MAPPING AND LAND USE LAND COVER CLASSIFICATION ANALYSIS OF GUNDLUPETE TALUK, KARNATAKA, INDIA USING GEOINFORMATICS

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Abstract: Land is a non-renewable resource and mapping of Land Use/Land Cover (LU/LC) is essential for planning & development of land and water resources in a region of engineering projects under progress. Land is an area of the earth surface, which embraces all reasonable stable or predictably cyclic, attribute of the biosphere including the atmosphere, soil and underlying geology. Remote Sensing (RS) satellite data with its synoptic view and multispectral data provides essential information in proper planning of LU/LC conditions of the larger areas. An attempt have been made to delineate the level-I, level-II and level-III LU/LC classification system through NRSC guidelines (1995) using both digital and visual image interpretation techniques by Geographic Information Systems (GIS) software's. The classification accuracy is found to be precise in case of digital technique as compared to that of visual technique in terms of area statistics. Efforts have been made to classify the LU/LC patterns using FCC data of IRS-1D PAN+LISS-III (Band: 2,3,4) through Erdas Imagine v2011 and ArcGIS v10. The final results highlight the potentiality of geoinformatics in natural resource mapping and its management which is a suitable model for application to similar geological terrain.

Keywords - LU/LC Classification, Level-I, Level-II, Level-III, Gundlupete, Geoinformatics.

I. INTRODUCTION

The land use-land cover pattern of a region is an outcome of both natural and socio-economic factors and their utilization by man in time and space (Zubair, Ayodeji Opeyemi, 2006). Land is becoming a scarce commodity due to immense agricultural and demographic pressure. Hence, information on land use land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land uses schemes to meet the increasing demands for basic human needs and welfare (Zubair, Ayodeji Opeyemi, 2006). Hydrology, plant and animal population are the results of the past and present human activity to the extent that significantly influences on present and future LU/LC system (Basavarjappa et al., 2014c). Proper management and development of these lands should be initiated to increase the land productivity, restoration of soil degradation, reclamation of wastelands, increase the environmental qualities and to meet the needs of rapidly growing population of the country (Pushpavathi., 2010). Increasing human interventions and unfavourable bio-climatic environment has led to transformation of large tracts of land into wasteland (Arvind and Nathawat, 2009). For effective developmental planning for wastelands correct assessment is needed which is being taken up by various land use development boards and organizations across the globe using Remote Sensing Techniques (Gautam & Misra, 2004). Land use systems need thorough systematic monitoring and management to maintain food security, to minimize deforestation, conservation of biological diversity and protection of natural resources (Basavarajappa et al., 2014a). It is necessary to enhance human occupation to the changing social, economic and natural environmental conditions. LU/LC exposes considerable influence on the various hydrological aspects such as interception, infiltration, catchment area, evaporation and surface flow (Sreenivasalu and Vijay Kumar., 2000; Kumar et al., 1999). LU/LC provides a better understanding on the cropping pattern and spatial distribution of fallow lands, forests, grazing lands, wastelands and surface water bodies, which is vital for developmental planning (Philip and Gupta, 1990).

2. STUDY AREA

Gundlupete taluk is located in between $11^0$33' to $11^0$59' N latitude and $76^0$25' to $76^0$52' E longitude with an aerial extent of 1372.12 Km^2 falling under semi-arid region (Basavarajappa et al., 2015) (Fig.1). Major parts of the taluk are covered with hill ranges, dense forests and partly bad land topography representing southern dry zone. The general ground elevation is 816 m (2,677 ft) above MSL representing thickest and richest forest cover in Southern tip of Karnataka State. The average annual rainfall is 802 mm (2012) and temperature ranges from 23^0C to 35^0C (CGWB, 2008).

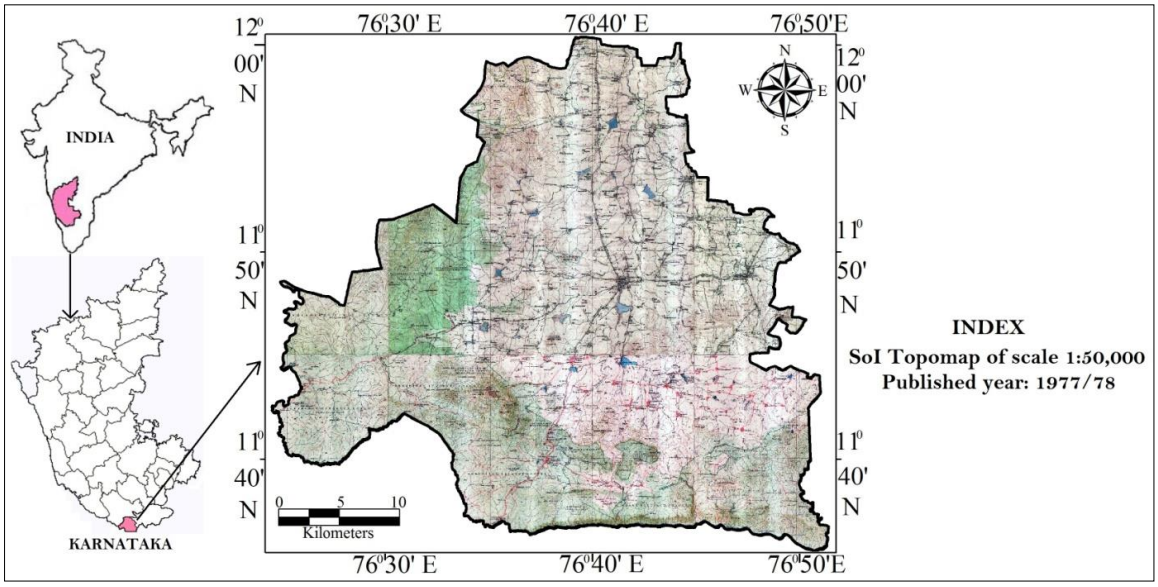

Fig.1. Location & SoI topomap of Gundlupete Taluk

3. METHODOLOGY

The land use/land cover maps were prepared using satellite images in conjunction with collateral data like SoI toposheets on 1:50,000 scales through ArcGIS v10 taking into consideration permanent features such as major roads, drainages, power-lines, railways, settlements, temples, co-ordinates, forests, village boundaries, tanks, etc (Basavarajappa et al., 2014a). Land use/land cover categorization is envisaged based on the classification scheme developed by National Remote Sensing Agency (NRSA, 1995) (Table.1 & 2). Detail methodology adopted in the study area is given in Figure.2. Visual interpretation of IRS-1D PAN+LISS-III FCC of Band 3, 2, 1 is carried out in delineating the various LU/LC categories (Basavarajappa et al., 2017b) (Fig.3). The satellite data of two seasons are acquired (Rabi in Nov-2008 and Kharif in Oct-2009) to estimate the spatial distribution and temporal variability of different LU/LC pattern (Basavarajappa et al., 2014c).

3.1 Materials

i. Topomaps: 58A/5; 6; 9; 10; 13 and 14.

Source: Survey of India (SoI) toposheets of 1:50,000 scale, Bangalore (year: 1975-84).

ii. Satellite data: IRS-1D, PAN+LISS-III image of 5.8m resolution (2nd Nov 2008-09).

Source: ISRO-NRSC, Hyderabad.

iii. GIS software's: Erdas Imagine v2011 and ArcGIS v10.

iv. GPS: Extensive Ground Truth Check (GTC) has been done using GPS-Garmin 12.

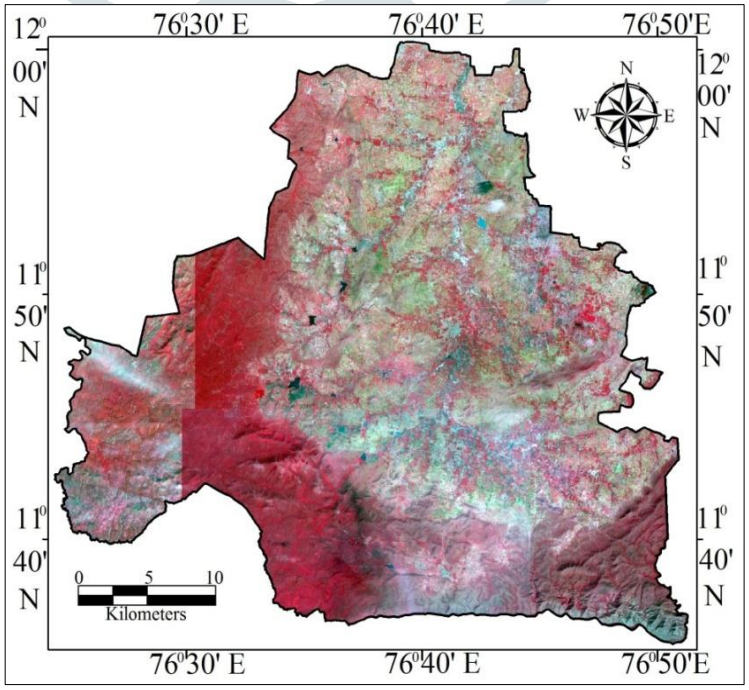

Fig.3. IRS-1D, LISS-III Satellite Image of Gundlupete taluk

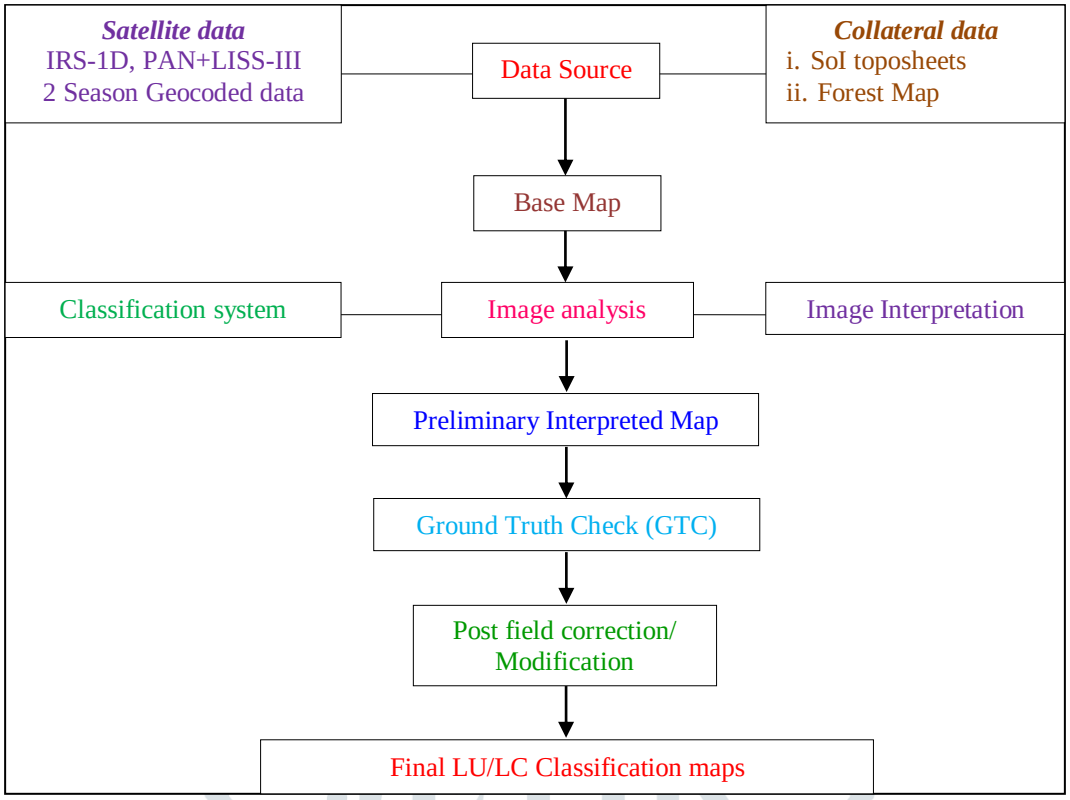

Fig.2. Flow chart of showing the methodology adopted in the preparation of Land Use/Land Cover maps

4. CLASSIFICATION ANALYSIS USING GEOINFORMATICS

Satellite Remote Sensing has been extensively utilized for Satellite data acquisition at periodic intervals to monitor the land resources and to evaluate the land use/ land cover classification & its impact on natural land resources (Basavarajappa and Dinakar., 2005; Basavarajappa et al., 2014c; NRSA, 1995). Information on land use/land cover is of utmost importance in hydro-geological investigation as the groundwater regime of a region is influenced by the type of land use/land cover patterns. Hence the satellite based data is very much useful in preparing the precise land use/land cover maps in a very short time period using geo-informatics as compared to that of conventional/traditional methods (Manjunatha et al., 2015a). Different LU/LC are delineated and classified based on the key elements of image characteristics like tone, texture, shape, shadow, pattern, association, background etc (Table.2). Level-I classification consists of 7 major categories (Fig.4, Table.3) which are further divided into sub-categories of level-II (Fig.6; Table.4); keeping specific land investigation for proper utilization. Level-III classification has been carried out in detail on agricultural land to study the cropping pattern and to determine forest density (Fig.8; Table.5). Digital interpretation and post classification comparison techniques are adopted to observe the changes among various land uses over a period (Rubee and Thie, 1978; Likens and Maw, 1982; Priyakant et al., 2001).

Table.1. Land Use/Land Cover Classification System Analysis (NRSC, 1995)

Sl. No	LEVEL-I	LEVEL-II		LEVEL-III	
1.	Agricultural land	1.1	Agricultural plantations		
		1.2	Crop land	1.2.1	Kharif crops
				1.2.2	Rabi crops
				1.2.3	Kharif + Rabi (Double) Cropped
		1.3	Fallow land		
2.	Built-up land	2.1	Town/ Cities (Urban)		
		2.2	Village (Rural)		
3.	Forest cover	3.1	Deciduous (Moist & Dry)	3.1.1	Open
				3.1.2	Dense/ Closed
				3.1.3	Forest blank
				3.1.4	Scrub forest
		3.2	Forest Plantations		
4.	Grass/ Grazing land	4.1	Dense grazing land		
5.	Wastelands	5.1	Salt Affected Land		
		5.2	Land with Scrub		
		5.3	Barren rocky/ Stony waste/ Sheet rock area		
6.	Water bodies	6.1	Rivers		
		6.2	Tanks		
7.	Others	7.1	Tree groves		

Table.2. Image Characteristics of various land use/land cover categories as seen in FCC (Dinakar, 2005)

Sl. No	LU/LC Category	Tone/ Color	Size	Shape	Texture	Pattern
1.	Barren rocky/ Sheet rock	Greenish blue to yellow to brownish	Varying in size	Irregular, discontinuous	Coarse to medium	Linear to contiguous and dispersed
2.	Built-up land	Dark bluish green	Small to big	Irregular	Coarse	Clustered to scattered
3.	Crop land	Bright red to red	Varying in size	Regular to irregular	Medium to smooth	Contiguous to non-contiguous
4.	Deciduous forest	Red	Varying in size	Irregular, discontinuous	Smooth to medium (depends on crown density)	Contiguous to non-contiguous
5.	Fallow land	Yellow to greenish blue	Varying in size	Irregular, discontinuous	Course to medium	Contiguous to non-Contiguous
6.	Forest cover	Dark red	Varying in size	Irregular, discontinuous	Smooth to medium (depends on crown density)	Contiguous to non-contiguous
7.	Forest plantation	Light red to red	Varying in size	Regular to irregular	Smooth to medium	Contiguous to non-contiguous
8.	Kharif crops	Bright red	Varying in size	Regular to Irregular	Medium to Smooth	Contiguous to non-Contiguous
9.	Land with scrub	Light yellow to brown to greenish blue	Varying in size	Irregular, discontinuous	Coarse to mottled	Contiguous dispersed
10.	Mining/ Industrial area	Light bluish to black dark gray	Small to medium in size	Irregular in shape	Mottled texture	Contiguous dispersed
11.	Rabi crops	Dark Red tone	Varying in size	Regular to Irregular	Medium to Smooth	Square pattern
12.	Salt affected land	White to light blue	Small to medium	Irregular, discontinuous	Smooth to mottled	Dispersed, non-contiguous
13.	Scrub Forest	Light Red to dark brown	Varying in size	Irregular, discontinuous	Course to medium (depends on crown density)	Contiguous to non-Contiguous
14.	Water bodies	Light blue to dark blue (Subject to depth, weeds)	Small, medium, large	Regular to Irregular	Smooth to mottled	Non-contiguous dispersed

5.I. LEVEL-I LU/LC CLASSIFICATION

I.1. Agricultural land: The agricultural land use is a function of land productivity and land utilization practices over a period of time (Pushpavathi., 2010). These covers farming, production of food, fiber, other commercial and horticultural crops including land under crops (irrigated and unirrigated), fallow, plantations, etc. This category covers an area of 702.88 Km^2 (51.22%) (Fig.5, Table.3).

I.2. Built-up land: The land surfaces of man-made constructions due to non-agricultural use including buildings, transportation network, communication, industrial, commercial complexes, utilities and services in association with water, vegetation and vacant lands. Collectively, cities, towns and habitations are included under this category (Basavarajappa et al., 2013). The total aerial extent of built-up land is 12.68 Km^2 (0.92%) (Fig.5, Table.3).

I.3. Forest: The area (within the notified forest boundary) bearing an association predominantly of trees, other vegetation types capable of producing timer and other forest products (Pushpavathi, 2010). 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 (Madhavanunni, 1992; Roy et al., 1990; Sudhakar et al., 1992). Forests exert influence on climate, water regime and provide shelter for wildlife and livestock. Dense forests (Himad Gopalaswamy hill) are noticed in the southern and southwestern parts of the taluk (FAO, 1963). The area under this category is 544.74 Km^2 (39.70 %) (Fig.5, Table.3).

I.4. Grass/ grazing land: Grasslands evolved under a system of grazing which is one of the most neglected ecosystems or under tremendous biotic pressure after biodiversity conservation in India (Grassland & Desert., 2006). Protection, development and sustainable use of grasslands are observed in southern parts which are very important for the rural economy and livestock (Basavarajappa et al., 2016a). Many natural grasslands have been converted to plantations, sometimes even in Protected Areas (Grassland & Desert., 2006). This category covers an area of 3.14 Km^2 (0.22 %) (Fig.5, Table.3).

I.5. Wastelands: These are degraded lands which can be brought under vegetative cover with reasonable effort (Basavarajappa et al 2016b). These are currently under utilized and deteriorating due to lack of appropriate water & soil management or on account of natural causes. Wastelands can result from inherent/imposed disabilities such as locations, environment, chemical and physical properties of the soil/financial/management constraints (NWDB, 1987; Pushpavathi and Basavarajappa., 2009; Basavarajappa and Manjunatha., 2014b). The total aerial extent of wasteland covers about 86.26 Km^2 (6.28 %) (Fig.5, Table.3).

I.6. Water bodies: This class comprises areas of surface water, either impounded in the form of ponds, lakes and reservoirs or flowing as streams, rivers, canals, etc (Dinakar., 2005). These are clearly observed on standard FCC in different shades of blackish blue to light blue color depending on the depth of water bodies (Manjunatha and Basavarajappa, 2015b). Gundluhole and Suvarnavathi are the seasonal rivers which flow through gundlupete taluk. The area occupied by this category is 13.56 Km^2 (0.98 %) (Fig.5, Table.3).

I.7. Others: This can be treated as miscellaneous due to their nature of occurrence, physical appearance and other characteristics (Basavarajappa et al., 2017) in the integrated thematic layer noticed in southern parts covering an area of 7.28 Km^2 (0.53 %) (Fig.5, Table.3).

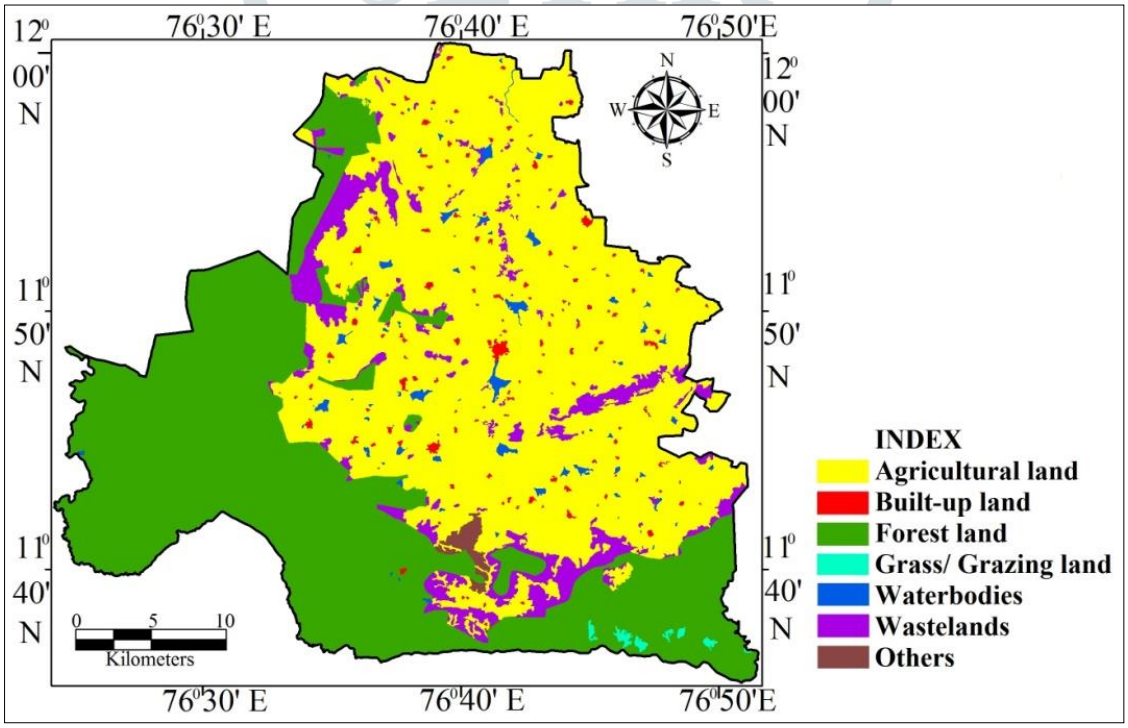

Fig.4. Level-I LU/LC Classified map of Gundlupete taluk

Table.3 Level-I land use /land cover classification

Sl. No	Level-I	Area (Km^2)	*Percentage (%)*
1.	Agricultural land	702.88	*51.22*
2.	Built up land	12.68	*0.92*
3.	Forest land	544.74	*39.70*
4.	Grass/ grazing land	3.14	*0.22*
5.	Wastelands	86.26	*6.28*
6.	Water bodies	13.56	*0.98*
7.	others	7.28	*0.53*
	Total	**1370.58**	***99.85***
	TGA	**1372.12**	

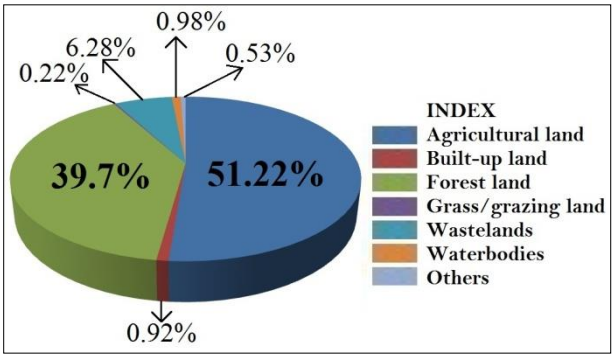

Fig.5. Pie-chart depicting Percentage of Level-I Land Use/Land Cover categories

5.II LEVEL-II LU/LC CLASSIFICATION

II.1. Agricultural plantations: These are the land with tree plantation or fruit orchards adopting by agricultural management techniques. Banana, cotton, vegetables, fruits are undoubtedly considered to be lucrative as compared to agriculture crops; further no tedious maintenance is required for the plantation (Basavarajappa et al. 2014c). Differentiation of plantation from cropland is possible by multi-temporal data of period matched harvesting time of inter-row crop/flowering of the plantation crops. Overall, Rabi season data is found to be better discrimination of plantations from croplands. The total area under this category is 39.98 Km^2 (2.91%) (Fig.7, Table.4).

II.2. Barren rocky/Stony Waste: As the area is exposed to the direct action of sun and wind, most of the area remains barren (Dinakar., 2005). These are the lands characterized by exposed massive rocks, sheet rocks, stony pavements or land with excessive surface, accumulation of stones that render them unsuitable for production of any green biomass. Such lands are easily discriminated from other categories of wastelands due to their characteristic spectral response (Basavarajappa et al., 2017). On FCC, they appears as greenish blue to yellow to brownish in tone with varying size associated with steep isolated hillocks, hill slopes and eroded plains. They occur as a linear form within the plain land mainly due to varying lithology (Basavarajappa and Manjunatha., 2014b). The area occupied by this category is 4.53 Km^2 (0.33 %) (Fig.7, Table.4).

II.3. Crop lands: The crops may be Kharif/Rabi seasons or double cropped including irrigated and unirrigated, fallow, plantation etc (NRSA, 1989). The area under crops have digitized based on the standing crops as on the date of satellite image acquisition using both Kharif & Rabi seasons. This covers an area of 657.12 Km^2 (47.89%) (Fig.7, Table.4).

II.4. Deciduous forest: It is the common type occurring over large areas in the plains in various stages of degradation of tropical dry deciduous forests (Dinakar., 2005). Type, crown density and composition of forest vegetation along with degradational stage help in the analysis of deciduous forest vegetation under acceptable limits of accuracy. These deciduous forests are well intermixed with evergreen forest in southern and western parts. Multi-temporal data, particularly during October and March/April seasons help in their discrimination from other forest types. The area occupied by this category is 541.54 Km^2 (39.46 %) (Fig.7, Table.4).

II.5. Fallow land: The agricultural land which is taken up for cultivation but is temporarily allowed to rest, uncropped for one more season with less than one year (Pushpavathi, 2010). These are particularly devoid of crops at the time; when the imagery is taken from both seasons. On FCC, fallow land shows yellow to greenish blue tone, irregular shape with varying size associated with amidst crop land as harvested agriculture field (Basavarajappa et al., 2017). The total area under this category is 5.77 Km^2 (0.42 %) (Fig.7, Table.4).

II.6. Forest plantation: Area of trees with species of forestry and its importance raised on notified forest lands (Manjunatha and Basavarajappa., 2017). These are artificially planted areas with tree cover, either in the open spaces or by clearing the existing forests for economically inferior species (Dinakar., 2005). New and young plantations can be readily separated from contiguous forested areas. The area occupied by this class is about 3.20 Km^2 (0.23 %) (Fig.7, Table.4).

II.7. Land with scrub: Scrub lands are observed along the ridges, valley complex, linear ridges and steep slope areas. Most of these areas are characterized by the presence of thorny scrub, herb species, many hillocks of steep and domal shaped are associated with poor vegetal cover. This category covers an aerial extent of 76.57 Km^2 (5.58 %) (Fig.7, Table.4).

II.8. River: The Natural course of water flowing openly on the land surface along a definite channel. Gundluhole and Suvarnavathi are the two seasonal rivers noticed to be flowing with an area of 0.66 Km^2 (0.04 %) (Fig.7, Table.4).

II.9. Rural (Villages): Land used for human settlement of size comparatively less than the urban settlement of which more than 80% of people are involved in agricultural activities (Pushpavathi, 2010). Villages can be clearly noticed from toposheet

& satellite images with number of houses, inter spread with trees and agriculture fields especially in south western parts of study area occupied by thick forest with hilly region (Basavarajappa et al., 2017). The area occupied by this class is about 11.42 Km^2 (0.83 %) (Fig.7, Table.4).

II.10. Salt-affected land: The areas are delineated based on white to light blue tone and its situation (Dinakar., 2005). These are found in river plains and in association with irrigated lands and adversely effecting the growth of most of the plants due to the action or presence of excess soluble or high exchangeable sodium. The area occupied by this category is 5.16 Km^2 (0.37 %) (Fig.7, Table.4).

II.11. Tanks: It is the natural course of water flowing openly on the land surface along a definite channel occupied either as seasonal or perennial river systems (Basavarajappa et al., 2017). The area is characterized by dendritic to sub-dendritic type of drainage patterns with general stream flow direction from northern to southern parts covering an area of 12.82 Km^2 (0.93 %) (Fig.7, Table.4).

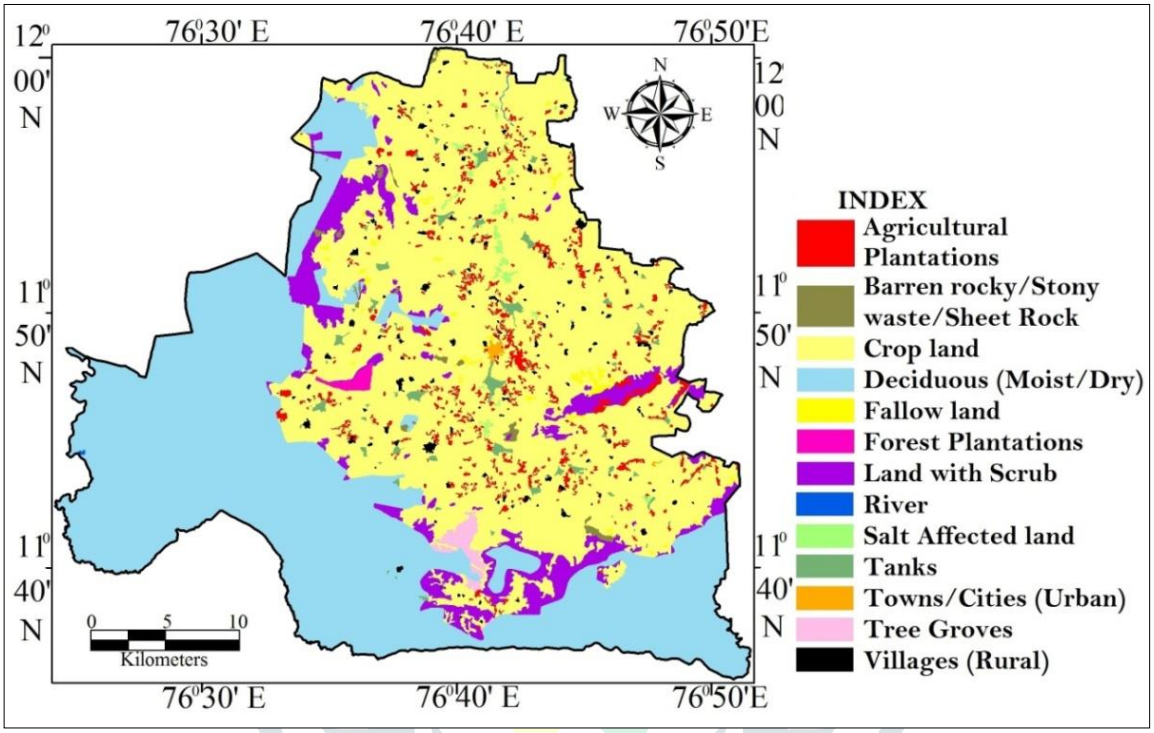

Fig.6. Level-II LU/LC Classified map of Gundlupete taluk

Table.4. Level-II LAND USE/LAND COVER classification

Sl. No	Level-II	Area (Km^2)	*Percentage (%)*
1.	Agricultural plantation	39.98	*2.91*
2.	Barren rocky/stony waste/sheet rock area	4.53	*0.33*
3.	Crop land	657.12	*47.89*
4.	Deciduous forest (Moist/Dry)	541.54	*39.46*
5.	Fallow land	5.77	*0.42*
6.	Forest plantations	3.20	*0.23*
7.	Land with scrub	76.57	*5.58*
8.	Rivers	0.66	*0.04*
9.	Rural (Village)	11.42	*0.83*
10.	Salt affected land	5.16	*0.37*
11.	Tanks	12.82	*0.93*
12.	Tree groves	7.28	*0.53*
13.	Urban (Town/cities)	1.26	*0.09*
	Total	**1367.35**	***99.61***
	TGA	**1372.12**	

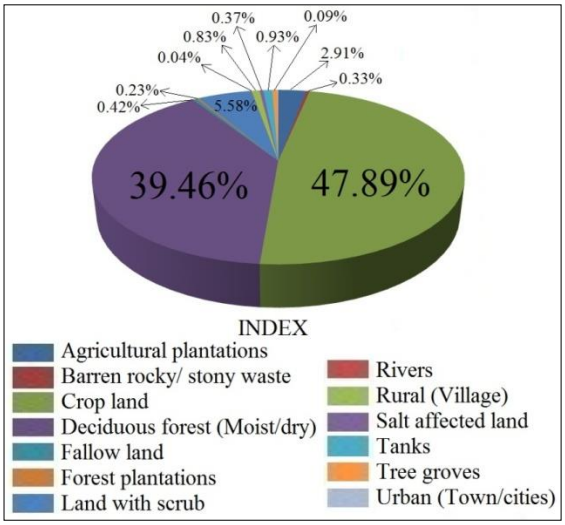

Fig.7. Pie-chart depicting Level-II LU/LC categories

II.12. Tree groves: These are clump of trees that doesn't have much undergrowth and occupies a contained area such as a small orchard planted for the cultivation of fruits or nuts. A group of trees that grow close together are noticed extensively towards southern parts of the study area, generally without many bushes or other plants underneath covering an area of 7.28 Km^2 (0.53 %) (Fig.7, Table.4).

II.13. Urban (Towns and Cities): Land used for human settlement of population more than 5000 of which more than 80% of the work forces are involved in non-agricultural activities is termed as urban land use. Most of the land covered by building structures is parks, institutions, playgrounds and other open space within built up areas. Urban land occupies an area of 1.26 Km^2 (0.09 %) (Fig.7, Table.4).

5.III LEVEL-III LU/LC CLASSIFICATION

III.1. Double Cropped: The main cropping season, kharif, starts from May and ends by September. The cropping intensity is very high due to physical factors such as flat terrain, fertile soil and irrigated from canal system. Most of the double crop areas are concentrated adjacent to the rivers flowing in the study area (Pushpavathi, 2010). On FCC, the double crop show a dark red tone with square pattern representing soil covers with higher amount of moisture near the streams (Basavarajappa et al., 2017). The cultivated lands at elevated zones represent bright red tone representing less amount of moisture and deeper levels of groundwater prospect zones. This category has been identified and mapped using the two season satellite images which covers an area of 192.57 Km^2 (14.03 %) (Fig.9, Table.5).

III.2. Kharif: These are the standing crops from June to September associated with rainfed crops under dry land farming and limited irrigation. Kharif crops are depicted by red tone on standard FCC image. The major kharif crops grown area maize, jowar, bajra, cotton, sugarcane, pulses grown under rainfed condition, whereas paddy are grown under irrigated conditions (CGWB, 2008). The land occupies an area of 460.54 Km^2 (33.56 %) (Fig.9, Table.5).

III.3. Rabi Season: These are another type of standing crops from October to February. Rabi season data found to be very much useful in discriminating other plantations from croplands by multi-temporal data of the period. These are noticed in north eastern parts of Chitradurga taluk, northwestern parts of Hiriyur taluk and in small parts of Holalkere, Hosadurga and Molkalmuru taluks covering an area of 3.99 Km^2 (0.29 %) (Fig.9, Table.5).

III.4. Open forest: It is the land covering 10% to 40% of tree canopy within the notified forest boundary. This category covers an area of 26.89 Km^2 (1.95 %) (Fig.9, Table.5).

III.5. Dense/Closed forest: It is the land covering more than 70% of tree canopy within the notified forest boundary. The area is topographically represented by mountain chains, flat terrains, dissected river drainage, Piedmonts, flood plains, valleys, gullies, gorges, pediplains etc., covered by dense forest vegetation in and around Himad Gopalaswamy hills with an area of 458.65 Km^2 (33.42 %) (Fig.9, Table.5).

III.6. Forest Blank: A patch within the notified forest boundary having few or no tree cover. This category covers an area of 8.56 Km^2 (0.62%) (Fig.9, Table.5).

III.7. Scrub forest: These are degraded forest lands having canopy density less than 10%. Scrub forest is associated with barren rocky/stony waste due to inadequate and erratic rainfall conditions that brings drought and extreme heat in summer

season which preclude hardly in any profitable forest. They appear as light red to dark brown tone on standard FCC due to canopy covers. The area covered by this category is found to be 47.43 Km^2 (3.45%) (Fig.9, Table.5).

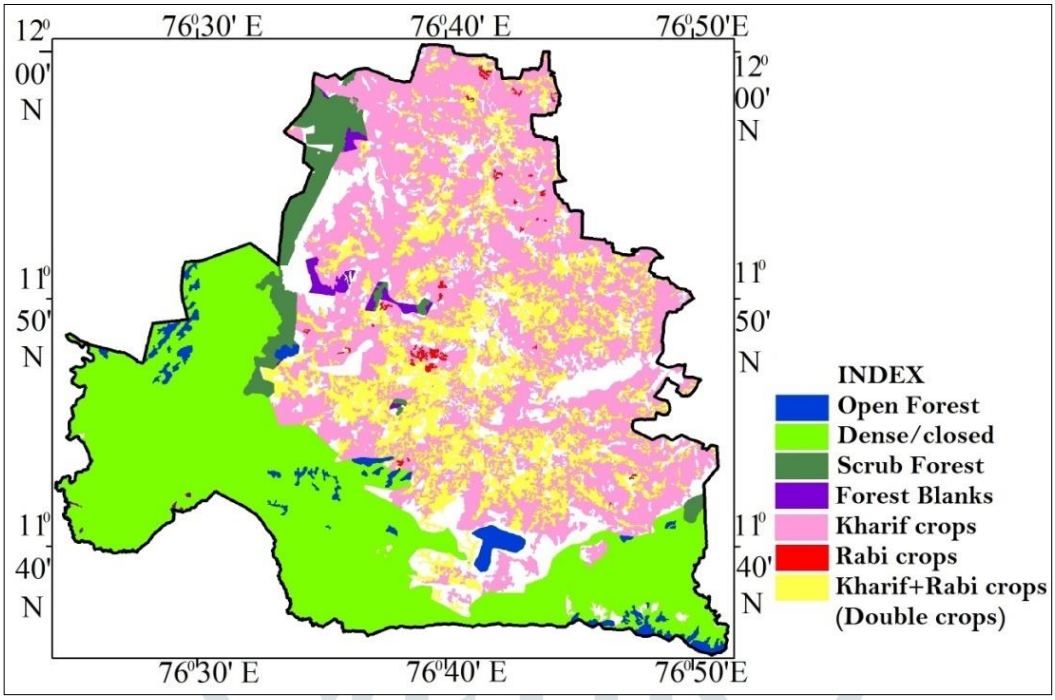

Fig.8. Level-III LU/LC Classified map of Gundlupete taluk

Table.5. Level-III land use/land cover classification

Sl. No.	Level-III	Area (Km^2)	*Percentage (%)*
1.	Kharif + Rabi (Double crop)	192.57	*14.03*
2.	Kharif crop	460.54	*33.56*
3.	Rabi crop	3.99	*0.29*
4.	Open forest	26.89	*1.95*
5.	Dense/ Closed Forest	458.65	*33.42*
6.	Forest blank	8.56	*0.62*
7.	Scrub forest	47.43	*3.45*
	Total	**1198.63**	***87.32***
	TGA	**1372.12**	

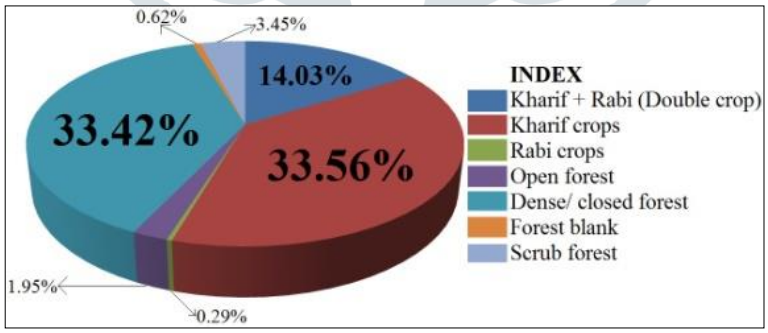

Fig.9. Pie-chart depicting Level-III LU/LC map of Gundlupete taluk

6. RESULTS & DISCUSSION: Level-I classification of LU/LC pattern consists of 7 major categories and Level-II consists of 13 categories. Level-III classification consists of 7 categories keeping cropping pattern and forest types under consideration for its future food security (Basavarajappa et al., 2017). Gundlupete taluk is highly drought prone lying in the rain shadow region of Western Ghats and located in southern dry zone possessing least irrigation potential (CGWB, 2008). Further, due to increased pressure more uncultivated land increases the soil erosion rate which highly impacts soil degradation and their productive capabilities. LU/LC provides a better understanding on the cropping pattern and spatial distribution of fallow lands, forests, wastelands and surface water bodies, which is vital for developmental planning (Philip and Gupta, 1990). LU/LC exposes considerable influence on the various hydrological aspects such as interception, infiltration, catchment area, evaporation and surface flow (Sreenivasalu and Vijay Kumar., 2000; Kumar et al., 1999). The impact of land use and land cover over the surface and sub-surface hydrologic condition is observed to be remarkably high on

agricultural practices. Change in land use is mainly due to the hydrological factors (Saraf and Choudhary., 1998). Opines that land use is a function of four factors namely land, water, air and man. Hence land use pattern in a region is governed in a large measure by physical controls and thereafter modified by socio-economic and technical organization variants (Manjunatha et al., 2019). Artificial mode of Sandal seed sowing in bushes and by areal sowing, rotational grazing, controlling fire hazards combined with rigid protection avoiding soil erosion and enriching moisture practices are very much necessary to convert forest blank & scrub forest into denser forest area (Manjunatha et al., 2018).

7. CONCLUSION: Geoinformatics application provide wide range of digital databank information in a synoptic, spatial and temporal manner for mapping and monitoring of land use/land cover in most time and cost effective manner. More accurate classification is observed in case of digital technique as compared to that of visual technique in terms of area statistics. The land use/land cover classification analysis of 1:50,000 scale is divided into Level-1: 7 classes; Level-2: 13 classes and Level-3: 7 classes carried out based on environmental and socioeconomic concerns. Level-3 classification has been carried out in detail on agricultural and forest lands to study the cropping pattern and future food security. Kharif crops are dependent mainly of rainfall and occupy the maximum areal extent of 460.54 Km^2 (33.56 %) that indirectly reflect that groundwater dependent crops are less. Double crops are noticed adjacent to the perennial rivers of Gundlu hole & Suvarnavathi which provide well developed canal system for irrigation purpose. The area occupied by built-up land is 12.68 Km^2 (0.92%) and further increase in population can negatively impacts on biodiversity and also disturbs natural land cover, increase in soil erosion into streams and lakes. Reclamation of wastelands is the important task in agricultural point of view.

ACKNOWLEDGEMENT

The authors are indepthly acknowledged Prof. M.S. Sethumadhav, Chairman, DoS in Earth Science, CAS in Precambrian Geology, Manasagangothri, University of Mysore, Mysore; Director of KSRC Mysuru ; Dr. Y.T. Krishne Gowda, Principal, MIT, Thandavapura, Mysore; CGWB, Bengaluru; Survey of India, Bengaluru, ISRO-NRSC, Hyderabad.

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