Change Detection of Land Use and Land Cover Over Ghataprabha River Basin

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Abstract: ***The region of the Ghataprabha River basin has undergone rapid, wide - ranging variation in land usage and land coverage (LULC) intensified by the alteration of natural topography for food purposes, urbanization, and other socioeconomic benefits. This study examined the usage of remote sensing and GIS techniques to gain a quantitative understanding of the spatiotemporal dynamics of LULC. The goal of the current study was to map land coverage and land usage changes that occurred in the Ghataprabha river basin between 2014 and 2016 and analyze them using Remote Sensing (RS) data, Global Positioning System (GPS), and Geographic Information System (GIS). The land cover and land use study were conducted by mapping LANDSAT 8 satellite data of 3 different years (2014 to 2016) with the help of Quantum GIS. The valuation of LU/LC in 2014, 2015, and 2016 derived from the satellite images which indicates that there is a noteworthy increase in built - up area, vegetation, and other lands. Additionally, it needs to be highlighted that a significant amount of agricultural land, water - spread land, and dense forest disappeared in the time of study period, possibly as a consequence of the area's quick urbanization.***

Keywords: LULC - Land use and land cover, image classification, The Ghataprabha river basin

1. Introduction

Land usage and land coverage indicates to the physical and anthropological actions that is performed on the earth's surface and the resulting characteristics of that surface. It provides an outline for understanding and categorizing the way land is utilized by human societies and the natural environment. Land use refers to the human activities and purposes for which land is used. This includes actions such as agriculture, residential areas, industrial sites, transportation infrastructure, commercial zones, recreational areas, and conservation areas. The usage of land results is influenced by social, economic, cultural factors, and environmental considerations. While land cover refers to the physical qualities of the earth's surface, it can also refer to man - made features like structures, highways, and impervious surfaces. Natural elements like forests, grasslands, marshes, deserts, and water bodies are all included in land cover. Land cover can be observed and categorized using remote sensing (RS) techniques, which involve capturing and analyzing satellite image data, airborne photographs, and other sources.

The relationship between LULC is interconnected. Human actions and land managing practices influence the land cover by changing natural regions into urban or agricultural landscapes. Conversely, variations in land cover, such as deforestation or urbanization, can have significant impacts on land use shapes and ecosystem services. Understanding LULC is crucial for various disciplines and sectors. Urban planners, environmental scientists, conservationists, policymakers, and land managers use LULC data to assess environmental changes, plan sustainable land use strategies, monitor ecosystem health, identify areas of conservation priority, and address issues related to land degradation, urban sprawl, biodiversity loss, and climate change. To analyze and depict land use and land cover, various classification systems and maps are employed. These systems categorize the landscape into different classes or categories based on specific criteria, allowing for spatial analysis, trend monitoring, and comparison across regions and time periods. In conclusion, LULC offers a useful framework for comprehending the intricate relationships between human activity and the natural environment, assisting in sustainable land management and decision - making procedures.

Variation over LULC refers to the procedure of identifying and analyzing the changes that happen in the earth's surface over time. It involves comparing different sets of data, such as satellite imagery or aerial photographs, captured at different periods to recognize and calculate the changes in LULC categories. Land use refers to how the land is utilized by humans, such as for residential, agricultural, industrial, or recreational purposes. Land cover describes the physical appearance of the earth's surface, including vegetation, water bodies, dry soil, and built - up areas. Change detection over LULC plays a crucial role in various lands, including urban planning, ecological monitoring, natural source managing, and disaster assessment. By identifying and quantifying changes, researchers, policymakers, and land managers may monitor environmental trends, understand the effects of human activity, and make wise choices for sustainable development. The process of change detection typically involves the: data acquisition, preprocessing, image registration, change detection, change classification, accuracy assessment, change examination and interpretation.

Change detection over LULC is facilitated by advancements in remote sensing (RS) technology, such as high - resolution satellite sensors, multi - temporal imagery, and automated image processing techniques. It offers useful knowledge for solving environmental problems, promoting sustainable development, and protecting natural resources.

From the last one decade it is observed that lot of activities such as industrialization, modern agricultural practices, urbanization, etc.; are reported over the Ghataprabha river basin. Therefore, the Ghataprabha River basin is considered as a study area in present study

2. Literature Survey

Pontius et al., (2004) [1] This paper focuses on the assessment and comparison of different modelling approaches used to pretend LULC. The authors analyze the input, output, and validation data of several land change models, highlighting the challenges and occasions associated with modelling LULC dynamics.

Foley et al., (2005) [2] This paper discusses the global consequences of land usage change, emphasizing its influence on carbon emissions, biodiversity loss, and climate change. It provides an overview of land use outline and the driving forces in land usage change.

Lambin et al., (2006) [3] This paper provides an in - depth analysis of LULC change processes, including deforestation, urbanization, and agricultural expansion. It explores the local and global implications of land use variation and presents case studies from various regions.

Turner et al., (2007) [4] This study analyse the intricate linkages between social, economic, and environmental main factors that drive LU change and illustrate the rise of land variation research as an interdisciplinary topic. It offers a conceptual framework for comprehending the processes involved in land change.

Seto et al., (2012) [5] This paper explores the teleconnections between urbanization in one region and LU change in distant locations, emphasizing the importance of considering the global impacts of urban expansion. The authors discuss the environmental and socioeconomic implications of urban land use changes and propose strategies for supportable urban development.

Hansen et al., (2013) [6] This technical paper shows a examination of worldwide forest cover change using high - resolution satellite imagery. The authors demonstrate the causes and significances of deforestation and the forest regrowth, highlighting the importance of regional and local factors in driving land use change.

Verburg et al., (2013) [7] This paper introduces the concept of land system science, which integrates social, economic, and environmental perspectives to study land use change. The authors discuss the importance of considering local contexts and spatial heterogeneity in land change research and advocate for better integration of land system science in policy - making processes.

3. Problem Definition

From the last one decade it is observed that lot of activities such as industrialization, modern agricultural practices, urbanization, etc.; are reported over the Ghataprabha river basin. Therefore, the Ghataprabha River basin is considered as a study area in present study

4. Study Area

The present study was conducted in the Ghataprabha river basin, forms the south - central part of the Indian peninsula. The study area is confined between the latitudes 15^0 39' N and 16^0 30' N and the longitudes 74^0 00' E and 76^0 61' E, as shown in Figure 1.

The Ghataprabha River is a major river in the Indian state of Karnataka. It is part of the Krishna River basin and flows through the Belagavi district of Karnataka. The river originates in the western ghats and is formed by the meeting of two smaller rivers, the Markandeya and the Malaprabha. The Ghataprabha River basin is spread over an area of approximately 8, 829 km^2. It is a tributary of the Krishna River and joins it near the town of Alamatti in Bagalkot district. The basin's productive agricultural regions are well known and are a vital source of water for irrigation. The Ghataprabha River passes through several towns and villages, including Gokak, Hukkeri, and Athani. It is home to the famous Gokak falls, a picturesque waterfall located near the town of Gokak. The river is utilized for irrigation purposes and along its path, numerous dams and reservoirs have been built, including the Hidkal dam.

The Ghataprabha River basin is ecologically significant and supports a diverse range of flora and fauna. The region is known for its good biodiversity, including several species of birds and fish. The river and its sides also have historical and cultural importance, with ancient temples and historical sites situated in the basin, overall, the Ghataprabha river basin is an important water resource in Karnataka, providing irrigation water for agriculture, supporting local ecosystems, and contributing to the cultural heritage of the area.

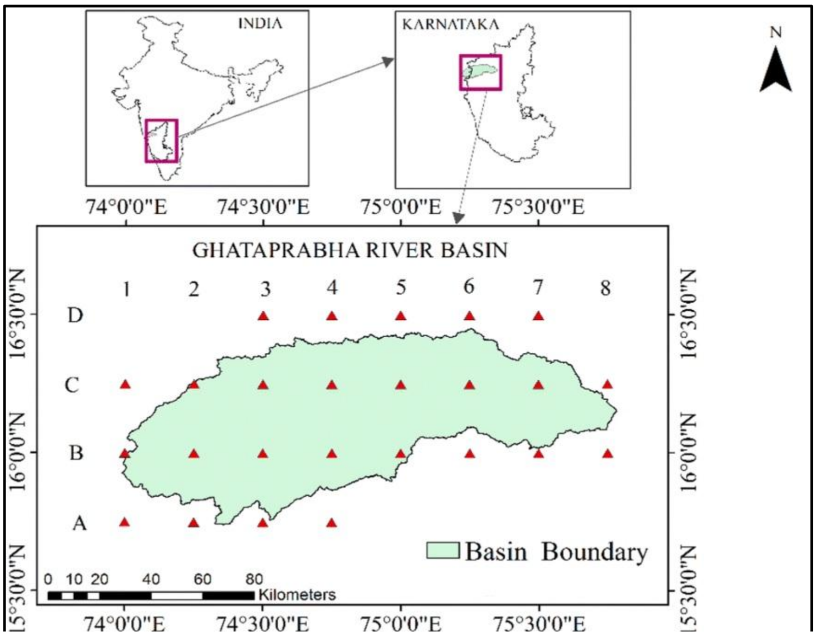

Figure 1: Study area of the Ghataprabha river basin

5. Materials and Methodology

5.1. Software Used

Quantum GIS (QGIS) is used to prepare LULC map. QGIS is a free and open - source GIS software. It is widely used for viewing, analysing, and editing geospatial data. QGIS provides a user - friendly interface with a comprehensive set of tools for working with various types of spatial data, such as shapefiles, geodatabases, raster images, and GPS data.

5.2. Data Used

For the current study, three years' worth of multispectral, multitemporal Landsat 8 satellite data of the Ghataprabha river basin were collected: 2014, 2015, and 2016. All of the images are from the pre - and post - monsoon months. Satellite imagery data was utilized for investigating the historical changes of LULC over 4 years from 2014 to 2016. Landsat data were taken from the "United States Geological Survey" (USGS) website (https: //earthexplorer. usgs. gov/). To assure the best comparability, images were chosen during March, April, and November when the sky is usually clear, which has made to obtain cloud - free imagery with the best visibility.

Landsat 8 is a satellite mission operated by NASA and the USGS as a portion of the Landsat program. It was launched on 11/02/2013 and is the most recent satellite in the Landsat series. Landsat 8 carries the "Operational Land Imager" (OLI) and the "Thermal Infrared Sensor" (TIRS) as its primary instruments. The OLI captures images of the Earth's surface in nine spectral bands, including visible, near infrared, and short - wave infrared regions of the EM spectrum. These bands offer useful statistics for a variety of applications, including mapping land cover, monitoring agriculture, and environmental assessments. The TIRS instrument on Landsat 8 measures the thermal infrared radiation emitted by the earth's surface. This data is utilized to calculate land surface temperatures, monitor volcanic activity, and assess water body temperatures, among other applications. The following Table 1 represents Landsat - 8 Bands, wavelengths in micrometres & resolution in meters.

Table 1: Landsat - 8 Band Details

Bands	Wavelength (micrometres)	Resolution (meters)
Band 1 - Coastal / Aerosol	0.433 - 0.453 µm	30 m
Band 2 - Blue	0.450 - 0.515 µm	30 m
Band 3 - Green	0.525 - 0.600 µm	30 m
Band 4 - Red	0.630 - 0.680 µm	30 m
Band 5 - Near Infrared	0.845 - 0.885 µm	30 m
Band 6 - Short Wavelength Infrared	1.560 - 1.660 µm	30 m
Band 7 - Short Wavelength Infrared	2.100 - 2.300 µm	30 m
Band 8 - Panchromatic	0.500 - 0.680 µm	15 m
Band 9 - Cirrus	1.360 - 1.390 µm	30 m
Band 10 - Long Wavelength Infrared	10.30 - 11.30 µm	100 m
Band 11 - Long Wavelength Infrared	11.50 - 12.50 µm	100 m

Landsat 8 orbits the Earth in a sun - synchronous polar orbit, which means it passes over the same location at approximately the same time each day. It captures images with a spatial resolution of thirty meters for many of the spectral bands, except for the panchromatic band with a resolution of 15 meters.

The data collected by Landsat 8 is freely available to the public and has been broadly used by scientists, researchers, government agencies, and other organizations for monitoring variations in the earth's land surface over time. The continuity of the Landsat program, with each satellite building upon the previous mission's data, has provided a valuable dataset for studying long - term environmental changes and making informed decisions related to land management and resource planning. It's worth noting that while strive to provide accurate and up - to - date information, my knowledge was last updated in September 2021.

The following Table 2 represents the Source and characteristics of satellite imagery utilized in this work.

Table 2: Source and characteristics of satellite imagery utilized in this work

Satellite data	Path/Row	Image date	Land cloud cover (Percentage)	Spatial resolution
L8 OLI/TIRS	146/049	14/04/2014	0.02	30 m
L8 OLI/TIRS	146/049	08/11/2014	0.38	30 m
L8 OLI/TIRS	146/049	01/04/2015	0.04	30 m
L8 OLI/TIRS	146/049	27/11/2015	0.02	30 m
L8 OLI/TIRS	146/049	18/03/2016	0.00	30 m
L8 OLI/TIRS	146/049	29/11/2016	0.14	30 m

5.3. Process flowchart:

Figure 2 depicts the general process of this work to derive statistics about the area's land use pattern.

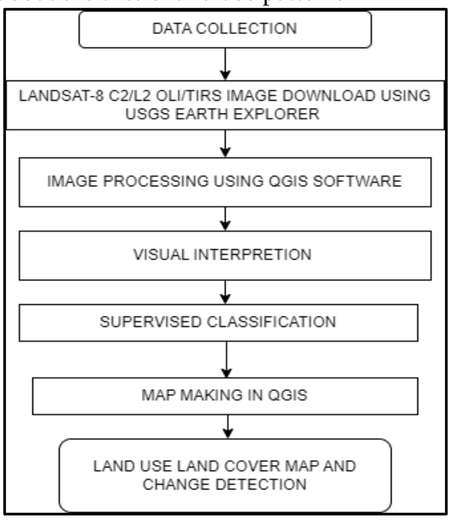

Figure 2: Flow chart

a) Data collection: For this study, Landsat 8 satellite images from the latest Landsat series were utilized. The data were sourced from the USGS Earth Explorer platform (http: //earthexplorer. usgs. gov). The date of satellite data were decided built on the less cloud cover over percentage. Satellite data of Landsat - 8 were taken from the USGS website.
b) Landsat 8: The Landsat 8 OLI/TIRS satellite, an American Earth observation satellite, was launched on Feb 11, 2013. This satellite comprises two instrument sensors: the "Operational Land Imager" (OLI) and the "Thermal Infrared Sensor" (TIRS). The OLI possesses 9 spectral bands with spatial resolutions ranging from 15 to 30 meters, capturing information across the visible, near infrared, and mid - infrared regions. Meanwhile, TIRS comprises 2 spectral bands of spatial resolution of 100 meters, acquiring data from the thermal region (U. S. Geological Survey (USGS) 2013).
c) Image processing: Preprocessing of raw Landsat data taken from USGS has been done using the metadata file supplied along with the satellite image. Correction factors given in the metadata have been used to correct the satellite image free from atmospheric abstraction. Similarly, sun angle correction is also applied to make the image free from radiometric correction.
d) Visual interpretation: Visual interpretation was done over the corrected image to identify different LULC patterns. True and false composition images, where layers are stacked to identify the different topographic features.
e) Supervised classification: Supervised classification was done by taking training samples and processing them in QGIS. Steps given in section 4.3 were followed during the classification process
f) Map making: The map of The Ghataprabha LULC was prepared using map layout in QGIS software by giving all map components such as map title, legend, scale, and north arrow.
g) LULC map and change detection: The percentage of each LULC feature covered in the map was extracted from supervised classification results for the pre - monsoon and post - monsoon period. Variation of percentage between the pre - monsoon and post - monsoon was tabulated along with a spatial map of LULC

The date of satellite data were decided founded on the less cloud cover over percentage. Satellite data of Landsat - 8 were taken from the USGS website. Supervised classification was done by taking training samples and processing them in QGIS. Visual interpretation was done to recognize the type of LULC features. A map of the Ghataprabha LULC was prepared using a map layout using QGIS then the percentage of LULC was extracted.

6. Results and Discussion

The following Table 3 represents the percentage of land usage & land coverage data for 2014

Table 3: Land use & land coverage data 2014

Land use/landcover	2014			
Month	April		November	
	Sq km	%	Sq km	%
Dense vegetation	663.27	7.99	2487.42	29.97
Sparse vegetation	2054.81	24.75	1638.78	19.74
Water	55.33	0.67	171.40	2.06
Barren land	3886.28	46.82	3157.72	38.04
Rock and built - up	1641.10	19.77	845.45	10.19

The data denotes the area of each LULC category of 2014. During 2014, dense vegetation areas showed an increase from April to November. The variation in the part of dense vegetation was the maximum when related to all the classes.

The LULC map of each pre - monsoon and post - monsoon for the 2014 is shown below.

The following maps in Figure 3 represents LULC of The Ghataprabha river basin in April and November 2014

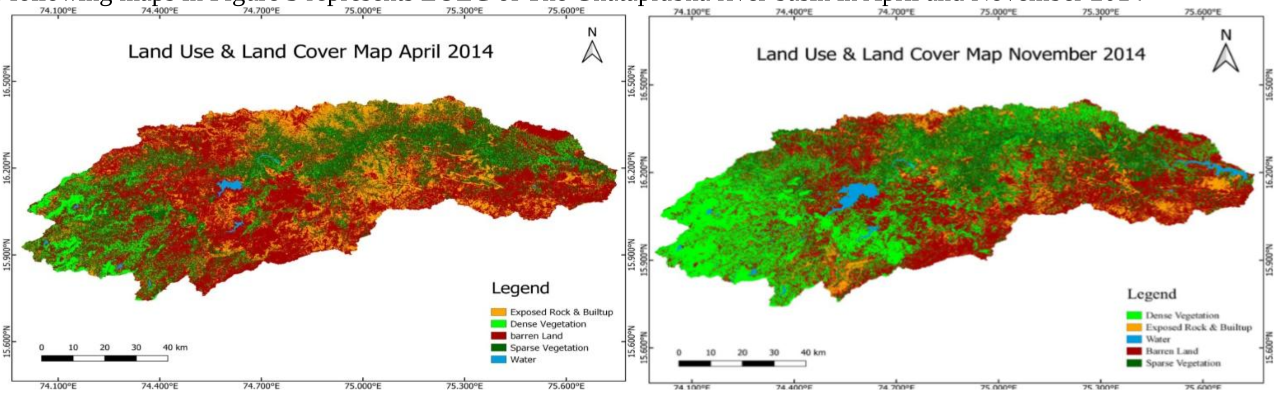

Figure 3: LULC map of The Ghataprabha river basin in 2014

The map gives a spatial variation of the April 2014 and observation says that the April 2014 map shows that most of the area is covered by barren land, that is 3886.28 Sq. Km, which is 46.82 % of total area. In April 2014 area occupied by dense vegetation was only 663.27 Sq. Km, 7.99 % of total area. Sparse vegetation occupied 2054.81 Sq. Km, which is 24.75 % of total study area. The area of the water body was 55.33 Sq. Km, only 0.67 % of the total study area. Rock and built - up area was 1641.10 Sq. Km which was 19.77 % of total area.

The November 2014 map shows that most of the study area is covered by barren land, which is 3157.72 Sq. Km, which is 38.04 % of the total area. In November 2014 area occupied by dense vegetation was only 2487.42 Sq. Km, 29.97 % of total area. Sparse vegetation occupied 1638.78 Sq. Km, which is 19.74 % of total study area. Area of the water body was 171.40 Sq. Km, only 2.06 % of the total study area. Rock and built - up area were 845.45 Sq. Km which was 10.19 % of total area. In November 2014, water bodies occupied the minimum area whereas barren land and dense vegetation percentage was the maximum.

The following Figure 4 represents the area occupied by each LULC in April 2014 and November 2014.

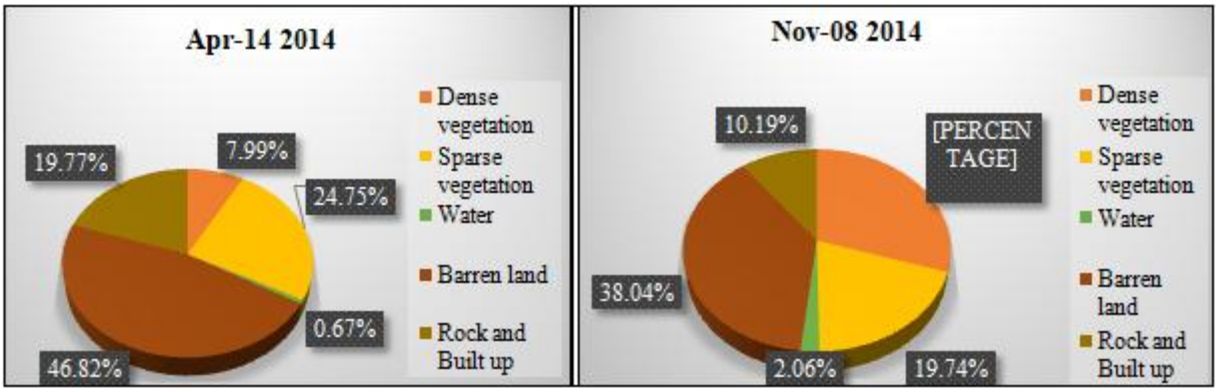

Figure 4: Area occupied by each LULC in 2014

It is clearly observed that in April 2014, water bodies occupied the minimum area whereas barren land and sparse vegetation percentage was the maximum.

During the period 2015, dense vegetation area as in Table 4 increased during the same period from April to November. The change in the part of dense vegetation was the extreme when compared with all the classes. The LU & LC map of the year 2015 is shown below. The changes that occurred during the period 2015 in pre - monsoon and post - monsoon are graphically represented in Fig.5.6 using data obtained from Excel sheet classification 2015.

The following Table 4 shows the percentage of land use & land coverage data for 2015

Table 4: Land use & land coverage data 2015

Land use/landcover	2015			
Month	April		November	
	Sq km	%	Sq km	%
Dense vegetation	1499.51	18.06	3170.80	38.20
Sparse vegetation	3400.74	40.97	2292.13	27.61
Water	71.86	0.87	89.11	1.07
Barren land	2484.22	29.93	2122.04	25.56
Rock and built - up	844.44	10.17	626.70	7.55

The following maps in Figure 5 represents LULC of the Ghataprabha river basin in April 2015 and November 2015

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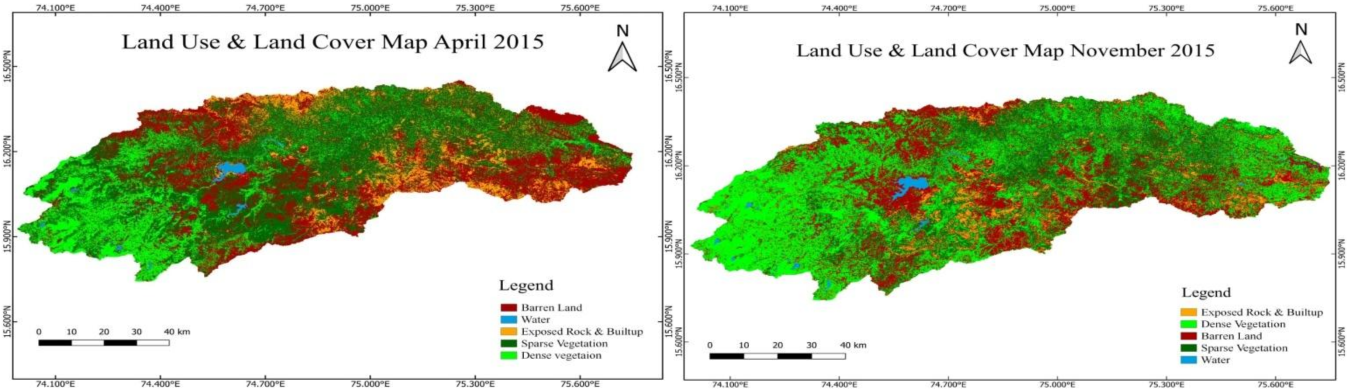

Figure 5: LULC map of The Ghataprabha river basin 2015

In April 2014 area occupied by dense vegetation was only 663.27 Sq. Km, 18.06 % of the total area. Sparse vegetation occupied 2054.81 Sq. Km, which is 40.97 % of the total study area. Area of the water body was 55.33 Sq. Km, only 0.87 % of the total study area. Rock and built - up area was 1641.10 Sq. Km which was 10.17 % of the total area. In April 2015, water bodies occupied the minimum area whereas barren land and sparse vegetation percentage was the maximum.

In November 2015 area occupied by barren land was 2122.04 Sq. Km, 25.56 % of the total area. Sparse vegetation occupied 2292.13 Sq. Km, which is 27.61 % of the total study area. Area of the water body was 89.11 Sq. Km, only 1.07 % of the total study area. Rock and built - up area was 626.70 Sq. Km which was 7.55 % of the total area. In November 2015, water bodies occupied the minimum area whereas dense vegetation and sparse vegetation percentage was the maximum

The following Figure6 represents the area occupied by each LULC in April 2015 and November 2015.

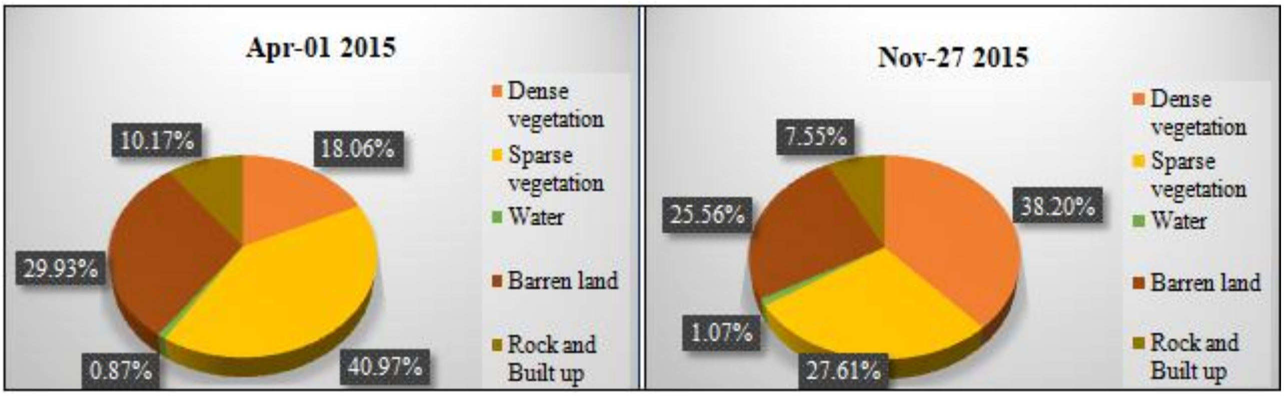

Figure 6: Area occupied by each LULC in November 2015

The following Table 5 shows the percentage of land use & land cover data for 2016

Table 5: Land use & land cover data 2016

Land use/landcover	2016			
Month	April		November	
	Sq km	%	Sq km	%
Dense vegetation	917.85	11.06	2553.08	30.76
Sparse vegetation	1543.41	18.59	2684.98	32.35
Water	51.86	0.62	129.53	1.56
Barren land	4421.32	53.26	2377.42	28.64
Rock and built - up	1366.37	16.46	555.78	6.70

The data is presented in Table 5 represents the area of each LULC category of 2016. During the period 2016, dense vegetation area shows an increase during the same period from March to November. The modification in the area of dense vegetation was the maximum when compared with other classes. The LU & LC map of the year 2016 is shown below.

The following map in Figure 7 represents LULC of The Ghataprabha river basin in March 2016 and November 2016

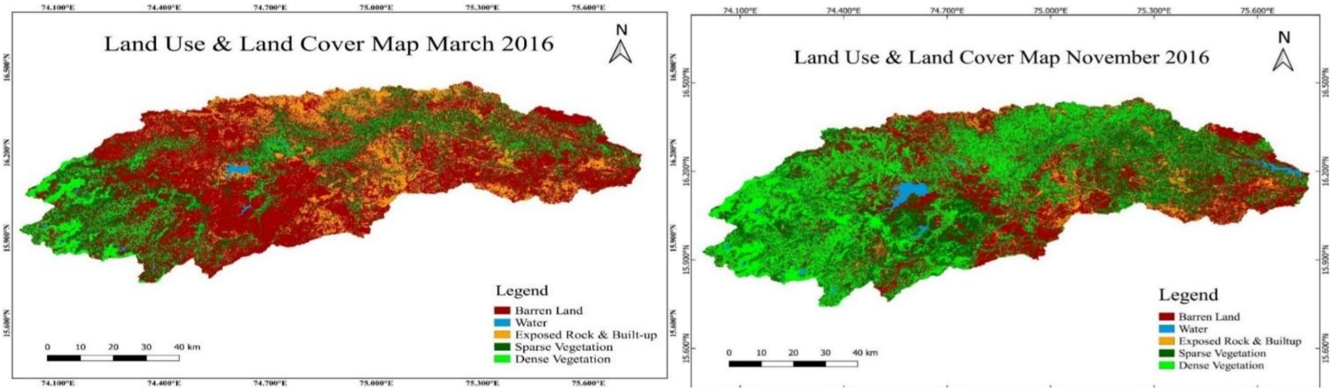

Figure 7: LULC map of the Ghataprabha river basin in2016

The March 2016 map shows that most of the study area is covered by barren land, that is 4952.48 Sq. Km, which is 53.26 % of the total area. In March 2016 area occupied by dense vegetation was only 1448.67 Sq. Km, 11.06 % of the total area. Sparse vegetation occupied 1098.22 Sq. Km, which is 18.59 % of the total study area. Area of the water body was 71.47 Sq. Km, only 0.62 % of the total study area. The rock and built - up area was 729.93 Sq. Km which was 16.46 % of the total area. In March 2016, water bodies occupied the minimum area whereas barren land and dense vegetation percentage was the maximum.

The November 2016 map shows that most of the study area is covered by sparse vegetation, that is 2684.98 Sq. Km, which is 32.35 % of the total area. In November 2016 area occupied by dense vegetation was only 2553.08 Sq. Km, 30.76 % of the total area. Barren land occupied 2377.42 Sq. Km, which is 28.64 % of the total study area. Area of the water body was 129.53 Sq. Km, only 1.56 % of the total study area. Rock and built - up area was 555.78 Sq. Km which was 6.70 % of the total area. In November 2016, water bodies occupied the minimum area whereas dense vegetation and sparse vegetation percentage was the maximum.

The following Figure8 represents the area occupied by each LULC in March 2016 and November 2016

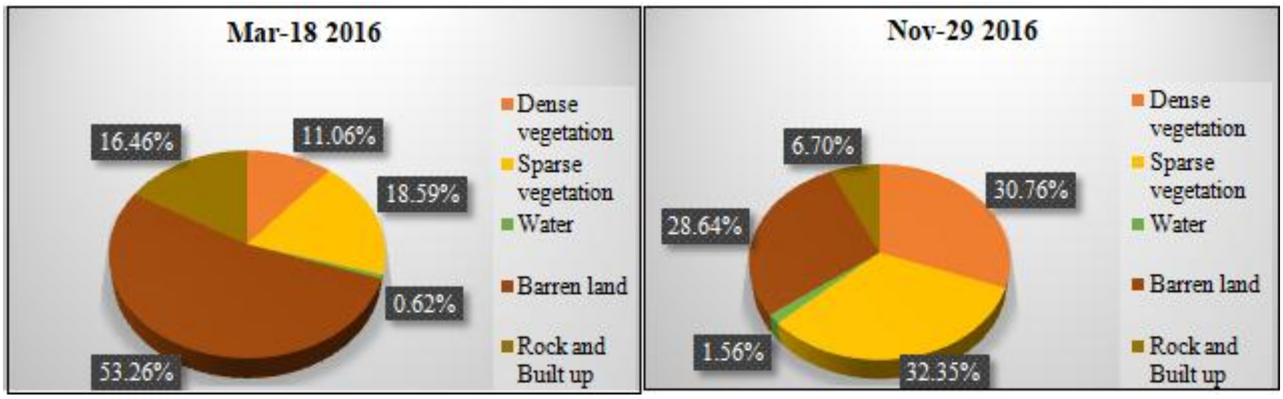

Figure 8: Area Occupied By Each LULC In 2016

7. Conclusions

1) The work's findings indicate a rapid transformation of arid land and dense forest cover between the years 2014 and 2016, which can be attributed to numerous factors like dense vegetation, sparse vegetation, water, barren land & rock built up.
2) It is concluded that a growth in urbanization is damaging to vegetation, the present study can be useful to perceive the vegetation areas which are at risk due to urbanisation.
3) The study highlights the utility of remote sensing (RS) as an effective tool for regional and temporal - spatial mapping of natural resources. The findings of the learning are extended by demonstrating the additional value derived from utilizing GIS technology for mapping and identifying LULC changes through satellite image processing.
4) For the prediction and generation of reasonably accurate maps depicting changes in LULC, the use of maximum likelihood supervised classification using Landsat - 8 OLI - TIRS imagery, in combination with the post - classification comparison technique, can be employed.
5) It was commonly noted that Natural Dense Forest (NDF) had significantly decreased, while other land uses such as barren land (BL), built - up land and rock (BR) had increased.
6) High levels of deforestation were typically caused by citizen exploitation, the majority of the densely vegetated region that was transformed was turned into farmland.
7) The study reflects that next ten years, the forest in the study region will lose more than 50% of its existing natural forest cover. If the current pattern of deforestation and urbanisation continues.

8. Future Scope

1) As LULC projects become more sophisticated and widely accessible, there will be an opportunity to involve local communities in data collection, interpretation, and decision - making processes. Community engagement can lead to more inclusive and sustainable land use practices.
2) Maximum of the Landsat - 8 images from the study zone in the year 2018 to 2023 are affected by the cloud cover therefore, preparation of the LULC map for the year 2018 to 2023 will remain as future scope of the work.

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