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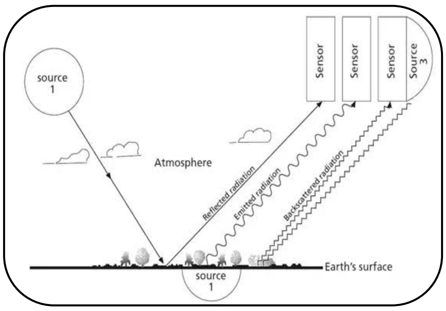
SPATIO-TEMPORAL ANALYSIS OF LAND USE/LAND COVER IN HONNAVAR TALUKA, UTTARA KANNADA DISTRICT: USING REMOTE SENSING TECHNIQUES



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ABSTRACT

The land use/land cover (LULC) pattern of a region in time and space is an outcome of natural and socio–economic factors and their utilization by man. In tropical Western Ghats of Karnataka, land use system is not a homogeneous process. Hence, land use manipulation by human beings is widespread and become a serious threat to watershed services including stream flow regulation, soil erosion control and low-flow augmentation at both micro- and macro-level catchments. The Understanding of Land Use through supervised and unsupervised classification of Land use by using RS and GIS technology help in understanding the driving mechanism that causes land use change. Therefore, an attempt is made to prepare LULC map of Honnavar Taluka, Karnataka by using Supervised and unsupervised classification. The classification were developed through unsupervised classification approach found prominent feature of the area together occupies 73% forest followed by moist followed by agriculture land 13.78% and minimum 0.03% under coastal area. However, analysis of supervised classification from multi-temporal satellite imageries estimated 16 land use/ land cover. With respect to rate of changes in Honnavar block.

KEYWORDS: *GIS technology , unsupervised classification ,*

1. INTRODUCTION :

The land use/land cover (LULC) pattern of a region in time and space is an outcome of natural and socio–economic factors and their utilization by man. Study on Land use and land cover become a central component in current strategies for sustainable management of natural resources and monitoring environmental changes in the territory. In tropical Western Ghats of Karnataka, land use system is not a homogeneous process. Hence, land use manipulation by human beings is widespread and become a serious threat to watershed services including stream flow regulation, soil erosion control and low-flow augmentation at both micro- and macro-level catchments. In the recent time, changes in land use and land cover have become one of the important components in monitoring watershed services especially hydrological services of the region. Further, change detection of vegetation pattern at the watershed level helps in enhancing the capacity of local governments to implement sound watershed management practices. New technologies like satellite Remote Sensing (RS) and Geographical Information Systems (GIS) provides a modern foray into the issues of resources management at regional and national scale. Further, these advanced geospatial technologies have improved the efficiency of mapping of land use land cover types at the landscape level. The Understanding of Land Use through supervised and unsupervised classification of Land use by using RS and GIS technology help in understanding the driving mechanism that causes land use change. In addition, they are valuable for a scientific base of the regional management, decision making and sustainable use of land and water (Fredrick et. al, 2013, LI Rui et. al., 2002). Thus, an integrated approach is essential and these combined techniques form a potential tool for land use land cover change detection analysis at both regional and local scales. Therefore, an attempt is made to prepare LULC map of Honnavar Taluka, Karnataka by using Supervised and unsupervised classification.

2. REVIEW OF LITERATURE

India

In India, the information on LULC change in the form of thematic maps, records and statistical figures are inadequate and do not provide up to date information on the changing land use pattern and process over the year. Technical Committee on Co-ordination of Agricultural Statistics (TCCAS) in 1950 recommended standard classification scheme, which is adopted by the States all over India. The concept of Remote Sensing data and its use in mapping and evaluating the LULC change begins as early as early as 1972 and maid effort to detect forest cover change using Landsat imagery Multi Spectral Sensor (MSS) data (NRSA, 1972-75). The initiatives of using remote sensing data were to meet the needs of national-level planning and management of natural resources. In addition, specific importance was to assess agriculture expansions at catchment levels, eco-development, afforestation and attention were paid in the preparation of plans for watershed development and irrigation projects. By and large, in the present context of management of natural resources, it has been felt that landscape dynamics and climate-related studies require updated information on a regular basis to arrive at proper management planning. Thereafter it is understood that knowledge about existing land use and land cover and its trend of change is essential for various reasons and information on the rate and kind of changes in the use of land resources is essential for proper planning, management and to regularise the use of such resources (Gautam and Narayanan, 1983, Zhu, 1997;). Further it is opinion that Satellite Remote Sensing plays an important role in generating information about the latest land use-land cover pattern in its spatial and temporal changes at local, regional and global scale (Foody, 1992; Yacouba et al., 2009). Additionally, the information being in digital form can be integrated into GIS to provide a suitable platform for data analysis, update, and retrieval (Poulami paria and Bindu Bhat, 2012). Then after, considerable progress has been made in both spatial and temporal assessment of land use land cover change at regional scale through RS and GIS. It is difficult to discuss all the studies; therefore, a mention has been made to all relevant studies and some they are attempted to delineate the land use classes from digital remote sensing data. They applied the supervised and rule-based classification technique to delineate the various land use class with high accuracy (Vijaykumar et. al., 2004). Nigam, (2000) has evaluated the effectiveness of High-Resolution satellite in assessing the land use change dynamics. Seleuk Reis et. al., (2003); Jayakumar and Arockiasamy, (2003); Mani and Rama Krishnan, (2013); Pandian et. al., (2014), have analysed land-use land-cover change and change detection in several places of Indian states. One of the studies undertaken recently by Chakraborty, (2009) used moderate resolution imaging called spectro-radiometer (MODIS) in order to determine forest cover in the Barak basin which is located in the North Eastern part of India. This study highlighted that use of remote sensing and geographic information system a potential tool in the analysis of landscape cover.

Yan Qin Zhang Jixian, (2002) Anita, et. al., (2007) has integrated application of RS and GIS to agriculture land use planning. Kotoky et. al., (2012) have studied changes in land use and land cover along the Dhansiri river channel, Assam by a remote sensing and GIS approach and opined that land use/ land cover change is a critical input for natural resource management and policy decisions. applied multi-criteria decision-making in the land evaluation of agricultural land use. Lallianthanga and Robert Lalchhanhima Sailo, (2013) have described land use planning for sustained utilization of resources using remote sensing and GIS techniques with a case study in Mamit District, Mizoram, India. Sarkar et. al., (2006) have studied, soil resource appraisal towards land use planning using satellite remote sensing and GIS. The study area was Patiloniala micro watershed, district Puruliya, West Bengal. IRS ID LISS-III fused with PAN data with scale l:12500 used for delineating the physiographic units based on the variations in image characteristics. Further, Ashok Mishra et. al., (2007) have studied, prioritizing structural management by quantifying the effect of land use and land cover on watershed runoff and sediment yield. Arabinda Sharma et. al., (2011) have carried out a study of the effect of land use/ land cover change on soil erosion potential in an agricultural watershed. Sandra et. al., (2013) have studied alternative land-use method for spatially informed watershed management decision making using SWAT. During recent year Wagner et al., (2013) have studied an assessment of land use change impacts on the water resources of the Mula and Mutha Rivers catchment upstream of Pune. Youngsug Kim et. al., (2002) have studied Runoff Impacts due to Land-Use Change in Indian River Lagoon Watershed through RS and GIS tool.

STUDY REGION SCENARIO

Amba Shetty, et al., (2005) effort were made on land use land cover of Yennehole river basin of west coast region of Karnataka through digital image processing of satellite data and found RS and GIS approach is ideal for land use land cover mapping of thickly vegetated western coast of India and it feels that it is cost effective and quick process. By taking Barchi sub river basin as an example later Dilip et. al., (2007) expressed that GIS application can used effectively in hydrological simulations through characterisation of watershed drainage. Further by Jagadish, et al., 2007 characterised the watershed of Bilegal and Nellibeedu, Bhadra river basin through LANDSAT TM image and DEM map for sediment yield estimation. Kiran kumar et. al., (2007), discussed methodological challenges of socio-hydrological research on land use change and watershed services insight of Western Ghats. In particular they have looked at the difficulties of using RS/GIS, finding different land use type in close proximity to each other and which comparable downstream communities, differentiating between catchments of hydrological concern and community catchment and actual undertaking the field work. Malissa et al., (2013), adapted both supervised and un-supervised classification methods and developed LULC using ASTER imagery and carried out LULC classification of 6 protected areas and their surroundings (20 km) buffer. Lakshumanan et al., 2012 assessed Land use land cover dynamics in the Nilgiri district of western Ghats Tamil Nadu for a period of 1973-2009 through Remote Sensing and GIS. Many studies used NDVI to characterise watershed vulnerability to water quality impacts without testing any emphatically relationships (Jones et al., 2000, Griffith et. al., 2002) Menon and Bawa (1997) inferred that NDVI can be used to assess the health of forest ecosystem and the extent of degradation in Western Ghats region of Karnataka. Vijith and Satheesh, (2007) have evaluated land use pattern and geomorphological of parts coming under the Western Ghats using IRS P6 LISS III data. The major ecological and environmental problem leading to degradation of Western Ghats is deforestation. Forests were cleared in the past for agriculture expansion, plantation development and for various other development activities (Menon and Bawa, 1997; Jha et. al., 2000). Therefore, in order to manage land resources, it is not only important to consider existing information on the land use and land cover but also valuable to consider capability in order to monitor dynamics of land use. Since such changes would be resulting from demands of growing population as well as drivers of nature affecting the shape of the landscape.

3. SPECIFIC OBJECTIVES

- To prepare land use/ land cover map of Honnavar Taluka of Uttara Kannada district by using Remote Sensing and GIS applications
- To compare the results of supervised and unsupervised classification map.

To estimate relative Change occurred in Land use land cover system in the study region.

4. METHODOLOGY

Coastal regions of Honnavar block is located between 14^0 56' 15" and 14^0 41’ 15” N latitude and 74^0 26’ 0” and 74^0 46’ 20” E longitude. The study area is situated in Aganashini and Sharavathi River basin and facing the Arabian Sea. The total geographical area of the Block is 754 sq. km. There are innumerable streams and rivulets that join Aganshini and Sharavathi River when they descend from Ghats to the Coastal region. Honnavar region is characterised by narrow Coastal plain and quickly merging with foothills of the Ghats. The altitude ranges from 2 m in the Coastal region to 1000 m above mean sea level towards eastern parts of the Ghats. The geology of the area mainly consists of Archaen-Proterozoic-Dharwar schist and granitic gneisses, meta-volcanic and recent sediments (Bourgeon, 1989). The most common type of soil is the lateritic soil. The region has a tropical humid climate with mean monthly temperature ranging from 27^0 to 29^0 C. Throughout the tract heavy rains are received from the south-west monsoon starting from 1st week of June. The average annual rainfall is 3900 mm. About 70-80% of the rainfall is received between June and September due to the south-west monsoon phenomenon, while the leftover rainfall is spread over remaining eight months. The number of rainy days during monsoon season (June to September) is about 100-110 days. The Coastal areas are very humid and the hilly regions.

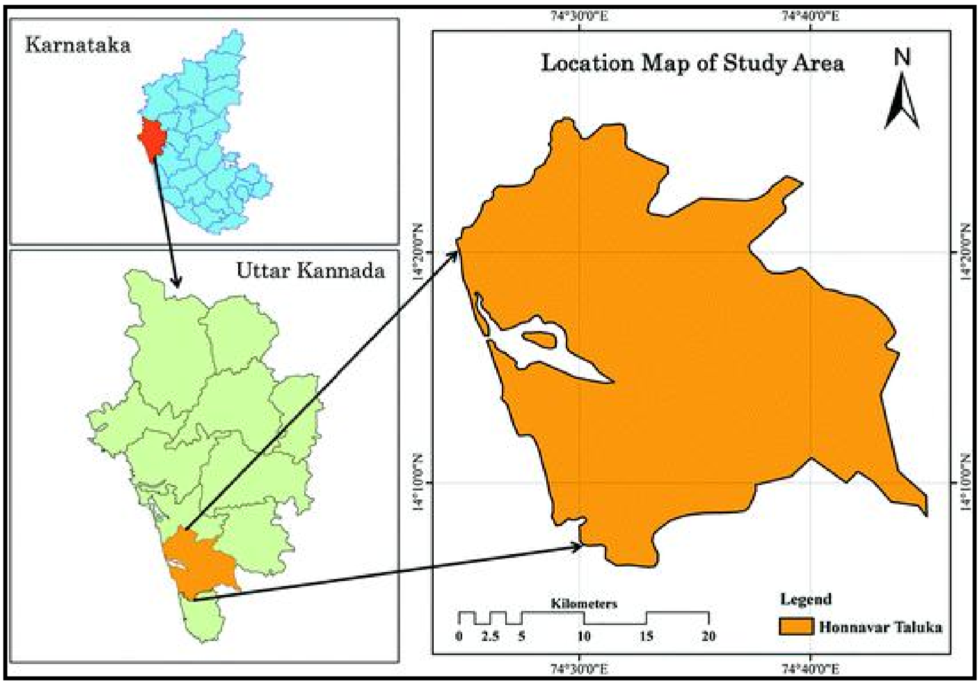


Figure 1. Location map of study area

LAND USE/LAND COVER MAPPING: REMOTE SENSING AND GIS APPROACH

Changes in the land use pattern were studied based on a comparison of time series satellite data of 2001 and 2012. The visual interpretation technique was used for LULC mapping of the study area. The LULC maps for the above period were integrated into a Geographic Information System (GIS) and change detection in different LULC was determined. Calculation of the area in hector (ha) of the resulting LULC type has been done for each study year and subsequently compared the results.

DATA COLLECTION AND PROCESSING

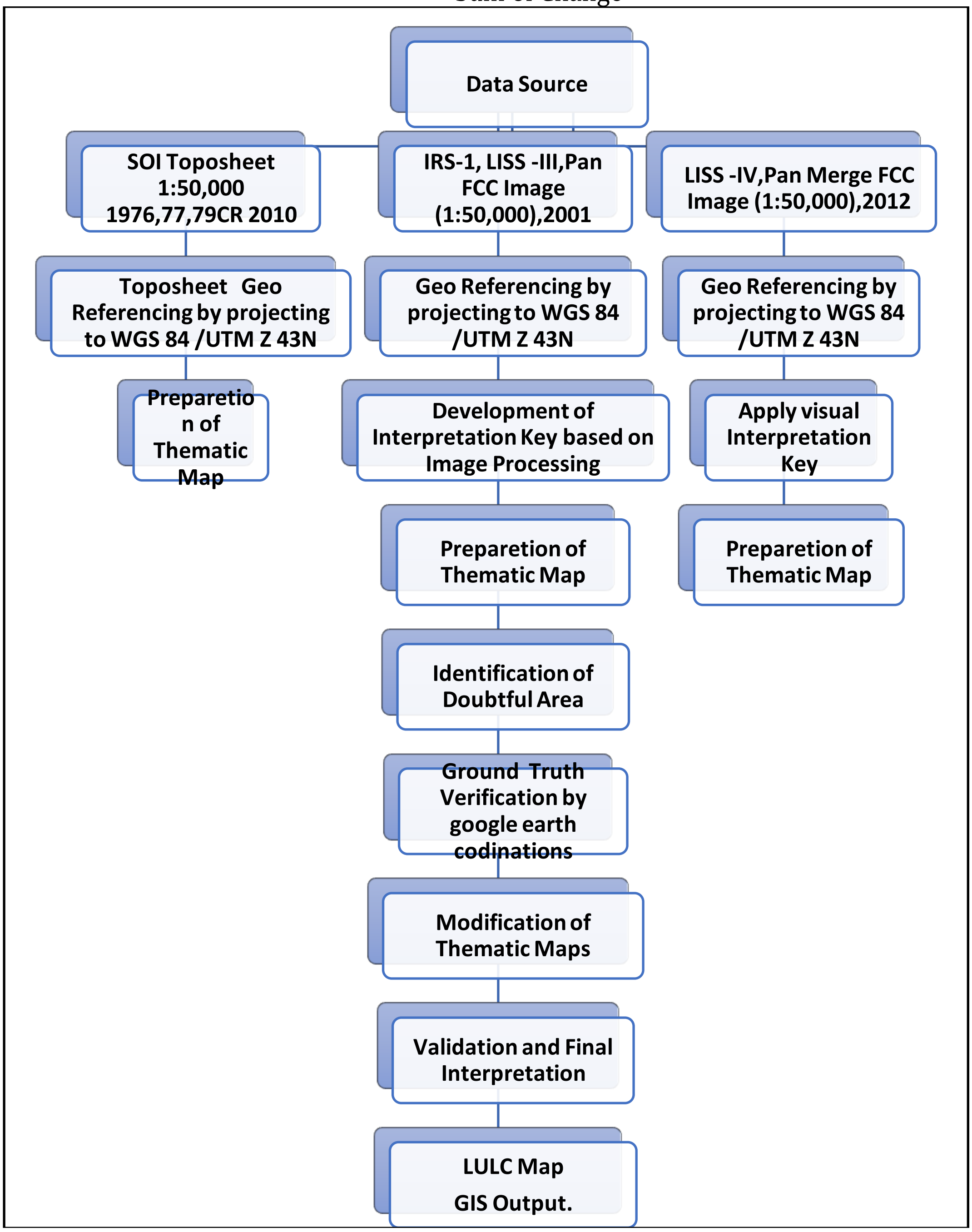
Satellite data of Indian remote sensing satellite IRS-1 LISS IV 5.8 m resolution merged data of PAN and FCC of Kharif seasons of June 2001, and 2012 was acquired from National Remote Sensing Centre (NRSC), Hyderabad, India. The study area lies in one swap (L1SS IV). The study area is covered by fifteen different topographic maps / sheets (48J7,48J10, 48J11 and 48 J/12; at 1:50,000 scale) which were collected from Survey of India (SoI) web site. All these SoI maps were scanned to QGIS 2.6.1 for understanding the land features.

The classification of the image was performed using unsupervised followed by Supervised classification method. Based on the field experience first we developed Un-supervised classification map. Keeping that as base map further effort was made to develop supervised classification by interpretation of satellite data and cross check with google earth imagery of the study area. Using QGIS 2.6.1 and SAGA 2.6.4 software, onscreen interpretation of satellite data is done with the help of interpretation key. Ground truth done by google earth engine. After verification, these areas were reconciled on the maps and corrections are incorporated before a finalizing the map. From the classified outputs, statistics are obtained with the help of SAGA 2.6.4. The methodology followed for interpretation of satellite image is shown in Flowchart-1.

The spatial analyses are carried out at the block level to describe LULC changes that have occurred and calculated percentage of change, trend, rate, and the pattern. The LULC area in 2001is denoted as A and the LULC area for 2012 as B. By subtracting A from B, the change is either positive (increase) or negative (decrease).

The expression is as follows:

$$\text{Change (\%)} = \frac{\text{Observed change} * 100}{\text{Sum of Change}} \qquad (1)$$



Flowchart 1: Methodology of land use land cover mapping

5. RESULTS AND DISCUSSIONS

The present study developed a spatial and temporal database of land use land cover of Honnavar blocks of Uttara Kannada district, Karnataka. A brief account of these results expressed and critical discussion has been made on each outcome with the similar work done elsewhere in the following paragraphs.

Land use land cover Mapping by using Unsupervised techniques.

Land use land cover status of unsupervised classification forth study area is presented Figure 3. Total 1 describes classification of land use land cover system were identified at the initial stage and a prominent feature of the area together occupies 73% forest followed by moist followed by agriculture land 13.78% and minimum 0.03% under coastal area (Figure 2).

Land use/land cover (LULC) assessment of Coastal region, Honnavar using supervised Classifications

Land use land cover classification statistic data obtained through the analysis of supervised classification from multi-temporal satellite imageries are presented in Table 1 and the LULC classification maps are presented as Figure. 4. The study area covers 75365.18 ha and LU/LC changes were estimated from 2001 to 2012. Altogether, 16 land use/ land cover identified and mapped in the study area and they are cropping land, Agriculture/ mixed vegetation, Forest; Evergreen/ semi-evergreen, dry/ moist deciduous, degraded forest and forest plantations, Barren Rocky with scrub land, water bodies: lakes/ rivers/ tanks/ streams and Habitations; village and towns/ cities.

Table 1, Figure 5 LULC status of year 2001, about 59.40% (44763.4 ha) area of Honnavar block was under Evergreen/ Semi evergreen forest, 7.90% (5951.21 ha) under Agriculture/ Mixed plantation (mostly Arecanut plantation), 5.51% (4152.44 ha) under crop land, 5.31% moist and dry deciduous forest (4003.95 ha), 4.37% (3294.39 ha) degraded forest, 4.14% (3121.85 ha) under Habitat with vegetation/ village, 3.53% (2656.9 ha) under River/ Stream, 2.33% (1752.54) under Forest plantations, 2.18% (1646.31 ha) under scrub forest, 2.15% (1618.74 ha) under Barren Rocky, 1.54% (1158.42 ha) under Land with scrub and < 1% ranging from 0.87 to 0.02% (< 1000 ha) area was covered by Lakes/tanks/River Islands, Towns/ Cities, Coastal, Inland wetlands and Aquaculture ponds.

However, during 2012 the area under these land categories was found 58.01% (43720 ha) area under Evergreen/ semi-evergreen forest, 7.14% (5379.79 ha) under Agriculture/ Mixed plantation (mostly Arecanut plantation), 5.88% (4433.13 ha) under crop land, 5.00% (3769.83 ha) moist and dry deciduous forest, 4.94% (3722.33 ha) scrub forest, 4.39% (3305.16 ha) under habitat with vegetation, 4.04% (3047.36 ha) under Degraded forest, 3.24% (2440.95 ha) under forest plantation, 3.05% (2300.61 ha) under River / stream, 1.45% (1089.68 ha) under Barren Rocky, 1.27% (959.9 ha) and < 1% ranging from 0.69 to 0.03% (< 600 ha) area was covered by Lakes/tanks/River Islands, Towns/ Cities, Coastal, Inland wetlands and Aquaculture ponds.

The data presented in Table 2 and Figure. 6 depict that both (relative change) positive and negative changes occurred in the land use/cover pattern in the coastal region of Honnavar block.

FOREST AND FOREST TYPES:

The Natural forests especially evergreen / semi-evergreen, moist / dry deciduous forests are mainly located in hilly and steep valley area. However, forest plantation and degraded forest are located in the upland area and these plays very important role in catchment hydrology. Vegetation especially Evergreen/ Semi-evergreen forest has been decreased from 44763.4 ha to 43720 ha during 2001 to 2012. This decrease in vegetation accounts for 1.38% of the total evergreen/semi-evergreen of Honnavar area. Similarly, moist/ dry deciduous and degraded forest being 4003.95 ha and 3294.39 ha in 2001 was shrunk to 3769.83 and 3047.36 of the study area in 2012 and net decrease accounts 0.3% each of the previous area. However, during the same period scrub forest area has increased from 1646.31 ha in 2001 to 3722.33 ha in 2012 which accounts for a net increase of 2.7% of the total sprawl area and forest plantation area marginally increase from 1752.54 ha in 2001 to 2440.95 ha in 2012, which accounts net increase of 0.91% of total plantation.

WATER BODIES:

A careful examination of the statistics revealed that the area covered by water bodies likes River/ streams and lakes/tanks decreased from 2001 to 2012 and accounts the net decrease of 0.47% and 0.22% respectively of the total land cover of water bodies in the year 2012.

Waste land: Most of the wasteland like land with scrub and barren rocky was noticed on uplands. The total land with scrub was 1158.42 ha in 2001 was reduced to 959.9 ha in 2012 and registered a net decrease of 0.26% by the year 2012. Similarly, a barren rocky account during 2001 was 1618.74 ha and it reduced to 1089.68 ha in the year 2012 which accounts 0.7% of the total geographical area of the wasteland.

AGRICULTURE:

Arecanut plantation and paddy cultivation are the main sources of socioeconomic of the village community in the region. Agriculture/ mixed plantation (areca nut plantation) and crop land (paddy field) predominantly occupied in Valley and downstream flat/ low-lying area. Agricultural land/mixed vegetation (mostly areca nut plantation) has slightly decreased from 5951.21 ha in 2001 to 5379.79 ha in 2012 which accounts for 0.76% of the total block area of agriculture land/ mixed vegetation. However, cropland found slightly increased from 41152.44 ha to 4433.13 ha and accounts a net increase of 0.37% of the total cropland area during 2012.

HABITATS/ SETTLEMENT:

Built-up area identified in the study area was mainly large city/ town settlements and village/ Habitat with vegetation. The total area of city/ towns was 459.39 ha. In 2001 increased to 520.4 ha. In 2012.This accounted net increase with 0.08% of the total geographical area of habitat during 2012. Similarly, village/ habitat with vegetation settlement also found increasing trend from 2001 to 2012. The total village settlement distributed in 2001 is 3121.85 ha has increased to 3305.16 ha in 2012. There is a net increase of 0.24% total geographical area.

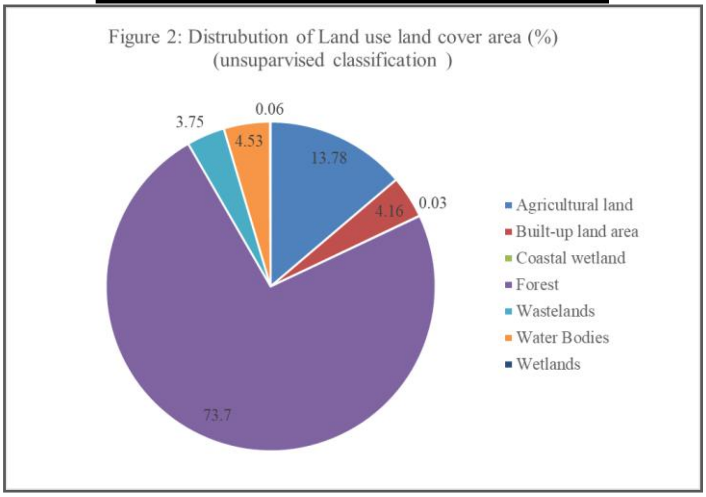
COASTAL, INLAND WETLANDS, AQUACULTURE PONDS:

Aquaculture ponds marginally increased from 12.44 ha in 2001 to 74.92 ha in 2012, which accounts 0.08% of total area of aquaculture ponds. Similarly, during the same period inland wetlands area registered almost similar pattern and there was no change observed in coastal area from 2001 to 2012.

Table 2 and Figure 6 shows that the calculation results of the areas of rate of changes, land use deviation in Honnavar block. The maximum rate of fluctuation was observed in Scrub forest followed by evergreen forest and forest plantation. The rate of land use change per year was found marginally increased with cropland (4.19%) habitat with vegetation, (2.73%/ year) and town and cities (0.91%/year) and aquaculture ponds (0.93%/ year). However, decreasing rate of land use change was observed with moist and dry deciduous forest (3.49), degraded forest (3.68), land with scrub (2.96) and inland wetlands (0.11).

Table 1 Land use/Land Cover statistics of Honnavar Unsupervised classification

LULC category	Area (Ha)
Agricultural land	10386.0
Built-up land	3135.0
Coastal	21.0
Forest	55541.8
Wastelands	2825.9
Water Bodies	3411.2
Wetlands	43.6
Grand Total	**75364.5**



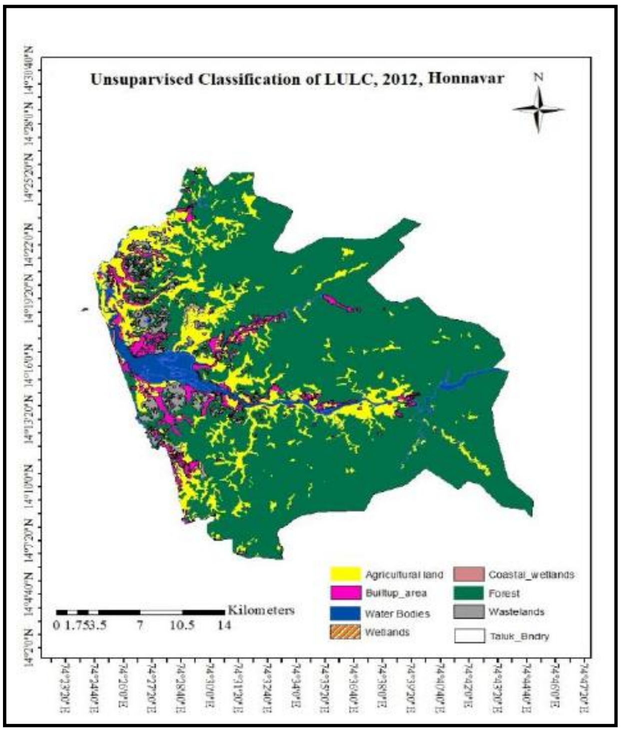


Figure 3: Land use and Land cover for the year 2001 and 2012, Honnavar block, Uttara Kannada district, Karnataka

Table 2 Land use/Land Cover statistics of Honnavar block during 2001 and 2012

LULC category	Year 2001 (A)		Year 2012 (B)		Relative Change (B-A)		Rate of change (%)
	Area (Ha)	% area	Area (Ha)	% area	Area (Ha)	% area	
Agricultural/Mixed Vegetation	5951.21	7.90	5379.79	7.14	-571.42	-0.76	8.52
Aquaculture pond	12.44	0.02	74.92	0.10	62.47	0.08	0.93
Barren Rocky / Stony Waste	1618.74	2.15	1089.68	1.45	-529.06	-0.70	7.89
Coastal	83.14	0.11	83.11	0.11	-0.03	0.00	0.00
Cropland	4152.44	5.51	4433.13	5.88	280.69	0.37	4.19
Degraded Forest/Tree Groves	3294.39	4.37	3047.36	4.04	-247.03	-0.33	3.68
Evergreen /Semi-evergreen Forest	44763.40	59.40	43720.00	58.01	-1043.40	-1.38	15.56
Forest Plantations	1752.54	2.33	2440.95	3.24	688.41	0.91	10.27
Habitation with Vegetation/Village	3121.85	4.14	3305.16	4.39	183.31	0.24	2.73
Inland Wetlands/Inland	32.45	0.04	25.11	0.03	-7.34	-0.01	0.11
Lake / Tanks / River Island	657.61	0.87	492.90	0.65	-164.71	-0.22	2.46
Land with scrub	1158.42	1.54	959.90	1.27	-198.53	-0.26	2.96
Moist & Dry Deciduous Forest	4003.95	5.31	3769.83	5.00	-234.12	-0.31	3.49
River / Stream	2656.90	3.53	2300.61	3.05	-356.29	-0.47	5.31
Scrub Forest	1646.31	2.18	3722.33	4.94	2076.02	2.75	30.97
Town / Cities	459.39	0.61	520.40	0.69	61.01	0.08	0.91
Grand Total	75365.18				6703.83		

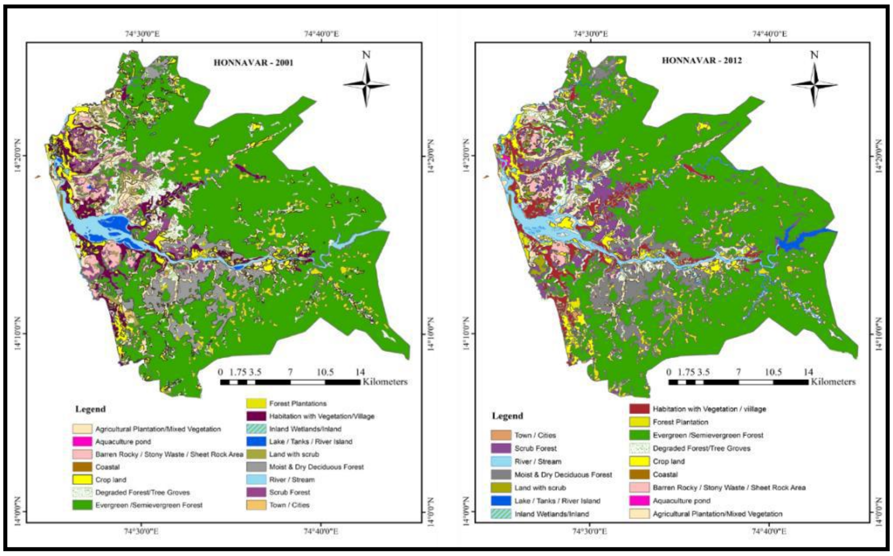


Figure 4: Land use and Land cover for the year 2001 and 2012, Honnavar block, Uttara Kannada district, Karnataka

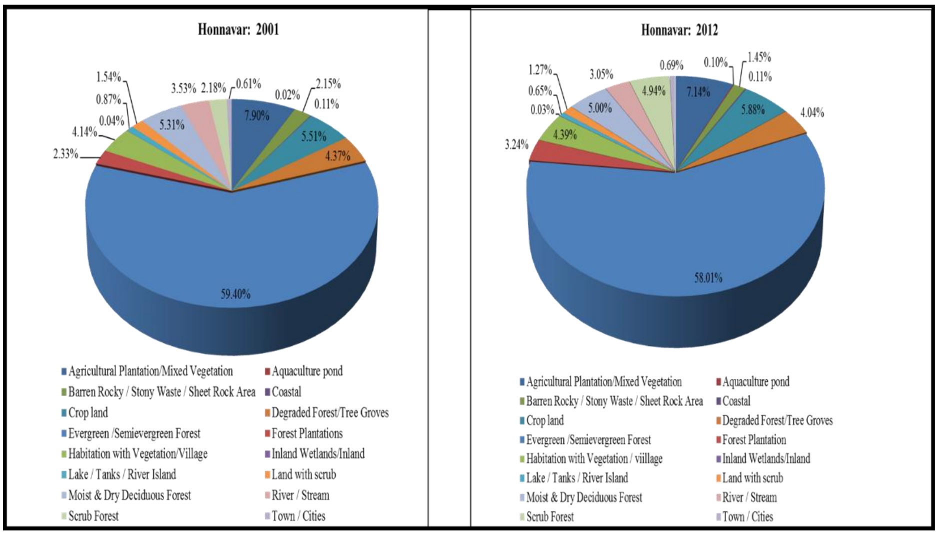


Figure 5: Percentage distribution of Land use/Land cover system Honnavar block from 2001 and 2012

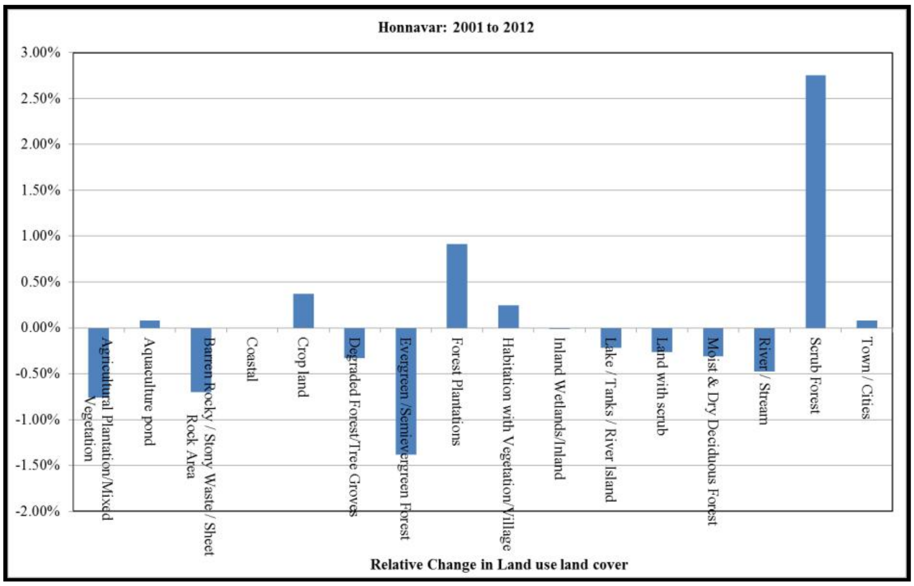


Figure 6: Percentage of relative Land use/land cover changes from 2001 to 2012.

6. SUMMARY, CONCLUSIONS AND WAY FORWARDS

Land use land cover map prepared for the study area using IRS temporal data. In Honnavar block, there are sixteen LULC classes. Largely, the result shows that reduction (1.38%) in major land cover within an 11-year period is tropical evergreen/ semi-evergreen forest in honnavar Taluka.

Statistics on water bodies shows a steady decline in the regions. The agricultural activities are more along the watercourse of the river and its tributaries in both eco-climatic regions. Thus conserving these valuable natural assets is essential for eco-hydrological services. Additionally, the study found that using satellite imagery and application of RS and GIS is a cost-effective and time-saving way to reveal the historical land cover states and trends. Such an approach can be used to construct missing information and data set sufficient for mapping of LULCC for watershed management.

Application of Remote Sensing (RS) and GIS in land use/land cover change mapping and assessment found Cost effective and time-saving procedure in identifying a critical area for assessing the hydrological impact due to land use land cover change in the Western Ghats.

Application of Geoinformatics in vegetation modelling and to understand and estimate hydrological process at cadastral level.

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