International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 09 Issue 12 ǁ 2021 ǁ PP. 32-40

Quantification of Land Use / Land Cover Changes - A Case Study of Bobbili Mandal, Vizianagaram District, Andhra Pradesh

M.Vanajakshi*, K. Appalanaidu, Ch.Tata Babu* and M.V.Ramana Murty
Andhra Pradesh Space Applications Centre, Andhra Pradesh, Vijayawada, INDIA

Abstract
Human factors pose a serious threat to the environment due to ill conceive land use practices. The dynamics of Land Use / Land Cover (LULC,) and its impact on ecological and hydrological processes have become a major concern. Hence, LULC is recognized as one of the major drivers of climate change. Adverse LULC changes are seen as a threat to the eco-system both locally as well as globally. An attempt has been made to review the changes within the LULC pattern of Bobbili Mandal, Vizianagaram District in Andhra Pradesh. Comparative analysis of multi-seasonal and temporal time scales provides reliable data on changes that happened in the land use pattern. Multi-temporal satellite data of Indian Remote Sensing Satellite (IRS) P6 LISS-III for the year 2005-06, IRS R2 LISS-III for the years 2011-12, and 2015-16 have been used for all three seasons (Kharif, Rabi, and Zaid) having a resolution of 23.5m. On-screen visual image interpretation techniques have been used to map various LULC classes in the GIS environment at 1:50,000 scale. Cross tabulation has been used to assess the changes in LULC. The study reveals that the built-up land increased by 383.38 ha (1.84%) and the cropland decreased by 365.53 ha (1.76%), while minor changes were observed in water bodies, wasteland, and other categories between the year 2005-06 and 2015-16. This study provides useful information and insight that can support future planning of the region, and also serves as a resource for understanding the evolution of land use planning.

Keywords: *Change Detection, GIS, Land Use / Land Cover, Remote Sensing, Temporal Change*

Date of Submission: 02-12-2021 Date of acceptance: 16-12-2021

I. INTRODUCTION

Land is a prime resource around the World. The increasing human activities on the land for fulfillment of their requirements are causing significant large-scale alterations on the Earth's surface, which affects on global environment and ecosystems [1]. Information on Land Use / Land Cover (LULC) is required to analyze environmental processes, and the problems that must be understood in order to enhance or sustain living conditions and standards at current levels [2]. LULC information is required for the investigation of ecological cycles and issues that should be perceived in the context of the environmental guidelines issued from time to time. Gautam and Narayanan [3] emphasized that the LULC information is important for various developmental activities and is considered an essential component for the understanding of the region. The rapid changes in the LULC pattern have resulted in the reduction of different vital resources [4]. The issues involved in LULC and its changes over time are becoming increasingly recognized [5].

LULC change is a dynamic process taking place on the bio-physical surfaces that have taken place over a period of time and space is of enormous importance in management of natural resources [6-8]. LULC change has become one of the major concerns of planners, decision-makers, and researchers around the world today [9]. Among the many drivers of LULC change, rapid urban growth and expansion of towns, rapid population growth, globalization, deforestation, rangeland modification, and agricultural intensification are the prime causes and factors for global and regional changes in the world today [10-15]. Knowledge about existing LULC and its trend to provides a better understanding of land utilization aspects is essential in policy formulation.

With the advancement of Remote Sensing (RS) and Geographical Information System (GIS) techniques, LULC mapping and its changes were given a useful and detailed way to improve the selection of areas designed to urban development, Special Economic Zones (SEZs), and industrial sector of any region. Prakasam has evaluated changes in land use/ land cover in the Kodaikanal area of the Western Ghats in Tamil Nadu from 1969 to 2008[16]. Geospatial technology also provides a cost-effective way of assessing the LULC change studies at different scales with better accuracy. Some of the recent studies have demonstrated the potential of RS and GIS in LULC mapping and change detection studies [17-20]. The present study aims to

produce LULC maps of the years 2005-06, 2011-12, and 2015-16 of Bobbili mandal in Vizianagaram District, and to quantify the changes in LULC pattern using geospatial techniques.

II. STUDY AREA

The LULC is attempted for Bobbili mandal in Vizianagaram district of Andhra Pradesh State which is having an area of about 208 sq. km. It lies in the central part of the district between 18^o 30' - 18^o 40' N latitudes and 83^o 15' - 83^o 30' E longitudes (**Figure 1**). The mandal is broadly divided into two physiographic divisions, namely, the hilly region and the plain region. The hilly region covers the west and northwestern parts of the mandal and the rest of the area is an open flat plain broken with few hills [21]. The predominant occupation in the mandal is agriculture, which is depending on rainfed. The average annual rainfall of the study area is about 1142 mm, which is almost equal to the districts average. This place is well known for Bobbili Veena (musical instrument). The historic battle (Bobbili Yuddham) fought by the Rajahs of Bobbili against the Rajahs of Vizianagaram and French.

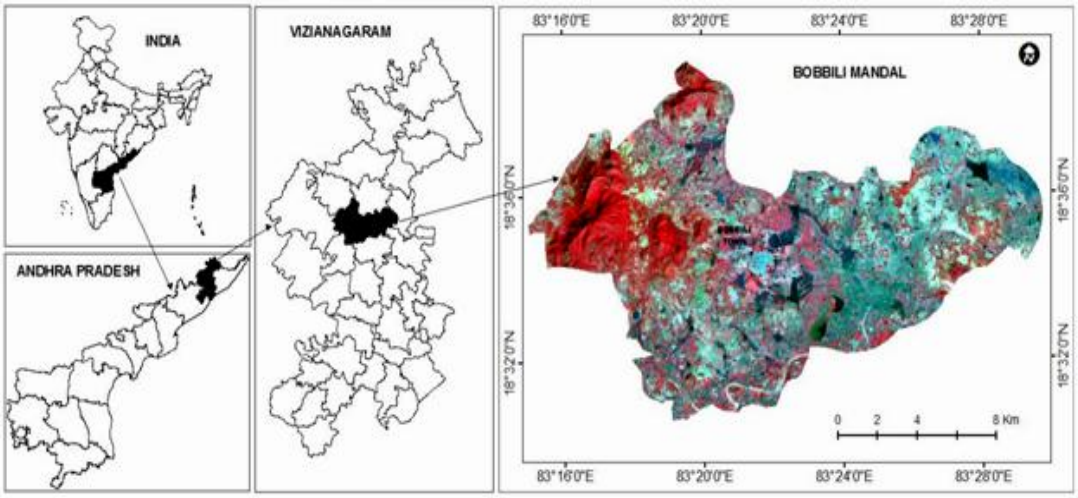

Figure 1: Location map of the study area

III.MATERIALS AND METHODS

3.1 Objectives

The main objective of this study is to analyze the LULC changes in Bobbili mandal using multi-temporal satellite data sets of 2005-06, 2011-12 and 2015-16 in GIS environment. This is being achieved through the following activities:

i. The interpretation of LULC mapping is attempted for the three selected periods using three seasons satellite data-set
ii. Analyze the dynamics of land use/land cover change
iii. Quantify the gain / losses of land use/land cover classes within the selected period
iv. Changes in LULC database is studied in change matrix

3.2 Data

In the present study, multi-temporal IRS P6 LISS - III for the year 2005-06, IRS R2 LISS-III for the years 2011-12 and 2015-16 satellite images were used with a spatial resolution of 23.5m (**Table 1**). The satellite data of three cropping seasons i.e. Kharif, Rabi, and Zaid were used for LULC classification. The Survey of India (SOI) topographical map 65N/6 on 1:50,000 scale has been used. The ground truth data is collected from selected locations for updation of LULC map. Based on the reference points collected using the Global Positioning System (GPS), image rectification and image to image registration is attempted in Erdas imagine. Mapping and analysis have been done in ArcGIS software.

Table 1: Details of Satellite data

Year	Satellite Data	Path/ Row	Date of Acquisition
2005 - 06	IRS P6 LISS - III	104 - 59	24th Nov 2005, 04th Feb 2006 & 22nd Apr2006
2011 - 12	IRS R2 LISS - III	104 - 59	05th Nov 2011, 16th Jan 2012 & 15th May 2012
2015 - 16	IRS R2 LISS - III	104 - 59	08th Nov 2015, 12th Feb 2016 & 24th Apr 2016

3.3 Methodology

To study the land use/ land cover change of the Bobbili mandal, IRS LISS III geometrically corrected satellite data of Kharif, Rabi, and Zaid for 2005-06, 2011-12, and 2015-16 were used. The multi-dated imagery has been rectified and registered (image to image) using the LCC projection and WGS84 datum in Erdas imagine software. The base map has been derived from the Survey of India (SoI) topographic map No.65N/6 on 1: 50,000 scale. On-screen visual image interpretation techniques have been used for delineating different LULC categories using Arc GIS software [22]. Visual interpretation elements, such as shape, size, pattern, tone, texture, shadow, and association, are used to distinguish the difference between an object and its surroundings. The ground truth data were collected by using GPS enabled camera for different LULC classes and the same are incorporated. The classified maps having different categories pertaining to three periods have been compared to derive information on changes [23]. The magnitude for each LULC class was calculated by subtracting the area coverage from the latest year (Af) and initial year (Ai) as shown in Eq. (1).

Magnitude (Ac) = magnitude of the latest year (Af) - magnitude of the initial year (Ai) ……...Eq. (1)

To obtain percentage change (trend) for each LULC type was calculated by dividing magnitude change by the initial year (Ai) and multiplied by 100 as shown in Eq. (2).

Percentage Change = Magnitude of Change (Ac) * 100 / initial Year (Ai) .....Eq. (2)

Quantitative data of LULC changes as well as gains and losses in each category during years 2006, 2012, and 2016 were compiled subsequently. The classified data were compared using cross-tabulation to determine qualitative and quantitative aspects of the changes for the study period. Fieldwork is undertaken to assess the changes in the land use pattern of the study area.

IV. RESULTS AND DISCUSSION

4.1 Land Use / Land Cover during 2006, 2012 and 2016

Data on the current LULC pattern, its spatial distribution, and changes within the LULC is a prerequisite for planning and formulation of policies for creating any developmental plan. This information provides a better understanding of land utilization of the region and also plays a vital role in developmental activities. The expected results of the study would provide information on (a) spatial distribution of LULC categories and (b) identification and estimation of LULC change over the past 10 years. During the years 2006-2016, a spatio-temporal quantification of variations in the LULC of Bobbili mandal was carried out. The spatial distribution of LULC maps derived from different periods is shown in **Figure 2A-C**. The aerial distribution of various LULC categories for the years 2006, 2012, and 2016 and their change scenario in between different time frames are presented in **Table 2** and **Table 3**. Considering the interest of the study and dominant LULC, twenty-four categories have been delineated under Level-III classification, which is grouped into five LULC classes in Level-I classification that are Built-Up, Agricultural Land, Forest, Wastelands, and Water Bodies [24].

In **Figure 2A-C**, light yellow to dark yellow patches indicates agriculture area, and gray colour is fallow land, which is well distributed in plains and the slopes (nearly level to gentle slopes). Agriculture is the prime activity and economic source of the mandal [25]. The agricultural land is the predominant category in the study area, which contributes 74.94%, 73.24%, and 73.18% in 2006, 2012, and 2016 respectively. The Kharif crop category is the major contributor to the agricultural land and most of the area under rainfed agriculture as well as tank command areas. Cropped in 2 seasons and more than 2 seasons were found along the river and canal command areas. The fallow land category is shown in a grey colour which is well distributed throughout the study area. The extent of fallow lands in 2006, 2012, and 2016 is 1136.90 ha (5.47%), 705.57 ha (3.39%), and 1225.67 ha (5.90%) respectively. The plantations are identified in the eastern part and western part of the mandal, which is shown in orange colour in **Figure 2A-C**. The plantation category occupies about 6% of the total geographical area, and a leading variety of mango is grown here.

The built-up land, which belongs to human habituated areas, is indicated in red to dark red colour and these habitations are well connected with the transport network. The built-up category increased persistently in the study period and occupied an area of 592.22 ha (2.85%), 879.55 ha (4.23%), and 975.60 ha (4.69%) in 2006, 2012, and 2016 respectively. This increase is due to continuous increase of population, the rural transition to the urban center for better living and industrial development in the region. The industrial area is shown in purple colour and identified around Mettavalasa Village, which is identified as an industrial growth center. There is a sharp increase in the extent of industrial area between 2006 and 2016 from 18.24 ha (0.09%) to 300.55 ha (1.45%). The Rural category increased slightly from 332.18 ha (1.60%) to 348.44 ha (1.68%).

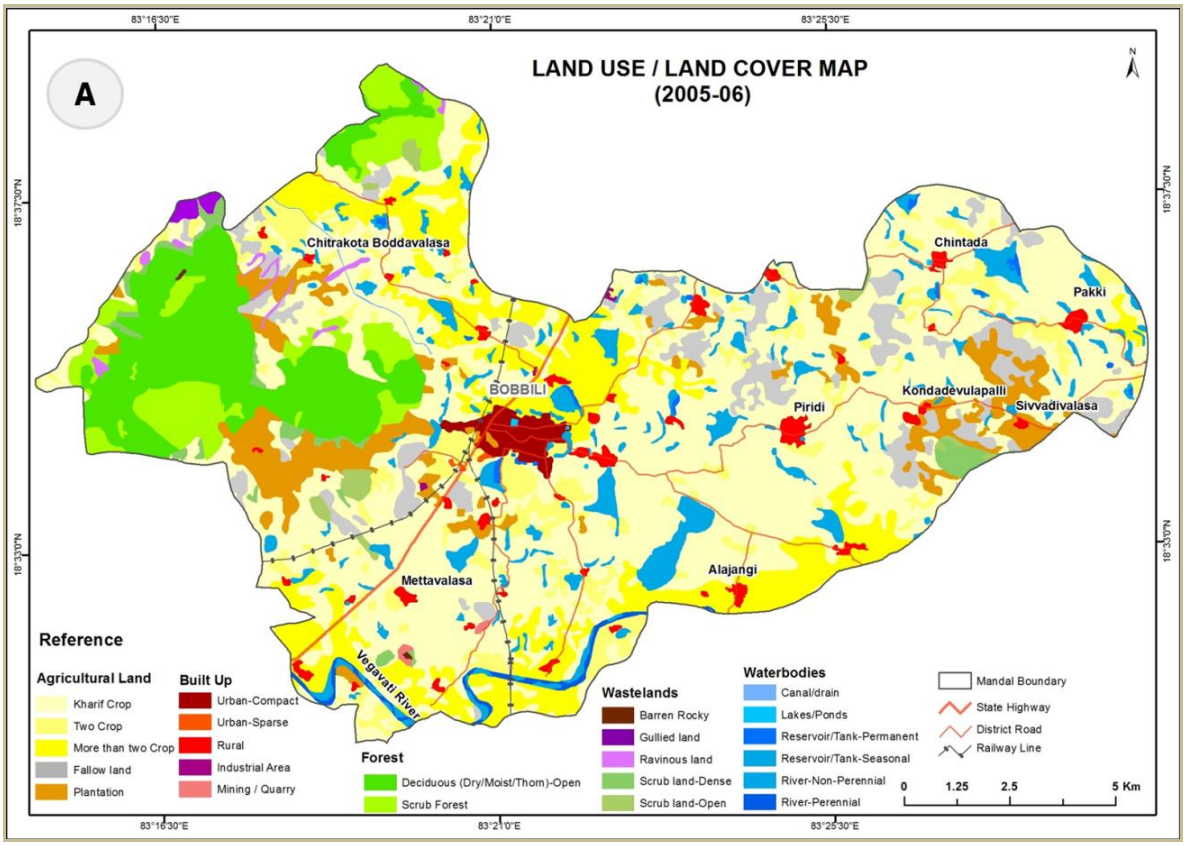

Figure 2A: LULC map of the study area in 2005-06

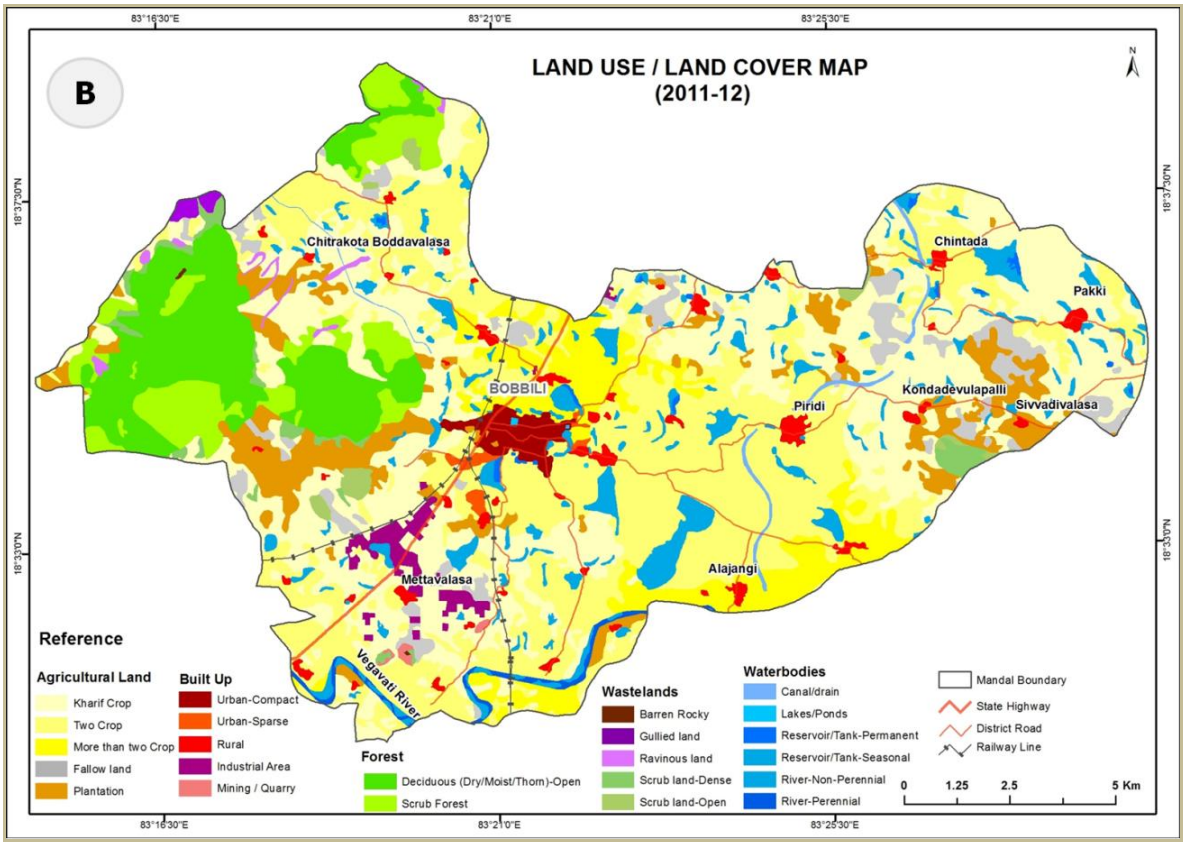

Figure 2B: LULC map of the study area in 2011-12

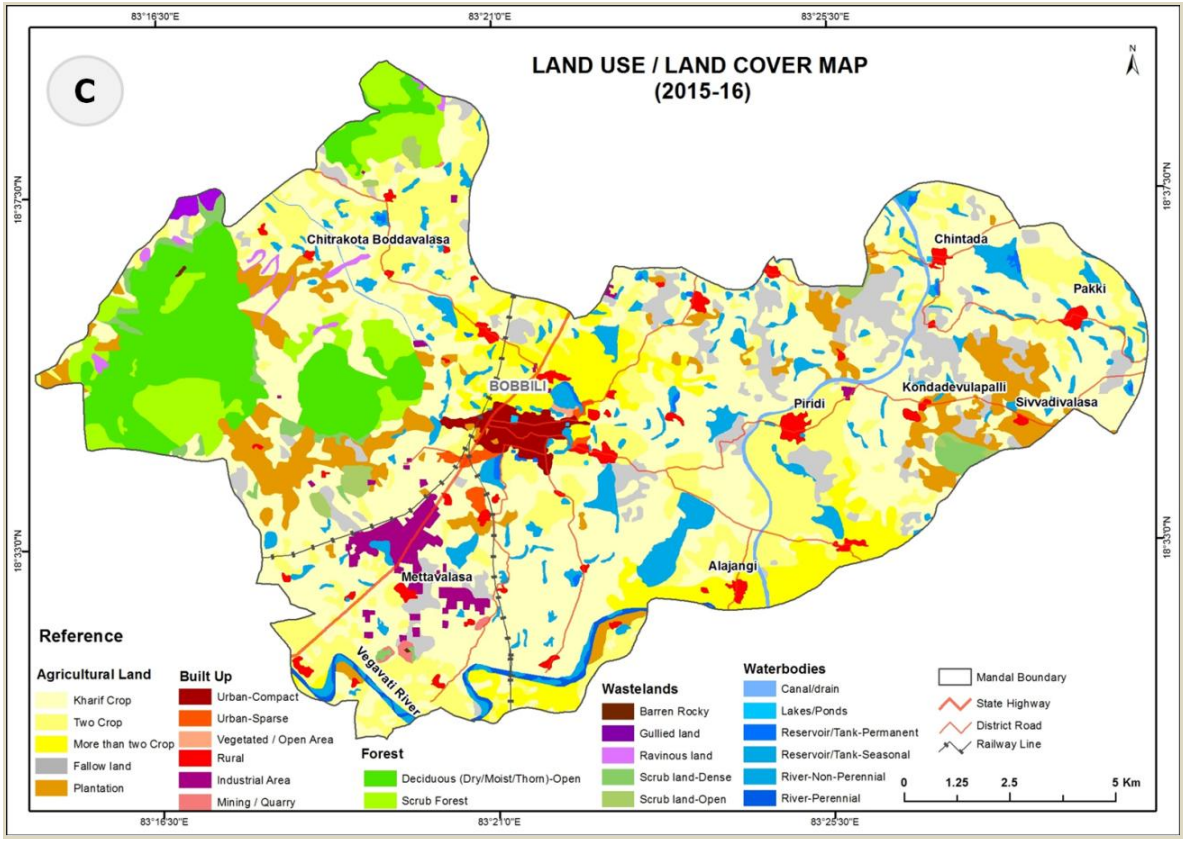

Figure 2C: LULC map of the study area in 2015-16

The vegetated / open areas are identified in and around the urban fringe of Bobbili town during 2016 with an extent of 8.34 ha (0.04%), which are mostly housing layouts and open plots. The forest cover is shown in light green and dark green and is located in the west and northwestern parts of the mandal, which are hilly regions with steep sloping areas. The area covered by such forest is dry deciduous and scrub forest. Forest category occupied about 13.39% in 2006 as well as 2012, and decreased to 12.89% in 2016 this is due to felling of trees for fodder and fuel. The wastelands, which are underutilized/ unproductive lands occupied 492.44 ha (2.37%) 475.86 ha (2.29%), and 474.80 ha (2.28%) in the years 2006, 2012, and 2016 respectively. It was noticed that the major contributors in the wastelands are dense scrub and open scrub (about 1.7%). The gullied lands are identified in foothill zones of northwestern parts of the mandal. The Barren Rocky/ Stony waste category is decreased from 5.01 ha to 3.53 ha between 2006 and 2016.

Table 2: Category wise LULC distribution of Bobbili mandal during the study period

Code	LULC Categories	Year 2005-06		Year 2011-12		Year 2015-16	
		Area in Hectare	% of Land	Area in Hectare	% of Land	Area in Hectare	% of Land
I	***Built-Up***	***592.22***	***2.85***	***879.55***	***4.23***	***975.60***	***4.69***
1	Compact	214.56	1.03	219.95	1.06	224.06	1.08
2	Sparse	9.62	0.05	62.85	0.30	68.54	0.33
3	Vegetated / Open Area	0.00	0.00	0.00	0.00	8.34	0.04
4	Rural	332.18	1.60	348.44	1.68	348.44	1.68
5	Industrial	18.24	0.09	224.29	1.08	300.55	1.45
6	Quarry	17.62	0.08	24.03	0.12	25.67	0.12
II	***Agricultural Land***	***15576.35***	***74.94***	***15222.07***	***73.24***	***15210.82***	***73.18***
7	Crop Land-Kharif Crop	9229.66	44.41	6003.35	28.88	8112.61	39.03
8	Crop Land-Cropped in 2 seasons	1454.14	7.00	5850.76	28.15	3336.62	16.05
9	Cropped in more than 2 Seasons	2533.07	12.19	1326.26	6.38	1243.94	5.98
10	Fallow	1136.90	5.47	705.57	3.39	1225.67	5.90
11	Plantation	1222.57	5.88	1336.14	6.43	1291.99	6.22

III	***Forest***	***2782.62***	***13.39***	***2782.62***	***13.39***	***2679.90***	***12.89***
12	Deciduous (Dry/Moist/Thorn)-Open	1848.32	8.89	1805.34	8.69	1749.81	8.42
13	Scrub Forest	934.30	4.50	977.27	4.70	930.09	4.47
IV	***Wastelands***	***492.44***	***2.37***	***475.86***	***2.29***	***474.80***	***2.28***
14	Gullied/Ravinous land-Gullied	44.07	0.21	44.07	0.21	44.07	0.21
15	Gullied/Ravinous land-Ravinous	74.18	0.36	74.18	0.36	74.18	0.36
16	Scrub land-Dense	229.64	1.10	224.71	1.08	224.71	1.08
17	Scrub land-Open	139.54	0.67	129.37	0.62	128.31	0.62
18	Barren Rocky/Stony waste	5.01	0.02	3.53	0.02	3.53	0.02
V	***Water Bodies***	***1349.54***	***6.49***	***1433.07***	***6.89***	***1452.05***	***6.99***
19	River/Stream-Non Perennial	82.59	0.40	82.59	0.40	83.04	0.40
20	River/Stream-Perennial	95.02	0.46	95.02	0.46	94.57	0.45
21	Canal/Drain	13.83	0.07	98.94	0.48	117.94	0.57
22	Lakes / Ponds Seasonal	6.54	0.03	6.54	0.03	6.54	0.03
23	Reservoir/ Tanks-Permanent	56.01	0.27	56.01	0.27	57.46	0.28
24	Reservoir/ Tanks-Seasonal	1095.56	5.27	1093.98	5.26	1092.51	5.26
	Total	**20785.10**	**100**	**20785.10**	**100**	**20785.10**	**100**

Table 3: Category wise LULC change assessment of Bobbili mandal during the study period

Code	LULC Categories	Area Change (+/-) 2006 to 2012		Area Change (+/-) 2012 to 2016		Area Change (+/-) 2006 to 2016	
		Magnitude Area in Hectare	% change	Magnitude Area in Hectare	% change	Magnitude Area in Hectare	% change
I	***Built Up***	***287.33***	***48.52***	***96.04***	***10.92***	***383.38***	***64.74***
1	Compact	5.39	2.51	4.11	1.87	9.50	4.43
2	Sparse	53.23	553.36	5.69	9.05	58.92	612.48
3	Vegetated / Open Area	0.00	0.00	8.34	834.00	8.34	834.00
4	Rural	16.26	4.89	0.00	0.00	16.26	4.89
5	Industrial	206.05	1129.70	76.26	34.00	282.31	1547.83
6	Quarry	6.41	36.36	1.64	6.82	8.05	45.66
II	***Agricultural Land***	***-354.28***	***-2.27***	***-11.25***	***-0.07***	***-365.53***	***-2.35***
7	Crop Land-Kharif Crop	-3226.31	-34.96	2109.26	35.13	-1117.05	-12.10
8	Crop Land-Cropped in 2 seasons	4396.61	302.35	-2514.14	-42.97	1882.48	129.46
9	Cropped in more than 2 Seasons	-1206.81	-47.64	-82.32	-6.21	-1289.13	-50.89
10	Fallow	-431.34	-37.94	520.10	73.71	88.77	7.81
11	Plantation	113.57	9.29	-44.15	-3.30	69.41	5.68
III	***Forest***	***0.00***	***0.00***	***-102.72***	***-3.69***	***-102.72***	***-3.69***
12	Deciduous (Dry/Moist/Thorn)-Open	-42.98	-2.33	-55.54	-3.08	-98.52	-5.33
13	Scrub Forest	42.98	4.60	-47.18	-4.83	-4.20	-0.45
IV	***Wastelands***	***-16.58***	***-3.37***	***-1.06***	***-0.22***	***-17.64***	***-3.58***
14	Gullied/Ravinous land-Gullied	0.00	0.00	0.00	0.00	0.00	0.00
15	Gullied/Ravinous land-Ravinous	0.00	0.00	0.00	0.00	0.00	0.00
16	Scrub land-Dense	-4.93	-2.15	0.00	0.00	-4.93	-2.15
17	Scrub land-Open	-10.17	-7.29	-1.06	-0.82	-11.23	-8.05
18	Barren Rocky/Stony waste	-1.48	-29.47	0.00	0.00	-1.48	-29.47

V	***Water Bodies***	***83.53***	***6.19***	***18.98***	***1.32***	***102.51***	***7.60***
19	River/Stream-Non Perennial	0.00	0.00	0.45	0.55	0.45	0.55
20	River/Stream-Perennial	0.00	0.00	-0.45	-0.47	-0.45	-0.47
21	Canal/Drain	85.11	615.57	19.00	19.21	104.11	753.02
22	Lakes / Ponds Seasonal	0.00	0.00	0.00	0.00	0.00	0.00
23	Reservoir/Tanks-Permanent	0.00	0.00	1.45	2.59	1.45	2.59
24	Reservoir/Tanks-Seasonal	-1.58	-0.14	-1.47	-0.13	-3.05	-0.28

Source: Compilation based on Table-2 database. *(1 ha = 0.01 sq. km) ***Note:*** All positive values denote increase and negative (-) sign indicate a decrease of magnitude of LULC categories. Zero denotes non available of that category in the corresponding time frame.

4.2 Relative Change in LULC during study period

Relative change in LULC of Bobbili mandal was assessed based on data presented in **Table 3**. The relative changes showed some irregular patterns in the study area from 2006 to 2016. From the statistics derived in **Table 3**, it is observed that the built-up category, compact, sparse, vegetated / open area and industrial categories were showing increasing tendency by 9.50 ha, 58.92 ha, 8.34 ha, and 282.31 ha of land respectively. In agriculture land, about 3226.31 ha (-35%) of kharif crop area had decreased during 2006-12 period indicating a negative change. While during 2012-16 data showed a positive increase of 2109.26 ha (35.13%) in the same land use category (**Table 3**), but overall percentage change in the kharif crop from 2006-16 showed a negative trend (-12.0%). No change was found in the forest during 2006-12 and witnessed a decrease of 102.72 ha (-3.69) during 2012-16. Wastelands, agricultural land, and forest categories showed a negative change in all the study period. But the water bodies category was still in its positive trend, which shared 102.51 ha (7.60%) in 2006-16 and observed that most of them are in seasonal tanks.

It is observed that the built-up and agricultural category of LULC have experienced the most change. The diagonal values presented in **Table 4** indicate that most of the areas have not changed in 2006-16. The results show that 3.63 sq. km of agriculture area is converted into built-up category, of which 2.70 sq. km is attributed to the industrial category during 2006-2012. The expansion of towns, industries, and non-agricultural activities are all contributing to this. The proliferation of built-up land has lead to loss of agricultural land. About 1.2 sq. km of agriculture area is converted into canal category, and 16.52 sq. km of Kharif crop is converted into the double-crop area. It is found that most of the scrub forest fringes are converted to agricultural

Table 4: Change matrix of LULC in 2005-06 to 2015-16 (Area in sq. km)

Code		Year 2015-16																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
Year 2005-06	1	2.15																								2.15
	2		0.10																							0.10
	3																									
	4				3.32																					3.32
	5					0.18																				0.18
	6						0.18																			0.18
	7		0.30		0.12	2.47	0.02	64.84	16.52	0.03	6.51	0.72										0.77				92.30
	8		0.12			0.05		4.66	8.76		0.12	0.69										0.14				14.54
	9	0.06	0.08	0.08	0.04	0.02		4.77	7.74	12.41	0.03											0.09				25.33
	10		0.04			0.16		4.94	0.35	0.00	5.47	0.38										0.03				11.37
	11	0.03	0.04					0.89			0.12	11.14										1.03				12.23
	12					0.01		0.98					17.50													18.48
	13					0.01		0.04						9.30												9.34
	14														0.44											0.44
	15															0.74										0.74
	16						0.05										2.25									2.30
	17					0.11												1.28								1.40
	18						0.01												0.04							0.05
	19																			0.95	0.00					0.95
	20																				0.83					0.83
	21																					0.14				0.14
	22																						0.07			0.07
	23																							0.54	0.02	0.56
	24																							0.03	10.90	10.96
	Total	2.24	0.69	0.08	3.48	3.01	0.26	81.13	33.37	12.44	12.26	12.92	17.50	9.30	0.44	0.74	2.25	1.28	0.04	0.95	0.83	1.18	0.07	0.57	10.93	**207.85**

Note: Built-up: 1.Compact (Continuous), 2.Sparse (Discontinuous), 3.Vegetated / Open Area, 4.Rural, 5.Industrial, 6.Quarry, **Agricultural Land:** 7.Kharif Crop, 8.Cropped in 2 seasons, 9.Cropped in more than 2Seasons,10.Fallow Land, 11.Plantation, **Forest:** 12.Deciduous (Dry/Moist/Thorn)-Open, 13.Scrub Forest, **Wastelands:** 14.Gullied/Ravinous land-Gullied, 15.Gullied/Ravinous land-Ravinous, 16.Scrub land-Dense, 17.Scrub land-Open, 18.Barren Rocky/Stony waste, **Water Bodies:** 19.River/Stream-Non Perennial, 20.River/Stream-Perennial, 21.Canal/Drain, 22.Lakes / Ponds Seasonal, 23.Reservoir/Tanks-Permanent, and 24.Reservoir/Tanks-Seasonal

land with an extent of 1.02 sq. km this is due to the implementation of the RoFR (Recognition of Forest Rights) scheme in the State for the scheduled tribes and other traditional forest dwellers. The area of 1.03 sq. km under plantations in 2006 has been converted to Canal category in 2016, which is due to construction of new canal for providing irrigation facilities. At the same time, an area of 0.72 sq. km 0.69 sq. km and 0.38 sq. km of Kharif Crop, Cropped in 2 seasons and Fallow Land has been converted to plantations respectively.

V. CONCLUSIONS

The present study has revealed that there are changes in different LULC categories over the years (2006- 2016). The areas of agricultural land, forest, and wastelands have decreased during the above period. Further, there is a considerably increase in the built-up category, exhibiting the characteristics of industrialization and expansion in urban fringe areas. There is a clear indication of fluctuating trend in the dominant agricultural land categories. The present study demonstrated the efficiency of geospatial technology in studying LULC and its changes. These results provide a better understanding of the spatial distribution of land use patterns and their changes, which will be helpful for policymakers to implement various resource conservation measures. It also allows researchers to see trend in LULC changes as a result of various driving variables. Furthermore, the study's findings will serve as the basis for future planning and decision-making for the region's long-term growth. The Government should comprehensively utilize the current status of land use patterns and take effective measures to improve the ecological sustainability in the region. The urban layouts around Bobbili municipality should be optimized. The water bodies and forest areas need to be fully protected and developed taking into account the balanced development.

ACKNOWLEDGEMENTS

The authors are grateful to the NRSC, ISRO for their support and technical guidance of land use cycle projects. The authors greatly acknowledge Dr. B.Sundar, IFS, Vice Chairman, APSAC for his constant encouragement and support. The authors wish to extend sincere appreciation for suggestions during the study.

REFERENCES

[1] Lunetta, R. S., and Elvidge, C. (1999), "Remote sensing change detection: environmental monitoring methods and applications, London" Taylor & Francis.

[2] Anderson, J. R., Hardy, E., Roach, J. T., and Wiremer, R. E. (1976), "A Land use and Land cover classification system for use with Remote Sensing data" A USGS Professional paper No.964. Reston Verginia, pp.28.

[3] Gautam, N. C., and Narayanan E. R. (1983), "Satellite remote sensing techniques for natural resources survey, Environmental Management" edited by L R Singh, Savindra Singh, R C Tiwari and R P Srivastava (Allahabad geophysical society), pp.177-181.

[4] Hegazy, I.R., and Mosbeh, R.K. (2015), "Monitoring urban growth and land use change detection with GIS and remote sensing technique in Daqahlia governorate Egypt" International Journal of Sustainable Built Environment, Vol. 4(1), pp.117–124.

[5] Meyer, W. B., and Turner, B. L. II eds. (1994), "Changes in land use and land cover: A global perspective. Cambridge" U.K. Cambridge University Press.

[6] Iqbal, M.F., and Khan, I.A. (2014). "Spatiotemporal land use land cover change analysis and erosion risk mapping of Azad Jammu and Kashmir, Pakistan" The Egyptian Journal of Remote Sensing and Space Science, Vol. 17(2), pp.209-229, DOI: http://dx.doi.org/10.1016/j.ejrs.2014.09.004.

[7] Lin, C., Wu, C.C., Tsogt, K., Ouyang, Y.C., and Chang, C.I. (2015), "Effects of atmospheric correction and pansharpening on LULC classification accuracy using WorldView-2 imagery, Information Processing in Agriculture" Vol. 2(1), pp.25–36. DOI: http://dx.doi.org/10.1016/j.inpa.2015.01.003.

[8] Kantakumar, L.N., and Neelamsetti, P. (2015), "Multi-temporal land use classification using hybrid approach" The Egyptian Journal of Remote Sensing and Space Science, Vol. 18(2), pp.289–295. DOI: http://dx.doi.org/10.1016/j.ejrs.2015.09.003.

[9] Lambin, E.F. (1997), "Modelling and monitoring land-cover change processes in tropical regions" Progress in Physical Geography: Earth and Environment. Vol. 21(3), pp.375-393. DOI: http://dx.doi.org/10.1177/030913339702100303

[10] Agarwal, C., Green, G.M., Grove, J.M., Evans, T.P., and Schweik, C.M. (2001), "A Review and Assessment of Land-Use Change Models Dynamics of Space, Time, and Human Choice". CIPEC Collaborative Report Series No. 1, Center for the Study of Institutions Population, and Environmental Change, Indiana University.

[11] Geist, H.J. (2005), "The land-use and cover change (lulc) project. land use, land cover and soil sciences" **I**, DOI: http://www.eolss.net/sample-chapters/c19/E1-05.pdf

[12] Lambin, E.F., Turner, B.L., Geist, H.J., Agbola, S.B., Angelsen, A., Folke, C., Bruce, J.W., Coomes, O.T., Dirzo, R., George, P.S., Homewood, K., Imbernon, J., Leemans, R., Li, X., Moran, E.F., Mortimore, M., Ramakrishnan, P.S., Richards, J.F., Steffen, W., Stone, G.D., Svedin, U., and Veldkamp, T.A. (2001), "The causes of land-use and land cover change moving beyond the myths" Global Environ. Change 11, 261–269.

[13] Veldkamp, A., and Lambin, E. (2001), "Predicting land-use change" Agriculture, Ecosystems & Environment, Vol. 85(1-3), pp.1–6. DOI: http://dx.doi.org/10.1016/S0167-8809(01)00199-2

[14] Barros, J.X. (2004), "Urban growth in Latin American cities: exploring urban dynamics through agent-based simulation" Doctoral Thesis, University of London, London.

[15] Zeng, Y.N., Wu, G.P., Zhan, F.B., and Zhang, H.H. (2008). "Modeling spatial land use pattern using autologistic regression" The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXXVII, pp. 115–118.

[16] Prakasam C. (2010). "Land Use and Land Cover Change Detection through Remote Sensing Approach: A Case Study of Kodaikanal Taluk, Tamil Nadu" *Int. J of Geom. and Geos.***1**, 46-55.

[17] Sreenivasulu, G., Jayaraju, N., Kumar, M.P., and Prasad, T. L. (2013). "An Analysis of Land use / Land cover using Remote Sensing and GIS: A case study of in and around Vempalli, Kadapa District, Andhra Pradesh, India" International Journal of Scientific and Research Publications, Vol. 3(5), pp.1-4. ISSN 2250-3153.

[18] Narayan, K., and Pathak, K. (2015), "Remote Sensing and GIS Based Land use/Land cover Change Detection Mapping in Saranda Forest, Jharkhand, India" International Research Journal of Earth Sciences, Vol. 3(10), pp.1-6.
[19] Kuchay, S. A., and Ramachandra T. V. (2016), "Land Use Land Cover Change Analysis of Uttara Kannada" Imperial Journal of Interdisciplinary Research, Vol. 2(4), pp.460-471.
[20] Vani, T., Kalyan, Y., Gangadhar, B., and Naidu, G.R. (2016), "Geospatial Approach of Land Use / Land Cover Studies on Swarnamukhi River Basin, Andhra Pradesh" International Journal of Engineering Research & Technology, Vol. 5(10), pp.230-37.
[21] Babu, C. T., Padma, G.V., and Suneetha, P., (2014). "Geoinformatics for Spatio-temporal analysis of Land use dynamics in Bobbili Mandal, Vizianagaram district, Andhra Pradesh" International Journal of Engineering Sciences & Research Technology, Vol. 3(9), pp. 401-408.
[22] NRSC (2006) "User Manual of National Land Use / Land Cover Mapping using Multi Temporal Satellite Data (1st cycle)" National Remote Sensing Agency, Hyderabad, Govt. of India.
[23] Babu, C. T., Vanajakshi, M., and Ramana K.V. (2018), "Quantitative Analysis of Land Use Change using Remote Sensing and GIS Techniques in Guntur Urban Mandal, Andhra Pradesh State" The Indian Geographical Journal, Vol. 93(1), pp.66-71.
[24] NRSC (2012) "User Manual of National Land Use / Land Cover Mapping using Multi Temporal Satellite Data (2nd cycle)" National Remote Sensing Centre, Hyderabad, Govt. of India. 2012.
[25] Suneetha, P. and Babu, C. T. (2008), "Land Use Modelling through GIS and Remote Sensing" The Indian Geographical Journal, Vol.82 (2), pp. 101-116.