ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2017; 3(7): 1047-1059
www.allresearchjournal.com
Received: 10-05-2017
Accepted: 11-06-2017

Katla Shankaraiah
Department of Applied Geochemistry, University College of Science, Osmania University, Hyderabad, Telangana, India

Narsimha Kota
Rural Development Society, Prestige Rai Towers, Flat No.404, B-Block, Punjagutta, Hyderabad, Telangana, and India

Ravi Sanatana
Rural Development Society, Prestige Rai Towers, Flat No.404, B-Block, Punjagutta, Hyderabad, Telangana, and India

Praveen Raj Saxena
Department of Applied Geochemistry, University College of Science, Osmania University, Hyderabad, Telangana, India

Correspondence
Katla Shankaraiah
Department of Applied Geochemistry, University College of Science, Osmania University, Hyderabad, Telangana, India

Supervised classification for Land use land cover analysis and its integration with geology for land resource evaluation in and around Suryapet, Nalgonda district, Telangana, India

Katla Shankaraiah, Narsimha Kota, Ravi Sanatana and Praveen Raj Saxena

Abstract
Categorizing of Land Use/Land Cover (LU/LC) is a dynamic investigation field in ecological remote sensing applications on the earth's surface. The latest multispectral sensors having good resolution with distinctive bands enabled a chance to plot the three-dimensional transmission of elaborated LU/LC categories on a huge disjointed region. The current research encompasses generation of thematic maps i.e. LU/LC map, Geology map and watershed map and finally preparing integrated map by merging LU/LC and geology layers to identify the area of LU/LC classes spread over in diverse lithological units of the area under study. IRS P6 (LISS-III) image data & Advanced Wide Field Sensor (AWiFS) image data were used to derive two seasons (Kharif & Rabi) information of LU/LC by using well versed supervised classification procedure. Geology map delineated from Geological Survey of India map and updated lithological boundaries by superimposing on IRS P6 LISS-III multi-spectral satellite data was used. Apart from these, drainage map and base map were prepared by using topographical maps of Survey of India (SOI) and updated these layers by superimposing on IRS P6 LISS-III multi-spectral satellite image. The study clinches that among all LU/LC classes of the study area; Fallow lands took first place by occupying an area of 443.42 Sq.Km. (35.27%), followed by double crop land occupying an area of 363.00 Sq.Km. (28.98%). The study area was categorized into six sub-watersheds and seventeen check dams, three percolation tanks and one nallah bund were suggested to enhance groundwater levels. Based on the integration of LU/LC and geology layers, it is observed that 99.72% of the LU/LC classes were spatially distributed in igneous rock body of Granieggneissic terrain and remaining part LU/LC classes spatially distributed in ABS & MB, AV and BIF.

Keywords: LU/LC, Watershed, Geology, Supervised classification, Suryapet area

Introduction
Reform of Land Use/Land Cover (LU/LC) is a foremost problem of world ecological apprehension. LU/LC mapping was merged with alternative factors and combined on necessity basis to originate different development indices for water and land resources. Change in LU/LC refers variation, direct or indirect, of traditional environments and their influence on the ecosystem of the region.

LU/LC map is a key information for monitoring many inter-related environmental phenomenon and land uses such as agriculture (Keer & Cihlar 2003) [21], urban planning (Mohan 2005) [30], etc. Despite its significance, producing an accurate land use land cover map is often very pricey and time consuming. Remote sensing technology allows the production of LU/LC map through image classification and this can reduce time, costs and man power which would have been required otherwise (Canadian Center for Remote Sensing, undated). By properly classifying satellite imageries, land use-land cover maps can be produced with better accuracy. However, performing image classification on satellite images can be a daunting task. Prior knowledge of the region under study is also critical when dealing with images that are difficult to interpret. In this study, an attempt is made to perform image classification on satellite-derived images using method of supervised classification to generate LU/LC map of the region under study.

Hence the current research was carried out to assess the present position of LU/LC in study area, by using two season digital satellite data. For Kharif crop evaluation, Satellite image of LISS-III, path/row 101/61, Dec, 2011, and for Rabi crop evaluation, Satellite image of AWiFS, path/row 100/62, Feb, 2012 were used.

Location and extent

The present area under study lies between 16°56′-17°18′ degrees latitude and 79°25′-79°48′ degrees longitude and falls in SOI toposheet number 56 O/12 and partially in its adjacent toposheets (56 O/7, 56 O/8, 56 O/11, 56 O/15, 56 O/16, 56 P/5, 56 P/9 and 56 P/13), covering total area of approximately 1253 Sq. Km (Shankaraiah 2015) [45]. It forms in a locality of Nalgonda district that is finite north by Rangareddy, Warangal districts and south by Krishna, Guntur districts, east by Khammam district and west by Mahabubnagar district (Fig. 1). The Suryapet is well known as main entry gate of Telangana state. Once upon a time this town was geographically a small area having a small group of citizens, in those days the Suryapet name was "Bhanupuri". Later passing days it was renamed as Suryapet and local people also called it as “Peta” and “Sun City”. This town is a big agriculture Centre in Nalgonda District and is having one of the biggest market yard in the Telangana state. Pedda gattu jathara (Golla gattu jathara) is the second largest cultural festival after Sammakka Sarakka jathara festival in Telangana state and it is located at Suryapet out cuts area (Durajpally). During the process of development the town has grown from agri- investments into an industrial hub.

The various types of roads constructed in the study area are: National Highway, metalled and non-metalled roads, cart tracks and foot tracks. One of the Indian National Highways, NH-65 (From Pune to Machilipatnam passing through Hyderabad, Suryapet and Vijayawada) is in the Study area. Metalled and un-metalled roads connect all the settlements in the study area. Suryapet is a one of the revenue divisions of Nalgonda district. It is not only the main city in the study area, but also in Nalgonda district (Fig. 2).

Drainage network pattern

The study area is drained by the left bank canal (Lal bahdur sastri canal) of Nagarjunasagar Reservoir and Musi River (tributary of river Krishna). The Musi River is joining in Krishna River at place of Wadapally and Krishna River joins Bay of Bengal at place of Antharvedi. The ways of both the river passages are structured by two principal lineaments in the directions of East-West and North West-South East. Minor lineaments controlled entire insignificant class streams and nallas. The Krishna River is perpetual and its main tributary Musi is periodic and short-lived. The complete drainage shape of the study area is dendritic to sub-dendritic (Fig. 3).

The weather in the area under study is normal throughout the year when it experiences rain, during the season of South-West monsoon; remaining all over the year weather is torrid and arid. In the study area, there are four types of climatic experiences in a year. From December to first half month of February it experiences cold season. The second half month of February to first seven days of June is summer season. The June to September is experiences South West monsoon season and during October to November is for post monsoon season.

Materials and methods

Survey of India Toposheets (Nos. 56 O/12, 56 O/7, 56 O/8, 56 O/11, 56 O/15, 56 O/16, 56 P/5, 56 P/9 and 56 P/13) was acquired from Survey of India, Hyderabad. A satellite image used for Kharif season is IRS-P6 LISS-III, path/row 101/61, Dec 2011, and for Rabi Season is IRS-P6 AWiFS, path/row 100/62, Feb, 2012 (Fig. 4). These are wont to perceive the three-dimensional dispersion modeling of LU/LC in Kharif and Rabi seasons. Finally level III classified LU/LC map was prepared. The information of LISS-III and AWiFS satellite images are given in (Table 2 & Table 3).

Land use/land cover classification system

The land use term is mostly indirect depended on the appropriate confirmation. The core purpose of a LU/LC scheme is to reform assembling the assortment of knowledge accessible beneath an acceptable frame to enable efficient sequence and mapping additional integrating facts of land use gained from satellite data and alternative sources. The LU/LC categorization prepared for the area under study debates the three levels of LU/LC classes i.e. Level-I, Level-II and Level-III (Table 1). Level-I provides a wide cataloging of various classes of LU/LC and Level-II stretches half-descripted sub-part of data of each wide class. Level-III provides elaborate sub-division of knowledge of every broad category.

Present study aims at bringing out various categories of LU/LC known on the source of satellite data and valid by field observations. The foremost classes recognized are Kharif crop, Rabi crop, double crop, Fallow land, Scrub land and Built-up land (Fig.5). The detailed explanation graph of the LU/LC classes as distribution is given in (Fig.6).

In the present study the supervised classification was done, using ERDAS 8.6 imagine processing software, as it is much extra precise for mapping LU/LC classes, but depends deeply on the abilities of the image professional. The specialist should acknowledge standard categories. He should apprehend whether or not the categories are real and acquainted, or purposeful, however slightly artificial categories, during a scene from earlier data, like personal expertise with the area, by proficiency with thematic maps or federal agency or by field visits. This knowledge allows the professional to settle on and established separate categories and allocates them class labels. The professional should additionally find area under study on the image to spot the categories. The regions representing every familiar land cowl class that seems properly, homogenized on the satellite image as firm by match in tone or color among shapes demarcating the class.

The professional locates the area under study on satellite images drawing them with two-dimensional figure boundaries interpret by the computer mouse on the image display. For every category outline, mean standards and differences for every band wont to classify them are calculated from totally the pixels bounded in the region. Greater than one polygon can be recognized for any category. The result is a spectral signature or spectral response curve for that category. Actually the spectral signature is for all of the materials among the area under study that move with the neighboring polygons. currently

continues by assessable supervision during which every and each element analyzed is compared with the varied signatures and allotted to the category whose signature approaches adjacent, a number of pixels during a scene don't match and stay unclassified, as a result of they will belong to a category not recognized or outlined.

Results

Various classes are identified by supervised classification for the area under study is given in (Table 4 & Table 5).

Built-up Land

It is man-made constructions. All man-made developments cover under this class. Collectively cities, towns and residences are incorporated under this classification. Their shape and high reflectivity differentiate them from other classes. Enhancement techniques and band combinations help segregation of different parcels. Rabi season data provide better expression of the built up area and appear in greenish blue tint. The major built up lands in the study area are Suryapet, Kethepally, Potlapahad, Nemmikal, Lingala, Chandupatla, etc. The total area of built-up land is about 30 Sq. Km, which is 2.39% of the total area under study (Fig. 5).

Agricultural Land

Agriculture is the mainstay of the economy. Agriculture is both irrigated as well as rain fed. The major cropped area appears bright red in colour and areas without crop appear yellowish to greenish blue on the satellite imagery depending on the soil cover and surface moisture. The ground water, major streams and surface storage tanks across higher order water channels provides irrigation for utmost of the regions and to a restricted range in some of the highland areas of the study area. The major crops grown include Paddy, Cotton, Chilly and Groundnut. Much of the crops are grown during Kharif season. The land of agricultural in the study area has been classified as 1. Kharif crop land 2. Rabi crop land 3. Double cropped land 4. Fallow land.

The agricultural land classes delineated in the study area are Kharif, Rabi, Double crop and Fallow land constitute an area of about 1037 Sq. Km, i.e. about 82.76 % of total area under study (Fig. 5).

Kharif crop land

It is irrigated in the period of June/July – October/November. The major water sources for cultivation in this season are rainfall, canals, tanks, dug wells and bore wells. Limited field checks and interaction with agriculturalists disclose that the cultivation in rain fed areas is depends purely on the rains, which are commonly uneven. This category covers an area of 159 Sq. Km. corresponding to 12.69 per cent of the total study area. The crops like Paddy, Cotton, Ground nut and Chilly are the foremost crops in the study area that are cultivated in the Kharif season (Fig. 5).

Rabi crop land

The Rabi crop land is irrigated in between November/December – February/March. However, Rabi crop also follow in rain-fed regions generally associated along with lands of black soil that are retained fallow during Kharif season. Paddy and Groundnut and Cotton are the main crops during this season (Fig.5) & (Table 4). This category covers an area of 72 Sq. Km corresponding to 5.75 per cent of the total area under study.

Double crop land

In this category of land, two crops - one during Kharif season (June – Oct) and the other during Rabi (November – March) or Zaid (February- April) season are raised, depending on the availability of irrigation facility. Generally, Paddy cultivation during both the seasons is the common practice. Alternatively, in Rabi / Zaid seasons, crops like chilly, maize, pulse and sorghum etc. are grown. This category covers an area of 363 Sq. Km, constituting 28.97 per cent of total area under study (Fig.5).

Fallow Land

Vacant agricultural lands where no crop is taken in either of the seasons during the year fall under this class. These lands are particularly seen lacking of crops at the time when the satellite picture is captured of both seasons. The total estimated fallow land area is 443 Sq. Km, which constitutes 35.36 % of total area under study (Fig.5).

The following remedies were suggested to fallow lands:

- Flattening of fallow land and strengthen its boundaries to be done with appropriate drain to removal of extra water.
- Soil test must be conduct to identify the soil problem and to find out the necessary modifications.
- Based on the requirement of soil, compost, urea to be use, especially vermicompost is suggested to apply in fallow lands. Last but not least farmers are suggested to follow the crop rotation method in these fallow lands and not to leave them ideal for many years.

Land with / without scrub

They occupy somewhat higher landscape like uplands or high grounds. These lands are generally prone to degradation or erosion. The total land with / without scrub in the study area is 68 Sq. Km, which constitutes 5.43% of the total area under study (Fig.5).

Water Bodies

This area comprises of Musi River, canals, tanks and one reservoir. Musi reservoir and some small tanks are present in the study area. The Musi River which is a major tributary of River Krishna passes through the study area. Nagarjun Sagar left bank canal (also known as Jawaharlal Nehru canal) also passes through this area. An area of 53 Sq. Km. has been estimated under this category which corresponds to 4.23 per cent of the total area under study (Fig. 5).

Mine / Quarry

Deposits of Granite occur in this area. In the study area, Rough stone and Road metal mineral is available in the small granite quarries and this is useful as building material after crushing. Based on the stone and metal deposits, there are few stone crushers established in study area. There are few Quarry Leases granted for extracting stone and metal. The metal subsequent to squashing will be helpful in building developments and for laying roads. This area is not a significant and is estimated to be about 0.41 Sq. Km (0.038%) in the area under study (Fig. 5).

Barren rocky/Stony waste
These lands are enormous rock outcrops, sheet rocks, and stony land along with extreme group of gravels that are not support to grow up any vegetation. An area of 41 Sq.Km has been estimated under this category which corresponds to 3.27 % area under study (Fig. 5)

Salt Effected Land
When salts more soluble than calcium carbonate and gypsum are present in the soil and affect crop growth and harvest of most crops, these loams are considered salt affected. Most of these soils have an Electrical Conductivity of more than 4 Ohms/cm. An area of 8.13 Sq. Km has been estimated under this category which corresponds to 0.65 per cent of the total area under study (Fig. 5).

Plantations
The plantation is a large piece of land (or water) usually in a semi-humid or humid area wherever one crop is precisely planted for widespread commercial sale and usually tended by resident laborers. Mango, Lemon, Mosmbi, guava plantations are the major plantations cultivated in the study area. The total area of plantations is about 14.38 Sq. Km, which is 1.15% of the total area under study (Fig. 5).

Geology of the study area
The area under study occupies Dharwar Carton's patch area (which is stable) of South Indian shield. It exposes mainly rocks of Peninsular Gneissic Complex, Dharwar Super group (Fig. 7) & (Table 6).

Peninsular Gneissic Complex
Most of the study area is covered by peninsular gneissic Complex (PGC) viz., granites, gneisses, migmatites and undigested patches of older metamorphic rocks. These are light gray, coarse-grained, very hard and moderately dense.
The hornblende schists and amphibolites (older metamorphic) which are the oldest rocks occur, as rafts, enclaves and sporadic lined bands, inside the PGC. These are observed in Northern part and North-Eastern part of the Study area at near Aregudem and Vatti Khammampahad villages of Suryapet division respectively.

Dharwar Super Group Rocks
In the study area, the Dharwar Super group Rocks are represented mainly by Metabasalt, metarhyolite and banded hematite quartzite, running in Southern part of the study area at Madaram village of Miryalaguda Division. It exposes basic, intermediate and acid volcanic rocks associated with agglomerate and thin bands of banded iron formation. These are hard and dense.

Intrusive
The rocks of Peninsular Gneissic Complex and Dharwar Super group are intruded by Younger granites, granitoids of tonalite- trondhjemite- granodiorite composition and dolerite dykes. These dykes are tholetitic to sub alkalic in composition and intrude along E-W, NW-SE and NE-SW. Dating of radiometric by Rb-Sr, Sm-Nd and Pb-Pb methods indicate the age of the dyke systems to be around 2200 Ma. (Pandey, 1997).

Integration of LU/LC and geology for the study area
Geographical Information System application tools are very friendly to process vector data. In present study, LU/LC and Geology layers are integrated by using union tool in Arc GIS 9.3 software and evaluated areas of different LU/LC classes found in different lithological units of the area under study.
By analyzing graphical picture and integration of LU/LC and Geology layers (Fig. 8) of the study area, it is observed that major zones of LU/LC classes were fallow land followed by crop lands. 35.27% fallow land out of total 35.37% fallow lands existed in Granite gneissic (Ggn) terrain in the study area. Table 7 & Table 8 are gives distribution of crop lands between Ggn and other terrains.
Including all existed LU/LC classes in the study, an area of 1249.51Sq.Km out of total 1253.00Sq.Km found in Granite gneissic terrain. Apart from these, other LU/LC classes found in Amphibolites, Biotite, and Schist (ABS) & in Metabasalt, Acid Volcanic and Banded Iron Formation (MB, AV & BIF) (Figure 8) & (Table 8).

Water Conservation and Harvesting
From so many decades agriculture is the main user of groundwater, and also showing major impact on the ecosystem, particularly aquatic ecosystems. However in order to meet food production targets, increase in water withdrawals is inevitable. What agriculture must do is to produce more food of better quality using less water per unit of output, which is why irrigation has a strategic role. Enhancing the facility of sustainable water to cultivation is the requisite to decrease starvation and poverty and also making rapid development in agrarian.
Water conservation measures purely depend upon kind of soils and precipitation of an area. In areas of arid land, rainfall became unique source to agronomic practices. In this study area the maximum annual rainfall is around 850 mm since last 10 years. The access of surface water into the subsurface soil strata is influenced by different factors as ground slope, surface covering and huge lands with no bunds to control runoff of the surface to some extent in order to permit penetration towards ground restore.

Watershed
Certain land area that delivers rain fall and watercourses to a unique channel can be said as Watershed. It comprises of reservoirs, ponds and watercourses. Watersheds can be divided into sub watersheds based on stream orders. The area under study categorized in to six sub watersheds (Fig.9). They are in the directions of North, NE, East, NS, SW-S and SW. The watersheds also have re-charge structures like Check dams, Nala-bunds, Percolation tanks.

Recharge structures
The check dams are on the 1st and 2nd order streams, made of locally available materials like loose rocks, woven wire, slabs etc. The life of the check dam depends on the quality of the materials and efficiency of construction. Check dams can be preventing the speed of surface water flow, and also decrease the attrition.
In the study area these check dams are intercepting the rainfall water from the upland water channel of the native catchments and it stocks for direct usage or to recharge groundwater of the lowland channel wells. In the study area, 17 check dams are suggested – four in North direction, nine

in NE direction, one in SE direction, two in SW directions and another one check dam is in NW direction (Fig. 9).

Percolation tanks and Nallah bunds are the continuous automated restore structures built crossing nallah to control the speed of run-off and to upsurge surface water percolation in order to recover soil wetness system. Nallah bunds are comparatively same structures as percolation tanks but they are used on diverse areas. In the area under one Nallah bund is in south direction and three percolation tanks are suggested – one in East, one in West and another one in South directions (Fig. 9).

Farm ponds

Farm ponds can be said as the artificial water storing basins and are generally develops in areas of agrarian by digging a well like with some width and enough depth. These ponds will offer water for livestock, cultivation and for aquaculture. This type of farm pond was observed in Potlapahad village in the study area. They can also bring about effective gully control. A farm pond has to be carefully located at the lower end of the farm to take advantage of available low ground or depression. Planning, designing, lying out, and constructing farm ponds involve competent engineering. Soils, runoff, hydrology, watershed characteristics, water movement and other local factors have to be carefully considered especially for large ponds.

Thus from above discussion, we can conclude that soil erosion which is the major problem in the study area should be curtailed. Water harvesting should be given importance, so as to avoid the wastage of water by runoff. This will also increase the groundwater recharge, besides providing supplementary irrigation during Rabi season.

Guidelines for watershed development

The key guidelines for watershed development consist of

- Identifying appropriate places for rain water harvesting through building of small structures across the minor streams (Fig.9).
- Renovation of existed tanks with enhancing its width and depth for increasing its water stocking capability and enabling groundwater recharge.
- The following recommendations were proposed for sustainable development of the study area.
- Degraded Forests are to be afforested with trees, which will produce raw material for rural industries, like leaf plates products, carpentry etc.
- Unused arable lands to be reclaimed through Agro-horticulture by proper construction of soil conservation and water harvesting structures like mini percolation tanks.
- Desilting of tanks to be carried out to increase the water storage capacity and recharge.
- Systematic and scientific approach to be followed for plantation.
- Systematic and scientific approach to be followed for cropping patterns, crop rotation, intensity of cropping, etc.
- Crop diversification by increasing area under crops and adaptation of crops requiring less water.

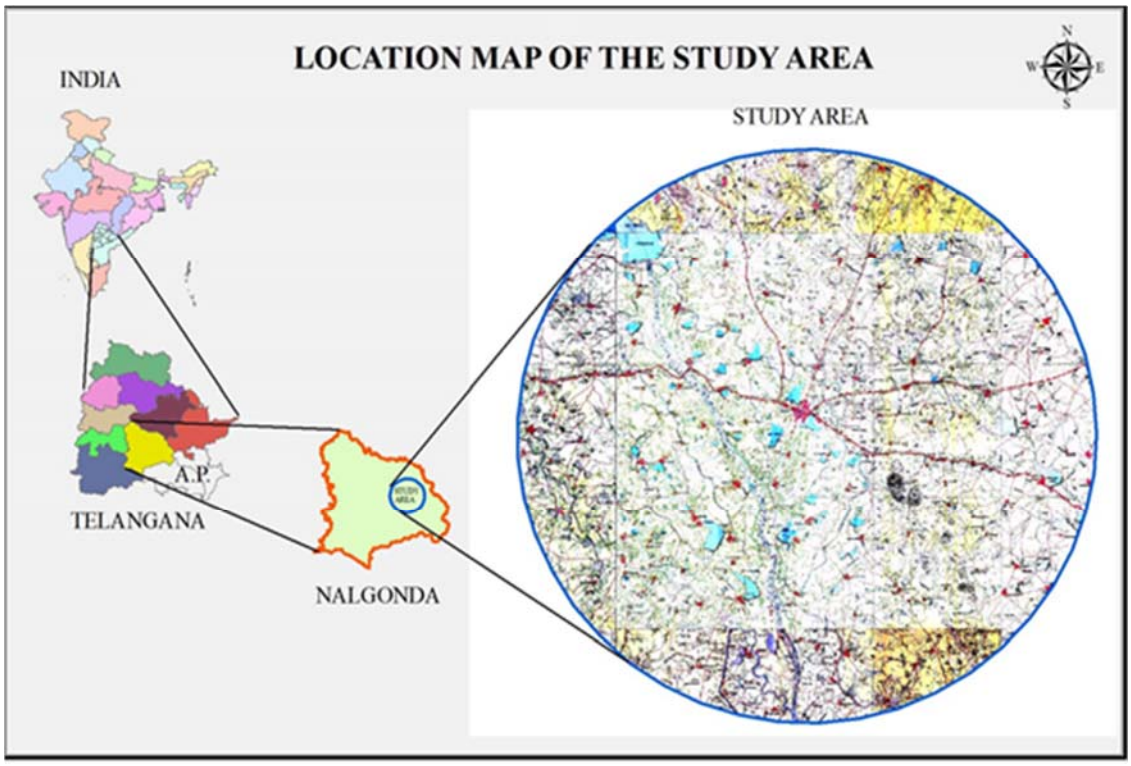

Fig 1: Location map of the study area

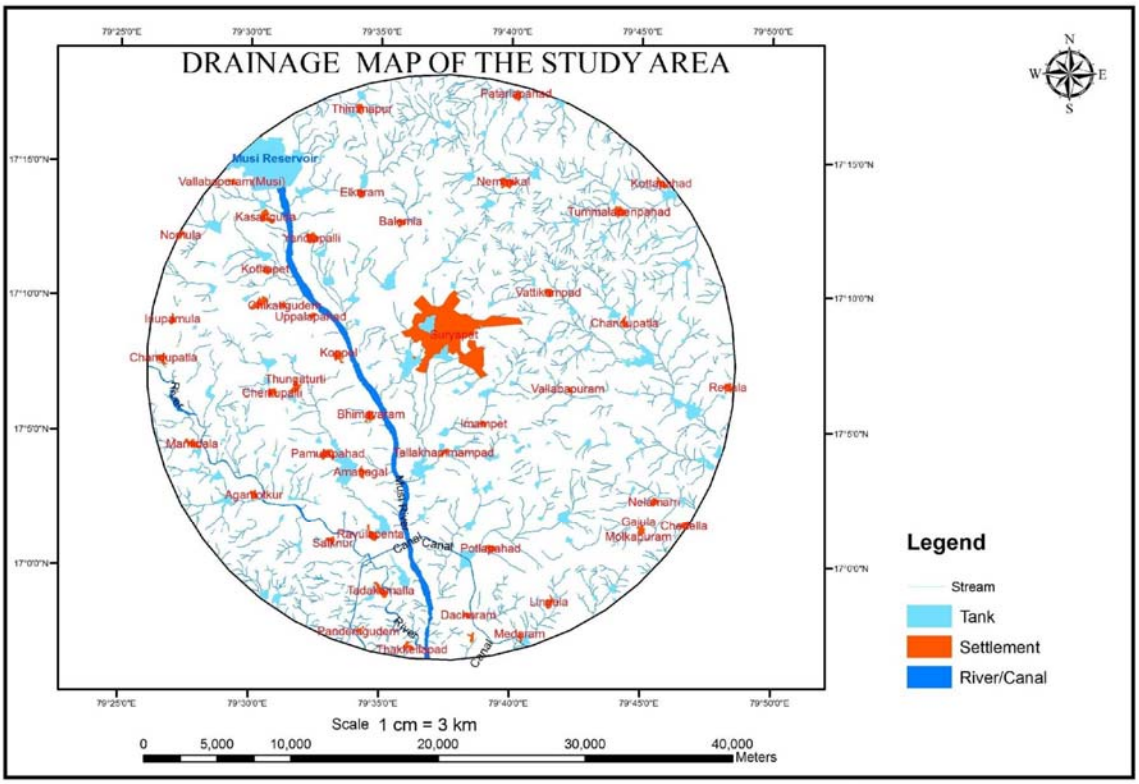

Fig 2: Base map of the study area

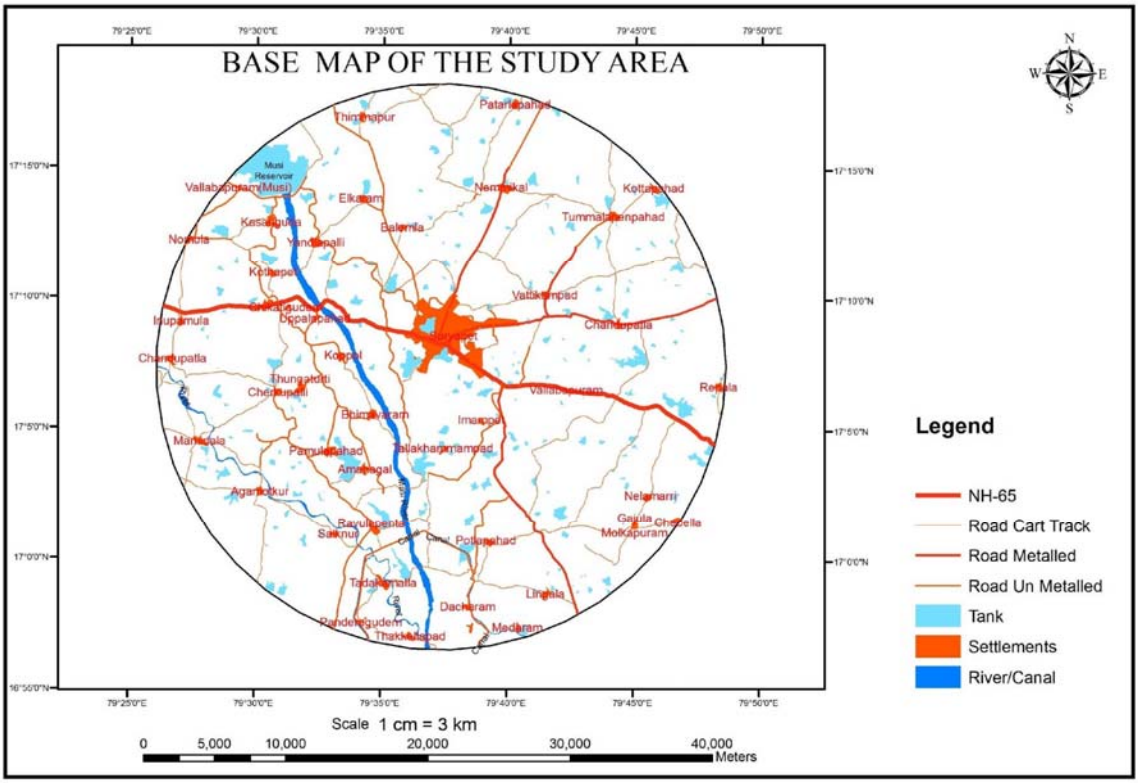

Fig 3: Drainage map of the study area

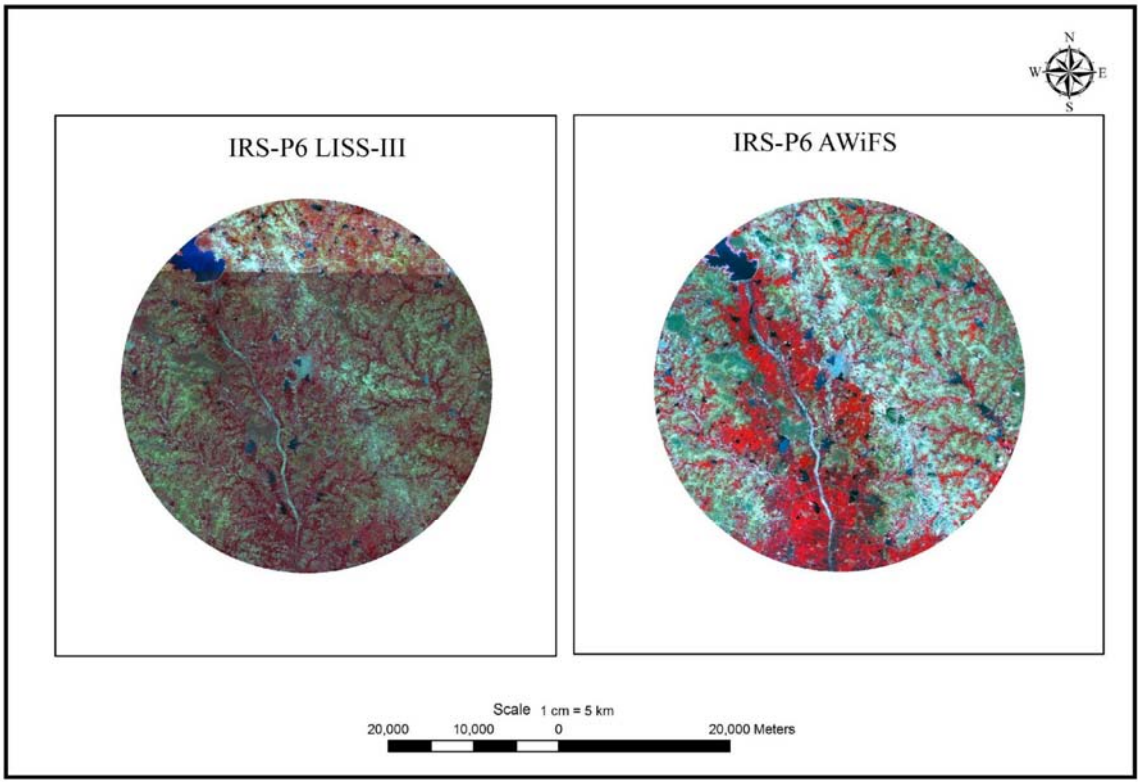

Fig 4: Satellite image of the study area

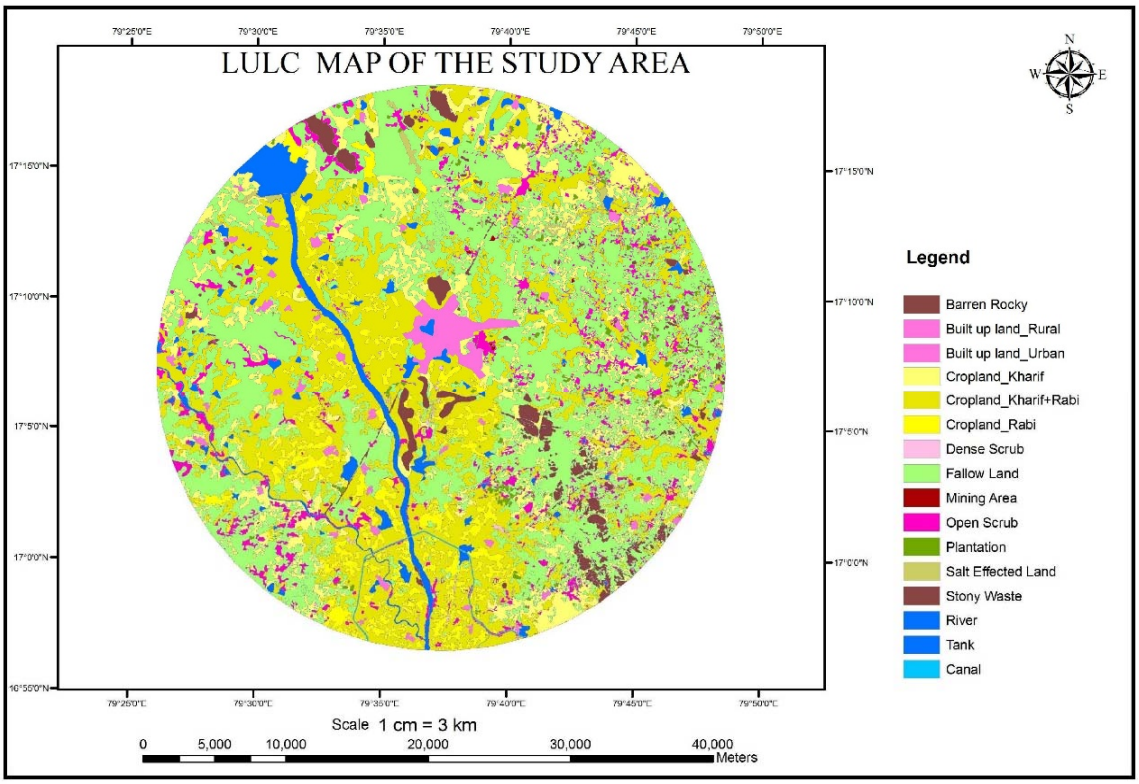

Fig 5: Satellite image of the study area

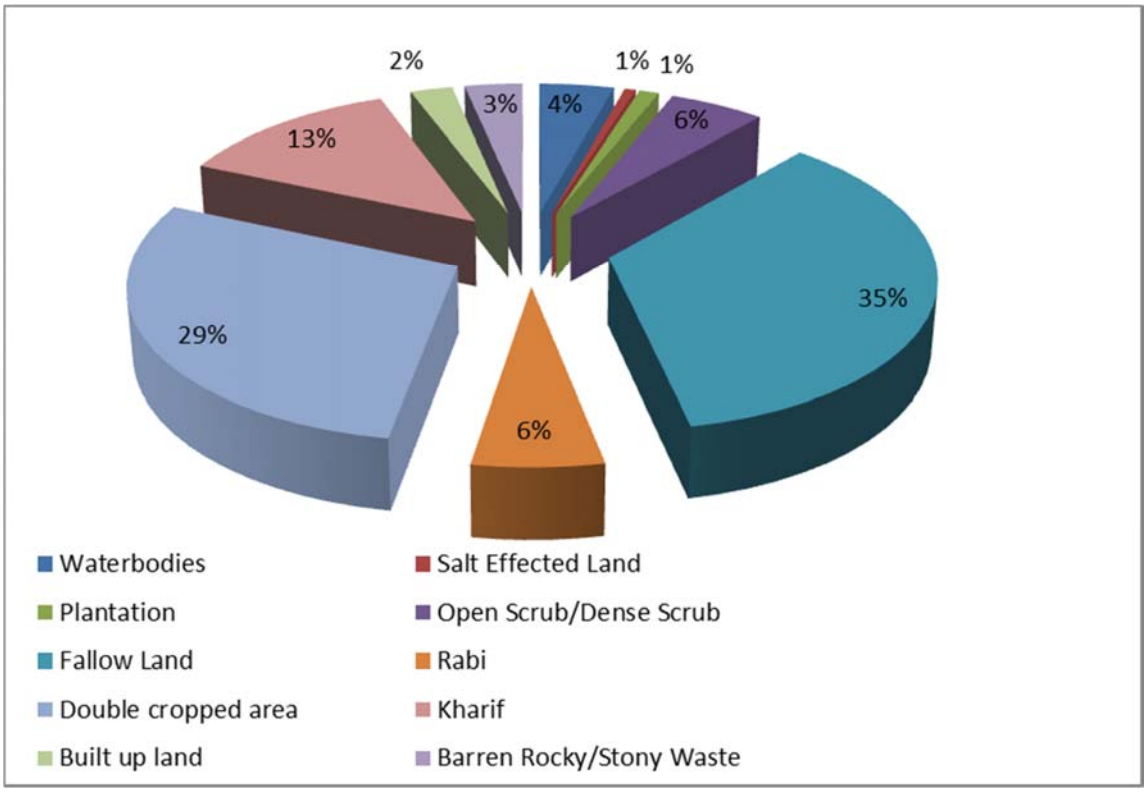

Fig 6: LU/LC map of the study area

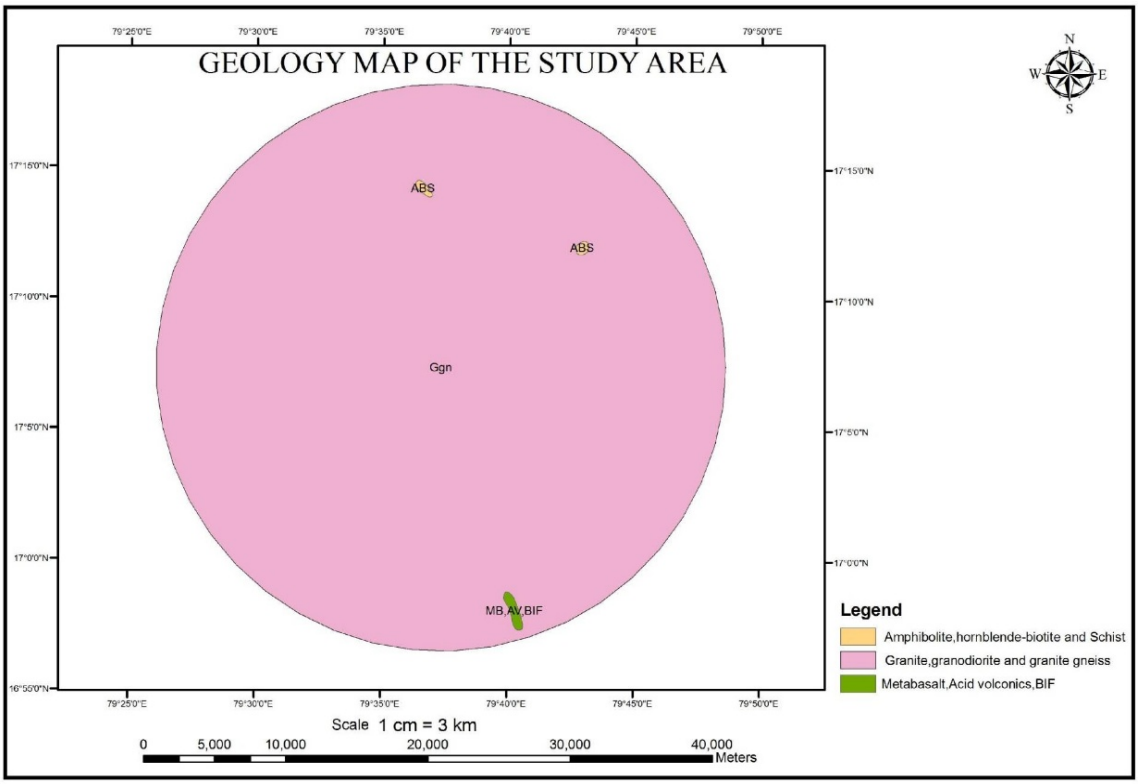

Fig 7: Geology map of the study area

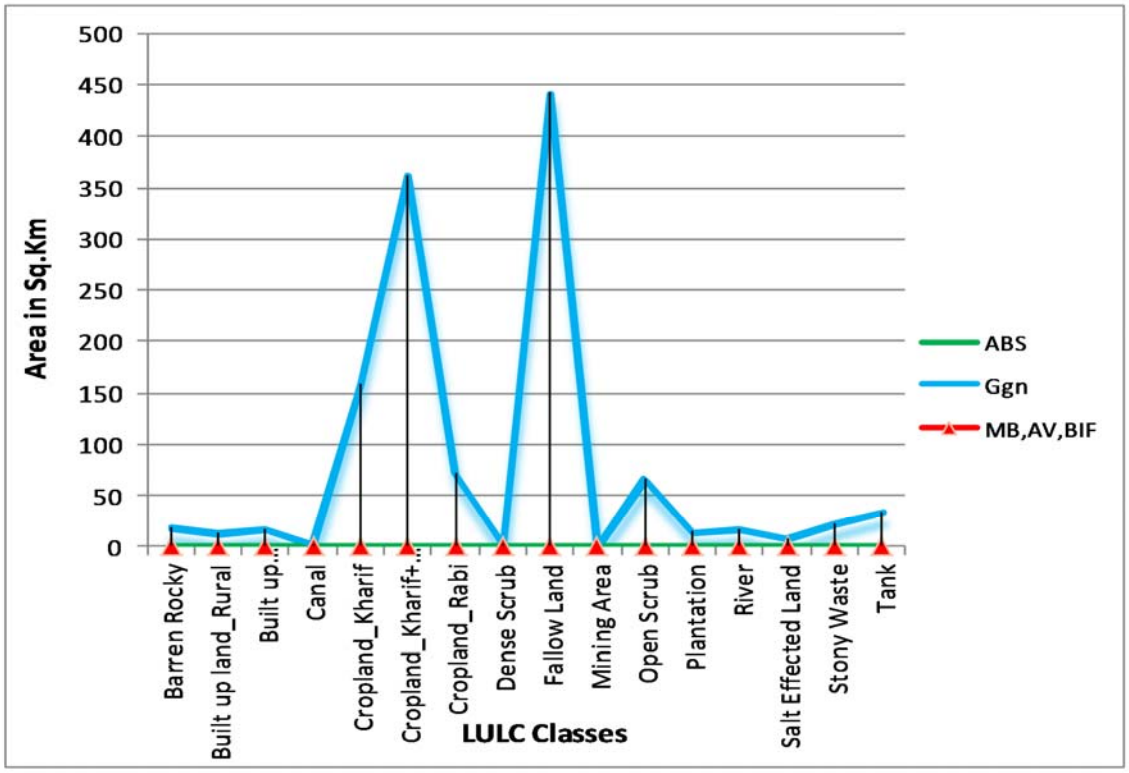

Fig 8: Integrated graph of LU/LC & Geology in the study area

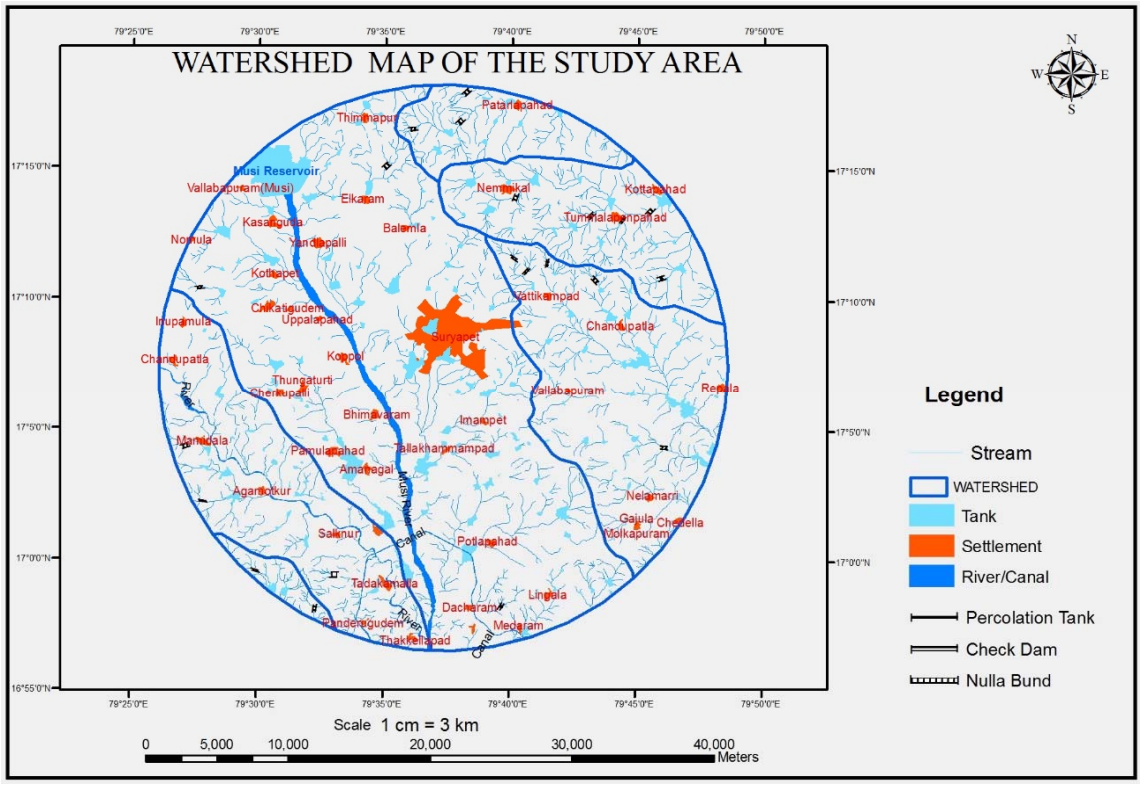

Fig 9: Watershed map of the study area

Table 1: Land Use / Land Cover classes

S. No.	Level - I	Level - II	Level - III
1	Built up	Urban	Residential
			Mixed builtup
			Recreational
		Rural	Rural
		Industrial	Industrial Area
		Mining/Quarry	Quarry
2	Agricultural Land	Crop Land	Khari crop land
			Rabi crop land
			Zaid crop land
			Double crop
		Fallow	Fallow
		Agriculture plantation	Agriculture plantation
		Aquaculture	Aquaculture
3	Waste Land	Scrub land	Open scrub
			Dense scrub
		Barren rocky	Barren rocky
4	Water bodies	River	Perinnial
			Non-Perinnial
		Canal/Drain	Canal/Drain – lined
			Canal/Drain – unlined
		Resevoir,Tank	Permanent
			Seasonal

(**Source:** North Eastern Space Application Centre (NESAC)

Table 2: Details of IRS P6 Satellite images of the study area

S. No	Path/Row for IRS - P6 Satellite Data	IRS - P6 Satellite Data type	Date of Satellite Image	
1	101/61	LISS-III	KHARIF	Dec-11
2	100/62	AWiFS	RABI	Feb-12

Table 3: IRS P6 Satellite data – spectral bands, spatial resolution and their principal applications of the study area

Sensor	Wavelength (microns)	Spatial Resolution (meters)	Ground swath (Km)	Principal application
LISS-III	0.52 – 0.59	23.5	141	Vegetation type and vigor assessment;
	0.62 – 0.68			Rock/soil boundary differentiation;
	0.77 – 0.86			surface water; turbidity and bathymetry in shallow waters;
	1.55 – 1.70			mining areas; settlement & transport network
AWiFS	0.52 – 0.59	56	740	Vegetation type and vigor assessment;
	0.62 – 0.68			rock/soil boundary differentiation;
	0.77 – 0.86			surface water; turbidity and bathymetry in shallow waters;
	1.55 – 1.70			mining areas; settlement & transport network

(**Source:** NRSC 2010)

Table 4: Land Use/Land Cover classes of the study area

S. No.	LULC Class	Area in Sq. Km	Area in %
1	Barren Rocky	18.44	1.47
2	Built up land_Rural	12.77	1.02
3	Built up land_Urban	17.31	1.38
4	Canal	1.64	0.13
5	Crop_land_Kharif	159.23	12.71
6	Double Crop_land_Kharif+Rabi	363	28.98
7	Crop_land_Rabi	71.81	5.73
8	Dense Scrub	1.93	0.15
9	Fallow Land	443.42	35.37
10	Mining Area	0.48	0.04
11	Open Scrub	66.27	5.29
12	Plantation	14.38	1.15
13	River	17.09	1.36
14	Salt Effected Land	8.13	0.65
15	Stony Waste	22.71	1.81
16	Tank	34.39	2.75
	Total	1253	100.00

Table 5: Land Use / Land Cover classes distribution

S. No.	LU/LC Class	Area (in Sq.Km.)	Area (in %)
1	Built up land	30	2.39
2	Kharif	159	12.69
3	Rabi	72	5.75
4	Double cropped area	363	28.97
5	Plantation	14	1.12
6	Fallow land	443	35.36
7	Salt effected land	8	0.64
8	Open/Dense scrub	68	5.43
9	Barren rocky/Stony waste	41	3.27
10	Water bodies	53	4.23
	Total	1253	100

Table 6: Geological succession in the study area

Type of Rock formation	Rock Group	Age	Characteristics
Basic Dyke, (Dolerite, Pyroxinite, Gabbro)			Hard, massive, dense
Granite = closepet granite	Younger intrusive	Paleo - Me so Proterozoic	Pinkish to whitish, hard, massive
Meta basalt with bands of BIF (Basic volcanic)	Dharwar Super group	Paleo Proterozoic	Hard, massive
Granodiorite-adamellite			Hard, foliated
Predom. granite & alkali feldspar granite	Peninsular Gneissic Complex		Hard, compact
Migmatite		Archaean	Hard, compact
Amphibolite, Hbl biotite schist	Older metamorphic		Moderately hard, foliated

Table 7: Distribution of Crop lands in various lithological units in the study area

Crop type	% of total area in (Sq.Km.)	% in Granite gneissic terrain. in (Sq.Km.)
Double crop land	28.98	28.94
Kharif crop land	12.70	12.65
Rabi crop land	5.70	5.73

Table 8: Distribution of LU/LC classes in various lithological units in the study area

S. No.	LULC CLASS	ABS area in (Sq.Km)	Ggn area in (Sq.Km)	MB,AV,BIF area in (Sq.Km)	Total area in (Sq.Km)
1	Barren Rocky	0.03	18.41	0	18.44
2	Built up land_Rural	0	12.68	0.08	12.77
3	Built up land_Urban	0	17.31	0	17.31
4	Canal	0	1.64	0	1.64
5	Cropland_Kharif	0.02	158.55	0.56	159.13
6	Cropland_Kharif+Rabi	0.02	362.71	0.26	363
7	Cropland_Rabi	0.44	71.37	0	71.81
8	Dense Scrub	0	1.93	0.01	1.93
9	Fallow Land	0.75	441.94	0.41	443.11
10	Mining Area	0	0.48	0	0.48
11	Open Scrub	0.02	65.97	0.28	66.27
12	Plantation	0.02	14.37	0	14.38
13	River	0	17.09	0	17.09
14	Salt Effected Land	0	8.08	0.05	8.13
15	Stony Waste	0.07	22.68	0	22.75
16	Tank	0	34.35	0.04	34.39
	Grand Total	1.37	1249.51	1.68	1253

Summary and conclusions

The present study has been carried out to sustainable land management by the help of Remote Sensing & GIS applications. Land resource evaluation of the study area based on the IRS- P6, LISS –III and AWiFS digital satellite data has been carried out. The methodology of supervised classification was used to prepare LU/LC map. Mapping of spatially distributed classes of LU/LC in the study area reveals that Fallow lands occupied major part followed by double crop land is in Granite gneissic terrain. The study area was categorized into six sub-watersheds and seventeen check dams, three percolation tanks and one nallah bund are suggested to enhance groundwater levels. Based on the integration of LU/LC and geology layers, it's observed that 99.72% of the LU/LC classes are spatially distributed in igneous rock body of granitegneissic terrain and remaining part LU/LC classes are spatially distributed in schists and amphibolites, Meta basalts and banded iron formations. Implementation of proper technical management of groundwater resources as drip irrigation sprinklers etc. and also soil corrosion stopping techniques as gully plugging, bundling, etc. These are all would practically improve the potential of groundwater. Superimposing admin boundaries on the LU/LC model will support agronomists for their field management. The present work will be useful to identify the land problems on its unsuitability for cultivation and its

potential to most suitability for which crop for whole growth on a viable source. Thus the way, groundwater source sensibly in a minor hydrology part has the primary priority. So the factual merge of technical methods and local intelligence would be a successful amalgamation.

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