Vol. 23, No. 2, pp. 196-205 (2023)
Journal of Agricultural Physics
ISSN 0973-032X
http://www.agrophysics.in

Research Article

Spatio-Dynamic Assessment of Land Use/Cover Changes in Upper Bhavani Basin using Remote Sensing and GIS

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ABSTRACT

Land use/land cover (LU/LC) changes were determined in Periyapallam catchment of Upper Bhavani basin in 2006 and 2016 by using Geographical Information System (GIS) and remote sensing technology. These studies were employed by using the remote sensing data obtained from IRS Resourcesat 1, LISS III and IV of National Remote Sensing Centre, ISRO, India for 2006 and 2016. The study area was classified into eleven categories on the basis of field study, geographical conditions, and remote sensing data using supervised classification technique. The comparison of LU/LC in 2006 and 2016 derived from satellite imagery interpretation indicates that there was a 70% increase in built-up area, 48% increase in open forest, and 36% increase in banana plantations. It was noted that 29% of dense forest area was vanished during the period of study which was due to shifting cultivation and rapid urbanization in the Upper Bhavani basin. There was an increase in water spread area of around 73% which directly increases the agriculture land as it favors crop cultivation.

Key words: Landuse/cover, Spatial, Dynamic, Remote sensing

Introduction

Land use change is a process by which human activities transform the natural landscape, referring to how land has been used, usually emphasizing the functional role of land for economic activities. Monitoring and management of land-use changes that occurs at different spatial and temporal levels require accurate information. Evaluation and development of river basins / watersheds require accurate measurement of the past and present land cover/land use parameters as changes observed in these parameters determine the hydrological and ecological processes taking place in a basin. Watershed is a hydrological unit (Singh *et al*., 2014) which plays a vital role in determining economical, food and social security and provision of life support services to local residents (Wani *et al*., 2008). Land use changes can be categorized by the complex interaction of structural and behavioral factors associated with technological capacity, demand, and social relations that affect both environmental capacity and the demand, along with the nature of the environment of interest (Verburg *et al*., 2004). LUCC has recently become a major focus area in the global research community.

In recent times, different remote sensing methods such as aerial photography and satellite imaging have become widely available as a source of data for mapping and monitoring land use and land cover. Due to rapid climate change, urbanization and other

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anthropogenic activities, land cover around many of the area changes more quickly than ever before. The data obtained from remote sensing platforms provide up-to-date information and a general view of landscape characteristics and changes in the areas.

Analysis of thematic change information can lead to more noticeable discernment to underlying process involved in upbringing of land cover and land use changes (Ahmad, 2012). Change detection involves applying multi-temporal remote Sensing information to analyze the historical effects of an occurrence quantitatively and thus helps in determining the changes associated with land cover and land use properties with reference to the multi-temporal datasets (Ahmad, 2012; Seif and Mokarram, 2012; Zoran, 2006).

Agriculture modernization and transformation through the use of high-yield varieties, extension of irrigation facilities, introduction of mechanized tools, and use of fertilizers and pesticides, resulted in significant increase of cropland in watersheds. This coincided with rapid urbanization due to population explosion and economic growth. Various studies have been conducted all over the world regarding the change analysis of watersheds through different methods. Several researchers have focused on LU/LC studies because of their adverse effects on ecology of the area and vegetation (El-Raey *et al*., 2000; Hathout, 2002). They are important to develop effective management strategies for watersheds worldwide (Bazgeera *et al*., 2008; Caruso *et al*., 2005; Gajbhiye and Sharma, 2012).

Knowledge of LU/LC will undoubtedly contribute to the ongoing and emerging challenges of our world, such as land degradation, agricultural abandonment, deforestation, severe air and water pollution, soil carbon emission.

Therefore, the main objective of the present research was to utilize GIS and Remote Sensing applications to discern the extent of changes occurred in Upper Bavani Basin, Periya Pallam Catchment and its sub-catchments. However the specific objectives included (i) to identify and delineate different LULC categories and pattern of land use changes in catchment from 2006 and 2016 (ii) to examine the potential changes in area of waterbodies, plantations through spatial comparison of the LULC maps produced.

Materials and Methods

Study area

There are 34 river basins in Tamil Nadu including minor river basins. For study purpose, they are grouped into 17 by clubbing the minor ones with the adjacent major river basins. Cauvery is the only major river basin (drainage area > 20,000 sq. km.) and out of the remaining basins, 13 are medium basins and 3 minor basins (< 2000 sq. km.). The total surface water potential of river basins is 24,160 MCM (853 TMC).

The Bhavani basin (4877.134 sq.km) is the sub-basin in the Cauvery basin spread over in Karnataka, Kerala and Tamil Nadu with majority of the catchment lies in Tamil Nadu. The main river, courses through Coimbatore, Nilgiris and Erode districts of Tamil Nadu. About 90 per cent of the river's water is used for irrigation. The study area is restricted to the upper Bhavani basin with specific reference to the ITC priority area in Karamadai block of Coimbatore district and the approximate area is around 250 sq. km. The priority area in Bhavani basin is chosen as it is dominated by agriculture with water intensive Banana and coconut as major crops. The change in land use study at the priority area gives a detailed picture of water use within the priority area as there is declining supply for irrigation water and it helps in providing proper technological and resource and application management for the efficient use of water.

The Figure 1 shows the boundary of the Bhavani basin. The study area chosen for this study is located at central part of the Bhavanisagar Catchment area (232165 ha). The total area of the priority area is around 20790 ha (Fig. 1). Kemmarampalayam, Thekkampatti, Marudur, Kalampalayam, Velliangadu and Tholampalayam villages are within the priority area.

Satellite data used

The data used in this research were divided into satellite data and ancillary data. Ancillary data included ground truth data for the land cover/use classes and its surrounding area, topographic maps.

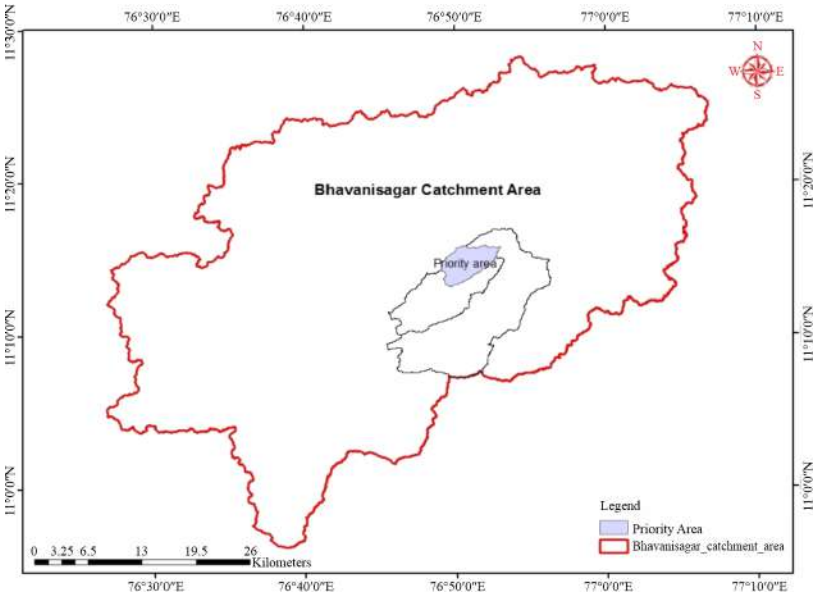


Fig. 1. Location of the Priority area in Bhavanisagar Catchment

The ground truth data were in the form of reference data points collected using Geographical Positioning System (GPS) were used for image classification and overall accuracy assessment of the classification results. Satellite data for 2 years on the other hand consisted of multi-spectral data acquired by IRS Resourcesat 1 and LISS III for the month of September provided by NRSC, ISRO, India. Specifications of the satellite data acquired for change analysis are given in Table 1. The spectral reflection will be different for each land use/cover. Based on the spectral classes, the land use/cover map was obtained. To study the decadal changes in the cropping pattern, the land use/cover map of 2006 and 2016 was used in this study. Resampling Technique was used to match the variation in resolution of the satellite data (IRS Resourcesat 1, LISS III and IV). PAN image was used to emphasize certain spectral characteristics and to obtain correct estimated data. The Table 2 presents the LU/LC classes delineated using supervised classification technique. Around ten randomly distributed ground truth data for each delineated classes was used. Post-classification change detection technique, performed in ArcGIS 10 was employed in this study.

Results and Discussion

In Upper Bhavani Basin, the dense forest cover was drastically reduced whereas the open forest cover was doubled (Fig. 2). There is no significant change in the agriculture, tea, coffee and other plantations area.

The classified LULC map of Periyapallam Catchment of years 2006 and 2016 is given in Fig. 4 and 5 respectively. In Periya Pallam Catchment, the decadal land use pattern between 2006 and 2016 reveals that the dense forest and scrub forest tends

Table 1. Satellite data specifications

Data	Year of acquisition	Bands/color (m)	Resolution	Source
IRS Resourcesat 1, LISS III	Feb 2005	4 Bands, False color composite	23.5	NRSC, ISRO, India
IRS 1D, PAN	Feb 2006	Panchromatic	5.8	NRSC, ISRO, India
IRS Resourcesat 1, LISS IV	Oct-15, March 16, Dec-15	4 Bands, False colour composite	5.8	NRSC, ISRO, India

Table 2. Classes delineated on the basis of supervised classification

S. No.	Class name	Description
1	Dense Forest	A forest thick with trees or having trees growing very closely together with tree canopy density of 70% and above.
2	Open Forest	All lands with tree canopy density of 10% and more but less than 40%.
3	Scrub Forest	Degraded forest lands with canopy density less than 10%.
4	Agriculture	Crop fields and fallow lands
5	Tea/Coffee Plantations	A huge area made up of small trees that rarely reach above 1.5m in height for beverage purpose
6	Open Barren Lands	Land areas of exposed soil and barren area influenced by human influence
7	Built-up Land	Residential, commercial, industrial, transportation, roads, mixed urban
8	Waterbodies	River, open water, lakes, ponds and reservoirs
9	Coconut	Plantation area having coconut trees
10	Beetalnuts	Plantation area having beetalnut palm
11	Banana plantations	Plantation area having banana plants

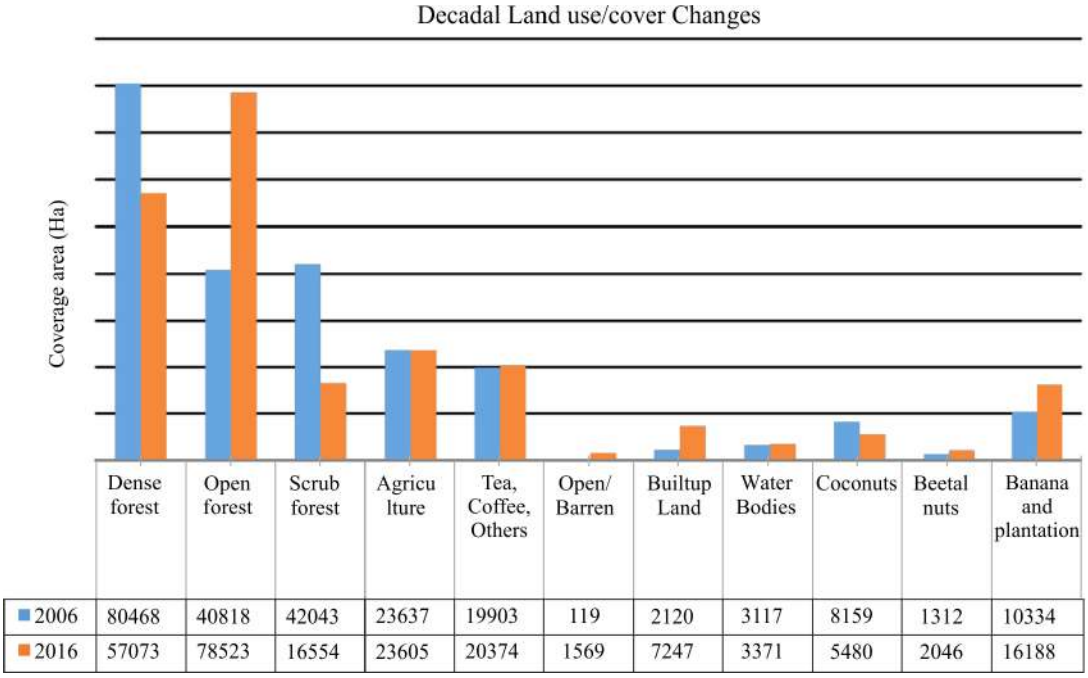
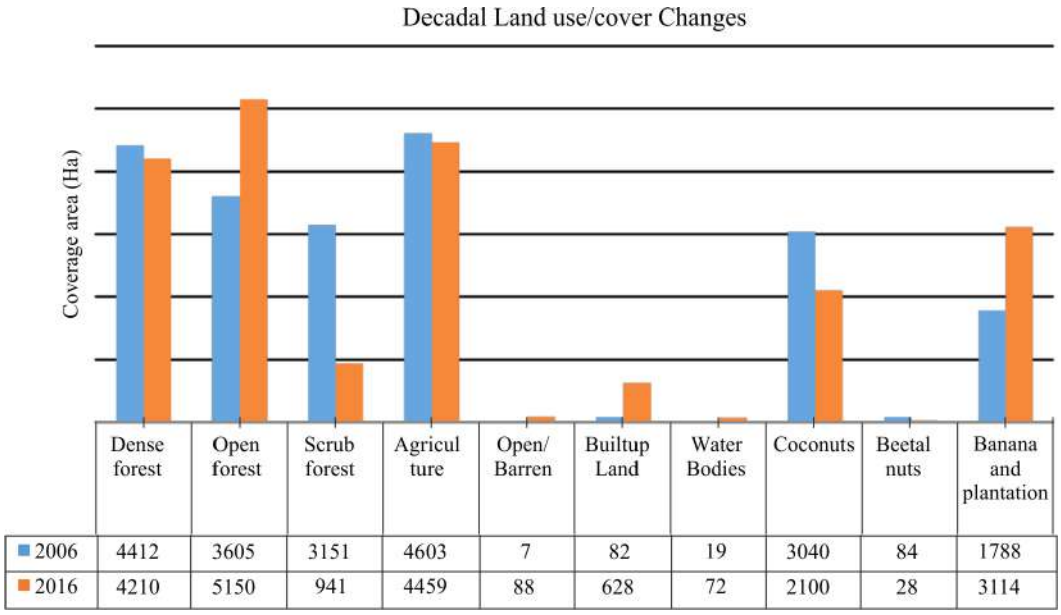


Fig. 2. Decadal Changes in Land use/cover in UBB

to decrease over years whereas open forest area increased from 3605 ha in 2006 to 5150 ha in 2016. The area under scrub forest significantly reduced from 3151 ha to 941 ha. Changes in the agriculture area was found to be less than 5 per cent. The area under barren land had increased over years, which is mainly due to the migration of farmers to urban locality for employment, education and other livelihoods.

It was also found that the built up area increased from 82 ha in 2006 to 628 ha in 2016, which is also evident from the increase in the population from 237805 in 2001 to 260172 in 2011 in Karamadai block (Fig. 3, 4 and 5). This was due to urban expansion and population increase in this study area during the study period which is also reported by Mallupattu and Sreenivasula Reddy (2013).



	Dense forest	Open forest	Scrub forest	Agricul ture	Open/ Barren	Builtup Land	Water Bodies	Coconuts	Beetal nuts	Banana and plantation
2006	4412	3605	3151	4603	7	82	19	3040	84	1788
2016	4210	5150	941	4459	88	628	72	2100	28	3114

Fig. 3. Decadal Changes in Land use/cover in Periya Pallam Catchment

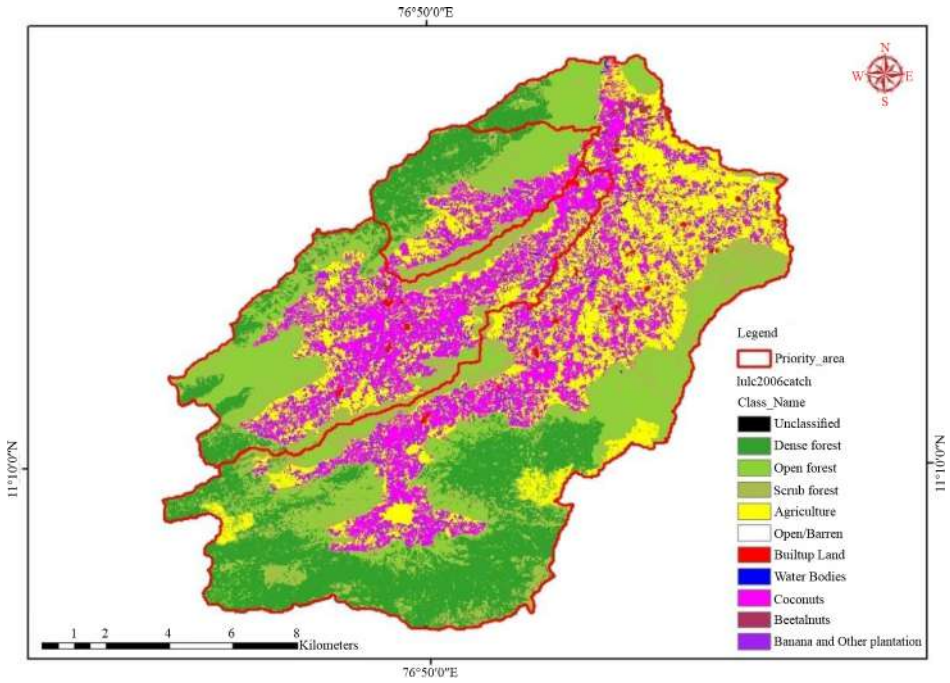


Fig. 4. Land use/cover map of priority area in 2006

The area under coconut reduced from 3040 ha in 2006 to 2100 ha in 2016. This increasing trend of land cover/land use change in the catchment area highlights that anthropogenic change of land (Wang *et al*., 2008) and it was the main reason why the area near and around the main water-bodies and streams has shifted from other land covers to Agriculture cover.

The Figure 6, 7 and 8 shows the decadal landuse changes in the three sub-catchments of the Periya Pallam catchment. In all the sub-catchments, there was a good increase in the banana plantations. In

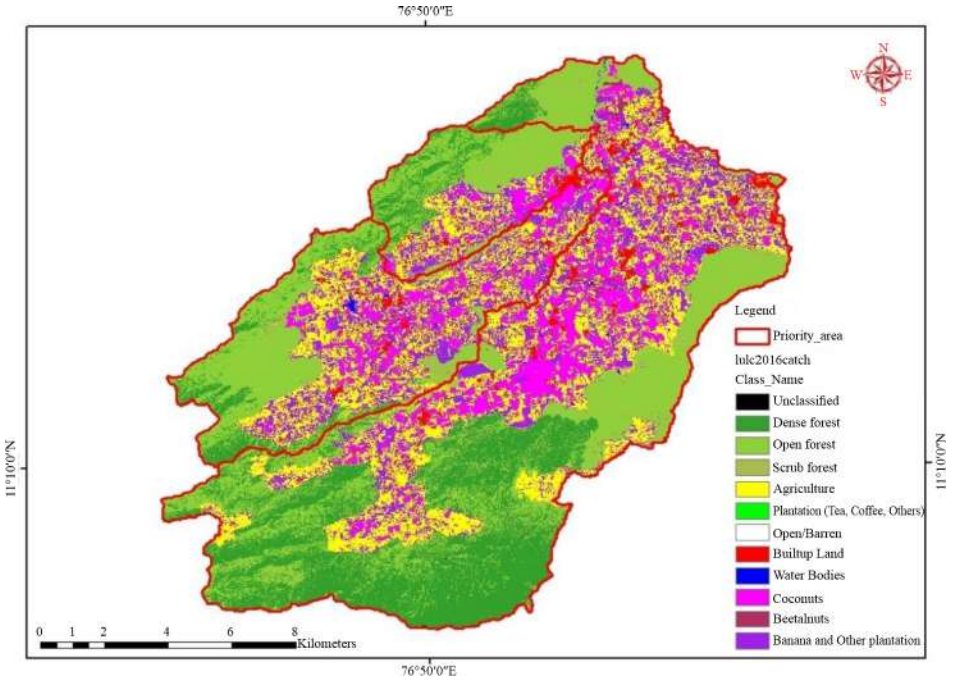
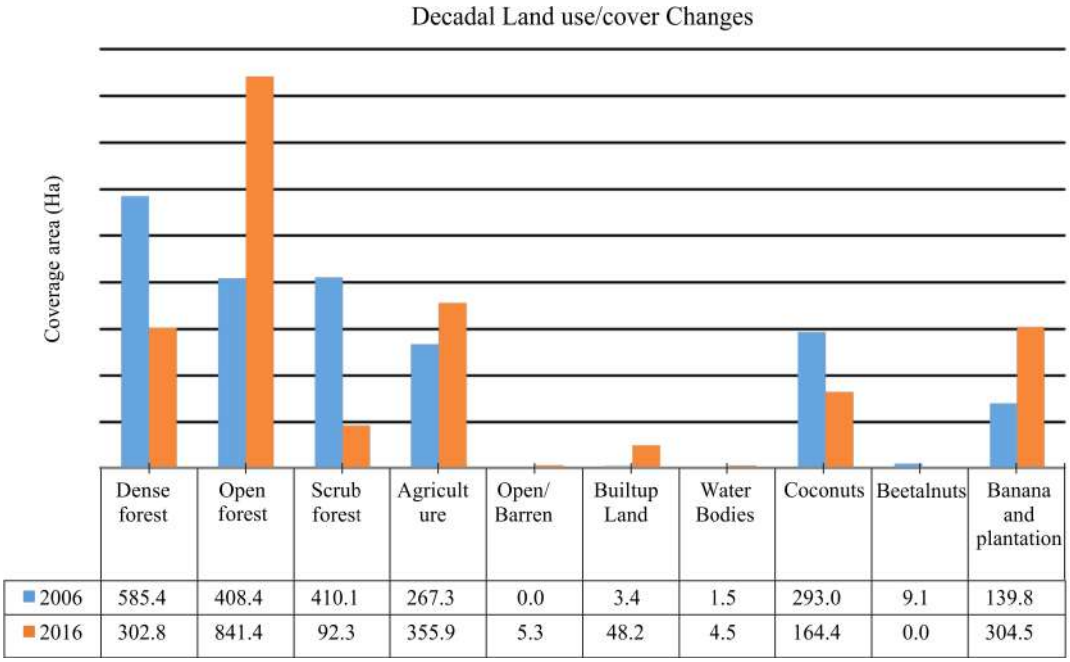


Fig. 5. Land use/cover map of priority area in 2016

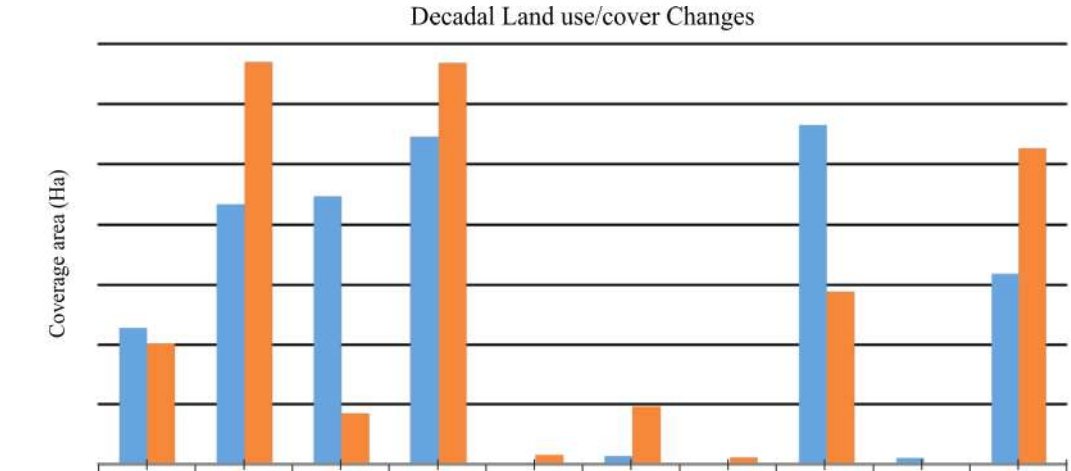


	Dense forest	Open forest	Scrub forest	Agriculture	Open/ Barren	Builtup Land	Water Bodies	Coconuts	Beetalnuts	Banana and plantation
2006	585.4	408.4	410.1	267.3	0.0	3.4	1.5	293.0	9.1	139.8
2016	302.8	841.4	92.3	355.9	5.3	48.2	4.5	164.4	0.0	304.5

Fig. 6. Decadal changes in Land use/cover in Sub-Catchment 1

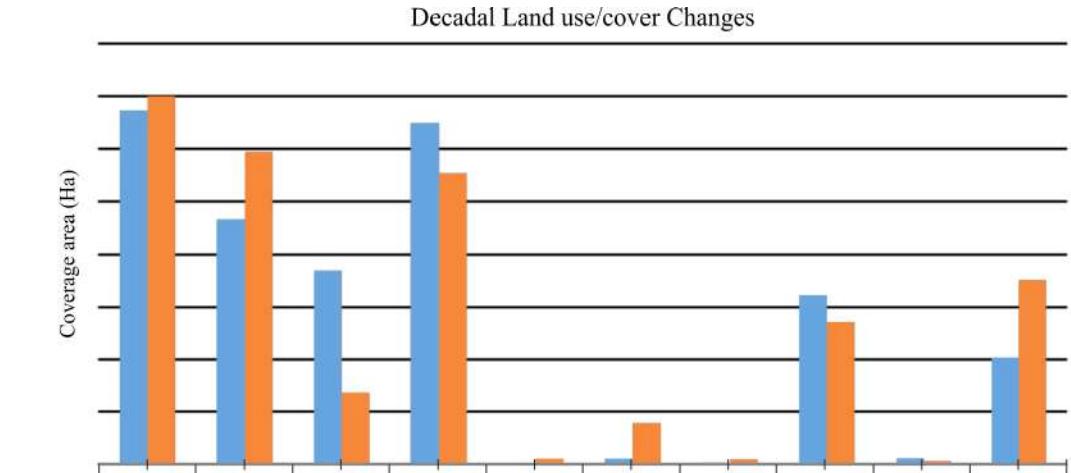
sub-catchment 3 there is good increase in the waterbodies compared to the others.

The area under water bodies increased from 19 ha in 2006 to 72 ha in 2016, which shows major watershed interventions promoted in the area by ITC over years. The phenomenal increase in the water bodies in the priority area was particularly in the agricultural and plantation area due to the interventions of integrated watershed management practices by ITC in priority area (Fig. 9). An increase



	Dense forest	Open forest	Scrub forest	Agriculture	Open/ Barren	Builtup Land	Water Bodies	Coconuts	Beetalnuts	Banana and plantation
2006	457	866	892	1090	1	27	3	1130	20	636
2016	404	1339	169	1336	31	192	22	577	0	1052

Fig. 7. Decadal changes in land use/cover in Sub-Catchment 2



	Dense forest	Open forest	Scrub forest	Agriculture	Open/ Barren	Builtup Land	Water Bodies	Coconuts	Beetalnuts	Banana and plantation
2006	3365	2329	1847	3244	7	51	15	1616	54	1019
2016	3501	2970	681	2767	52	388	45	1359	28	1758

Fig. 8. Decadal changes in land use/cover in Sub-Catchment 3

in coverage area of water bodies in the priority area indicates the measures taken by the farmers to harvest water for meeting out the water demand.

There is a significant increase in the area under Banana and plantations from 1788 ha in 2006 to 3114 ha in 2016, an increase of about 43 per cent area, which led to supply demand gap increase from 26.88 MCM in 2006 to 47.08 MCM in 2016. Since majority of the area is having banana plantations and high demand for water, it can recommend adopting drip irrigation technology which will reduce the demand supply water throughout the growing period. It was

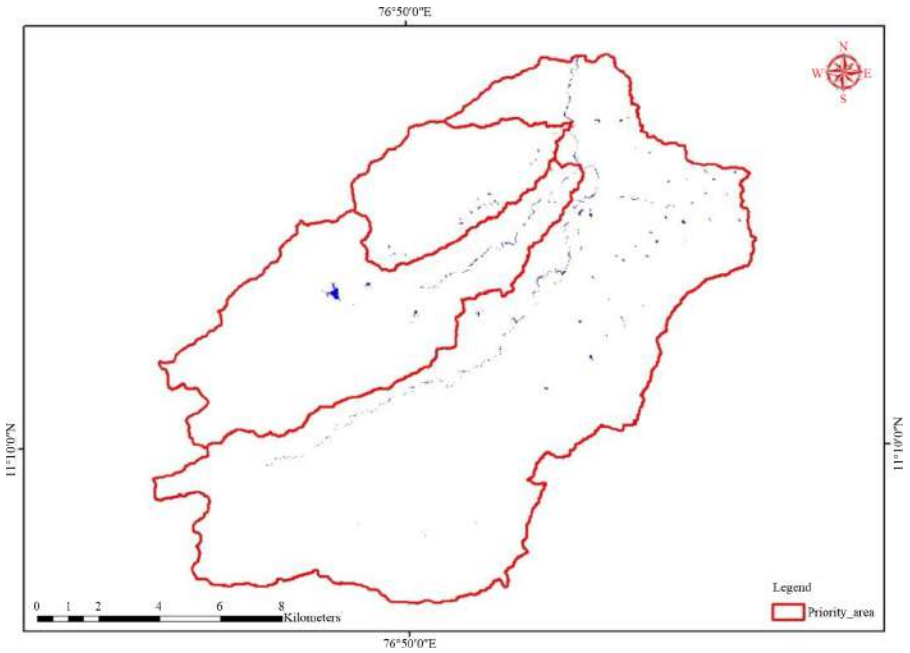


Fig. 9. Water bodies in the priority area during 2016

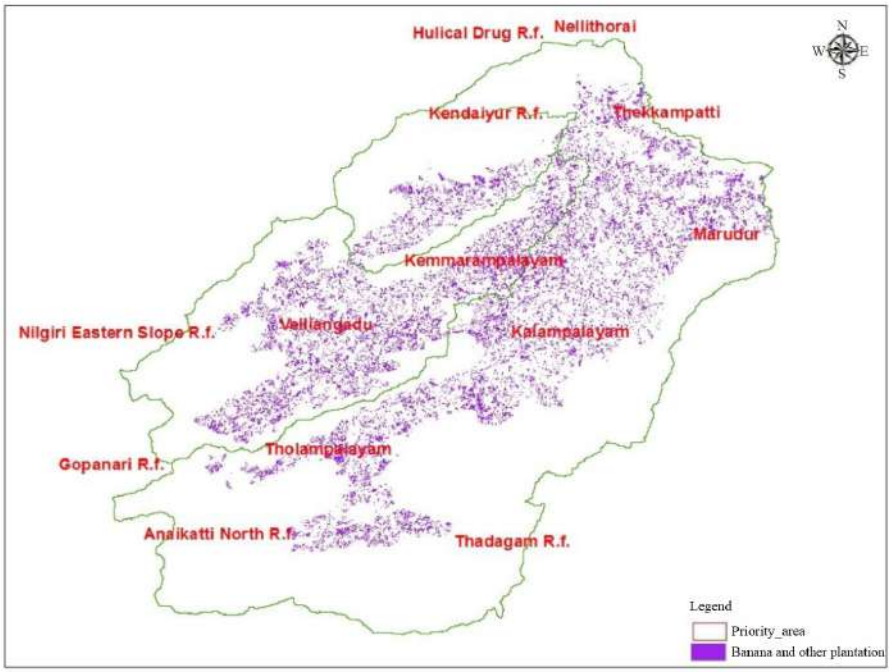


Fig. 10. Banana plantations in different villages during 2006

also observed that the area under beetal nuts had reduced from 84 ha to 28 ha within 10 years and the area under the built up land has tripled between the years 2006 and 2016.

Conclusion

Remote Sensing has been used to classify and map decadal land cover and land use changes in

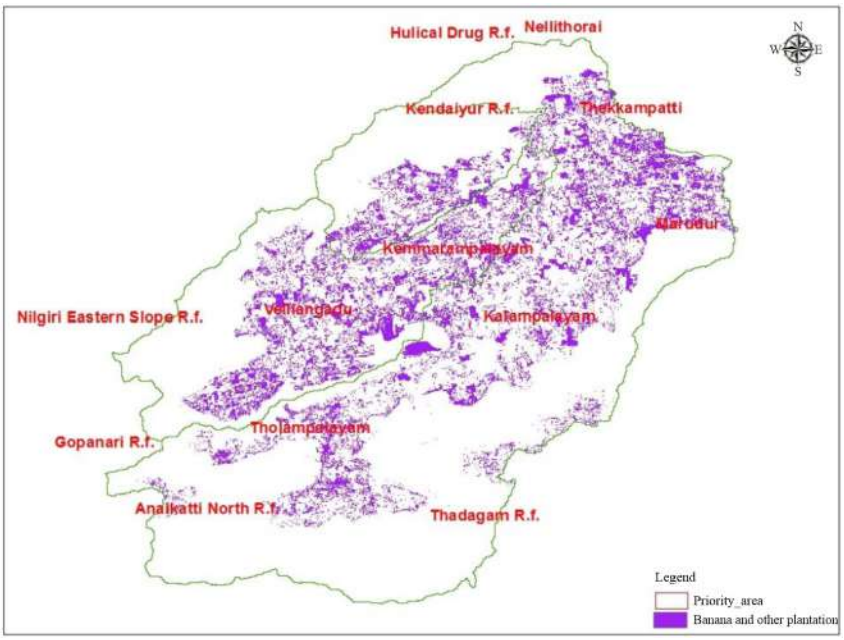


Fig. 11. Banana plantations in different villages during 2016

Upper Bhavani Basin. Based on the results obtained, it was found that the land cover/land use practices in the study area has altered significantly in ten years. The LULC shift in the catchment area was evident by the decline in the area of dense forest cover and expansion of area covered by classes of Settlements, Agriculture and barren land. There was 70% increase in built-up area, 48% increase in open forest, and 36% increase in banana plantations. It is also noted that 29% of dense forest area was vanished during the period of study which is due to shifting cultivation and rapid urbanization in the Upper Bhavani basin. There was an increase in water spread area of around 73% which directly increases the agriculture land as it favors crop cultivation. The haphazard expansion of Settlement and Agriculture area in the catchment was mainly due to lack of proper management and land use planning. With proper understanding of the spatial and temporal variations occurring in a watershed over time and the interaction of the hydrological components of a watershed with each other, helps in formulating better water conservation strategies.

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Received: 27 July 2023; Accepted: 16 October 2023