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RESEARCH ARTICLE

Analysis of land use land cover changes in Thirthahalli taluk using remote sensing and GIS

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Abstract

Mapping and monitoring of land use land cover is essential for many management and planning activities as it is considered as an important element for understanding the earth and its whole system. The present study focused on the utilization of remote sensing and GIS technology for land use land cover classification and its change analysis for local areas like Thirthahalli over the period of two decades. Multitemporal satellite imagery of the Landsat series was used to map land use land cover changes in the years 1997 and 2017. Supervised classification using Maximum Likelihood technique was used resulting in the classes: forest, agricultural plantations, agricultural croplands, wastelands, water bodies and settlement areas. The study showed the major changes occurred in forest, agricultural plantations and settlement classes. Modifications in the pattern of agricultural activities are the main reasons for the changes in land use land cover distributions in the study area during the study period.

Keywords: LULC; Change Detection; Remote Sensing; GIS; Thirthahalli

Introduction

Land is one of the most important natural resources, as life and various developmental activities are based on it (George et al 2016). Land use refers to the human induced changes for agricultural, industrial, residential or recreational purposes whereas land over describes features that are present on the earth's surface (Bharath and Ramachandra 2012). The study of land use and land cover change is one of the foremost arenas to understand the degree of interaction between man and environment. The changing nature of land use and land cover depends on the existing ecological factors and the level of socio-economic development.

Land has proven to be a key component in the development of the human population and is viewed as one of the most significant natural resources currently available. This observation brings into question the recent debates surrounding the pressures people tend to impose on the land, which have resulted in transformations in its physical landscape and usage. Mans impact on the earth in terms of the transformations in land cover and land use have rapidly increased over the years. However, as a result of these continuous land transformations, planning and designing sustainable urban development has become challenging due to the additional fact that the available mapped resources of the land can be outdated or of very poor quality. In order to recognize the clear picture of the land use land cover change which is affected by the human intervention as well as the developments in natural phenomena such as agriculture, population growth, consumption, patterns, urbanization, economic development etc. the timely and precise information about land use land cover change detection of the area of interest is extremely important. This helps in understanding relationships and interactions between human and natural resources for better decision making.

The environmental factors reveal the status of land as a key and finite resource for most human activities including agriculture, industry, forestry, energy production, settlement, recreation and water sources and storage (Thanushkodi et al 2012). The deterioration of environment due to population explosion and its interference leading to the over exploitation of natural resources, pollution and random land use for basic needs. Hence it is essential to collect information about various changes occurring in land use and land cover for proper land management practices (Attri et al 2015, Twisa and Buchroithner 2019). Remote sensing based change detection analysis enables the user to analyse the transformations of land use and land cover as it is able to provide consistent coverage at short intervals. The major advantages of remote sensing systems is their capability for repetitive coverage, which is necessary for change detection studies at global and regional scales. With the increasing ability to quantify and monitor the expansion of urban environments, remote sensing offers users a set of spatially consistent data, greater spatial precision and an overall higher resolution when compared to that of existing aerial imagery (Kulo 2018).

Change detection analysis are used to monitor the dynamic nature of biophysical and anthropogenic features on the earth's surface. Several techniques are developed in literature for change detection analysis using post classification comparison (El-Hattab 2016), conventional image differentiation (Afify 2011), image ratio (Shaoqing and Lu 2008), image regression (Luppino et al 2018), and manual on-screen digitization of change principal components analysis and multi date image classification (Deng et al 2008). A variety of studies have addressed that post-classification comparison was found to be the most accurate procedure and presented the advantage of indicating the nature of the changes.

Rawat and Kumar, 2015 carried out a change detection analysis by employing supervised classification methodology using maximum likelihood technique for Hawalbagh block of district Almora, Uttarakhand, India in order to understand the spatio-temporal dynamics of land use land and found maximum increase in vegetation and built up areas while decrease in water body and agricultural lands. Similarly Haque and Basak, 2017, used both pre-classification and post classification change detection approach to assess the change from over the decades in rich biodiversity area Tanguar Haor, Sunamganj, Bangladesh. They implemented CVA, NDVI and NDWI techniques as a pre-classification approach to assess the change scenario. To obtain the classified data in a timely manner and also for efficient planning and management of the land resources satellites are the best resources to provide the data in a timely manner (Babykalpana and ThanushKodi, 2010).

Considering the capabilities of the remote sensing techniques present study made an effort to analyse the land use changes in rural areas as there is an increasing need for proper land use planning to control various problems in the regional areas. This helps the government and policy makers in understanding relationships and interactions between human as well as natural resources for better decision making.

Study Area

The study area, Thirthahalli taluk is located in the south western part of Karnataka with an aerial extent of 1252.59 sq kms (Figure 1). The study area is bounded by the Western Ghats Mountains with an average elevation of 566 meters above the mean sea level (Figure 2). The study area is one of the "Hottest biodiversity hotspots" and has different varieties of flora, fauna, mammal species, bird species, fresh water fish species and insects. The area enjoys tropical climate throughout the year. Generally, the weather is very pleasant in the all parts of the study area. The evapotranspiration is normally high in ghat sections. Summer prevails between March to early June, the wet months start from early June to September, October and November months experience scanty rain by North East monsoon. The study area receives an average annual rainfall of around 3000mm/ season (Nischitha et al 2014) during the monsoon season. Throughout the monsoon season, the unbroken Western Ghats chain acts as a barrier to the moisture laden clouds which forcefully rises the clouds and the process deposit most of their rain on the windward side of the study area. The rainfall pattern suggests a steady decline in rainfall as we move from west to east. The average daily temperature of the area is about 24.5^0 C.

Data and Methodology

In order to study the land use land cover changes in the study region medium scale Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager and Thermal Infrared Sensor satellite data is used for the years 1997 and 2017. The data were obtained for the month of April from United States Geological Survey (USGS) (https://earthexplorer.usgs.gov/), an Earth Science Data Interface for geo-spatial data. Specifications of the satellite data acquired for change analysis are given in Table 1. In addition to using satellite imagery, ancillary data is collected which included the ground truth data was in the form of reference data points collected using Geographical Positioning System (GPS) in the year

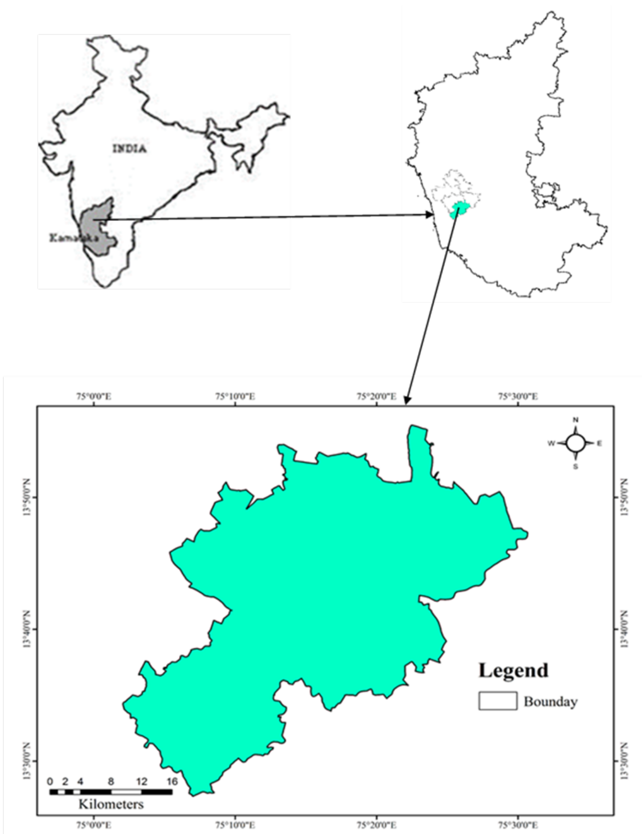

Fig. 1. Location map of the study area

2017 which was used for image classification and accuracy assessment of the results. Addition to this the study used SPOT (2017) image from Google Earth for creation of the road network map and settlement map of the study area.

Initially, the image files are downloadable in Landsat Level 1 Data Products that standard radiometric and geometric correction was processed. As each band file is provided unlayered in GeoTIFF output format, the downloaded band files were layer stacked in ERDAS Imagine for the further analysis. Then the images are reprojected to match the projection of the study area boundary in order to subset the area of interest of the study region from the huge Landsat 5 TM and Landsat 8 datasets. The projection used for the images in the present study is UTM WGS 1984 Zone 43 North. The same projection is maintained for other thematic maps also. The digitization process is performed to extract the road network map and settlement map from the SPOT image downloaded from Google Earth.

Subsequently, the supervised classification method is applied for the classification of the Landsat images. It is a statistical process which can be used to extract the class descriptors. The process involves the selection of representative samples for each land cover class based on the visual interpretation of the image characteristics like color, tone, size, shape, pattern, texture, association etc. The details were then ground checked to verify the doubtful areas. The classification scheme was designed keeping in view of the management practices addressing each land use land cover parcels, the Landsat data are categorized in to Settlements, Water body, Agricultural crop land, Agricultural plantations, Forest and Waste lands under the level I classification. Supervised classification uses the spectral signature defined in the training sites and applies them to the entire image. For instance, it determines each class on what it resembles most in the training set. Afterward, the maximum likelihood classification algorithm was used for the supervised classification of the images. This is the type of image classification that is mainly controlled by the analyst by selecting the pixels that are representative of the identified classes (Bolstad and Lillesand 1991). Further, visual comparison of the classified maps is carried out to make the change detection analysis to find out the changes associated with land use land cover distribution in the study area.

Table 1. Specifications of Landsat data used for the study

Year	Satellite/Sensor	Bands used	Spectral wavelength in (μm)	Spatial Resolution (meters)
1997	Landsat 5 Thematic Mapper (TM)	Band 2 - Green	0.52-0.60	30
		Band 3 - Red	0.63-0.69	30
		Band 4 - Near Infrared (NIR)	0.76-0.90	30
2017	Landsat 8 OLI and TIS	Band 3 - Green	0.533 - 0.590	30
		Band 4 - Red	0.636 - 0.673	30
		Band 5 – Near Infrared (NIR)	0.851 - 0.879	30

Results and Discussions

Mapping and identifying land use and land cover change is the most important, as well as the most widely researched, topic in remote sensing as the information from it has been used extensively to derive a number of biophysical variables, such as vegetation index, biomass, biodiversity, deterioration of environmental quality, loss of agricultural lands, destruction of wetlands. More importantly, land use land cover pattern and its change reflect the underlying natural or social processes, thus providing essential information for modelling and understanding many different phenomena on the Earth. Knowledge of land use land cover and its change is also critical to effective planning and management of natural resources**.**

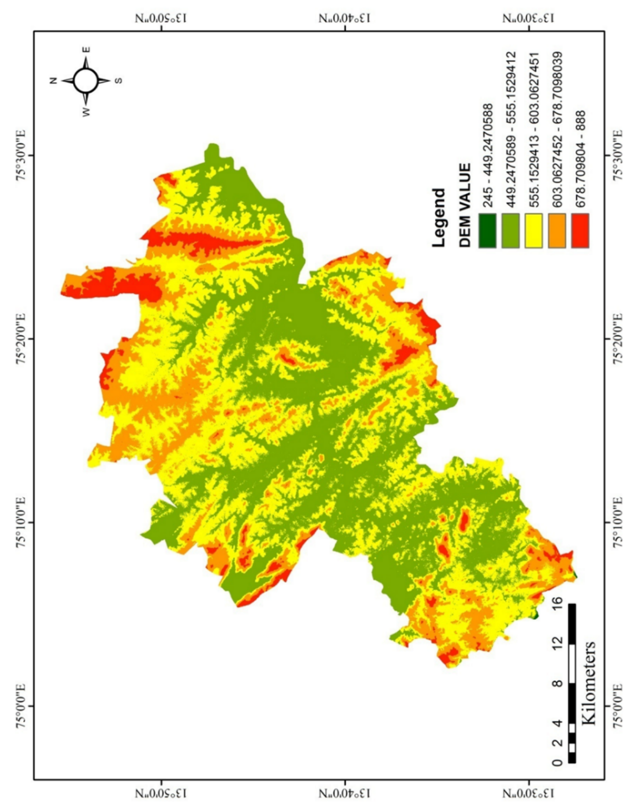

Fig. 2. Digital elevation model of the study area

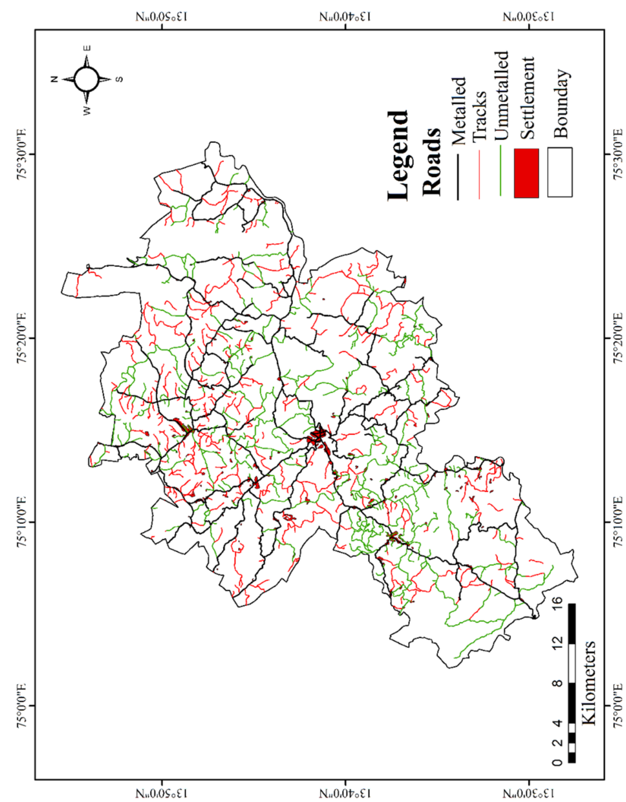

Fig. 3. Transportation network map of Thirthalli taluk.

Present study area is one of the biodiversity hotspot and is one of the tourist attraction in Karnataka state. Here identified the study area is well connected with the road networks to the settlements identified with three types of transportation network metalled roads, cart tracks and unmetalled roads. The transportation network map of Thirthalli taluk is showed in figure 3.

Analysis of land use land cover distribution

A supervised classification technique was adopted to categorize each Landsat image digitally, since this technique has been revealed to achieve better in the case of spectral variability of individual cover types. The delineated classes consists of water body, agricultural cropland, waste land, agricultural plantation, settlements, and forest lands (Table 2). For each of the predetermined land use land cover types, training samples were selected by delimiting polygons around representative sites. A total of 48 spectral signatures for the respective land use land cover types derived from the satellite imagery were recorded using the pixels enclosed by these polygons.

The spatial representation of land use land cover types from 1997 to 2017 is shown in figure 4. Initially, when the

Table 2. Description of land-use and land-cover classification scheme.

Class	Descriptions
Forest	Area dominated by trees including natural vegetation like evergreen forest, semi evergreen, moist and dry deciduous forests with tree grooves
Agricultural plantation	Commercial farming mainly meant for the crops grown for profit- Arecanut is the main crop grown.
Agricultural cropland	Cultivation of crops including both Kharif and Rabhi crops growing areas- Paddy is the main crop grown
Settlements	Residential, commercial, industry, transportation, roads, mixed urban.
Water body	Land areas with accumulation of water on the surface including lakes, rivers, ponds, reservoirs
Wastelands	Barren rocky or stony waste and other unwanted land

study began in the year 1997, the pattern of land use land cover as a percentage of the total area studied was dominated by forest (71%), followed by agricultural cropland (20%), agricultural plantation (5%), water body (2%), settlements (1%) and wasteland areas (1%) (figure 5). In the year 2017, when the study ended, the trend changes were observed for all land uses. The observed land use land cover pattern as a percentage of the total area studied was dominated by forest (62%), followed by agricultural plantation (17%), agricultural cropland (15%), wasteland (3%), settlements (2%) and water body (1%) (figure 5). This indicates that forest experienced the highest conversion followed by the agricultural croplands. The area statistics of the land use changes during the study period is presented in table 3.

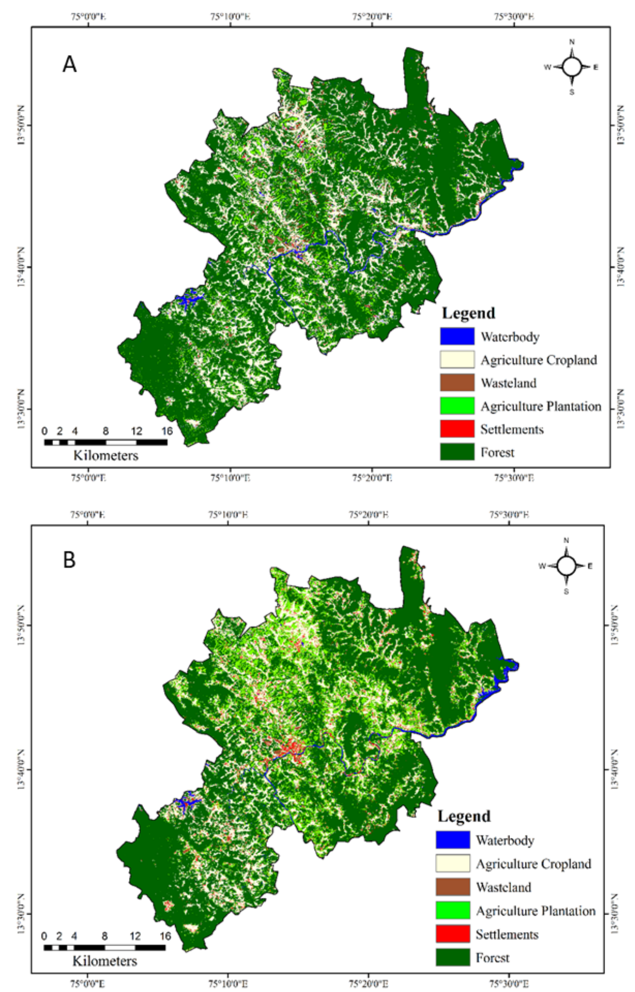

Fig. 4. Spatial distribution of land use land cover for the years (a) 1997 (b) 2017

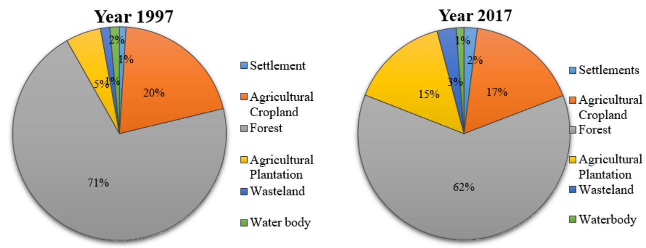

Fig. 5. Pie chart showing the area percentage of land use and land cover changes for the year 1997 and 2017

Table 3. Area statistics of different land use land cover classes

Classes	Year 1997	Year 2017
	Area in Sq km	**Area in Sqkm**
Settlement	12.47	25.56
Agricultural Cropland	253.24	215.32
Forest	883.06	775.84
Agricultural Plantation	66.79	188.25
Wasteland	17.57	36.35
Water body	18.10	14.8329

Normalized Difference Vegetation Index (NDVI) Distribution in the study area

Normalized Difference Vegetation Index quantifies vegetation by measuring the difference between near-infrared and red light. NDVI values always ranges from -1 to +1where the negative values indicates water bodies and the values close to +1, indicates the high possibility of dense green leaves. Giving weight to the land use change results the study made an effort to compute the NDVI for both the study years (figure 6a and 6b). The south western, north eastern and some regions of south east and north west parts of the study area exhibits highest NDVI values that is close to 0.8 for the year 1997 and 0.54 for the year 2017. These are the areas witnessed with thick forest cover in the study region. On the other hand, the identification of negative NDVI values of -0.93 for the year 1997 and -0.18 for the year 2017 indicates the presence of water bodies in the study area. The comparison of NDVI maps of the years 1997 and 2017 depicts the increased NDVI values throughout the study area in the year 2017. This shows many agricultural croplands that were present in the year 1997 were converted to agricultural plantations which lead to attain maximum NDVI values in the year 2017.

Analysis of change detection during the study period

Land management and land planning requires a knowledge of the current state of the landscape. Understanding current land cover and how it is being used, along with an accurate means of monitoring change over time, is essential for proper land management. The multi-temporal satellite datasets used in the present study yielded the following results when

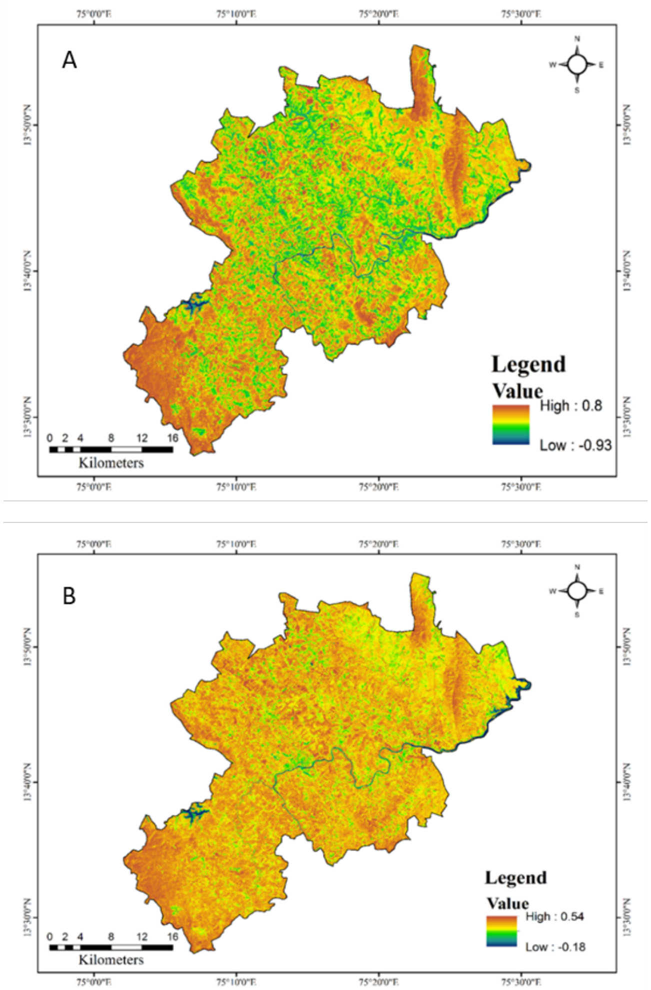

Fig. 6. Normalized Difference Vegetation Index Distribution for the years (a) 1997 (b) 2017

comparisons were made between the outputs of the years 1997 and 2017. The results of the present study showed that the study area exhibits a considerable decrease in the Agricultural croplands, Forest lands and water body during the study period. While the study showed an evident for increase in Settlements, Agricultural plantations and Wastelands. Agricultural activities are the principal reasons for ongoing deforestation which is directly related to biodiversity loss in this region. Large scale land cover changes involving the conversion of forests into other land use categories are one of the primary drivers of climate changes and biodiversity loss. The overall trend in the land use land cover change in Thirthahalli taluk during the study period is shown in the table 4 and figure 7.

Table 4. Land use land cover change analysis of study from 1997 to 2017

Class	1997	2017	Analysis	
	Area in Sq. Kms	**Area in Sq. Kms**	**Difference**	**Remarks**
Settlements	12.47	25.56	-13.09	Increased
Agricultural Crop	253.24	215.32	37.92	Decreased
Forest Land	883.06	775.84	107.22	Decreased
Agricultural Plantation	66.76	188.25	-121.49	Increased
Waste Land	17.57	36.35	-18.78	Increased
Water Body	18.1	14.8329	3.26	Decreased

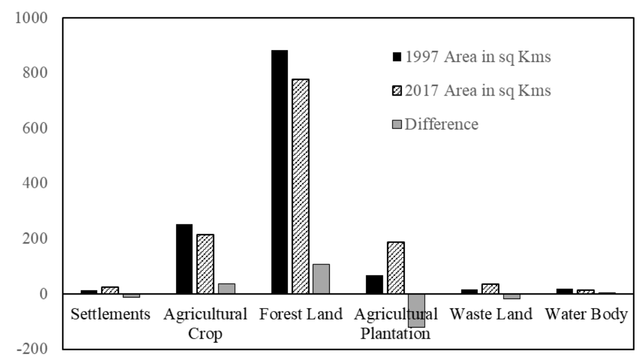

Fig. 7. Graph showing the statistics of land use land cover change in the study area from 1997 to 2017

Conclusions

The growing population and increasing socio-economic necessities creates a pressure on land use land cover which results in unplanned and uncontrolled changes on the existing land use distributions. Remote sensing and geographical information systems are the powerful tools to derive accurate and timely information on the spatial distribution of land use land cover changes over large areas. Present study carried out the change detection analysis for the Thirthahalli Taluk, using the Landsat satellite data for the years 1997 and 2017. The supervised classification method is used for classification of the images along with the field information. Six different land use land cover classes are identified in the study area namely forest, agricultural plantations, agricultural croplands, wastelands, water bodies and settlement areas.

The study revealed that the major changes occurred in forest, agricultural plantations and settlement areas. The classes such as agricultural cropland, forest land and water bodies showed noticeable decreasing trend whereas the classes agricultural plantations, wasteland and settlements showed considerable increasing trend. The reason for the changes in land cover classes is mainly attributed to the changes in the pattern of agricultural activities in the study area during the study period. The significant changes in the land use land cover may directly affects the biodiversity loss in the study region as the study area is characterized as one of the important hotspots of biodiversity of Western Ghats in India. However, these trends need to be closely monitored for maintaining the sustainability of the environment in future.

References

1) Babykalpana Y, Thanushkodi K. Classification of LULC Change Detection using Remotely Sensed Data for Coimbatore City. *Journal of Computing*. 2010;2(5):150–157.
2) Afify HA. Evaluation of change detection techniques for monitoring land-cover changes: A case study in new Burg El-Arab area. *Alexandria Engineering Journal*. 2011;50(2):187–195. Available from: https://dx.doi.org/10.1016/j.aej.2011.06.001.
3) Bolstad P, Lillesand TD. Rapid maximum likelihood classification. *Photogrammetric Engineering and Remote Sensing*;57(1):67–74.
4) George J, Baby L, Arickal AP, Vattoly JD. Land Use/ Land Cover Mapping With Change Detection Analysis of Aluva Taluk Using Remote Sensing and GIS. *International Journal of Science, Engineering and Technology*. 2016;4(2).
5) Deng JS, Wang K, Deng YH, Qi GJ. PCA- based land-use change detection and analysis using multitemporal and multisensor satellite data. *International Journal of Remote Sensing*. 2008;29(16):4823–4838. Available from: https://dx.doi.org/10.1080/01431160801950162.
6) Luppino LT, Bianchi FM, Moser G, Anfinsen SN. Remote sensing image regression for heterogenous change detection. *2018 IEEE 28th International Workshop on Machine Learning for Signal Processing (MLSP)*. 2018. doi:10.1109/MLSP.2018.8517033.
7) Bharath S, Ramachandra TV. Landscape dynamics of Uttara Kannada district. *LAKE 2012: National Conference on Conservation and Management of Wetland Ecosystems*. 2012;p. 1595–1598.
8) Attri P, Chaudhry S, Sharma S. Remote Sensing & GIS based Approaches for LULC Change Detection - A Review. *International Journal of Current Engineering and Technology*. 2015;5(5):3126–3137.
9) Haque MI, Basak R. Land cover change detection using GIS and remote sensing techniques: A spatio-temporal study on Tanguar Haor, Sunamganj, Bangladesh. *The Egyptian Journal of Remote Sensing and Space Science*. 2017;20(2):251–263. Available from: https://dx.doi.org/10.1016/j.ejrs.2016.12.003.
10) Twisa S, Buchroithner MF. Land-Use and Land-Cover (LULC) Change Detection in Wami River Basin, Tanzania. *Land*. 2019;8(9):136. Available from: https://dx.doi.org/10.3390/land8090136.
11) Thanushkodi DK, Kalpana Y, Sharath M. Image Processing and Remote Sensing - A Lulc Change Detection Using Remotely Sensed Data for COIMBATORE District, India. *International Journal of Advanced Research in Computer Science and Electronics Engineering*. 2012;1(10):23–31.
12) Nischitha V, Ahmed SA, Varikoden H, Revadekar JV. The impact of seasonal rainfall variability on NDVI in the Tunga and Bhadra river basins, Karnataka, India. *International Journal of Remote Sensing*. 2014;35(23):8025–8043. Available from: https://dx.doi.org/10.1080/01431161.2014.979301.
13) Rawat JS, Kumar M. Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh block, district Almora, Uttarakhand, India. *The Egyptian Journal of Remote Sensing and Space Science*. 2015;18(1):77–84. Available from: https://dx.doi.org/10.1016/j.ejrs.2015.02.002.
14) El-Hattab MM. Applying post classification change detection technique to monitor an Egyptian coastal zone (Abu Qir Bay). *The Egyptian Journal of Remote Sensing and Space Science*. 2016;19(1):23–36. Available from: https://dx.doi.org/10.1016/j.ejrs.2016.02.002.
15) Kulo N. Benefits of the Remote Sensing Data Integration. In: 1st Western Balkan Conference on GIS, Mine Surveying, Geodesy and Geomatic, Tirana. ;p. 1–14.