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Land Classification Analysis using Geospatial approach in Nanjangud Taluk of Karnataka State, India

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Abstract: Specific group of land categorization on a satellite image is a fundamental task to determine the spatial knowledge and its importance. Several image classification techniques are produced to create standardized Land use and Land cover (LULC) maps that facilitate analysis on ecological processes and human activities. Mapping land use/land cover changes at regional scales is essential for a wide range of applications including landslide, erosion, land planning, global warming etc. LULC alterations by human intrusions negatively affect the patterns of climate, the patterns of natural hazard and socio-economic dynamics in global and local scale. The present study aims to map the existing LU/LC classification scientifically using geospatial tools in database generation, analyses and information extraction. Thematic maps of the study area are prepared using satellite images in conjunction with collateral data such as Survey of India (SoI) toposheets, forest and wasteland maps by GIS software's. An attempt is created to extract Level-I, Level-II and Level-III LU/LC classification through NRSC guidelines (2011) using both Digital Image Processing (DIP) and Visual Image Interpretation Techniques (VIIT) with limited Ground Truth Check (GTC). The present study helps in understanding various land use and land cover patterns for efficient environmental monitoring and effective water management.

Keywords: LU/LC Classification; Geospatial technology; IRS-1D, LISS-III Image; Nanjangud taluk.

I. INTRODUCTION

Urban growth is a global phenomenon and one of the most important reforming processes affecting both natural and human environment through many ecological and socio-economic processes (Mandelas et al., 2007). Recently, innovative approaches to urban land use design and management like property development and good growth has been projected and mentioned (Kaiser et al., 1995). It's widely known that the spatial category of a landscape affects ecological processes (Wu and Loucks, 1995). Fast rates of urban land use swap and rate urbanization are now at the front of native political disputes. Global and regional scale studies are often focused on mapping just the extent of urban areas (Schneider et al., 2001). In India, spatial accounting and monitoring have been carried out at a national level on 1:250,000 scale, using multi-temporal Indian Remote Sensing (IRS) satellites to address the spatial and temporal variability in land use patterns to understand and manage country's natural resources (NRSA, 1989). Thereafter further efforts to map on 1:50,000 scales followed certain standards that required modifications in the current day's context. To this extent, an exhaustive LULC classification was evolved to facilitate an in-depth assessment of all the LULC categories (Saharia Saswata and Singh Prafull, 2014; NRSA, 2005). Land-use/land-cover is a distinct concept applied to the classification of the earth's land surface (Estes et al., 1982). LULC classification maps may be applied in numerous fields' insight into a region's soils and geology (Ustin et al., 1999; Gupta, 2003).

Land-use/Land-cover classification maps are used extensively in conservation planning (Turner et al., 2003; Kerr, 2003), informing land development decisions in metropolitan areas (Ridd, 1995; Weber and Puissant, 2003), planning and implementing large-scale inventories of natural resources (Anderson, 1982; Volgelmann et al., 1998), and monitoring change in ecosystem/landscape condition over time (Robert Weih and White, 2008; Frohn, 1998; Lambin, 1996; Weng, 2002). Remote sensing provides an additional source of information that more closely respect the actual physical extent of a city based on land cover characteristics (Weber, 2001). However, the definition of urban extent still remains problematic and individual studies must determine their own rules for differentiating urban-rural lands (Herold et al., 2003). Remotely sensed imagery, i.e., satellite and aerial photography, has become a cost efficient, accurate, and precise tool for developing LULC classifications (McRoberts and Tomppo, 2007). Now a day's remote sensing data, along with increased resolution from satellite platforms make better impact on land resource management at varying spatial ranges (Singh et al., 2010; Thakur, 2010).

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II. MATERIALS AND METHODS

A. Study Area

The study area located in between $76^0$26' E to $76^0$56' E and $11^0$55' N to $12^0$12' N with an aerial extent of 973 km^2 covering parts or whole of 184 villages falling in Nanjangud taluk (Fig.1). The general elevation records to 600 to 700 ft above MSL. Nanjangud taluk lies on Southwestern parts of Mysore District and forms almost a plain boundary except for a few isolated hillocks to the south and western regions. The highest peak lying on the South–western corner measures 3,111 ft above MSL. The hills are bare and stand out prominently in this flat stretch of the boundary. The general slope is from south to north and there is a small but gradual and wide depression is noticed in northern parts of the taluk following the Kabini river basin.

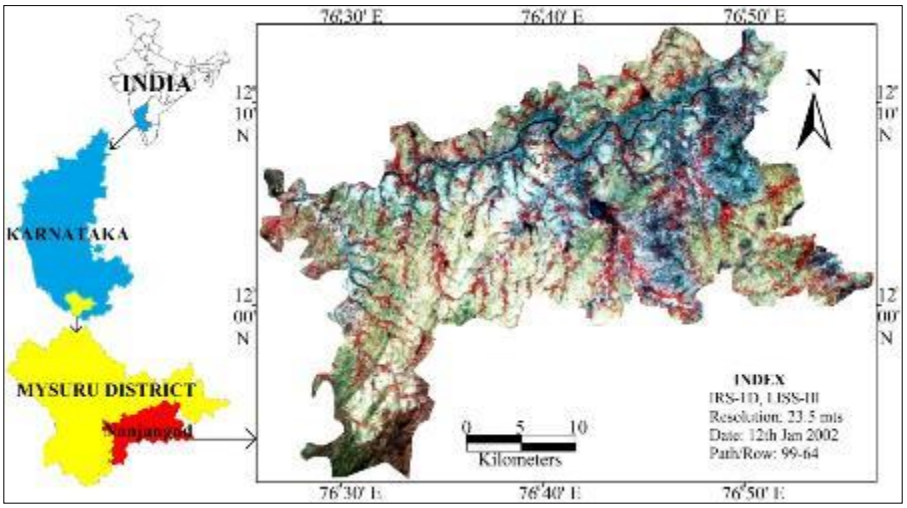

Fig.1. Location and IRS-1D, LISS-III satellite image of Nanjangud taluk

B. Methodology

The images of IRS-1D and PAN (Path 99 and Row 64) were geometrically corrected and geocoded to the Universal Transverse Mercator (UTM) coordinate system by using a reference image of SoI toposheets. Image interpretation has been carried out in two most popular ways e.g. digital analysis and visual interpretation. In the digital classification process, training areas for different classes were defined for the satellite imagery on spectral response pattern in different spectral bands generated. Accurate registrations of satellite images are essential for analyzing LULC conditions of a particular geographic position. In the present study, satellite data was geometrically corrected for the distortions and degradations caused by the errors due to variation in altitude, velocity of the sensor platform, earth curvature and relief displacement (Jay Krishna et al., 2011).

Supervised classification was performed to produce land cover map from the IRS satellite data (Prafull Singh, 2012; Manjunatha and Basavarajappa, 2020a). Defining of the training sites, extraction of signatures from the image and then classification of the image was done (Bhatt et al., 2015). Unsupervised methods were analyzed by the separation of image pixels into natural groupings based upon similar spectral characteristics by means of a classification algorithm and assignment of groupings into classes (Robert Weih and White, 2008). The pre-classification techniques apply various algorithms including image differencing and image rationing to single or multiple spectral bands, vegetation indices (NDVI) or principal components, directly to multiple dates of satellite imageries to generate "change" vs. "no-change" maps. These techniques locate changes but do not provide information on the nature of change (Ridd and Liu, 1998; Singh, 1989; Yuan et al., 1998). On the other hand, post classification comparison methods use separate classifications of images acquired at different times to produce difference maps from which "from-to" change information can be generated (Jensen, 2004; Fei Yuan et al., 2005). Post-classification comparison and multi-date composite image change detection are the two most commonly used methods in change detection (Jensen, 1996; Seyed Omid, 2017). ArcGIS v10 and ERDAS Imagine v2011 were used to extract land use/land cover information and further analysis of relationships, patterns and trends for better land sustainability.

C. Materials used

i. Base map: Survey of India toposheets of 57D/8, 12, 16; 58A/5, 9, 13 in 1:50,000 scale (Fig.1). Source: Survey of India (SoI) Office, Govt. of India, Bengaluru.

ii. Satellite Data: IRS-1D LISS-III of 23.5m Resolution and PAN of 5.8m (Nov-2001 & Jan-2002). Source: National Remote Sensing Agency (NRSA), Hyderabad.

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

iv. GPS: Garmin 12 is used to mark exact boundaries and to check the conditions of the land use/land cover patterns during field visits.

III. RESULTS AND ANALYSIS

A. Level-I Classification

i. Agricultural land: Agricultural land has been defined to include cropland and pasture, orchards, groves, vineyards, nurseries and ornamental horticultural areas (Anderson et al., 1976). This category covers an area of 861.49 km^2 (88.53%) (Figure.2, 3; Table.1).

ii. Built-up land: These are comprised as intensive use covered by buildings, transportation, powerlines, shopping centers, industrial and commercial complexes (Anderson et al, 1976). Collectively any man-made constructions due to non-agricultural use are included under this category (Basavarajappa et al., 2013) covering an area of 26.89 km^2 (2.76%) (Figure.2,3; Table.1).

iii. Forest: The term forest is used to refer to land with a tree crown areal density of 10 percent or more, stocked with trees capable of producing timber or other wood products and exert an influence on the climate or water regime (Anderson et al., 1976; Manjunatha et al, 2018). Forest lands can be identified rather easily on high-altitude imagery by 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). The total forest cover measures an area of 47.84 km^2 (4.91%) (Figure.2,3; Table.1).

iv. Water bodies: These are the 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). The area occupied by this category is 20.33 km^2 (2.08%) (Figure.2,3; Table.1).

v. Wastelands: These are barren or degraded lands which do not fulfill their life sustaining potential with lack of water and soil management due to natural or anthropogenic pressures (NRSC, 2011). Wastelands can result from inherent/ imposed disabilities such as locations, environment, chemical and physical properties of the soil/ financial/ management constraints (NWDB, 1987; Manjunatha and Basavarajappa, 2020b). The total aerial extent of wasteland covers about 12.54 km^2 (1.28%) (Figure.2,3; Table.1).

vi. 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 eastern and western parts covering an area of 3.7 km^2 (0.38%) (Figure.2,3; Table.1).

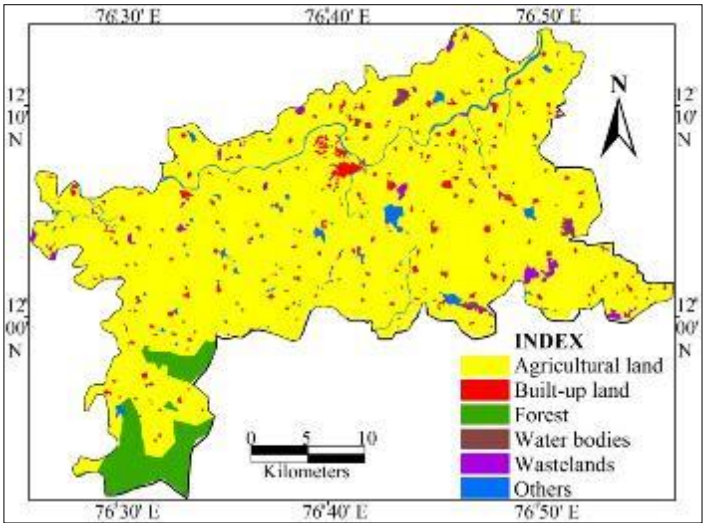

Figure.2. Level-I LU/LC Classified map of Nanjangud taluk

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Table 1: Level-I Land Use /Land Cover Classification of Nanjangud taluk

Sl No	Land patterns	Area (km^2)	*Percentage (%)*
1.	Agricultural land	861.49	*88.53*
2.	Built-up land	26.89	*2.76*
3.	Forest land	47.84	*4.91*
4.	Water bodies	20.33	*2.08*
5.	Wastelands	12.54	*1.28*
6.	Others	3.70	*0.38*
Total		**972.81**	***99.94***
Total Geographical Area		**973.00**	

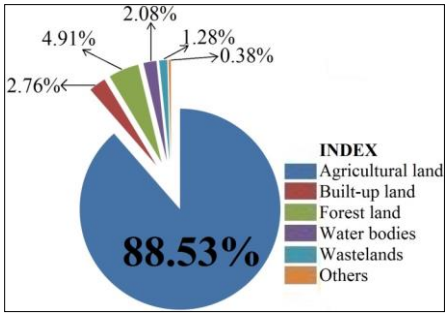

Fig.3. Pie-chart depicting Percentage of Level-I LU/LC categories of Nanjangud taluk

B. Level-II Classification

i. Agricultural plantations: These are dispersed and contiguous patterns of agricultural tree crops adopting agricultural management techniques (NRSC, 2011). It includes citrus, orchards and others horticultural nurseries. 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. The total area under this category is 39.05 km^2 (4.01%) (Figure.4,5; Table.2).

ii. Barren rocky/Stony Waste: These are rock exposures of varying lithology often barren and devoid of soil and vegetation cover (NRSC, 2011). These occurs as openings or scattered as isolated exposures or loose fragments of boulders or as sheet rocks. 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 (Manjunatha and Basavarajappa, 2020b). These are notified as linear forms trending NE-SW within the plain lands in Bendagahalli village and behind Adakanahalli industrial area (NRSC, 2011) covering an area of 0.5 km^2 (0.05%) (Figure.4,5; Table.2).

iii. Crop lands: These are irrigated & un-irrigated, fallow and plantations under double or triple cropping patterns of kharif, rabi and zaid crop growing seasons (NRSC, 2011). The area under crops have digitized based on the standing crops as on the date of satellite image acquisition using both Kharif & Rabi seasons. Cropped areas appear in bright red toned in color with varying shape and size in a contiguous to non-contiguous pattern (Basavarajappa et al., 2017). This category covers an area of 820.86 km^2 (84.36%) (Figure.4,5; Table.2).

iv. Degraded forest: These are the lands of less than 10% cover which are notified as degraded forest. The degradation is brought about by maltreatment meted out by repeated felling, grazing and forest fires (Manjunatha et al., 2015a). On the contrary, if further ravaged it, ultimately degrades into thorny type and ultimately dry grass prevails and naked boulders are exposed (Manjunatha et al., 2015a). These are notified in the south-western corner of the taluk with an aerial extent of 14.77 km^2 (1.51%) (Figure.4,5; Table.2).

v. Fallow land: It is the agricultural land, which is temporarily allowed to rest uncropped for one or more seasons, but not less than one year (NRSC, 2011). 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 1.57 km^2 (0.16%) (Figure.4,5; Table.2). These are observed around the villages of Kurahattikaval, Jodihariharapura, Hallikerehundi, Sindhuvallipura, Bagooru and Chikkahomma.

vi. Lakes/ Tanks: Rivers and tanks are the major water sources in the taluk. 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

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(Basavarajappa et al., 2017; 2019). These tanks have been extracted effectively from LISS-III image based on the color/ tonal variation from dark to light blue (Satish et al., 2008) covering an area of 10.77 km^2 (1.10%) (Figure.4,5; Table.2).

vii. ***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 (Basavarajappa et al., 2014; Manjunatha and Basavarajappa, 2020b). This category covers an aerial extent of 8.03 km^2 (0.82%) noticed majorly in south-eastern, north-eastern and western parts of the taluk (Figure.4,5; Table.2).

viii. ***Mining/ Industrial wastelands:*** These are the lands with large-scale mining operations, mine dumps and discharge of large scale industrial effluents causing land degradation (Pushpavathi and Basavarajappa, 2009). The features exhibit dark gray (coal mining areas) to light bluish to black (iron ore waste) tone on standard FCC based on the color of the mine dump, small to medium in size, irregular in shape with mottled texture, located at or near active mining areas and industrial complexes. Conspicuously around urban areas and other areas where industrial activity is prominent. Mining areas encompass area under surface mining operations. Industrial areas include a wide array of land uses from light manufacturing to heavy manufacturing Plants (Anderson et al., 1976). These are areas of stockpile of storage dump of industrial raw material or slag/effluents or waste material or quarried/ mixed debris from earth's surface (NRSC, 2011; Manjunatha and Basavarajappa, 2020b). This category covers an area of 2.92 km^2 (0.29%) (Figure.4,5; Table.2).

ix. ***Moist & Dry Deciduous Forest:*** Moist deciduous forests are more pronounced in the regions which record rainfall between 100-200 cms with main species of Teak, sal, sandalwood and other (NCERT, 2019). Dry deciduous forest covers vast areas of the country, where rainfall ranges between 70 -100 cms and interspersed with patches of grass. As the dry season begins, the trees shed their leaves completely and the forest appears like vast grassland with naked trees all around (NCERT, 2019). Multi-temporal data, particularly during October and March/April seasons help in their discrimination from other forest types. On FCC, it appears as dark red to red tone mainly due to rich in timber trees like Teakwood, Bamboo, Eucalyptus plantations etc. Chikkanahalli is one of the state reserved moist-dry deciduous forests identified in the southern-western part of the study area through LISS-III satellite image. This category covers an area of 31.54 km^2 (3.24%) (Figure.4,5; Table.2).

x. ***Prosophys Juliflora:*** Prosopis juliflora is capable of growing in problematic salt affected soils and one of the most tolerant species for saline, alkaline soils (Maliwal, 1999). Growing Prosophys juliflora for ten years can significantly decreases pH, EC, Ca, Mg, K, CO3, HCO3, SO4 and Cl. These are noticed on red sandy loam soils of Hiriyur taluk derived from gneiss and schist-chlorites with few bands of ferruginous quartzite (Basavaraja et al., 2007). These are noticed occupying almost all the road sides, neglected areas, lakes and margins of forest lands covering an area of 0.84 Km^2 (0.08%) (Figure.4,5; Table.2).

xi. ***River/ stream/ canals:*** The Natural course of water flowing openly on the land surface along a definite channel. Rivers/streams are natural course of water flowing on the land surface along a definite channel/slope regularly or intermittently towards a sea in most cases or in to a lake or another river. Canals are artificial water course constructed for irrigation, navigation or to drain out excess water from agricultural lands. These cover an area of 9.55 Km^2 (0.98%) (Figure.4,5; Table.2).

xii. ***Rural (Villages):*** These are the built-up areas, smaller in size, mainly associated with agriculture and allied sectors and non-commercial activities. They can be seen in clusters non- contiguous or scattered (NRSC, 2011). 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 deciduous forest of Chikkanahalli (Basavarajappa et al., 2017). The area occupied by this class is about 21.92 km^2 (2.25%) (Figure.4,5; Table.2).

xiii. ***Salt-affected land:*** These are the lands that has excess salt in the soils with patchy growth of grasses (NRSC, 2011). These are found in river plains and in association with irrigated lands and adversely affecting the growth of most of the plants due to the action or presence of excess soluble or high exchangeable sodium (Pushpavathi and Basavarajappa, 2009). The areas are delineated based on white to light blue tone and its situation (Dinakar, 2005; Basavarajappa et al., 2019). Salt affected lands are observed near Sindhuvalli village with an extent of 3.01km^2 (0.3%) (Figure.4,5; Table.2) noticed in southern part of the taluk.

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xiv. ***Scrub Forest:*** Forest blanks which are the openings amidst forest areas, devoid of tree cover, observed as openings of assorted size and shapes as manifested on the imagery are also included in this category (NRSC, 2011). Scrub forest of Chamundi hill is noticed in central part of the taluk having canopy density less than 10% during extreme summer conditions (FAO, 2017). They appear as light red to dark brown tone on standard FCC due to canopy covers. This category covers an area of 1.52 km^2 (0.15%) (Figure.4,5; Table.2).

xv. ***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 (Basavarajappa et al., 2019). A group of trees that grow close together are noticed extensively towards eastern and western parts of the study area, generally without many bushes or other plants underneath. This category covers an area of 2.85 km^2 (0.29%) (Figure.4,5; Table.2).

xvi. ***Urban (Towns and Cities):*** It includes residential areas, mixed built-up, recreational places, public/ semi-public utilities, communications, public utilizes/ facility, commercial areas, reclaimed areas, vegetated areas, transportation, industrial areas and their dumps, and ash/cooling ponds (NRSC, 2011). 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 (Pushpavathi, 2010). Most of the land covered by building structures is parks, institutions, playgrounds and other open space within built up areas. This class usually occurs in combination with, vegetated areas that are connected to buildings that show a regular pattern, such as vegetated areas, gardens, industrial and/or other areas (FAO, 2017). Urban land occupies an area of 3.03 km^2 (0.31%) (Figure.4,5; Table.2).

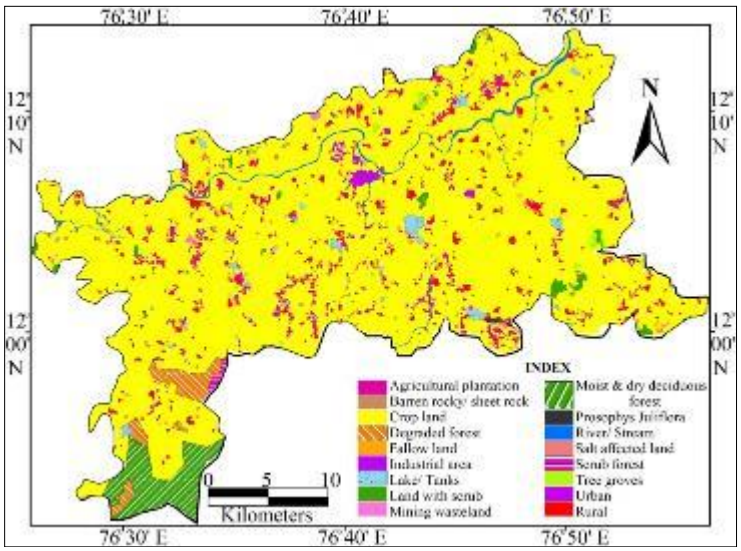

Fig.4. Level-II LU/LC Classified map of Nanjangud taluk

Table.4. Level-II Land Use /Land Cover Classification of Nanjangud taluk

Sl. No	Level-II Land patterns	Area (km^2)	*Percentage (%)*
1.	Agricultural Plantation	39.05	*4.01*
2.	Barren rocky / Sheet rock area	0.50	*0.05*
3.	Crop land	820.86	*84.36*
4.	Degraded forest	14.77	*1.51*
5.	Fallow land	1.57	*0.16*
6.	Lake/ Tanks	10.77	*1.10*
7.	Land with scrub	8.03	*0.82*
8.	Mining wastelands	2.92	*0.29*
9.	Moist Dry deciduous forest	31.54	*3.24*
10.	Prosophys Juliflora	0.84	*0.08*
11.	River/ Stream	9.55	*0.98*
12.	Rural	21.92	*2.25*
13.	Salt affected land	3.01	*0.30*
14.	Scrub forest	1.52	*0.15*
15.	Tree groves	2.85	*0.29*
16.	Urban	3.03	*0.31*

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	Total	**972.73**	***99.97***
	Total Geographical Area	**973.00**	

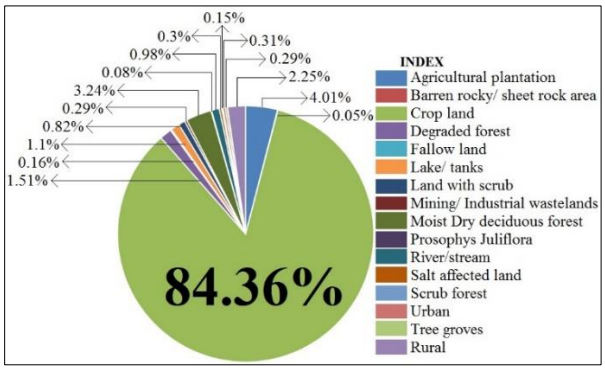

Fig.5. Pie-chart depicting Percentage of Level-II LU/LC categories of Nanjangud taluk

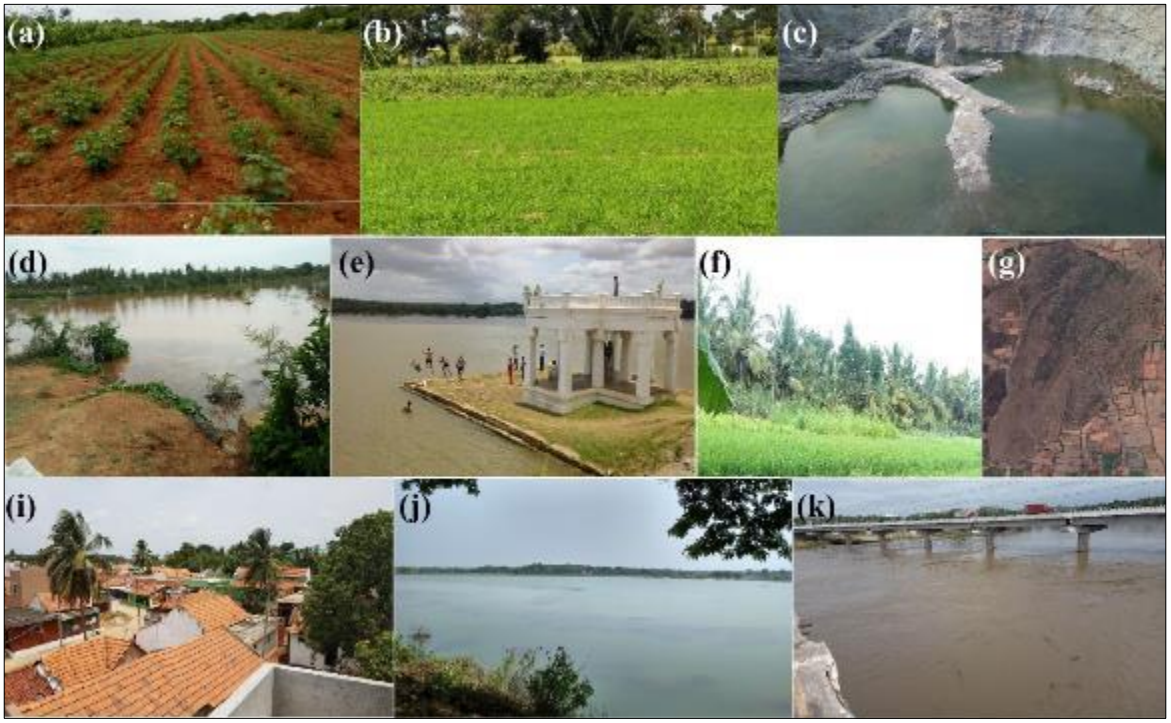

Fig.6. Cropping patterns near ***(a)*** Hura village and ***(b)*** Amakahalli; Grey granite quarry near ***(c)*** Hunasanalu village; ***(d)*** Kudlapura and ***(e)*** Konanur village Lakes; Coconut plantation near ***(f)*** Mallupura; Google Earth image of Barren rocky area behind ***(g)*** Adakanahalli village; Aerial view of Nandigundapura ***(i); (j)*** Kallale village lake; Kapila river ***(k)***

C. Level-III Classification

i. Double Cropped (Kharif + Rabi): 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 256.34 km^2 (26.34%) (Figure.6,7; Table.3).

ii. 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, 2012). The land occupies an area of 564.51 km^2 (58.01%) (Figure.6,7; Table.3).

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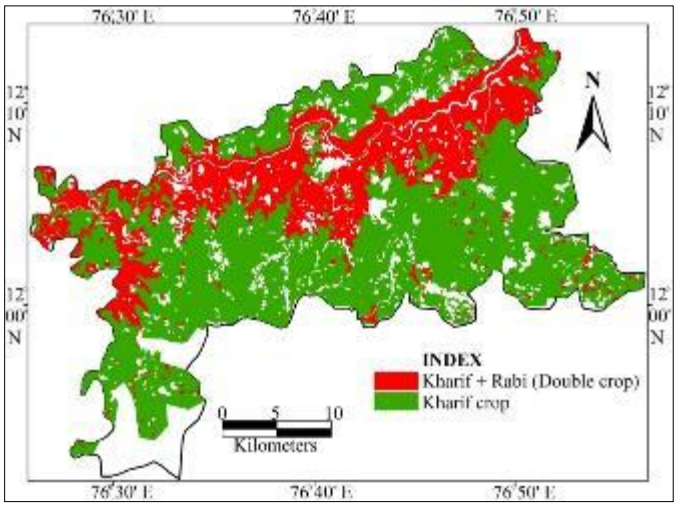

Fig.6. Level-III LU/LC Classified map of Nanjangud taluk

Table.6. Level-III Land Use/Land Cover Classification of Nanjangud taluk

Sl. No	Level-III Land patterns	Area (km^2)	*Percentage (%)*
1.	Kharif + Rabi (Double crops)	256.34	*26.34*
2.	Kharif crops	564.51	*58.01*
	Total	**820.85**	***84.35***
	Total Geographical Area	**973.00**	

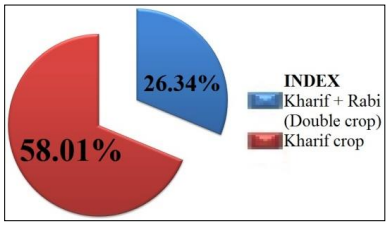

Fig.7. Pie-chart depicting Percentage of Level-III LU/LC categories of Nanjangud taluk

IV. DISCUSSION

The land use pattern and its spatial distribution are the prime requisites for the preparation of an effective land use policy needed for the proper planning and management of an area. Analysis shows the agricultural area mostly found in the northern portion whereas southern portion of the basin is occupied by the forest cover over the denudational hills. Wastelands must be converted into cultivable land through massive programs of afforestation, plantation or pasture development to increase food, fodder and fuel production. Land with and without scrub can be utilized for growing plants, which need soil cover (Jay Krishna et al., 2011). These plants are a source of fuel wood whereas some of them are of medicinal and economic importance. It is expected that this trend will have dramatic implications in the field of geospatial for the natural resource mapping, monitoring and modelling over the next decade. Currently, monitoring and mediating the adverse consequences of Land use /land cover change while sustaining the production of essential resources has become a major priority of researchers and policy makers around the world (Erle and Pontius, 2007).

V. CONCLUSION

The present research work demonstrates the capability of geospatial techniques to capture the land use categories which are necessary for optimum and sustainable utilization of land resources and prevention of further undesirable deterioration in land use. Satellite remote sensing integrated with GIS can play a useful role in effective land use planning and management. This would be useful to protect the fertile agricultural land in the region and further reduce environmental degradation in the form of soil erosion, water stress and pollution. Moreover, this research work draw attention to urban land use modeling and techniques integrating socio-economic data and GIS tools to predict future land change pattern.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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