lands is largely associated with their conversion into built-up and agricultural lands. Agricultural land and plantation areas show dynamic interchange due to changing cropping patterns and variability in rainfall. Overall, the findings highlight the increasing pressure of urbanization and agricultural transformation on natural land resources. This study emphasizes the need for effective land management strategies and sustainable

planning practices to balance developmental activities with environmental conservation in Theni District.

Index Terms— Theni District; land use/land cover (LULC); change detection; remote sensing; Geographic Information System (GIS); supervised classification; Maximum Likelihood Classifier (MLC); Landsat imagery; urban expansion; environmental management.

I. INTRODUCTION

Land use and land cover (LULC) dynamism is a direct reflection of both anthropogenic activities and the biophysical characteristics of the Earth's surface. These driving forces continuously alter land use patterns, making their assessment essential for understanding environmental processes and their impacts. Among the various drivers of global environmental change, human-induced activities have been recognized as one of the most significant factors influencing regional ecological processes and ecosystem functioning (Hao Zhang et al., 2011). Rapid population growth, urbanization, and industrialization have further accelerated LULC changes, highlighting the importance of change detection studies in quantifying the rate, pattern, and extent of such transformations over time. LULC change information plays a crucial role in planning and management at local, regional, and global scales. The analysis of temporal changes provides insights into the processes driving land transformation, which cannot be effectively captured through static observations. However, planning and resource management efforts are often constrained by insufficient and inconsistent data on land use dynamics. In this context, advancements in geospatial technologies such as

Remote Sensing, Geographic Information System, and Global Positioning System have significantly improved the ability to monitor, analyze, and manage land use changes with greater accuracy and efficiency. Change detection is defined as the process of identifying differences in the state of an object or phenomenon by observing it at different times (Nagaraja and Navalgund, 2002). It involves the use of multi-temporal datasets to detect and quantify changes in land cover between different periods. This approach has wide applications in environmental monitoring, including deforestation assessment, vegetation dynamics, seasonal land changes, disaster impact analysis, and natural resource management. The integration of multi-temporal remote sensing data enables continuous monitoring and provides valuable inputs for sustainable land use planning, environmental impact assessment, hazard zonation, and infrastructure development in both rural and urban regions. In the Indian context, rapid economic development coupled with increasing population pressure has placed immense stress on limited natural resources. Urban expansion and industrial growth have significantly altered traditional land use patterns, posing challenges for sustainable development and environmental conservation (Bardhan, 2010). The interaction between population growth and land use change is closely linked, as increasing population demands lead to the conversion of natural and agricultural lands into built-up areas. While such transformations contribute to improved living standards, they also result in environmental degradation, reduced agricultural productivity, and increased pressure on ecosystems. In recent years, human-induced LULC changes have significantly affected ecological processes at both local and regional scales. The transformation of land for agriculture, urban development, and industrial activities has led to imbalances in ecosystem functioning and resource availability. Therefore, systematic analysis of LULC changes is essential for understanding these dynamics and for formulating effective strategies aimed at sustainable land management, environmental conservation, and long-term socio-economic development.

II. MATERIALS AND METHODS

2.1 Study Area

Theni District, located in the southern part of Tamil Nadu, India, has been selected for the present study. The district lies between 9°30' to 10°30' North latitude and 77°00' to 78°30' East longitude. It is bounded by the state of Kerala to the west and south, Madurai District to the east, Dindigul District to the north, and Virudhunagar District to the southeast. The geographical extent of the district covers an area of approximately 2,869 km². The location map of the study area. The district was formed after its bifurcation from Madurai District as per Government Order G.O.Ms.No.679, Revenue Department, dated 25.07.1996. Administratively, Theni District comprises five taluks, namely Andipatti, Bodinayakanur, Periyakulam, Theni, and Uthamapalayam, along with nine development blocks, 113 revenue villages, 130 village panchayats, and 13 town panchayats. The district is predominantly rural, with nearly 67% of the population engaged in agricultural activities, making farming the principal occupation. Physiographically, Theni District exhibits diverse terrain influenced by the Western Ghats along its western boundary. The region adjoining the Western Ghats falls under the Western agro-climatic zone (about 10%), while the remaining 90% of the district lies within the Southern agro-climatic zone. The district experiences a moderate and salubrious climate, with temperatures ranging from about 26.3°C to 38.5°C, which is favorable for a wide range of agricultural and horticultural crops. The drainage system of the district is well developed, with several important rivers such as Vaigai River, Periyar River, Manjalar River, Varahanadhi River, and Theniar flowing through the region. Among these, the Vaigai River is the major river system, playing a vital role in irrigation and water supply. Climatically, Theni District falls under a medium rainfall zone, receiving an average annual rainfall of about 829.8 mm. The district predominantly depends on the Northeast Monsoon, which contributes around 46% of the total rainfall, occurring between October and December due to low-pressure systems in the Bay of Bengal. The Southwest Monsoon contributes approximately 21%, while summer and winter rains account for about 27% and 6%, respectively. The combination of favorable climatic conditions, fertile soils, and availability of

water resources supports intensive agricultural practices in the district. However, the dependence on monsoonal rainfall and increasing anthropogenic pressures necessitate effective land and water resource management strategies for sustainable development in Theni District.

2.2 Data Source:

Multi-temporal satellite datasets were utilized to analyze the land use and land cover (LULC) changes in Theni District over a period of 21 years (1997–2018). Landsat 5 imagery acquired on 05.02.1997 and 01.02.2007, and Landsat 8 imagery acquired on 22.02.2018 were used for delineating and classifying LULC classes. These datasets were obtained from the United States Geological Survey Earth Explorer platform. The Landsat series data provide medium-resolution multispectral imagery suitable for monitoring changes in agriculture, water resources, forest cover, and urban expansion. Landsat-5 Thematic Mapper (TM) and Landsat-8 Operational Land Imager (OLI) datasets consist of multiple spectral bands, which are useful for distinguishing different land cover features based on their spectral signatures. The datasets are provided in Top of Atmosphere (TOA) reflectance and are projected in the Universal Transverse Mercator (UTM) coordinate system with the World Geodetic System (WGS 84) datum. The selected satellite images correspond to similar seasonal periods to ensure consistency in classification and to minimize seasonal variability. These multi-temporal datasets were used to generate LULC maps for the years 1997, 2007, and 2018, enabling effective change detection analysis. The overall methodology adopted in this study, including data acquisition, preprocessing, classification, and change detection, is illustrated through a flowchart

2.3 Methodology

The overall methodology adopted for the present study is illustrated in Fig. X. The detailed steps followed for land use/land cover (LULC) change detection in Theni District are described below.

2.3.1 Pre-processing

Pre-processing of satellite data is an essential step to maintain the spectral integrity of images and to establish a relationship between satellite observations and ground features. The multi-temporal satellite imageries of

1997, 2007, and 2018 were obtained from United States Geological Survey Earth Explorer.

The acquired datasets were geometrically corrected and projected to the Universal Transverse Mercator (UTM) coordinate system with WGS 84 datum. Radiometric corrections were applied to improve image quality and consistency. The images were then subsetting to the boundary of Theni District. Standard False Colour Composite (FCC) images were generated for all three time periods to facilitate visual interpretation and classification.

2.3.2 Land Use/Land Cover Classification Scheme

A suitable classification scheme was adopted based on the Indian LULC classification system to generate thematic maps. Eleven LULC classes were identified for the study area, namely Dense Forest with Plantations, Mixed Forest, Plantation, Water Bodies, Rock Outcrop, Barren Land, Built-up Land, Dense Forest, Fallow Land, Scrub Land, and Agricultural Land.

The selection of classification categories was based on the study objectives and the capability of satellite data to distinguish different land cover types.

2.3.3 Image Classification

Supervised classification using the Maximum Likelihood Classifier (MLC) was employed to classify the satellite imageries of 1997, 2007, and 2018. Training samples for each LULC class were selected based on visual interpretation of satellite imagery, reference data, and ancillary information.

Different spectral band combinations were used to improve the separability of land cover classes. The Maximum Likelihood method was applied as it considers the statistical distribution of pixel values and provides reliable classification results for multi-spectral data.

2.3.4 Accuracy Assessment

The accuracy of the classified LULC maps was evaluated using a stratified random sampling method. Reference points were selected for each land cover class, and the classified results were compared with ground truth data and high-resolution imagery. Accuracy assessment metrics such as overall accuracy and classification reliability were used to validate the classification results.

2.3.5 Post-classification Processing and Change Detection

Post-classification processing techniques were applied to improve classification accuracy and remove misclassified pixels. The classified images were further analyzed to detect changes in LULC patterns between 1997–2007, 2007–2018, and 1997–2018.

Change detection analysis was carried out by comparing classified maps of different years. The changes in area and percentage for each LULC class were computed and presented in tabular form (Table 4.1). The results indicate both positive and negative changes across different land cover classes.

**Table 4.1 - Theni District
Positive and Negative changes in Land use/Land cover - (1997-2018)**

Land use/ Land Cover Classes	1997		2007		2018		1997/2007		2007/2018		1997/2018	
	Area Km ²	%	Area Km ²	%	Area Km ²	%	Area Km ²	%	Area Km ²	%	Area Km ²	%
Dense Forest with Plantations	297.02	10.35	297.20	10.35	297.20	10.35	-	-	-	-	-	-
Mixed Forest	70.14	2.44	70.28	2.44	70.85	2.46	+ 0.14	+ 0.0	+0.57	- 0.00	+ 0.71	+0.02
Plantation	435.48	15.17	427.72	14.90	419.66	14.62	- 7.76	- 0.27	- 8.6	- 0.28	- 15.82	- 0.55
Water Bodies	76.38	2.6	64.71	2.25	55.25	1.92	- 11.67	- 0.35	- 9.46	- 0.33	- 21.13	- 1.14
Rock Outcrop	46.34	1.6	46.09	1.60	46.07	1.61	0.5	-	0.38	0.01	-0.13	0.01
Barren Land	7.67	0.25	6.88	0.23	6.48	0.22	- 0.79	- 0.02	- 0.4	- 0.01	- 1.19	- 0.03
Buildup Land	51.51	1.79	71.23	2.48	114.36	3.98	+ 19.72	+ 0.69	+ 43.11	+ 1.5	+ 62.85	+ 2.19
Dense Forest	549.54	19.15	549.38	19.14	549.16	19.14	- 0.16	- 0.01	- 0.22	-	0.38	-
Fallow Land	227.45	7.92	222.64	7.76	216.8	7.55	- 4.81	- 0.16	- 5.84	- 0.21	- 10.64	- 0.37
Scrub Land	137.76	4.80	132.39	4.61	122.18	4.25	- 5.37	- 0.19	- 10.21	- 0.36	- 15.58	- 0.55
Agricultural Land	975.62	34.00	972.02	33.88	970.18	33.81	- 3.6	- 0.12	- 1.84	- 0.07	- 5.44	- 0.19
Total	2869	100	2869	100	2869	100	-	-	-	-	-	-

Source: computed by Researcher

Agricultural Land

Table 4.2

Theni District - Agricultural Land Change Detection (Area in Km²)

Agriculture Land Change Detection	1997-2007	2007-2018	1997 - 2018
Agriculture Land Remained as Agriculture Land	960.97	945.68	934.57
Agriculture Land Became as Fallow Land	0.22	1.74	0.6
Agriculture Land became Built-Up Land	14.94	14.60	28.65
Agriculture Land became Plantation	0.19	15.97	12.10
Agriculture Land became Scrub Land	0.00	0.16	0.25

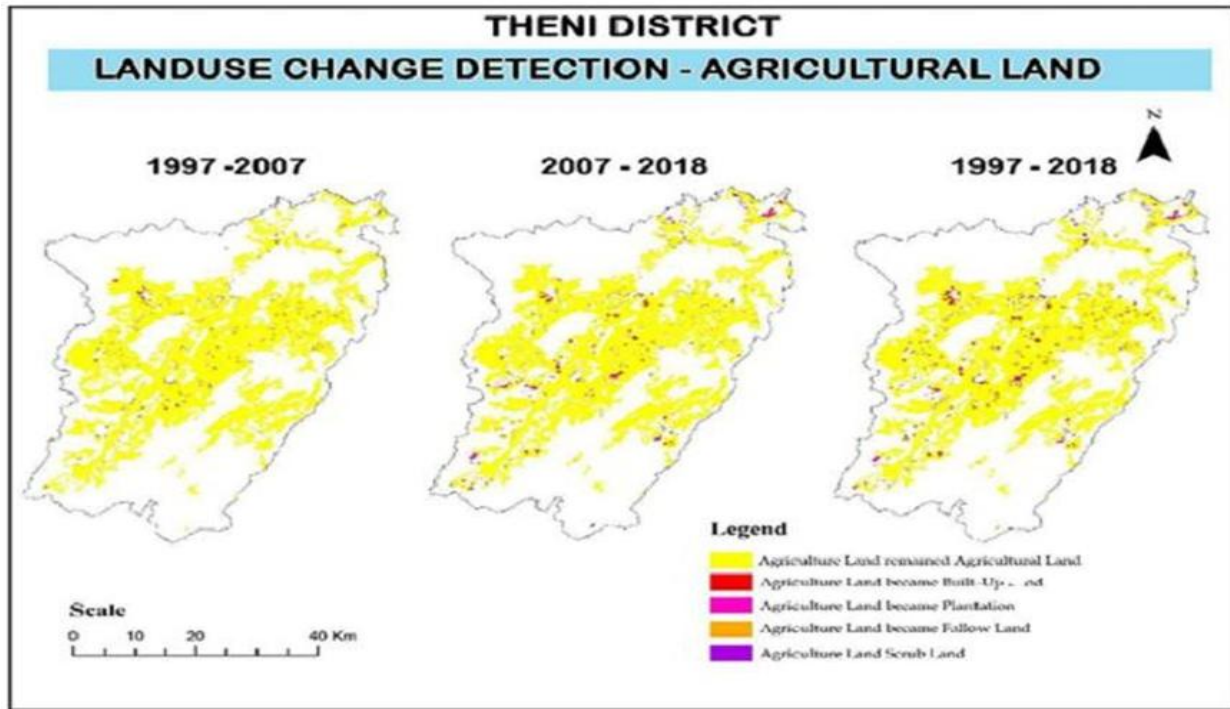
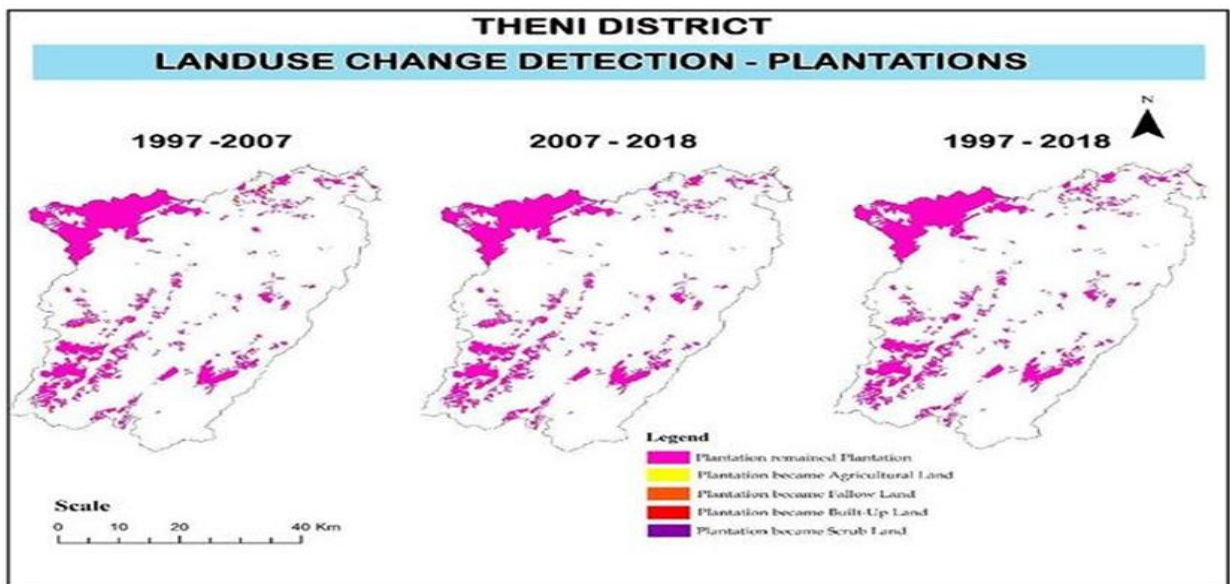


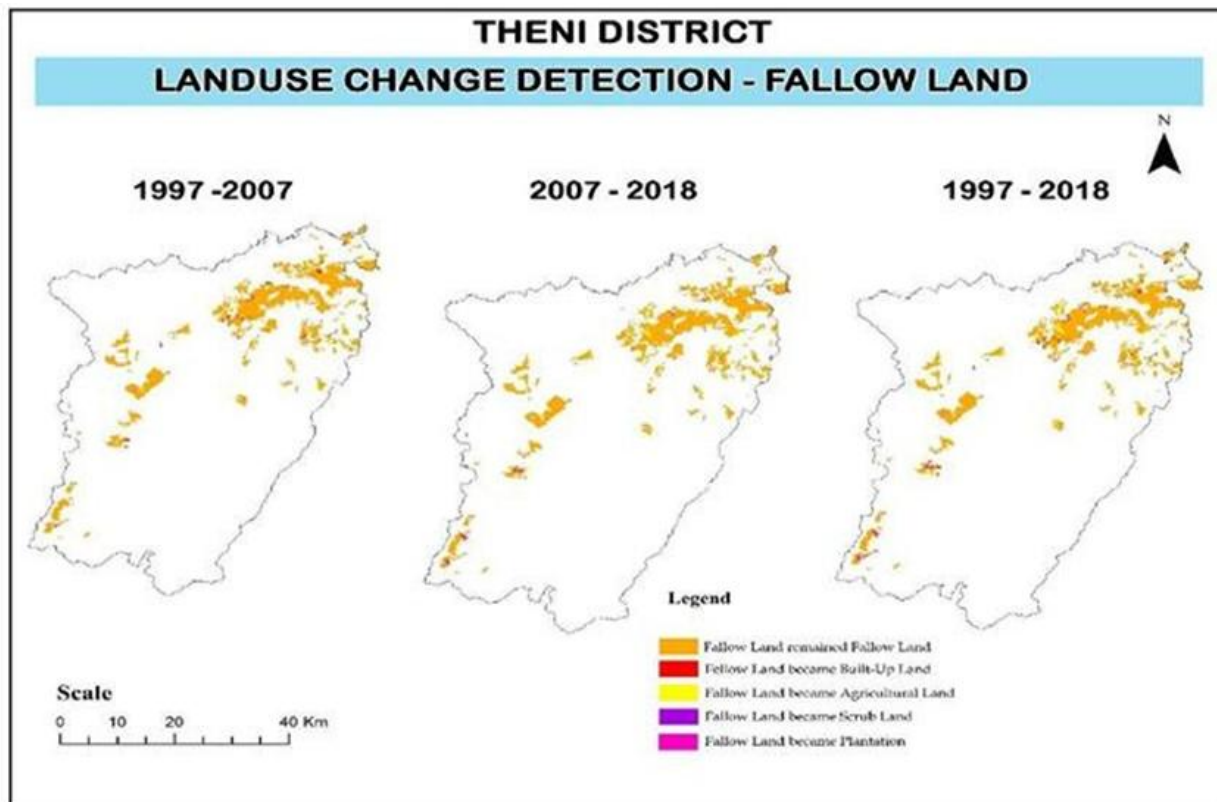
Table 4.3
Theni District - Change Detection – Plantations (Area in Km²)

Plantation Change Detection	1997-2007	2007 to 2018	1997 to 2018
Plantation remained as Plantation	425.33	424.41	430.74
Plantation Became Scrub Land	0.10	0.00	0.00
Plantation became Fallow Land	0.79	1.34	0.11
Plantation became Agricultural Land	3.60	0.59	0.35
Plantation became Buildup Land	6.50	2.56	4.94



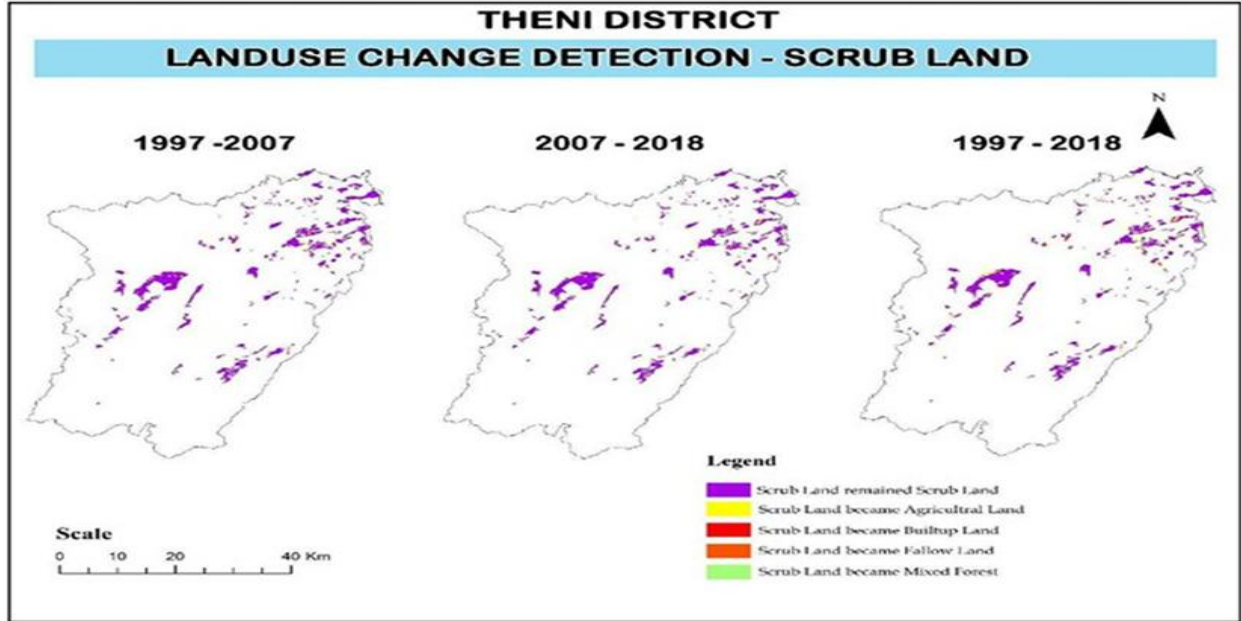
Theni District Change Detection – Fallow Land (Area in Km²)

Fallow Land Change Detection	1997-2007	2007 to 2018	1997 to 2018
Fallow Land remained as Fallow Land	217.53	213.40	208.92
Fallow Land became Scrub Land	0.70	0.11	0.79
Fallow Land became Agricultural Land	3.81	5.99	9.76
Fallow Land became Buildup Land	5.01	0.14	4.6
Fallow Land became Plantation	0.57	0.08	3.08



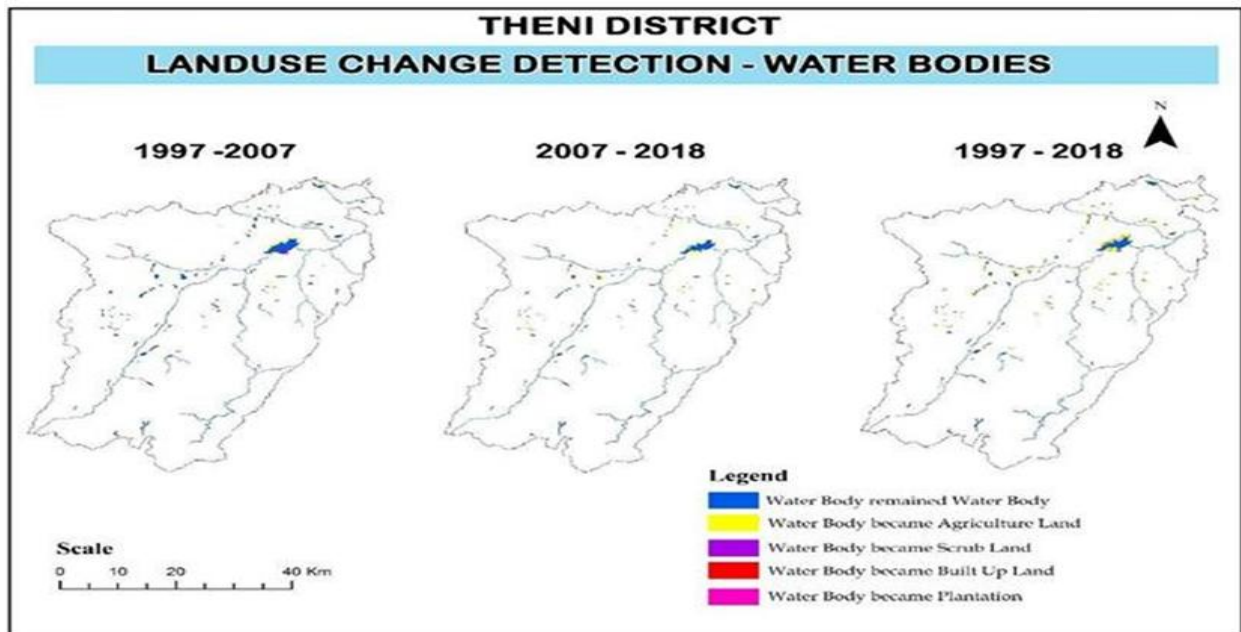
Theni District Change Detection - Scrub Land (Area in Km²)

Agriculture Land Change Detection	1997- 2007	2007 to 2018	1997 to 2018
Scrub Land remains Scrub Land	130.20	121.94	120.43
Scrub Land became Fallow Land	1.54	2.85	4.37
Scrub Land became Agricultural Land	4.02	7.06	9.96
Scrub Land became Buildup Land	2.09	0.01	1.74
Scrub Land became Mixed Forest	0.36	0.51	0.13



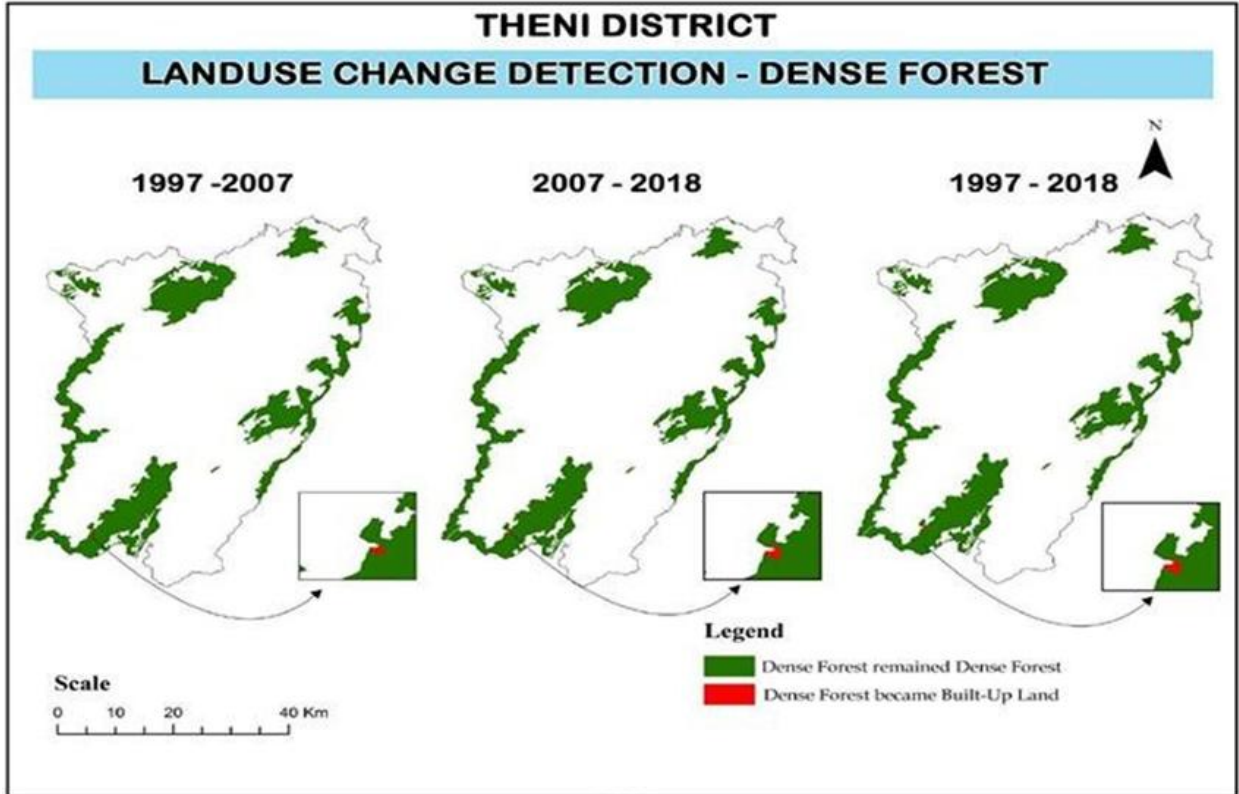
Theni District Change Detection – Water Body (Area in Km²)

Water Bodies Change Detection	1997- 2007	2007 to 2018	1997 to 2018
Water Bodies remained as Water Bodies	64.57	54.01	55.50
Water Bodies became Scrub Land	1.71	0.34	1.43
Water Bodies became Agricultural Land	9.63	9.56	15.24
Water Bodies became Buildup Land	0.50	0.18	0.57
Water Bodies became Plantation	0.91	0.71	1.03



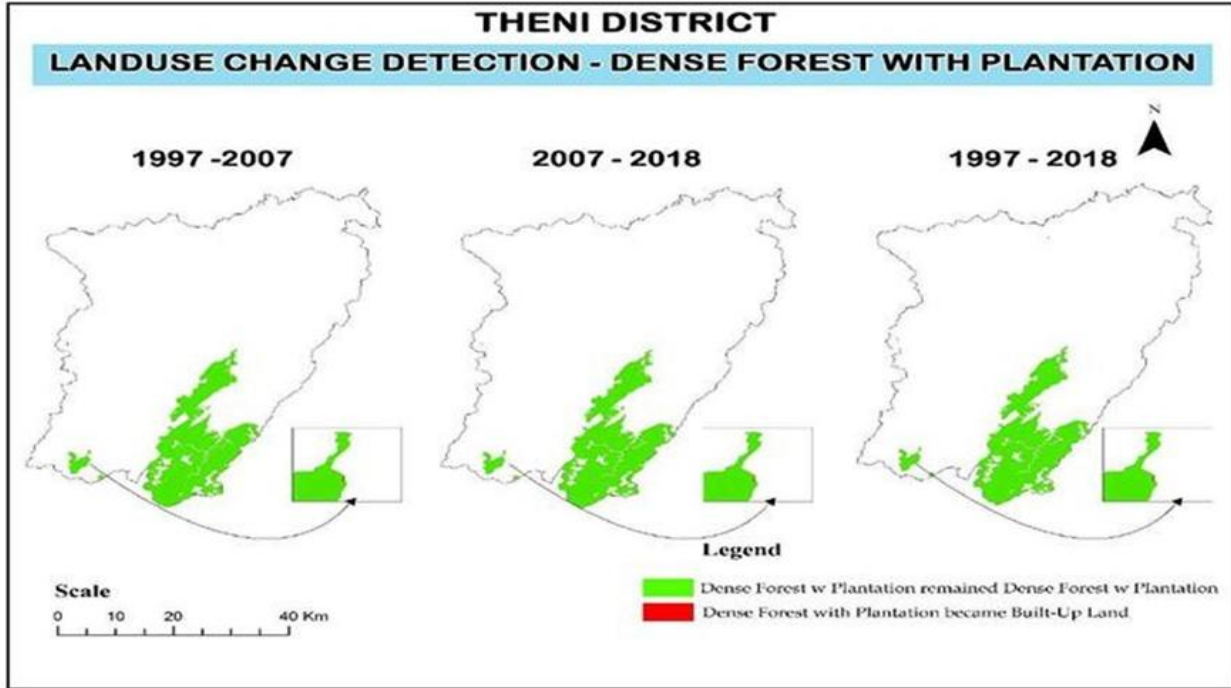
Theni District Change Detection – Dense Forest - (Area in Km²)

Dense Forest Change Detection	1997- 2007	2007 to 2018	1997 to 2018
Dense Forest remained Dense Forest	549.27	549.16	549.07
Dense Forest became Buildup Land	0.26	0. 32	0.46



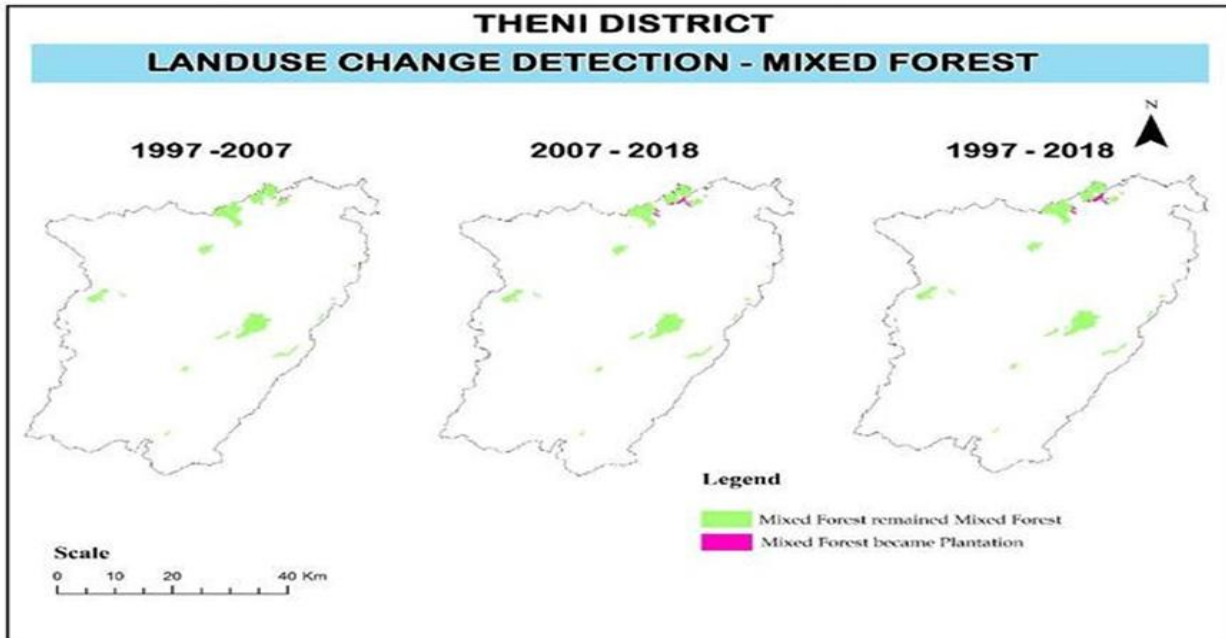
Theni District Change Detection – Dense Forest with Plantation (Area in Km²)

Dense Forest with Plantation Change Detection	1997- 2007	2007 to 2018	1997 to 2018
Dense Forest with Plantation remained as same	297.01	297.01	297.01
Dense Forest with Plantation became Build up Land	0.01	0.01	0.01



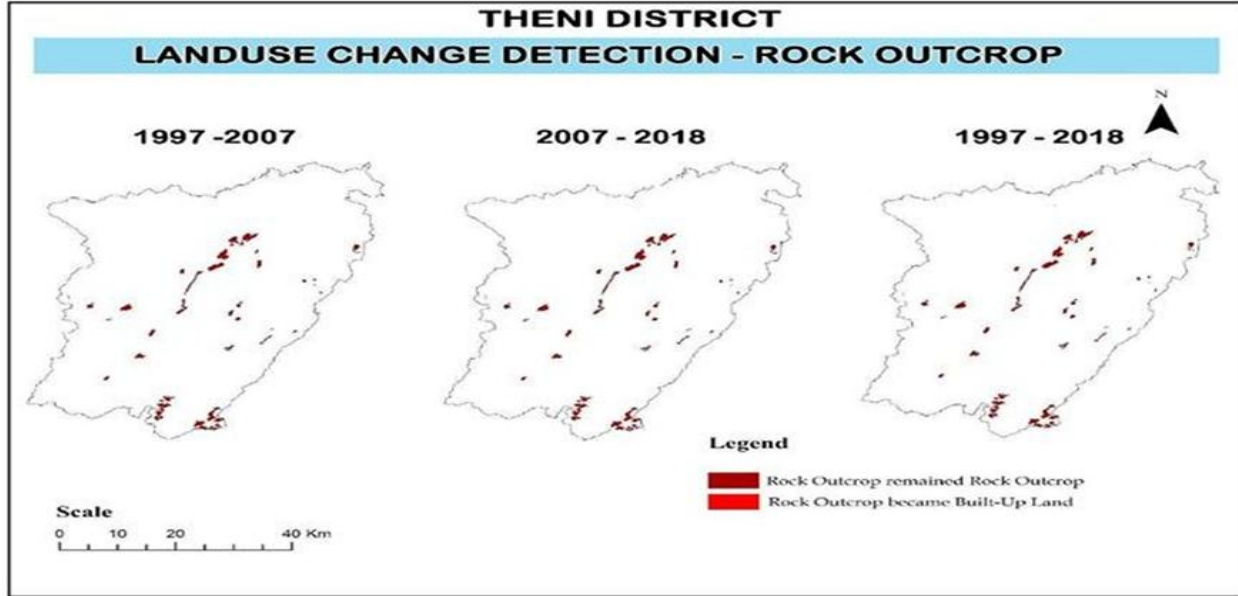
Theni District Change Detection – Mixed Forest (Area in Km²)

Mixed Forest Change Detection	1997- 2007	2007- 2018	1997 - 2018
Mixed Forest reminds Mixed Forest	70.14	70.28	70.85
Mixed Forest became Plantation	0.73	0.87	1.44



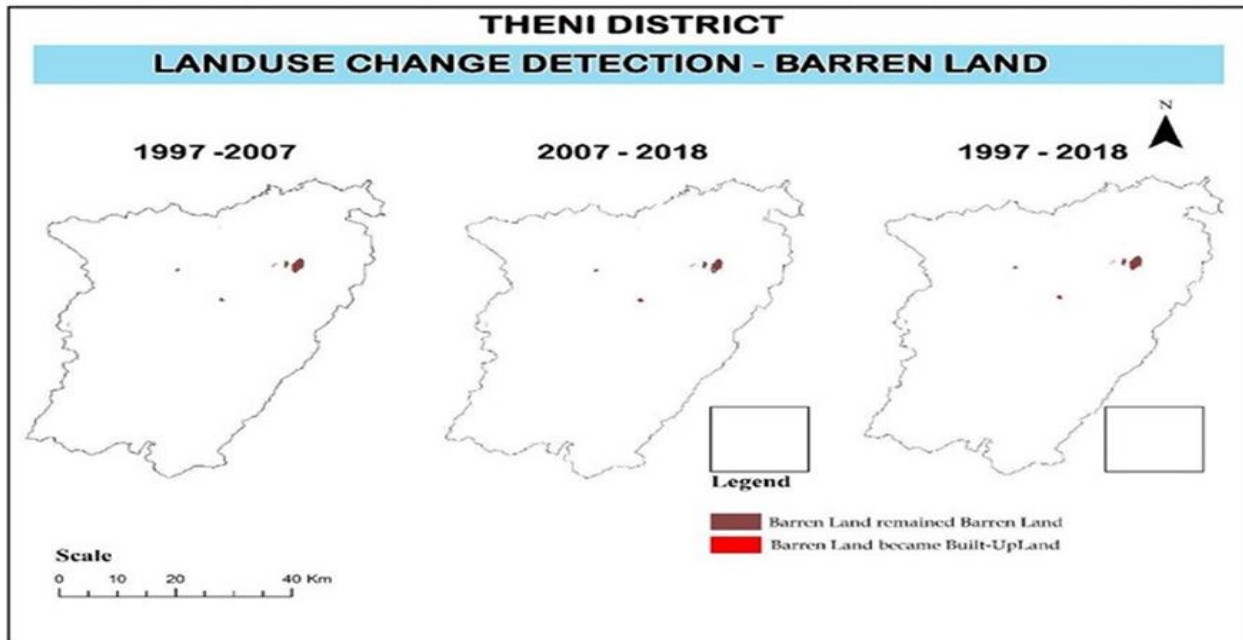
Theni District Change Detection – Rock Outcrop (Area in Km²)

Rock Outcrop Change Detection	1997- 2007	2007- 2018	1997 - 2018
Rock Outcrop reminds Mixed Forest	70.14	70.28	70.85



Change Detection – Barren Land (Area in Km²)

Barren Land Change Detection	1997- 2007	2007 to 2018	1997 to 2018
Barren Land reminded Barren Land	6.88	6.21	6.21
Barren Land became Buildup Land	0.32	0.67	0.99



2.3.6. Positive and Negative changes in Land use/Land cover - (1997-2018)

Detailed change detection analysis was also performed for major LULC categories such as Agricultural Land, Plantation, Fallow Land, Scrub Land, Water Bodies, Forest Classes, Rock Outcrop, and Barren Land. The transformation of one land use category into another (e.g., agricultural land to built-up land, water bodies to agricultural land, plantation to scrub land) was quantified to understand land dynamics.

The results reveal significant trends such as:
 Increase in built-up land due to urbanization
 Decrease in water bodies due to conversion into agricultural and built-up areas
 Reduction in scrub and fallow land due to agricultural expansion
 Slight decrease in forest and plantation areas

Dynamic interchange between agricultural land and plantation

These changes highlight the impact of anthropogenic activities, changing agricultural practices, and rainfall variability on LULC patterns in Theni District.

2.3.7. Accuracy Assessment of Land use/Land Cover

The accuracy of spatial data has been definite by the United States of Geological Survey during 1990 as Accuracy assessment or validation is an important step in the processing of Remote Sensing data (Congalton 1996 and Foody 1992). The accuracy assessment has been carried out based on Abubaker Haroun Mohamed Adam et al. (2013). In this study, it is comparatively noticeable that the accuracy has been examined with reference data and classified data. The satellite image has been used for the year 2018 is landsat 8, during the

field visit Ground Control Points (GCPs) were collected, distinguished and considered by Global Positioning System (GPS). The reference data is collected by GPS, which has been evaluated to map to find if the class type on classified map equals to class type resolute from reference data. The sample size of 669 points was Used from the field and the sampling technique is the organized non-aligned sampling (a grid provides even allocation of at random placed GPS ground truth) used for the study. The data is recapitulated and quantified with error matrix and the result is accessible the Given Table. 4.12 In this study, maker accuracy, user accuracy and on the whole accuracy have been discussed. The producer accuracy is derived by number correctly identified in the given map points/Number actually in the reference data.

Overall accuracy = $\frac{470+40+21+36+20+8+18+8+9+9+7}{470+1+1+2+1+40+2+1+21+1+1+36+2+20+1+1+8+1+18+1+1+8+1+9+1+1+9+1+1+7+1} = \frac{669}{680} = 0.95$ i.e 95% Error matrices

and Cohen’s kappa (K) are commonly used for accuracy assessment. Kappa is computed as:

$$K = \frac{\sum_{i=1}^r \sum_{j=1}^R N_{xii}}{N^2 \sum_{i=1}^r \sum_{j=1}^R x_i \times x_j}$$

Where N is the total number of positions in the matrix, r is the number of rows in the matrix, x_i is the number in row i and column i, x_{i+} is the total for row i, and x_{+i} is the total for column I. Therefore, Kappa

Accuracy Assessment of Land use/Land Cover

REFERENCED DATA : Georeferenced Raster Image of Land Sat 8 for the year 2018														
Classified Data	Agricultural Land	Buildup Land	Plantation	Fallow Land	Scrub Land	Water Bodies	Dense Forest	Dense Forest with Plantations	Mixed Forest	Rock Outcrop	Barren Land	Row Total	Commission Error (%)	User Accuracy (%)
Agricultural Land	470	0	0	0	0	1	1	2	1	0	0	475	1	99
Buildup Land	0	40	0	2	0	0	1	0	0	0	0	43	7	93
Plantation	0	0	21	0	0	0	0	0	1	1	0	23	9	91
Fallow Land	0	2	0	36	0	0	0	0	0	0	0	38	5	95
Scrub Land	1	0	0	0	20	0	1	0	0	0	0	22	9	91
Water Bodies	0	0	0	0	1	8	0	0	0	0	0	9	11	89
Dense Forest	0	0	1	0	1	0	18	0	0	0	0	20	10	90
Dense Forest with Plantations	0	0	0	0	0	1	0	8	0	0	0	9	11	89
Mixed Forest	0	0	1	0	0	0	0	0	9	1	0	11	18	82
Rock Outcrop	0	0	1	0	0	0	0	0	0	9	1	11	18	82
Barren Land	0	0	1	0	0	0	0	0	0	0	7	8	12	88
Coloum Total	471	42	25	38	22	10	21	10	11	11	8	669		
Omission Error (%)	12	9	20	5	9	20	14	20	18	18	12			
Producer Accuracy (%)	88	91	80	95	91	80	86	80	82	82	88			

Source- Computed by Researcher

2.3.8. Accuracy Assessment of Land use/Land Cover
 $K = \frac{669(470+40+21+36+20+8+18+8+9+9+7+6)}{[(475 \times 471) + (43 \times 42) + (23 \times 25) + (38 \times 38) + (22 \times 22) + (9 \times 10) + (20 \times 21) + (9 \times 10) + (11 \times 11) + (11 \times 11) + (8 \times 8) + (6 \times 6)]}$
 $= \frac{217822}{237151} = 0.92$ i.e 92%

According to Adepoju M. O et al. (2006), the Kappa value derived in this study is 0.92 (i.e above 80%), it represents strong agreement in the accuracy assessment of Land use/Land cover change in the study area.

III. CONCLUSION

The land use land cover change detection analysis in Theni District reveals a dynamism in its land use land cover pattern. Secondly area under Built Up land area reveal an increasing trend. This may be due to Urban Development and Population Growth. The area classed as Agricultural Land, plantations, Fellow Land, Water Body and land with scrub reveal a declining trend. From the observation of the change in area under dense forest and dense forest with Plantation it is concluded very Low Changes due to the Reserve Forest. The forest Area was one of the major land use land cover types in the district its partially cover the Block namely Cumbum, Myladumparai, Andipatti, Bodinayakkanur, Periyakulam Area. This may be attributed to favorable physiographic condition such as altitude, moderate slope and climate. The change detection analysis of Theni District reveals that Agricultural Land is one of the major land use land covers in the study area. The area under Agricultural Land exposes a fluctuating trend because of the Agricultural Practices and Seasonal Rainfall. In the study area during the period of study Dense Forest has no much changes. it exposes proper management of Reserve Forest and its need for better management perform in the study area towards conservation of forests. The scrub Land are mostly found at the Periyakulam, Andipatti, Bodinayakkanur Minakumari situated in the north eastern, western and center parts of the district. The change detection analysis of area under scrub land revealed change in the study area throughout the period of study. The analysis discloses that area under scrub land has become converted either area under fallow and Agricultural land or some of the area it becomes

changing in to built-up Land. The shift from scrub forest to Fellow land and Agricultural land is negligible. Thus, it may safely be stated that the awareness of the people and the efforts of the agricultural practices in the study area. The area under plantation discovered that in the study area

REFERENCES

- [1] P. O. Adeniyi, "Land use change analysis using sequential aerial photography and computer techniques," *Photogram. Eng. Remote Sens.*, vol. 46, no. 11, pp. 144–164, 1989.
- [2] F. Alqurashi and L. Kumar, "Investigating the use of remote sensing and GIS techniques to detect land use and land cover change: A review," *Adv. Remote Sens.*, vol. 2, pp. 193–204, 2013.
- [3] C. Pandey and M. S. Nathawat, "Land use land cover mapping through digital image processing of satellite data: A case study from Panchkula, Ambala and Yamuna Nagar districts, Haryana, India," 2006.
- [4] Bhagowatrimal, "Application of remote sensing and GIS: Land use change analysis of Kathmandu metropolitan city, Nepal," *J. Theor. Appl. Inf. Technol.*, pp. 80–86, 2007.
- [5] D. G. Brown et al., "Modeling the relationships between land use/land cover on private lands in the Upper Midwest, USA," *J. Environ. Manage.*, vol. 59, pp. 247–263, 2000.
- [6] H. B. Chauhan and S. Nayak, "Land use land cover changes near Hazira region, Gujarat using remote sensing satellite data," *Photonirvachak: J. Indian Soc. Remote Sens.*, vol. 33, no. 3, pp. 413–420, 2005.
- [7] P. S. Dhinwa, S. K. Pathan, and S. V. C. Sastry, "Land use change analysis of Bharatpur district using GIS," *J. Indian Soc. Remote Sens.*, vol. 20, no. 4, pp. 237–250, 1992.
- [8] S. Gupta and M. Roy, "Land use/land cover classification of an urban area: A case study of Burdwan municipality, India," *Int. J. Geomatics Geosci.*, vol. 2, no. 4, pp. 1014–1026, 2012.
- [9] H. A. Oumer, "Land use/land cover change drivers and its impact: A comparative study from Blue Nile and A wash basins of Ethiopia," M.P.S. thesis, Cornell Univ., USA, 2009, pp.

- 2–7.
- [10] N. Kavitha et al., “Land use/land cover changes in Nellore district,” **Indian Geographical J.**, vol. 82, no. 1, pp. 60–66, 2008.
 - [11] M. Heric et al., “Land cover/land use classification of Cairns, Queensland, Australia: A remote sensing study involving airborne imaging spectrometer, large format camera and thematic mapper simulator,” Falls Church, VA, USA, pp. 56–63, 1987.
 - [12] Prakasam, “Land use and land cover change detection through remote sensing approach: A case study of Kodaikanal Taluk, Tamil Nadu,” **Int. J. Geomatics Geosci.**, vol. 1, no. 2, pp. 158–168, 2010.