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GEOINFORMATICS APPLICATION ON LAND USE/ LAND COVER CLASSIFICATION ANALYSIS IN KOLLEGALA TALUK OF CHAMARAJANAGARA DISTRICT, KARNATAKA, INDIA

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KEYWORDS: LU/LC Classification; Visual & digital interpretation; Kollegala and Geoinformatics.

ABSTRACT
Land resources planning and its development is an important issue in the present era. Major changes in any part of earth's surfaces will significantly influences the environmental factors such as atmosphere, soil, topography, vegetation, underlying geology, hydrology, plant & animal population. The present aim is to classify the Land Use/ Land Cover (LU/LC) categories based on NRSC' standards (1995) to increase land productivity, restoration of soil degradation, reclamation of wastelands and increase the environmental qualities. An attempt have been made to evaluate the level-I, level-II and level-III LU/LC classification system using IRS-1D PAN+LISS-III through GIS. The classification accuracy is found to be more in case of digital technique as compared to that of visual technique in terms of area statistics. The final results demonstrate the accurate mapping of classified LU/LC categories for implementation, management, mapping, measurement and monitoring through geoinformatics techniques.

INTRODUCTION
Land classification relates to the grouping of land according to their suitability for producing plants of economic importance (Jack., 1946). LU/LC classifications should undergo essential practices to maintain food security, to minimize deforestation, conservation of biological diversity, protection of natural resources, enhancing the human occupation to the changing social, economic and natural environmental conditions (Basavarajappa et al., 2014). Any significant change on earth's surface impacts directly on climatic conditions, rapid increase in population and over demand of the growing economic minerals (Manjunatha et al., 2015). 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. 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). The term LU/LC is closely related and interchangeable (Basavarajappa et al., 2016). 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). Satellite based Remote Sensing (SRS) technology provide synoptic view of LU/LC categories and its monitoring by multi-temporal images (Kumar et al., 2004; NWDB., 1987) for proper utilization of land for 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; Palaniyandi and Nagarthinam., 1997). Land use/land cover provides an idea of relative infiltration capacity of different land cover types and intercepts the surface flow of runoff water. (Basavarajappa and Dinakar., 2005). Multidisciplinary approach and research in identifying the specific land is very much needed for better utilization, maintenance of soil fertility and rehabilitation of degraded lands (Pushpavathi., 2010).

STUDY AREA
The study area lies between $11^0$45' to $12^0$45' N latitude and $77^0$00' to $77^0$46' E longitude covering an area of 2,791.29 Km^2 with an average elevation of 588 m (1,929 ft) above MSL (Fig.1) (Basavarajappa et al., 2013). The river Cauvery flows along the northern boundary of Kollegal taluk. The river Cauvery and its tributaries viz., Moyar, Bhavani, Palar and Suvarnavathi drain the study area (Satish., 2003; Pushpavathi and Basavarajappa.,

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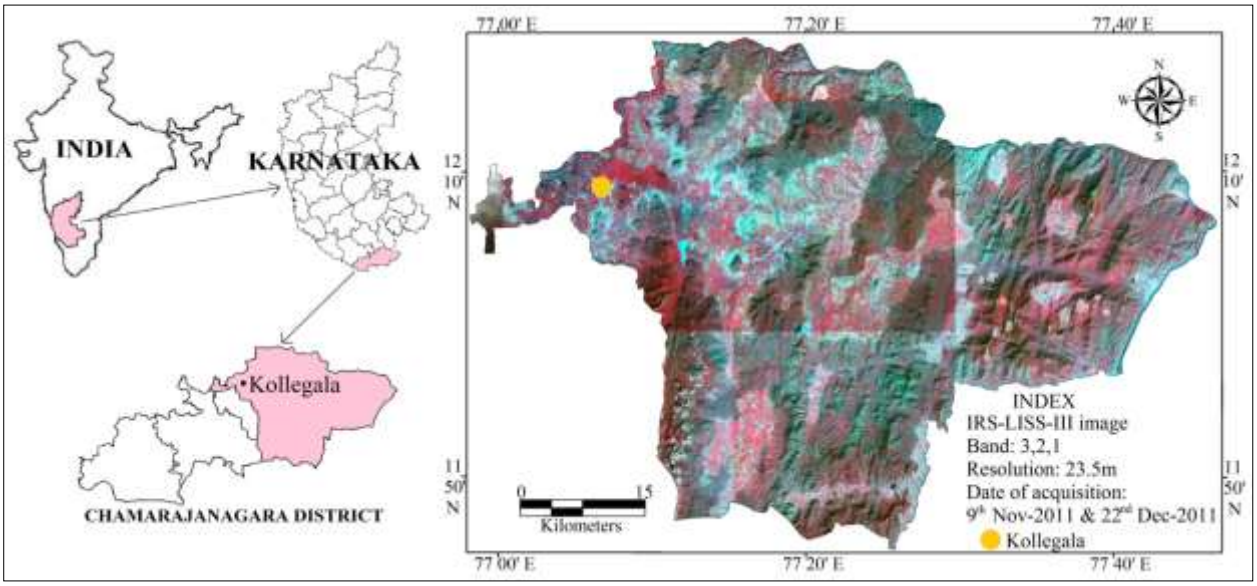
2009). Annual rainfall for the last three decades of Kollegal taluk is 768.1mm. The average annual rainfall is found to be 689 mm (CGWB., 2008).

Figure: 1



Location and Satellite image of the study area

METHODS & MATERIALS

LU/LC maps are prepared using satellite images in conjunction with collateral data like SoI topomaps on 1:50,000 scale by considering permanent features such as major roads, drainages, power-lines, railways, settlements, co-ordinates, forests and village boundaries (Manjunatha et al., 2015). Visual Image Interpretation Techniques (VIIT) on IRS-1D PAN+LISS-III FCC of Band 3,2,1 on 1:50,000 scale (Fig.1) is carried out in delineating the various LU/LC categories (Basavarajappa et al., 2015). The satellite data of two seasons are acquired (Kharif and Double crop areas) to estimate the spatial distribution and temporal variability of cropping pattern based on the standard schemes developed by National Remote Sensing Agency (NRSA, 1995).

Topomaps: Survey of India (SoI) toposheet no's of 57D/16; 57H/3, 4, 7, 8, 12, 16; 58E/1, 2, 5, 9 of 1:50,000 scale considered as base maps for geo-referencing the Satellite images.
Source: (SoI, Bengaluru).
Satellite Data: FCC of IRS-1D, LISS-III of 23.5m Resolution, Date of acquisition: 2005/06; 9th Nov-2011 & 22nd Dec-2011; PAN (2005-06) images of 5.8m Resolution.
Source: Bhuvan-ISRO, NRSC-Hyderabad.
GIS software's: ArcGIS v10; Erdas Imagine v2013.
GPS: Garmin-12 is used to check the conditions of land use/land cover patterns during field visits.

LU/LC CLASSIFICATION ANALYSIS

LU/LC classes such as agricultural land (crop land), built-up land, fallow land, plantation, forest (evergreen, deciduous, scrub, etc), grasslands, wastelands (salt affected land, waterlogged land, gullied/ ravinous land, barren rock/stony waste etc), water bodies (rivers, streams, canals, lakes, etc) are delineated based on the image characteristics like tone, texture, shape, association, background, etc. The level-1 classification consists of 6 major categories such as built-up land, agricultural land, forest, grassland, wastelands, water bodies and others (Dinakar., 2005). These 5 major classes of level-1 are further divided into sub-categories of level-2; keeping the area under investigation for better land and water implementation strategies (Basavarajappa et al., 2015); while level-3 classification is mainly focused on agricultural lands to study the cropping patterns (Manjunatha et al., 2015).

LU/LC influences the hydrogeological characteristics as the groundwater regime are impacted by the type of land use/land cover categories (Basavarajappa and Dinakar., 2005). Remote Sensing Satellite images are very much useful in preparing the precise LU/LC patterns in short period of time using geoinformatics as compared to the conventional methods. This helps in analyzing, mapping and integrating the information database to generate thematic maps for development and management of natural resources (NRSA., 1995). Digital interpretation and post classification comparison techniques are adopted to find out the changes among various land uses over a period (Rubee and Thie, 1978; Likens and Maw, 1982; Priyakant et al., 2001).

LEVEL-I CLASSIFICATION

Agricultural lands: Are primarily used for farming, production of food, fiber, other commercial and horticultural crops including crops land (irrigated and unirrigated), fallow, plantations, etc (Basavarajappa et al., 2015). This covers an area of 748.43 Km^2 (26.81%).

Built-up lands: Are man-made constructions such as buildings, transportation network, communication, industrial, commercial complexes, utilities and services in association with water, vegetation and vacant lands. This covers an area of 18.60 Km^2 (0.66%) which includes cities, towns and habitations (Basavarajappa et al., 2015).

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. 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). Forest cover with 40% or move vegetation density (crown cover) is called dense or closed forest; while between 10-40% of vegetation density is called as scrub whereas <10% is called as degraded forest. Forests exert influence on climate, water regime and provide shelter for wildlife and livestock (FAO, 1963). The area under this category is 1809.59 Km^2 (64.82%).

Wastelands: These are degraded lands which can be brought under vegetative cover with reasonable effort. 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). The wasteland mapping is done using the Survey of India (SoI) toposheet on 1:50,000 scale and Satellite Remote Sensing data (NRSA., 1995). Thirteen types of wastelands are identified and digitized. The total aerial extent of wasteland covers about 103.60 Km^2 (3.71%).

Table.1 Level-1 land use /land cover classification

Sl. No	Level-1	Area in Km^2	Percentage (%)
1.	Agricultural land	748.4318	26.8130
2.	Built up land	18.6077	0.6666
3.	Forest land	1809.5911	64.8298
4.	Grass/ grazing land	6.2253	0.2230
4.	Wastelands	103.6076	3.7118
5.	Water bodies	36.0184	1.2903
6.	others	59.6406	2.1366
	Total	***2782.1225***	***99.6711***
	TGA	***2791.2925***	

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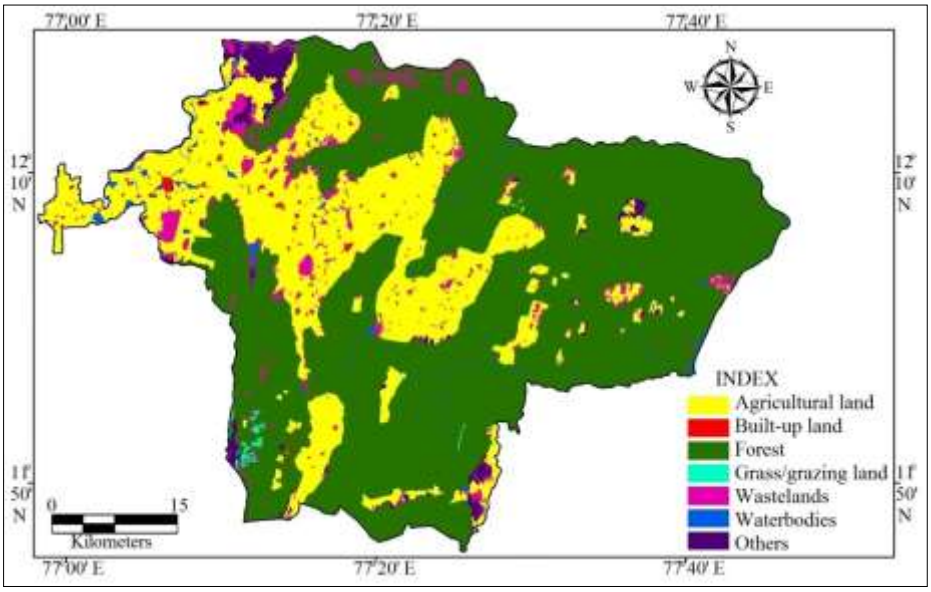
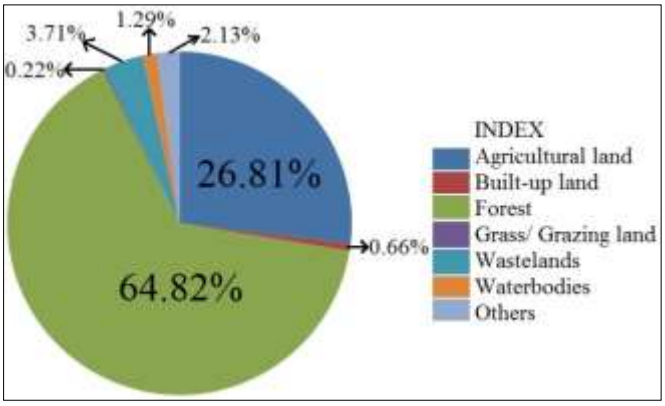
Figure: 2



Level-I LU/LC map of the study area

Figure: 3



Pie chart depicting the Level-I LU/LC classification in Percentage-wise

Water bodies: This class comprises areas of surface water, either impounded in the form of ponds, lakes and reservoirs or flowing as streams, rivers, canal, etc. These are clearly observed on standard FCC in different shades of blackish blue to light blue color depending on the depth of water bodies. The area occupied by this category is 36.01 Km^2 (1.29%).

Others: This can be treated as miscellaneous due to their nature of occurrence, physical appearance and other characteristics in the integrated thematic layer covering an area of 59.64 Km^2 (2.13%).

LEVEL-II CLASSIFICATION

Agricultural plantation: Agricultural land with tree plantation or fruit orchards; planned by adopting certain agricultural management techniques. It includes mainly cash crops such as Sugarcane, Maize, Ragi, Paddy, Jowar, Sunflower, Coconut and Sericulture; while Banana and Sugarcane are normally grown in low lying area. Seasonal crops like Mustard seeds, Groundnut and other cereals are also noticed (Basavarajappa et al., 2013).

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 40.19 Km^2 (1.43%).

Barren rocky: Lands are 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. 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 found in the villages occupied by an area of 42.28 Km^2 (1.51%).

Crop Land: Lands with standing crops as on the date of the satellite data acquisition which may be either Kharif or double cropped including fallow, plantation, etc (NRSA, 1989). The area under crops have been identified during Kharif (June to Sept) and double crop (May to Sept) (land cultivated both during Kharif and Rabi seasons) are mapped covering an area of 695.07 Km^2 (24.90%).

Deciduous forest: The forest cover predominantly comprises of deciduous species and the trees shed their leaves once in a year. These deciduous forests are well intermixed with evergreen forest in south-eastern parts. Multi-temporal data, particularly during October and March/April seasons help in their discrimination from other forest types. Medium relief mountain/hill slopes occupies the South-eastern parts. On FCC, it appears as dark red to red tone mainly due to rich in timber trees like Teakwood, Rosewood, Honne, Bamboo occupied by 1585.05 Km^2 (56.78%).

Dense forest: 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 with an area of 5.52 Km^2 (0.19%).

Evergreen Forest: Forest cover comprising thick and dense canopy of tall trees that predominantly remain green throughout the year including both coniferous and tropical broad leaf evergreen trees. Semi-evergreen forest is a mixture of both deciduous and evergreen trees, however the later is predominate. Multi-temporal data and area specificity of forest type helps in discriminating evergreen forests from other forest classes. Male Mahadeshwara represents parallel hill ranges belonging to Western Ghats (Basavarajappa et al., 2013). It provides raw materials for industries like paper, rayon, saw mills, safety matches and sandalwood. The total area covered by evergreen forest is 224.16 Km^2 (8.03%).

Fallow land: The agricultural land which is taken up for cultivation but is temporarily allowed to rest, uncropped for one more season, but less than one year. 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. The total area under this category is 11.41 Km^2 (0.40%).

Forest plantation: It is described as an area of trees with species of forestry and its importance raised on notified forest lands. These are artificially planted areas with tree cover, either in the open spaces or by clearing the existing forests for economically inferior species. New and young plantations can be readily separated from contiguous forested areas. Few mass of artificial planted medicinal plantations are noticed on foot hills of Biligiri-Rangan Hills. The area occupied by this class is about 1.04 Km^2 (0.03%).

Gullied land: Gullies are narrow and deep channels developed as a result of weaving away of soil by running water develops from rills which are tiny channels of few centimeters deep; more common on sloping land. In the study area, these lands are noticed in eroded plains along streams, on sloping surface made of loose sediments adjacent to pediments and residual hills. These areas are having entrenched drainage system, good rainfall and surface runoff. On FCC, they appears as light yellow to bluish green depending upon the surface moisture and depth of erosion with varying size. These gullies and ravines contribute to soil erosion and land degradation. The area under this class is 1.07 Km^2 (0.03%).

Land with scrub: Scrub lands are observed along the ridges, valley complex, linear ridges and steep slope areas characterized by the presence of thorny scrub, herb species, many hillocks of steep with poor vegetal cover. As a consequence, severe soil erosion frequently occurs during rainy seasons and later most of the hill tops become barren/ rocky. These lands are mainly observed in North-eastern parts of hilly regions with an aerial extent of 56.47 Km^2 (2.02%).

Land without scrub: Land under this class is generally prone to degradation/deterioration and may not have scrub cover. It is confined to (relatively) higher topography such as uplands or high grounds etc excluding the hills and mountainous terrain. On FCC, they appear as light yellow to brown to greenish blue, varying in size associated with gentle relief with moderate slope in plain and foothills surrounded by agricultural lands with an aerial extent of 0.43 Km^2 (0.01%).

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Global Journal of Engineering Science and Research Management

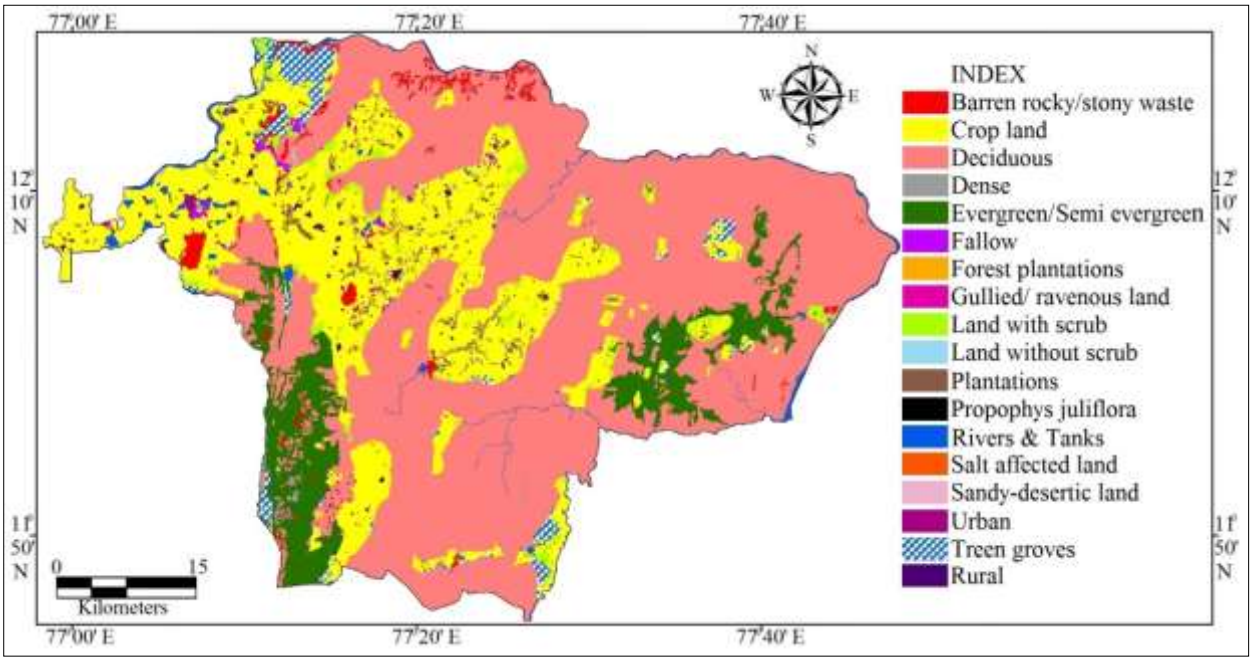
Prosophys Juliflora: Prosophys juliflora is capable of growing in problematic salt affected soils and one of the most tolerant species for saline, alkaline soils (Maliwal, 1999). Growing Prosophys juliflora for ten years can significantly decreases pH, EC, Ca, Mg, K, CO_3, HCO_3, SO_4 and Cl. These are noticed on clayey; clayey-skeletal soil types (Basavarajappa et al., 2013). These are noticed occupying almost all the road sides, neglected areas, lakes and margins of forest lands covering an area of 0.19 Km^2.

River and 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. The area is characterized by sub-dendritic to subparallel drainage pattern. The perennial river Cauvery flows along the northern border of Kollegal taluk and drains the study area with its tributaries Suvarnavathi and Chikkahole (Basavarajappa et al., 2013). The area occupied by river Cauvery, Suvarnavathi and Chikkahole is 25.22 Km^2, 4.13 Km^2, and 0.82 Km^2 respectively. Besides these Gundal, Thattaihalla, Uduthore halla and Palar are the tributaries of Cauvery River which also drains major parts of Kollegal taluk with an area of 4.14 Km^2.

Rural: 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 (Basavarajappa and Dinakar., 2005). Settlements can be clearly noticed from the satellite data due to less number of houses (less than 10 houses) in a village, inter spread with trees and agriculture fields especially in North-western parts occupied by 15.45 Km^2 (0.55%).

Salt-affected area: The areas are delineated based on white to light blue tone and its situation observed in river plains and in association with irrigated lands. These areas are adversely affecting 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 1.70 Km^2 (0.06%).

Figure: 4



Level-II Land Use/ Land Cover map of the study area

Sandy desertic land: Sandy areas are developed insitu or transported by Aeolian or fluvial processes. These occur as a sandy plain in the form of sand dunes, beach sands and dune sands etc., in the study area. Patches of sand bars are observed along the river Cauvery and meandering areas. The area occupied by this category is 0.82 Km^2 and (0.02%).

Urban: 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 (Basavarajappa and Dinakar., 2005).

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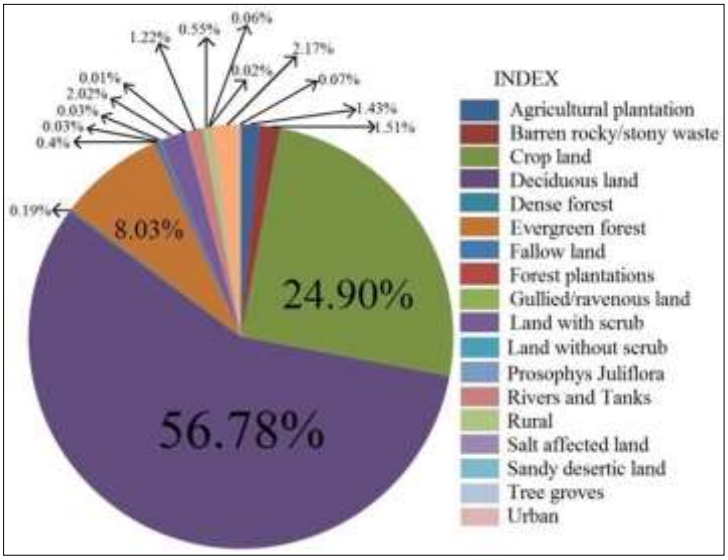
Most of the land covered by building structures such as parks, institutions, playgrounds and other open space within built up areas occupying an area of 2.05 Km^2 (0.07%).

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 in north-western & south-eastern parts of the study area, generally without many bushes or other plants underneath covering an area of 60.78 Km^2 (2.17%).

Table.2. Level-2 land use/land cover classification

Sl. No	Level-2	Area in Km^2	Percentage (%)
1.	Agricultural plantation	40.1937	1.4399
2.	Barren rocky/stony waste/sheet rock area	42.2804	1.5147
3.	Crop land	695.0775	24.9016
4.	Deciduous forest	1585.0505	56.7855
5.	Dense forest	5.5253	0.1979
6.	Evergreen forest	224.1658	8.0308
7.	Fallow land	11.4104	0.4087
8.	Forest plantations	1.0431	0.0373
9.	Gullied/Ravenous land	1.0732	0.0384
10.	Land with scrub	56.4767	2.0233
11.	Land without scrub	0.4391	0.0157
12.	Prosophys Juliflora	0.1971	0.0070
13.	Rivers & Tanks	34.3184	1.2294
14.	Rural	15.4581	0.5537
15.	Salt affected land	1.7064	0.0611
16.	Sandy desertic land	0.8216	0.0294
17.	Tree groves	60.7850	2.1776
18.	Urban (Town/cities)	2.0596	0.0737
	Total	***2778.0820***	***99.5257***
	Total Geographical Area	***2791.2925***	

Figure: 5



Pie chart depicting the Level-II LU/LC classification in Percentage-wise

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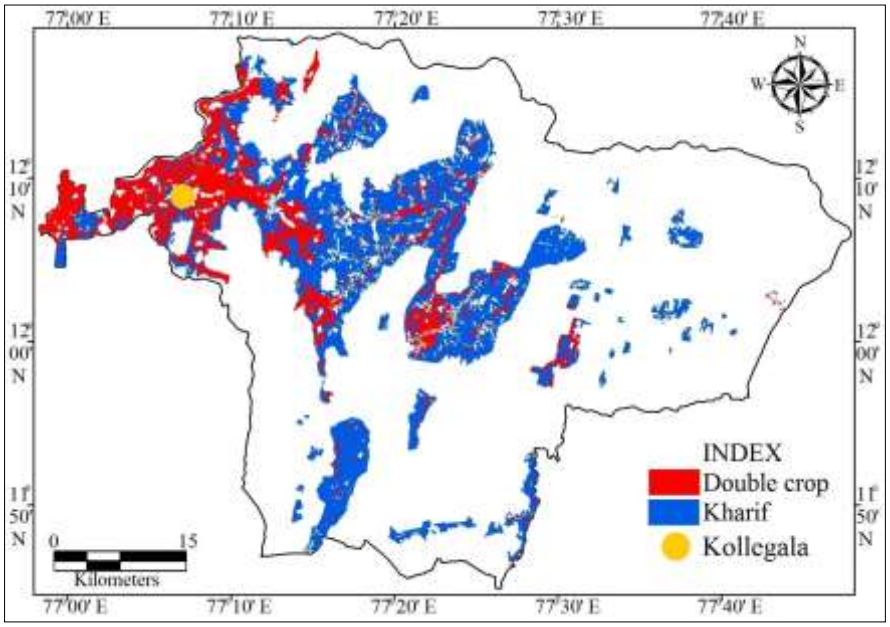
LEVEL-III CLASSIFICATION

Double Cropped: These are identified and mapped using the two season (multi-temporal) satellite images. Double crop areas are concentrated adjacent to the river Cauvery flowing in north-western parts representing Coconut, Sugarcane, Sericulture and others. On FCC, the double crop show a dark red tone with square pattern representing soil covers with higher amount of moisture near the streams. Higher the growth of natural vegetation; higher will be the groundwater availability. The cultivated land at elevated zones show bright red tone generally representing the less amount of moisture and deeper levels of groundwater prospect indicates the moderate groundwater prospect zones. Intensive agriculture is seen in north-western and central parts growing multiple crops in sequence on same land. They are mostly confined to valleys, low lands, alluvial tracts where the groundwater potential is good. The soils are deep, provide good groundwater yield with maximum nutrient holding capacity. This category covers an area of 218.14 Km^2 (%).

Kharif: Kharif includes standing crops from June to September in associated with rainfed crops under dry land farming and limited irrigation. Kharif crops include Jowar, Ragi, Horsegram and others in the study area. The prospect of Kharif crops mainly depends upon the regularity of monsoon to some extent on irrigation facilities. The cultivated land of Kharif season on FCC shows bright red tone. The areas in single crop system with moderately deep to deep soil on nearly level to very gently sloping with good to moderate groundwater potential/accessible surface water resources or both can be put into intensive cropping system. This land occupies an area of 479.56 Km^2 (%).

Figure: 6



Level-III Land Use/ Land Cover map of the study area

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

Sl. No.	Level-3	Area (Km^2)	Percentage (%)
1.	Double crop	218.1424	7.8151
2.	Kharif crop	479.5651	17.1807
	Total	***697.7075***	***24.9958***
	TGA	***2791.2925***	

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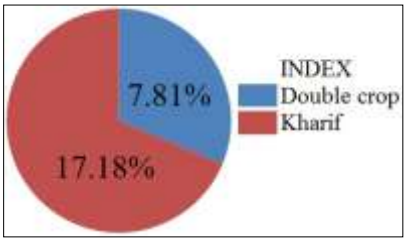
Figure: 7



Pie chart depicting Level-III LU/LC classification in Percentage-wise

CONCLUSIONS

The level-1 classification consists of 6 major categories such as agricultural land, built-up land, forest, grass/ grazing land, wastelands, water bodies and others. These 6 major classes of level-1 are further divided into sub-categories of level-2 for further in detailed study of different LU/LC patterns. Level-3 classification had mapped by keeping cropping pattern under consideration. North-western parts of the study area are almost flat in topography representing agricultural fields on pediplain region, while eastern and southeastern parts are undulated hilly terrain interspersed with cultivated lands confined along the valley. Though it is thickly vegetated, groundwater condition is very poor due to its topography, steep slope and high runoff conditions. Forest covers an area of 64.82% represented by thickly vegetated with evergreen and deciduous forest by thick and parallel chain of hills. Agricultural land covers about 26.18% which includes 17.18% of Kharif crop noticed on pediplain region which are rainfed crops. Double crops are also noticed in pediplains, well developed canal command and tank command areas. The water tanks are located mostly along the drainage course within the pediplain, which are often structurally controlled terrain. Wastelands such as barren rocky/ stony waste/ sheet rocks are noticed as small isolated hillocks found in gneissic terrain in south-western and north-western parts. Scrub lands are observed on pediplains and all along the fringes of the forest areas due to lack of water potential. Understanding the past LU/LC changes highlights the basic human forces & demand of natural mineral consumption and sustainability.

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