IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Vol. 7, Issue 7, July 2020

Mapping of Land Units and its Change Detection Analysis in Chitradurga Taluk of Karnataka State, India Using Geospatial Technology

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Abstract: Land is one among the non-renewable resources and mapping of Land Use/ Land Cover (LU/LC) is vital for designing and development of land, water resources with appropriate tools. There is a significant change in LC/LU across the globe due to the climatic changes, rapid increase in population and over demand of the growing economic resources. The present aim is to detect the changes in LU/LC patterns and its aerial extent due to different socio-economic factors in the study area. Efforts have been made to evaluate the LU/LC patterns using SoI topomap (1:50,000) with limited field visits; geo-coded FCC of IRS-1D, PAN+LISS-III multispectral, multi-temporal satellite images. Spatial, spectral and temporal analysis kind of approach has bigger importance in mapping of appropriate LU/LC categories and its change detection over time period and coverage areas calculated using ArcGIS v10. Supervised classification using Maximum Likelihood Classifier (MLC) is applied to prepare LULC maps using NRSC guidelines (1995) through GIS software's. Various categories of vegetation activities have an effect on the surface flow of run-off water resulting in maximize infiltration. The final results highlight the capability of geospatial techniques to bring out the real changes observed in LU/LC patterns and provide meaningful information in proper planning and developmental strategies for land sustainability.

Keywords: Land Use/ Land Cover; Change Detection; Chitradurga; Geospatial technology.

I. INTRODUCTION

LU/LC changes on the surface of the earth are generally divided into land use and land cover which are two concepts [2] and are often used interchangeably [10]. Over the last few decades various techniques of LU/LC mapping and change detection have been developed and applied all over the globe [37]. Land becoming a scarce resource due to immense agricultural and demographic pressure; but at current strategies, the natural resources can be managed and monitored for environmental changes [28] to initiate & increase the land productivity, restoration of soil degradation, reclamation of wastelands, increases in environmental qualities and to meet the needs of rapidly growing population of the country [3,19].

In view of pressure exerted by rapid increase in population, require more mitigating demands of natural resources, acceptable scientific land use designing and land management practices may offer the choice for sustainable development including forest cover [30]. Improper management of LU/LC may affect immensely on geo-environmental and natural ecosystems such as biodiversity, water resources and radiation budget [36]. Information on change in resources, classes, area covered and patterns of land use/land cover are essential for future planning [25]. The importance of investigating LULC and their impacts as a baseline requirement for food security, land sustainability, biodiversity and socio-economic vulnerability of people & ecosystems and management of natural resources [5,16].

The potential of satellite based data as a basis for generating valuable information for LU/LC is by now widely recognized [17,35], although initial efforts was made since mid seventies for application of different interpretation techniques in LU/LC mapping [1,9]. Geospatial technology and its applications provide better results on land resource management, monitoring, mapping and change detection at varying spatial ranges [31] in monitoring of ecosystems, biodiversity, water, predictive land use implementation strategies and climate change variability. In the present era, satellite based mostly Remote Sensing (RS) technology revealing its meaningful information in preparation of LU/LC layers through synoptic reading and observation at regular intervals of time [15, 24] for proper utilization of land for agriculture, forestry, pasture, urban-industrial, environmental studies, economic production etc. This desires land use inventory surveys periodically, to acquire the valuable information of the kind, aerial extent, location, spatial distribution, rate and pattern of modification of each class of LU/LC categories.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

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Vol. 7, Issue 7, July 2020

II. MATERIAL AND METHODS

A. Study Area

It lies in between $14^0$03’7” to $14^0$27’10” N latitude and $76^0$06’22” to $76^0$34’53” E longitude with an aerial extent of 1383 km^2 (Fig.1a). Physiographically, it is a dry and thirsty land with broken hills ranges and huge undulating plains with general elevation of 732 m [13]. The study area undergo a hot, seasonally dry, tropical savannah climate that receives low to moderate rain. The quality of vegetation is poor because of poor rains. However, small grooves of the trees are to be seen in rural villages. The average annual rainfall in the district is 574 mm (1980-2010) recorded from last three decades. The average annual rain is 355.6 mm (2011). The maximum temperature recorded is 37^0 c, whereas minimum is 15^0 c; could falls up to 12^0 c throughout winter season (Nov-Jan). SW monsoon (June-Sep) contributes major portion of rainfall about 194.56 mm [8].

B. Materials

a. Topomaps: 57B/3, 4, 7, 8, 11, 12 of updated edition of the year 2009/10 (SoI), (Fig.1a).
Source: Survey of India (SoI) of 1:50,000 scale, Bengaluru.
b. IRS Satellite Data: IRS-1D/P6, PAN+LISS-III of 5.8m Resolution (D43K03; 04; 07; 08; 11; 12) [Year of Pass: 2000-01 & 2005-06] (Fig.1b).
Source: Bhuvan-portal, ISRO-NRSA, Hyderabad.
c. Software’s: Erdas Imagine v2013 and Arc GIS v10.
d. GPS: Garmin eTrex-10 of 3m error handheld GPS is used to check the conditions of land use/land cover patterns during limited field survey.

C. Methodology

Topomap of 1:50,000 scale from Survey of India (SoI, Bengaluru) (Fig.1a) have been acquired as a base map, geo-rectified and digitized each individual LU/LC themes as layers such as agricultural land, built-up land, forest cover, wastelands, water bodies, others using ArcGIS v10 software. Indian Remote Sensing (IRS)-1C/1D, PAN+LISS-III imageries of 2001 & 2005 was acquired (Fig.1b) (NRSC, Hyderabad) and Supervised Classification analyses have been carried out to extract desired meaningful information to observe recent changes occurred in the study area. Survey of India (SoI) topomaps of 1:50,000 scale are acquired for registration of satellite images, selection of Ground Control Points (GCP) and locating training sets on the satellite images. LU/LC maps are prepared using satellite image in conjunction with collateral data like SoI topomap on 1:50,000 scale by considering permanent features such as temples, major roads (NH/ SH), drainages, power-lines, railways, settlements, co-ordinates, forests and village boundaries [19]. A field survey was conducted for ground verification of doubtful areas with the help of GPS and local guides in different parts of remote villages and hilly terrains covering all the LULC classes. Due to mountainous topography, rough terrain and steep slopes, few areas were not accessible.

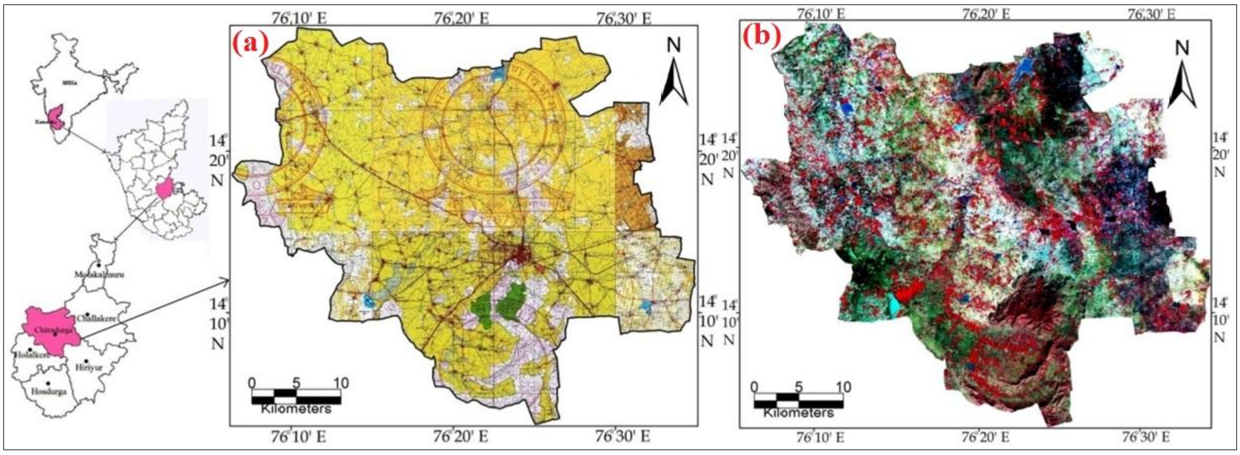

Fig.1.(a) Location and Topomap and (b) IRS-1D, LISS-III Satellite Image of Chitradurga taluk

D. Supervised classification

Supervised classification analyses are carried out on multispectral, multi-temporal IRS-1D, PAN+LISS-III FCC [Year of Pass: 2000-01 (Feb) & 2005-06 (Nov)] with medium scale through ArcGIS v10 (Fig.1b). The LU/LC patterns are digitized based on the standard schemes developed by National Remote Sensing Agency [22,23] (Table.1). Maximum Likelihood Classification (MLC) scheme is one of the most widely used image classification technique adopted on LISS-III images for mapping all the land use/cover classes. Before the selection of training samples, empirical analysis of satellite imagery and specific features on the toposheets are investigated carefully. For most of the classes, a minimum

DOI 10.17148/IARJSET.2020.7711

number of training samples were 100. Selecting training samples for water was tough because of the dense canopy of forests along with the river channel and lack of water in the river channels since the acquisition date of imagery was in mid-November and at that time most of the rivers in the mountains carry less water as compared to the monsoon season. Different LU/LC categories are extracted from the key interpretation elements such as tone, texture, shape, shadow, pattern, association, background etc. Changes in land surface conditions can affect the volume, timings and quality of run-off water.

Table 1. Description of different LULC categories

Sl. No	LULC category	Classes included-general description
1.	Agricultural land	Agricultural plantations, crop lands, Vine on trellis, Palms, palmyra, conifer & bamboo plantation, Wooded/ cultivated areas, surveyed trees
2.	Built-up land	Towns, villages, buildings, huts, temples, church, Mosque, Idgah, Tomb, graves, Post-office, Power lines, metalled & unmetalled roads, bridges
3.	Forest land	Reserved & protected forest, scrub forest, deciduous forest
4.	Water bodies	Streams, canal, tidal river, swamp, springs, tanks, perennial dry
5.	Waste/ vacant lands	Barren rocky, land with/ without scrub, Mining/ industrial wastelands, Salt affected area
6.	Others	Shifting cultivation, Sand deposits

III. RESULTS AND ANALYSIS

A. Land Use/Land Cover Study

Land use is influenced by economic, cultural, political, historical and land-tenure factors at multiple scales. Land uses are cited as man's activities and numerous uses that are practiced on the same land. Land cover, on the other hand are the biophysical attributes of the land that affect how ecosystem functions [34]. Land cover is referred to natural vegetation, water bodies, rock/soil, wastelands, sand/ snow cover results due to land transformation and both LU/LC are closely related & interchangeable [19]. In the past few decades there is change in land use due to illegal mining activities, immense agricultural practices, encroachment of forest cover, construction of mega & mini check-dams, industrialization, urbanization, biogeophysical characteristics which need mapping to avoid deforestation and biodiversity loss [6]. Viewing the Earth from space is now crucial to understand the influence of man's activities on his natural resources over time due to mining, industrialization and urbanization. Geospatial technique is one of the advent high-tech tools in analyzing the causes, rates, magnitude, patterns, trends in landscape changes at local scales. These inputs forms the first basis for the study on regional climatic changes, accounting changes in deforestation/ degradation, forest encroachment, evapo-transpiration and regional ecosystem mapping and observation.

1) Agricultural land: These are primarily used as farming & production of commercial and horticultural crops. It consists of cropland, plantations, fallow land, current shifting cultivation, irrigated & un-irrigated land and plantations [5] (Fig.2,3). The prevailing cropping patterns replicate resources availability, physiography and climatic conditions. Pixel reflection ranges from light red to bright red and green in color. Area under this category follows regular shape with scattered to continuous pattern.

2) Built–up land: These are the human habitation areas developed due to non-agricultural use including buildings, major towns, villages, transportation networks, communication & recreational utilities in association with water, vegetation, open and underground mining lands [26] (Fig.2,3). These may be simply detected on FCC image by its bluish to bluish green tone with definite size, shape and texture. The road network is distinguished by their characteristic linear features [3] having regular pattern and appears in cyan color.

3) Forest: Forest covers are (within the notified State forest boundary) the lands with tree canopy cover of more than 10 percent and area of more than 0.5 ha [12]. It consists of evergreen/semi-evergreen, deciduous, forest plantation, scrub forests, grass/grazing land and other vegetation types capable of producing timer and other forest products [3] (Fig.2,3). Satellite data has become useful tool in mapping the different forest types and density classes with reliable accuracy through visual as well as digital techniques [18,29,33]. Forests exert influence on climate, water regime and provide shelter for wildlife and livestock [11].

4) Wastelands: Wastelands are the degraded land/ bare exposed land devoid of vegetation which can be brought under vegetative cover with reasonable efforts [26] (Fig.2,3). Wastelands may end up from inherent/ imposed constraints like by location, chemical and physical properties of the soil/ financial/ management constraints, environment and presently not productive because of numerous problems such as soil erosion, salinity, water logging etc [4]. Barren rocky appears in greenish blue and brown in color with varying size and irregular to discontinuous shape.

5) Water bodies: The water bodies include both impounded as well as the regular flowing water, streams and tanks. It includes manmade ponds/ reservoirs/ lakes/ tanks/ canals, besides natural lakes, rivers/ streams and creeks [26] (Fig.2,3). It is represented by light blue very dark blue tone depending upon the depth, volume and turbidity of the water bodies [20]. Water bodies include those pixels reflecting dark blue to light blue and cyan color in standard FCC.

6) Others: This category is treated as miscellaneous being of their nature of appearance, physical look and different characteristics within the integrated thematic layer like sand dunes, massive snow/ ice cover etc [3].

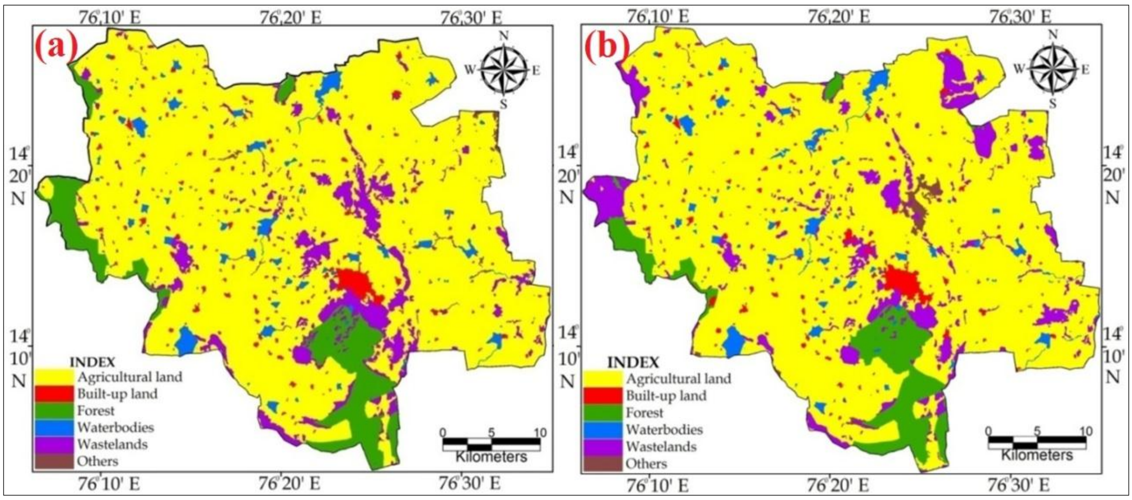

Fig.2. (a) LU/LC map of Chitradurga taluk in 2000-01 and (b) 2005-06

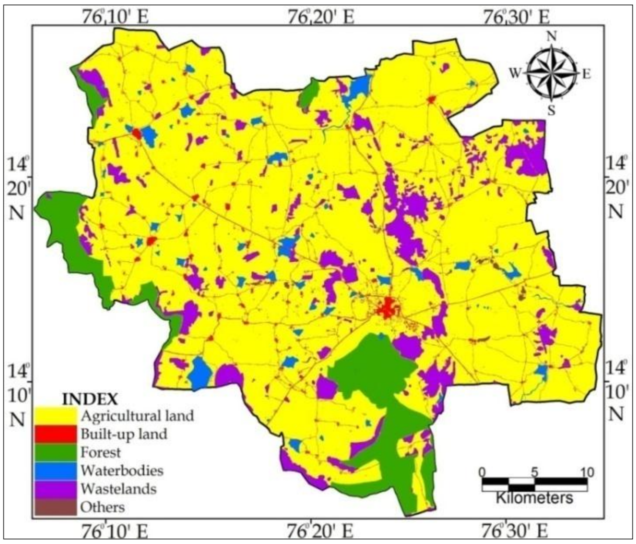

Fig.3. LU/LC map of Chitradurga taluk in 2009-10

Table 2. LU/LC Categories of Chitradurga taluk from 2000 to 2010

Sl. No	**LU/LC Categories**	**2000-01 (PAN + LISS-III)**	**2005-06 (PAN + LISS-III)**	**2009-2010 (SoI Toposheet)**
		Area in km²	**Area in km²**	**Area in km²**
1.	Agricultural land	1094.07	1090.61	1058.57
2.	Built-up land	29.66	33.11	43.84
3.	Forest cover	102.98	89.84	112.96
4.	Water bodies	38.08	38.15	33.31
5.	Waste/ vacant lands	106.67	121.90	129.40
6.	Others	4.86	8.92	3.62
	Total	***1376.32***	***1382.53***	***1381.7***
Total Geographic Area		***1383.04***	***1383.04***	***1383.04***

 DOI 10.17148/IARJSET.2020.7711

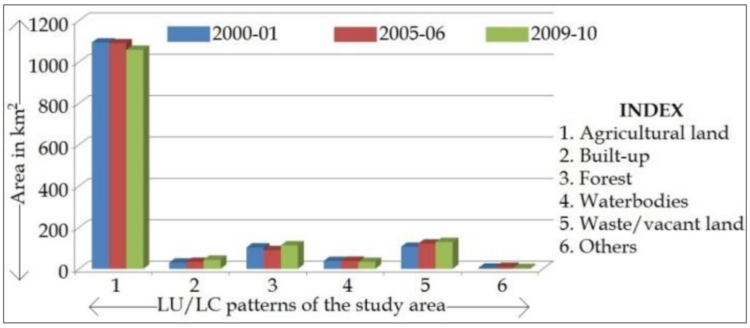

Fig.4. Column graph depicting the temporal change analysis in LU/LC patterns

Table 3. Change Detection Analysis (CDA) of LU/LC in Chitradurga taluk

Sl. No	LU/LC Categories	Change Detection analysis			
		2000 to 2005		2006 to 2010	
		Area in km^2	*Percentage*	Area in km^2	*Percentage*
1.	Agricultural land	-3.46	***-0.25***	-32.04	***-2.32***
2.	Built-up land	+3.45	***+0.25***	+10.73	***+0.78***
3.	Forest cover	-13.14	***-0.95***	+23.12	***+1.67***
4.	Water bodies	+0.07	***0***	-4.84	***-0.35***
5.	Wastelands	+15.23	***+1.1***	+7.50	***+0.54***
6.	Others	+4.06	***+0.29***	-5.3	***-0.38***

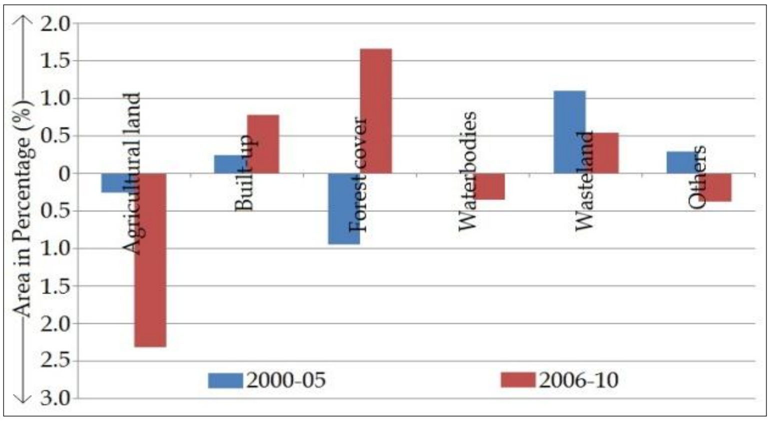

Fig.5. Column graph depicting the Percentage-wise variation in LU/LC patterns

B. Change Detection Analysis (CDA)

1) LULC patterns over the period of 2000–2005: Built up and wastelands show increasing trend during this time period in contrast to decrease rate of other land use classes. Built-up land covers an area of 29.66 km^2 in 2000-01; later shows increase in its area due to gradual increase in population and this also impacted on agricultural and forest encroachment. Forest covers an area of 102.98 km^2 in 2000-01 has been degraded to 89.84 km^2 (2005-06) due to human intrusions at each forest boundaries by installation of wind turbines and illegal mining activities (Fig.2a,b). Forest degradation was also recorded by the intensity of over-grazing and other anthropogenic factors due to economic demand [21]. Illicit cutting of trees were commonly observed by the vicinity of village peoples to fulfill their needs of fuel, small timbers for huts & houses and agricultural implementations [7]. Over-grazing was observed by the large population of cattle, goat & sheep in the forest premises which affecting the natural regeneration status causing deterioration of wild life habitat [7]. Major proportions of iron, manganese and limestone deposits were being mined rapidly and mine waste dump were noticed [6, 23]. Storage of mine waste materials, sliding of the dump outside the leased area, encroachment of forest area for dumping, mining pits, trenches, routes for wind turbine installation and other activities were gradually increasing the deforestation. Approximately 12 km^2 of the forest cover has been degraded/ converted to wastelands during 2000 to 2005 observed through Change Detection Analysis (CDA) in western and north-western parts of the study area.

2) LULC patterns over the period of 2006-2010: Major decrease in agricultural lands had been observed due to low rainfall intensity and global warming (?). Chitradurga taluk is highly dependent on rainfall and climatic conditions due to which the severe drought has been experienced during 2002-06 [8] resulted in the failure of agriculture land. Due to the scarcity of abundant surface water, farmers have to turn groundwater resources for irrigation. Groundwater contributes to more than 70% for irrigation. Rapid loss of agricultural lands is noticed in the study area due to gradual increase in population, unplanned urbanization, industrialization, soil degradation, soil erosion, pollution, depletion of groundwater levels, and illegal mining activities for economic deposits. The aerial extent of these major changes over time has been recorded and change analysis has been shown in column graph (Fig.4; Table 2) and also percentage-wise variation is shown using column graph (Fig.5; Table 3).

Karnataka Forest Department Authority came up with many regeneration programs along with local village peoples to retain the forest resources during 2006-10 [21]. In freshly leased forest and illegal mining lands were demarcated and maintained to enlarge the forest covers in the study area. Regeneration has been assisted through artificial mode by sowing of seeds of sandal in bushes and also by areal sowing [7]. Large areal extent of encroachments of illegal mining lands has been evicted and plantations have been raised. Rotational grazing, controlling fire hazards combined with rigid protection avoiding soil erosion and enriching moisture regime were practiced periodically by the Forest Department Authorities [7]. More than 22 km^2 area of forest cover has been restored and reclaimed through periodic implementation programs by Forest Authorities (2009-10). It is necessary to take up periodic re-surveys and demarcations in order to protect the forest ecosystems to prevent further encroachments in other similar forest land.

IV. DISCUSSION

Multi-temporal mapping of LU/LC categories cover six major classes such as agricultural land, built-up land, forest cover, waste/ vacant land, water bodies and others of 2000, 2005 and 2010. The spatial distribution pattern of LU/LC obtained from supervised classification is registered in Table 2. The significant changes in the land use/land cover throughout the study period between the years 2000 to 2010 recorded some fascinating observations. The features namely agricultural land, water bodies are indicated a decreasing trend where as built-up land, forest and wastelands are indicated an increasing trend. It is recommended that the manufacturing units and urbanization has to be restricted to barren or unproductive areas.

The performance of agriculture by crop classes clearly records the retardation of agricultural activities in our country. During the decade (2000-10), the area occupied by agricultural area shows gradual decrease in cultivated land due to change in climatic conditions and various anthropogenic activities. Agricultural land covers 1094.07 km^2 during 2000; was gradual decreased to 1058.57 km^2 at the end of the decade. The built up area has increased from 29.66 km^2 to 43.84 km^2 during the decade. Forest cover shows major loss by 13 km^2 from 2000 to 2005; while by the efforts of Karnataka Forest Department Authority 23 km^2 freshly leased and illegal mining areas were demarcated and reclaimed during 2010. Mapping of water bodies was difficult in 5.8 m spatial resolution due to the shallow water and dense canopy along the rivers and tanks. Areas covered by water body decreases in 2010 due to low intensity in rainfall conditions, rise in temperature and over withdrawal of groundwater. Agricultural lands are being converted into wastelands due to soil erosion, soil degradation and construction of highways, housing, industries, check dams & factories. Wastelands show rapid increasing in its area from 106.67 km^2 to 129.4 km^2 during the decade of 2000-10.

V. CONCLUSION

The study clearly established that the satellite Remote Sensing coupled with GIS can be a powerful tool for mapping and evaluation of land use/land cover changes for its sustainability. Precise land use and land cover themes are critically necessary for growing demands of natural resources and its utilization. LU/LC modifications in the present study disclosed major decrease in agricultural area; encroachment of forest cover by human forces; major increase in barren classes and fluctuation in water bodies because of difference in seasonal variation. There is a gradual increase in built-up due to increase in population, mining activities and its transportation network that can negatively impacts on biodiversity & also disturbs natural land category, increase in erosion of soil types into streams and lakes. Increase in wastelands shows negative impact especially on agricultural point of view.

Geo-spatial application provides wide range of digital databank information in a synoptic, spatial and temporal manner for mapping & monitoring of LU/LC in most time and cost effective manner as such in the study area. This helps to record the land consumption rate and the possible changes that may occur in future, so that the planners can have a basic tool for planning. Ultimately it will contribute to the establishment of information and data products, services, models and tools for multiple users like resource managers, scientists and policy makers to establish specific scenario in human health issues, global warming (?), ecosystem impacts, food security and future sustainability.

Conflict of Interest
There is no conflict of interest between authors.

ACKNOWLEDGEMENT

The authors are in depthly acknowledged to **Prof. M.S. Sethumadhav**, Chairman, Department of Studies in Earth Science, Centre for Advanced Studies in Precambrian Geology, University of Mysore, Manasagangothri, Mysuru; **Prof. Y.T. Krishne Gowda,** Maharaja Institute of Technology, Thandavapura, Mysuru; Survey of India (SoI); CGWB, Bengaluru; ISRO-NRSC, Hyderabad; Zilla Panchayath, Chitradurga; USGS-Earth explorer; Google Earth Software and UGC, New Delhi for financial support in the form of MRP No.42.73(SR)/2012-13, dt:12.03.2012.

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IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 7, July 2020

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BIOGRAPHIES

Dr. M.C. Manjunatha, is working as Assistant Professor in the Department of Civil Engineering, Maharaja Institute of Technology Thandavapura, Karnataka, India completing 3 years of Teaching Experience and 8 years of Research Experience. He has published more **59** research papers in National/International peer reviewed journals/ Proceedings. He has presented over **40** Research outcomes in National/ International Seminars and Conferences in India and abroad and participated over 29 training programmes in different states of India. Currently he is serving as **Editorial/ Review board Member** for JAERI, IJFWS, IJERT, IJCRT, IJEDR, JETIR, IJGM, IJSRCE, IJAIEM, IJSET journals. He is also serving as **Lifetime Member** in Professional bodies of MSI & DoSGAA Mysuru; ISCA, Kolkata and IAEME, Chennai. His Google Scholar Citations score has reached **235** with **8** h-index. He had nominated for several Prestigeous Awards & Professional Posts such as ***Bharath Ratna Mother Theresa Gold Medal Award, Highest Honor of Prestigeous Award, Bharath Shiksha Ratan Award, Super Honorary Doctoral Degree with Gold Medal Award and Editor-in-Chief*** Post for International Journal of Remote Sensing & Letters, Taylor & Francis, UK.

Dr. H.T. Basavarajappa, is a Professor of Geology in Department of Studies in Earth Science, Centre for Advanced Studies in Precambrian Geology, University of Mysore, Mysuru. He has received the **Young Scientist Award** from the **Karnataka Advanced Applied Science Association (KAAS)** in 1998 and **Vijayashree Award** by India International Friendship Society, New Delhi in 2005, in recognition of his merit and contribution to Earth Science. He has successfully guided **12** research students for their PhD degree, and also actively representing several scientific bodies on the Earth Science in our country. Presently serving as the **Coordinator** of the UGC-SAP CAS-I; **Chairman** of ISG-Mysore Chapter since from 2004; **Treasurer** of Mineralogical Society of India (MSI) from 2003 and **President** of DOSGAA since from 2008. He has successfully completed **6** Major Research Project under **UGC-MRP, UGC-CAS, ISRO-NRSC, DST** and **University of Mysore**. He has visited **France** (Paris) and **Germany** (Bonn University) during 1991 to participate in several international training programs on EPMA and Geochemical analysis. He has over **126** research publications to his credit. He has attended and presented about more than **106** research articles in conferences and seminars. He has also conducted successfully about **31** National and International Seminars/ Conferences/ Workshops/ Field Trainings in the department. He has edited **9** abstract Volumes/ proceedings. He has successfully adjudicated around **42** PhD thesis all over the country including the Technical Universities and has successfully guided around **45** Post Graduate Students during their dissertation work. He has been specialized in most of the analytical instruments in Geological aspects. He has successfully developed **2** scientific laboratory using advanced high-tech tools such as Remote Sensing and GIS.