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An Approach to Delineate Land Use/ Land Cover Classification Analysis Through Geospatial Technology: A Case Study of Krishna Raja Nagara Taluk of Karnataka State, India

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Abstract- Land is one among the non-renewable resources and its mapping is vital in land and water resource development. Land is a part of earth surface that supports all attributes of regions together with the atmosphere, soil and underlying geology. Hydrology, plant and animal population are the results of the past and present human actions to the extent that considerably influences on land patterns sustainability. Remote Sensing (RS) satellite images with its synoptic reading and multispectral informationembrace essential data for scientific handling of LU/LC conditions of the larger areas. Efforts have been made to classify the LU/LC patterns using False Color Composite (FCC) data of IRS-1D PAN+LISS-III (Band: 2,3,4) through ArcGIS v10. An attempt have been made to delineate the level-I, level-II and level-III LU/LC classification analysis through NRSC guidelines (1995) using both digital and visual image interpretation techniques in GIS environment. The classification accuracy is found to be more precise in case of digital technique as compared to that of visual technique in terms of area statistics. The database provides spatial baseline information in distribution, extent and temporal behavior of specific land pattern in planning and implementation of development strategies in the country.

Keywords:- LU/LC Classification; LISS-III Image; Geospatial technology; Krishna Raja Nagarataluk.

I. INTRODUCTION

Earth's land use/land cover (LU/LC) patterns provide information particularly on natural resources, mapping and it's monitoring in future sustainability (Zhang, 2011).

Land use describes how a parcel of land is used such as agriculture, settlements or industry, whereas land cover refers to the material such as vegetation, rocks or water bodies that are present on the surface (Anderson et al., 1976; Brebbia and Viktor, 2011). The term LU/LC is closely related and inter changeable (Basavarajappa et al., 2016).

LU/LC exposes considerable influence on the various hydrological aspects such as interception, infiltration, catchment area, evaporation and surface flow (Basavarajappa et al, 2014b). The LULC alterations are generally caused by mismanagement of agriculture, urban pressure, forest lands which lead to severe environmental problems andnegatively affect climatic conditions, natural hazard (floods, landslides) and socio-economic dynamics in global and local scale (Selcuk Reis, 2008).

(Selcuk Reis, 2008). Mapping of those land classesat regional scales is important for a great variety of applications together with landslides, soil erosion, land monitoring, global warming (Selcuk Reis, 2008).

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Land use/landcover and human/natural modifications have largely resulted in deforestation, biodiversity loss, globalwarming and increase of natural disasters (Mas et al, 2004; Zhao et al, 2004; Dwivedi et al, 2005). Unscientific handling of land as natural resource had resulted within the development of immense stretches of wastelands which is one of the major reason behind the decrease in per capita productivity (Basavarajappa et al, 2014a).

Agricultural practices embraces the shortage of conservation measures and irrigation practices that always cause the formation of the salt affected soils (Basavarajappa et al, 2014a).

Rapid increase in population and basic human forces demand for more food, fodder and fuel wood have led to large scale environment degradation and ecological imbalance (Basavarajappa et al, 2016).

Land use system needs thorough systematic monitoring and management to maintain food security, to minimize deforestation, conservation of biological diversity and protection of natural resources (Basavarajappa et al, 2017b). Remote Sensing Satellite imagery is that the most vital knowledge resources of GIS used for recognition of synoptic view of earth's surface (Ulbricht, 1998).

The wealthy archive and spectral resolution of satellite data are the foremost vital reasons for their use. GIS provides a flexible environment for collecting, storing, displaying and analyzing digital data necessary for land developmental strategies (Yomrahoglu et al, 2000; Demers, 2005; Wu et al, 2006). Geospatial techniques (RS & GIS) are powerful tools to derive accurate and timely information on the spatial distribution of land use/land cover classification over large areas (Carlson and Azofeifa, 1999).

II. MATERIALS AND METHODS

1. Study Area:

The study area located in between 76008' E to 76030' E and 12023' N to 12039' N with an aerial extent of 622.74 km2.The general elevation recorded at 788 mts above MSL. Actual rainfall recorded for the year 2005 is 923.5 mm with 59 rainy days (District at a glance, 2005-06). The main Cauvery River flows from west to eastern direction drains major parts of the taluk and confluences in the Krishna Raja Sagar reservoir.

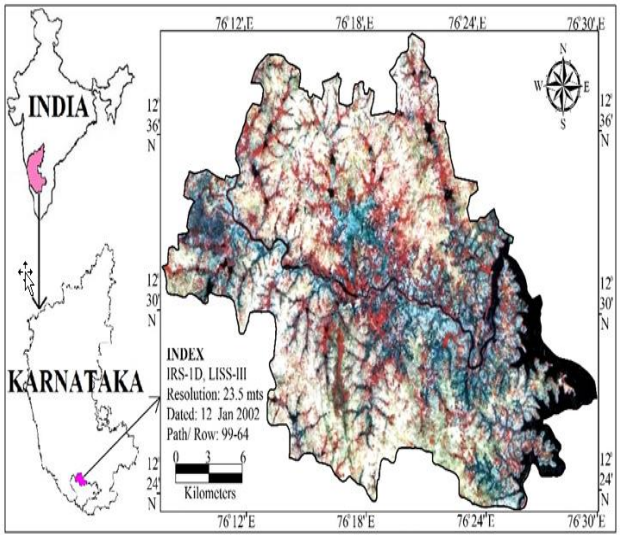

Fig 1. Location and IRS-1D, LISS-III satellite image of Krishna Raja Nagara taluk.

2. Methodology:

The methodology adopted consists of meaningful information extraction from Remote Sensing Satellite image, data preparation, interpretation (on-screen visual), Ground Truth Check (GTC), map finalization and database organization as per NNRMS standards (NRSC, 2011).

Similarly, available ancillary data on wastelands, forest that was generated earlier was also referred during mapping. LU/LC maps are prepared using satellite image in conjunction with collateral data like Soltopomaps on 1:50,000 scale by considering permanent features such as major roads, drainages, power-lines, railways, coordinates, village boundaries and settlements (Manjunatha et al, 2015a). Multi-temporal Resourcesat-1 of LISS III data of 2001-02 acquired during kharif (Aug –Nov), and rabi seasons (Jan- Mar) are acquired to estimate the spatial distribution variability of cropping pattern (NRSC, 2011). Preliminary analyzed LULC categories from satellite data are updated by extensive field survey& information and the final thematic details are overlaid on the base map.

On-screen Visual Image Interpretation Techniques (VIIT) are extracted manually and compared with digitally extracted vector layers in delineating land use land cover categories (Manjunatha and Basavarajappa, 2020). Supervised classification analyses are carried out on multispectral IRS-1D,

LISS-III FCC with medium scale through ArcGIS v10 (Fig.3).

The LU/LC patterns are digitized supported the quality schemes developed by National Remote Sensing Agency (NRSA, 1995; Manjunatha and Basavarajappa, 2020b).

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 (Manjunatha and Basavarajappa, 2020a).

3. Materials Used

3.1 Base Map: Survey of India toposheets of 57D/2, 3, 6, 7 and 11in 1:50,000 scale (Fig.1). Source: Survey of India (SoI) Office, Govt. of India, Bengaluru.

3.2 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 (Manjunatha and Basavarajappa, 2020).

3.3 GIS Software's: Erdas Imagine v2011 and Arc GIS v10 (Manjunatha and Basavarajappa, 2020).

3.4 GPS: Garmin 12 is used to mark exact boundaries and to check the conditions of the land use/land cover patterns during field visits (Manjunatha and Basavarajappa, 2020).

III. RESULTS AND DISCUSSION

1. Level-I Classification:

1.1 Agricultural Land: The land primarily used for growing food, fiber and horticultural/plantation crops under irrigated and rainfed conditions including croplands, fallow land and plantations (Basavarajappa et al, 2013). These covers farming, fallow, plantations, production of food, fiber and other commercial/ horticultural crops including land under crops (irrigated and un-irrigated) etc. This category covers an area of 542.68 km2 (87.14%) (Fig.2 & 3, Table.1).

1.2 Built-up Land: It is an area of human habitation developed due to non-agricultural use and that has a cover of buildings, transport and communication, utilities in association with water, vegetation and vacant lands (NRSC, 2011; Anderson et al, 1976). Collectively any man-made constructions due to non-agricultural use are included under this category (Basavarajappaet al, 2013). The total aerial extent of built-up land is 10.91 km2 (1.75%) (Fig.2 & 3, Table.1).

1.3 Water Bodies: This category contains areas of surface water, either impounded within the sort of ponds, lakes and reservoirs or flowing as streams, rivers, canals, etc (Dinakar, 2005; Manjunatha and Basavarajappa, 2015b). These are clearly observed on standard FCC in different shades of blackish blue to light blue color depending on the depth of water (Manjunatha and Basavarajappa, 2015b). The water level rangedbetween 3.18 m bgl and 17.52 m bgl during pre-monsoon (May 2006) and between 1.72 m bgl and 6.16 m bgl during post-monsoon season (Nov 2006). The area occupied by this category is 57.94 km2 (9.3%) (CGWB, 2012) (Fig.2 & 3, Table.1).

1.4 Waste Lands: These are described as land which can be brought under vegetative cover with reasonable effort and which is currently underutilized and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes (NRSC, 2011; Basavarajappa et al, 2014c). Wastelands may result from inherent/ obligatory disabilities like locations, environment, chemical and physical properties of the soil/ financial/ management constraints (NWDB, 1987). The total aerial extent of wasteland covers about 3.57 km2 (0.57%) (Fig.2 & 3, Table.1).

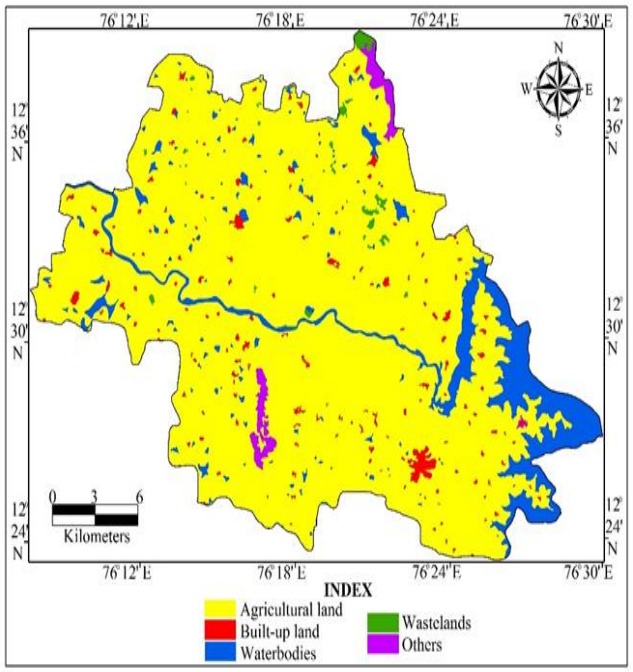

Fig 2. Level-I LU/LC Classified map of Krishna Raja nagara taluk.

1.5 Others: This can be treated as miscellaneous due to their nature of occurrence, physical appearance and other characteristics (Basavarajappaet al, 2012; 2017) in the integrated thematic layer noticed in eastern and western parts covering an area of 7.61 km2 (1.22%) (Fig.2 & 3, Table.1).

Table 1. Level-I Land Use /Land Cover Classification of Krishna Raja nagara taluk.

Sl No	Land patterns	Area (km^2)	Percentage (%)
1.	Agricultural land	542.6862	87.14
2.	Built-up land	10.9128	1.75
3.	Water bodies	57.9411	9.30
4.	Wastelands	3.5746	0.57
5.	Others	7.6118	1.22
Total		622.7265	99.98
Total Geographical Area		622.7478	

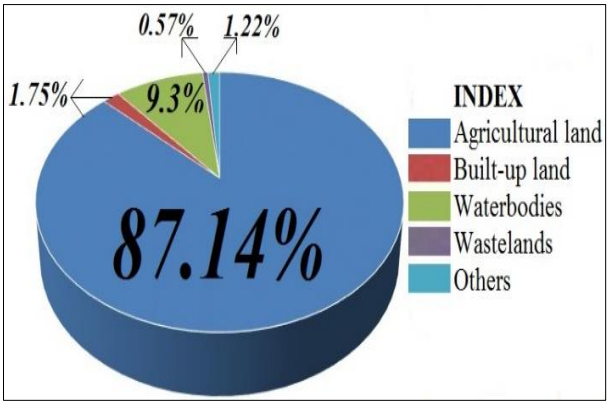

Fig 3. Pie-chart depicting Percentage of Level-I LU/LC categories of Krishna Raja nagara taluk.

2. Level-II Classification:

2.1 Agricultural Plantations: These are the areas under agricultural tree crops exhibit a dispersed or contiguous pattern planted adopting agricultural management techniques (NRSC, 2011). Use of multi-season data will enable their separation in a better way which includes agricultural plantations (like tea, coffee, rubber etc) horticultural plantations (like coconut, arecanut, citrus fruits, orchards, fruits, ornamental shrubs and trees, vegetable gardens etc) and agro-horticultural plantations (NRSC, 2011). Differentiation of plantation from cropland is feasible by multi-temporal images of period matched harvesting time of inter-row crop/flowering of the plantation crops (Basavarajappa et al, 2014b). The total area under this category is 20.09 km2 (3.22%) observed majorly in northern and south-eastern parts of the taluk (Fig.4 & 5, Table.2).

2.2 Barren Rocky/Stony Waste: The rock exposures of varying lithology often barren & vegetation cover appear as isolated hill exposures located in steep isolated hillocks/ hill slopes, crests, plateau & eroded plains associated with lateritic out-crops, mining, quarrying sites (Basavarajappa et al, 2016a).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 huge 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 simply discriminated from different classes of wastelands based on their characteristic spectral response (Manjunatha et al, 2015a; Basavarajappaet al., 2017). On FCC, they represent greenish blue to yellow to brownish in tone with variable size related to steep isolated hillocks, hill slopes and worn plains. These are notified as linear forms within the plain land mainly due to varying lithology noticed near the villages of Bettahallikaval, Dadadahalli, Gerudada and HosaAgrahara (NRSC, 2011) covering an area of 0.3 km2 (0.06%) (Fig.4 & 5, Table.2).

2.3 Crop Lands: It includes kharif, rabi and zaid crop lands in conjunction with double or triple cropping patterns (NRSC, 2011) together with irrigated and un-irrigated, fallow, plantation etc (NRSA, 1989; Manjunatha and Basavarajappa, 2020). The area under crops have digitized supported the standing crops as on the date of satellite data acquisition using both Kharif& Rabi seasons (Manjunatha et al, 2015a). Cropped areas appear in bright red toned in color with variable form and size during a contiguous to non-contiguous pattern (Manjunatha et al, 2015a). They are widely distributed in several terrains; conspicuously seen within the irrigated areas regardless of the supply of irrigation (Rajesh, 2018). This category covers an area of 522.59 km2 (83.91%) (Fig.4 & 5, Table.2).

2.4 Lakes/ 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 (Basavarajappaet al, 2017). Rivers and tanks are the foremost water sources within the

taluk. Lakes and tanks are extracted effectively from LISS-III data supported the color/ tonal variation from dark to light blue (Satish et al, 2008). This covering an area of 11.04 km2 (1.77%) noticed mainly in northern parts (Fig.4 & 5, Table.2).

2.5 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 (Basavarajappaet al, 2014a). This category covers an aerial extent of 2.68 km2 (0.43%) noticed in the villages of Guluvinaattiguppe, Gerudada, Hanumanahalli, Kakana halli, HosaAgrahara, Madahalli, MavathurHantha, Damma nahalli, Honnenahalli, Harada nahalli, (Fig 4 & 5, Table2).

2.6 Mining/ Industrial Wastelands: These are the areas of large-scale mining operations, mine dumps and discharge of enormous industrial effluents inflicting land degradation (Basavarajappa et al, 2017). The features exhibit dark gray (coal mining areas) to light bluish to black (iron ore waste) tone on standard FCC supported the color of the mine dump, small to medium in size, irregular in form with mottled texture, placed closely to active mining areas and industrial complexes (Basavarajappa et al, 2015). Prominently around urban areas and different areas whereverindustrial activity is distinguished. 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 noticed near the village of Maragowdanahalli (NRSC, 2011). This category covers an area of 0.02 km2(Fig.4 & 5, Table.2).

2.7 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. The areas are delineated based on white to light blue tone and its situation (Dinakar, 2005). Salt affected lands are observed near Sindhuvalli village with an extent of 0.47 km2(0.07%) (Fig.4 & 5, Table.2) noticed near the villages of Thandre, Bachahalli, Gerudada and Beechanahalli.

2.8 Rural (Villages): These are the built-up areas, smaller in size, mainly associated with agriculture and allied sectors and non-commercial activities (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 are clearly extracted from toposheet& satellite images with variety of houses, inter spread with trees and agriculture fields particularly in south eastern parts of study area (Manjunatha and Basavarajappa, 2020). The area occupied by this class is about 2.09 km2 (0.33%) (Fig.4 & 5, Table.2).

2.9 Tree Groves: These are clump of trees that does not have abundant brushwood and occupies a contained land space like small orchard plantation planted for the cultivation of fruits or nuts (Manjunatha and Basavarajappa, 2021). A group of trees that grow close together are noticed extensively towards northern and southern parts occurs as a linear ridge, generally without many bushes or other plants underneath. This category covers an area of 7.6 km2 (1.22%) observed near the villages of Matadakaval, Hosuru, Sambaravalli, Kuppe, Kestur and Malali(Fig.4 & 5, Table.2).

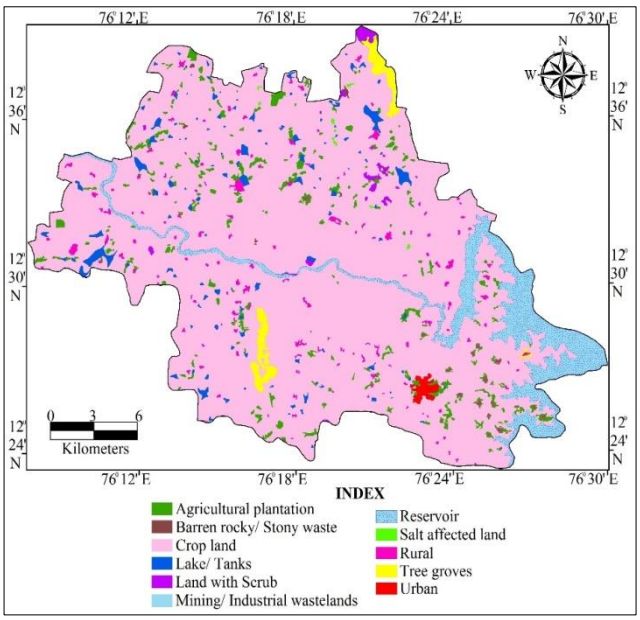

Fig 4. Level-II LU/LC Classified map of Krishna Raja nagara taluk.

2.10 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

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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 different open space within built up areas (Basavarajappa et al, 2014b). This category sometimes occurs together with vegetated areas that are connected to buildings that show a regular pattern, like vegetated areas, gardens, industrial and/or different areas (Basavarajappa et al, 2014b; FAO, 2017). Urban land occupies an area of 8.82 km2 (1.41%) (Fig.4 & 5, Table.2).

Table 2. Level-II Land Use /Land Cover Classification of Krishna Raja nagara taluk.

Sl. No	Level-II Land patterns	Area (km^2)	Percentage (%)
1.	Agricultural Plantation	20.0932	3.22
2.	Barren rocky/ Sheet rock area	0.3885	0.06
3.	Crop land	522.5930	83.91
4.	Lake/ Tanks	11.0423	1.77
5.	Land with scrub	2.6827	0.43
6.	Mining/ Industrial wastelands	0.0274	0.00
7.	Reservoir	46.8988	7.53
8.	Salt affected land	0.4758	0.07
9.	Rural	2.0924	0.33
10.	Tree groves	7.6004	1.22
11.	Urban	8.8204	1.41
	Total	622.7149	99.95
	Total Geographical Area	622.7478	

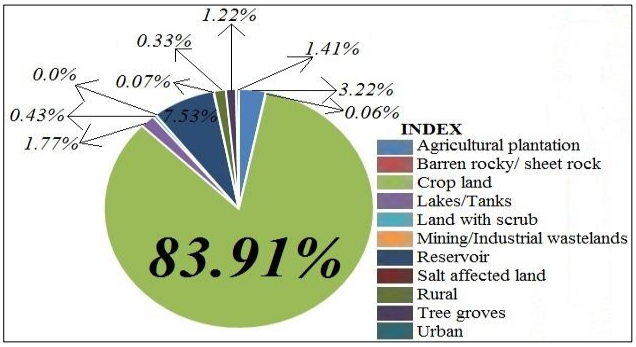

Fig 5. Pie-chart depicting Percentage of Level-II LU/LC categories of Krishna Raja nagara taluk.

3. Level-III Classification:

3.1 Double Cropped (Kharif + Rabi): The main cropping season, kharif, starts from May and ends by September (Basavarajappa et al, 2019). The cropping intensity is extremely high due to physical factors like flatland parcel, fertile soil and irrigated from canal system. Most of the double crop areas are targeted adjacent to the rivers flowing within the study area (Pushpavathi, 2010; Manjunatha et al, 2015a). On FCC, the double crop show a dark red tone with square pattern representing soil covers with higher amount of moisture near the streams (Basavarajappaet al, 2017).

The cultivated lands at elevated zones represent bright red tone representing less amount of moisture and deeper levels of groundwater prospect zones (Manjunatha et al, 2015a). This category has been identified and mapped using the two season satellite images which covers an area of 297.08 km2 (47.7%) (Fig.6 & 7, Table.3).

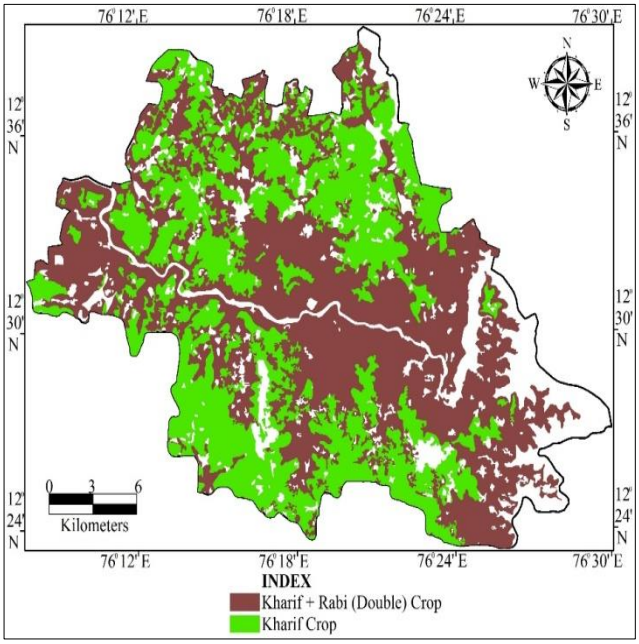

Fig 6. Level-III LU/LC Classified map of Krishna Raja nagara taluk.

3.2 Kharif: These are the standing crops from June to September related torainfed crops under dry land farming and restricted 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 225.5km2(36.21%) (Fig.6 & 7, Table.3).

Table 3. Level-III Land Use/Land Cover Classification of Krishna Raja nagara taluk.

Sl. No	Level-III Land patterns	Area (km^2)	Percentage (%)
1.	Kharif + Rabi (Double crops)	297.0854	47.70
2.	Kharif crops	225.5075	36.21
	Total	522.5929	83.91
	Total Geographical Area	622.7478	

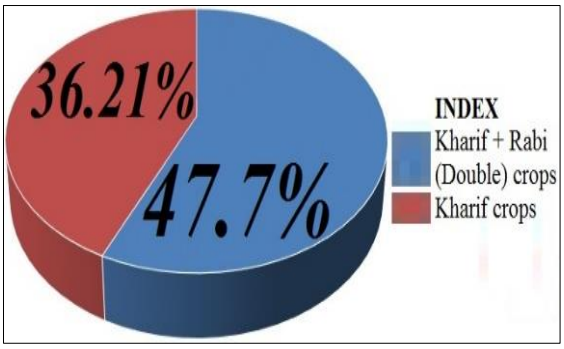

Fig 7. Pie-chart depicting Percentage of Level-III LU/LC categories of Krishna Raja nagara taluk.

IV. CONCLUSION

Geospatial approach provides 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. Precise and timely interpretation of LULC classification knowledge are the valuable information in addressing the spatial changes, environmental & socio-economic issues, growing demand for economic natural resources, risks related to public health, cropping patterns, vulnerability to certain management practices, future food security and decision making in land use planning & its policy.

Thus this study highlights the potential of geospatial approach in extracting meaningful information that are very vital in management and monitoring of dynamic LULC categories and its proper utilization.

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1. Conflicts of Interest:

The authors declare no conflicts of interest.

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