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Detecting Changes in Land Use and Land Cover using GIS and Remote Sensing Methods in Pauri District of Uttarakhand State, India

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***Abstract*— The relationship between humans and nature must be taken into account as LULC changes in order to map and monitor the natural resources accessible on earth's surface. The amalgamation of remote sensing and GIS advancements in technology has made it easier to track variations in land use and cover from times gone by to the today. To properly represent the city, decision makers and policy makers frequently need accurate and updated LULC data. By utilizing remote sensing and GIS methodologies, this study piece illustrates the changes to the LULC status and driving factors associated to it in study area from 2010 to 2020. Machine learning Random Forest (RF) classifier was used to categorize LANDSAT photos in Google Earth Engine. The results of this analysis show that the Pauri Garhwal district in the state of Uttarakhand has experienced a rapid LULC changes from 2010 to 2020 using GIS and remote sensing methods. The fundamental reason for these changes in the study area is the conversion of forest, agricultural land, and arid land into urban areas. Therefore, it is crucial to control the factors causing LULC changes for sustainable ecosystem; otherwise, these LULC classes lose their ability to provide essential services for a healthy ecosystem.**

***Index Terms*— Google Earth Engine, Land use land cover changes, Remote Sensing, Random Forest, Change Detection.**

I. INTRODUCTION

Variations in land use cover, one of the fundamental drivers of environmental change on a global scale, are at the focus of the debate over environmentally friendly development. A number of viewpoints on the subject have been explored in order to pinpoint the components that influence to LULC change, as well as its path and effects. Urban development, long regarded as a sign of regional economic growth is the relocation of residences and commercial property to rural areas on the outskirts of major cities. Humans have historically investigated the environment at large and their capacity to spot changes in land use-land cover (LULC) [1].

The precise type of land that is found on the surface of the world is highlighted by the land cover; it encompasses a forest, agricultural, barren, water bodies, etc. On Earth's surface, a change in land use or cover (LULC) brought on by the actions of humans is referred to as such. In search of better living conditions, employment opportunities, and accessibility to high-quality healthcare, people migrate from rural to urban locations. Urbanization results from this process of transition. The Repercussions of this urbanization have been detrimental to the environment,

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the economy, and society [2]. Therefore, it is crucial for academics and politicians everywhere to keep an eye on and lessen the adverse effects of LU/LC fluctuations for a number of management and scheduling jobs [3].

The majority of studies aimed at how geographical LULC changes evolve and how such changes affect the socioeconomic and environmental aspects of the region. Many number of change detection technique have been created in order to study and track LULC change and its implications on variable environmental conditions. Determining the rate of land use changes in time and space as well as the causes of these changes are essential for developing models and future estimates of these changes.

Geographic Information Systems has become an increasingly convoluted intellectual subject as an outcome of the appearance of programming for developmental environments. The most efficient, free and open-source and accessible via the internet cloud-based computing platform for performing satellite imagery analytics, planning, and swiftly comprehending massive volumes of satellite data is Google Earth Engine (GEE) [4]. Users of the Google Earth Engine computing platform can do spatial analyses on Google's system [5]. GEE's advantage is that it makes it possible for users to operate in surroundings with processing that is parallel.

Sustainable change is being caused by a number of vital varying worldwide, including commute in land use and cover. LULC has been deliberated from a variety of viewpoint to identify the factors that contribute to its causes, processes, and effects. The speedy commute in land use and cover are frequently characterized by widespread urbanization, land destruction, or the conversion of agricultural land to mussel farming, which has considerable detrimental effects on the environment, especially in developing nations [6].These changes have a major influence on the local, regional, or global climate, which inevitably affects the environment on a global scale. For instance, human-caused changes in land cover have an effect on the global carbon cycle and raise atmospheric carbon dioxide levels [7].

In order to understand how changes in land use and cover affect the terrestrial ecosystem and develop sustainable land use plans, it is imperative to take a close look at these changes [8]. To analyze land cover changes, one can use the secular dynamics of remote sensing datasets. Current, precise information is needed in order to take in and assess the sustainable effects of land cover commute [9]. Even if remote sensing can be used to record these changes, it is still necessary to use effective, automated change detection processes to extract the information from satellite data. Utilizing remote sensing data for commute analysis is based on the basic premise that the technique can identify changes between two or more dates that are abnormal [10].

The major purposes of the assessment of transformation are to assess urbanization, land use and cover, and widen agriculture. The interconnectedness and connection that exists between human beings and enhanced understanding of natural events will improve the use of natural resources, if change detection method is applied precisely and promptly on the earth's surface [11]. Traditional change detection (TCD) approach can be used to do LULC, but TCD is a laborious and inaccurate process. Due to its greater accuracy and real data acquisition, efficiency, and reduced time requirements, we mostly favor remote sensing post classification change detection techniques [12].

Given that India's population has doubled in the previous 50 years, the issue of urbanization is crucial. Urban sprawl as a result has negative consequences on the surroundings, finances, and civilization. According to Pauri Garhwal, a district of Uttarakhand state, India's built-up area has significantly increased over the past year. Earlier investigations have revealed the change in urban sprawl in numerous cities around the world [13]. LULC are very much area specific. However, only a small number of research teams have examined the direction and trend analyses LULC change in the study area, as well as its underlying causes. Geospatial techniques have been used by very few study groups to document the transformational effects of land use and cover transformation of wet lands in the Tarai region of Garhwal. The authors did not, however, evaluate the results' kappa coefficient and overall accuracy using the error matrix. [14].

Therefore, an effort was made to examine the effects of urbanization on various types of land cover by various classes in the district Pauri Garhwal in the state of Uttarakhand by using cutting-edge information processing methods like remote sensing and GIS. Many researchers had carried out change detection, but fewer had identified the factors that were responsible for it. Using LANDSAT data, these two questions are addressed: (i) what influence does urbanization has on different types of land cover? (ii) What is the LULC change's direction, and what are the reasons that are fueling it?

II. Study Area And Data Used

A. Study area

Pauri Garhwal is a district located in the Garhwal region of the Indian state of Uttarakhand (Fig.1). The district is situated between 29° 45' and 30°15' North latitude and 78° 24' and 79° 23' East longitude. It is bordered by the districts of Rudraprayag and Chamoli to the north, Tehri Garhwal to the west, Uttarkashi to the northwest, Dehradun to the southwest, and Almora and Nainital to the east.The district has an area of 5,398 square kilometers and is situated at an elevation ranging from 800 meters to 7,000 meters above sea level. The district is characterized by its diverse topography, with the Himalayan mountain range to the north and the Ganges river valley to the south. The district is drained by several rivers, including the Alaknanda, Bhagirathi, Mandakini, and Pindar, which flow through the district and provide water for agriculture and hydropower generation. Pauri Garhwal has a population of approximately 686,000 people, according to the 2011 census.

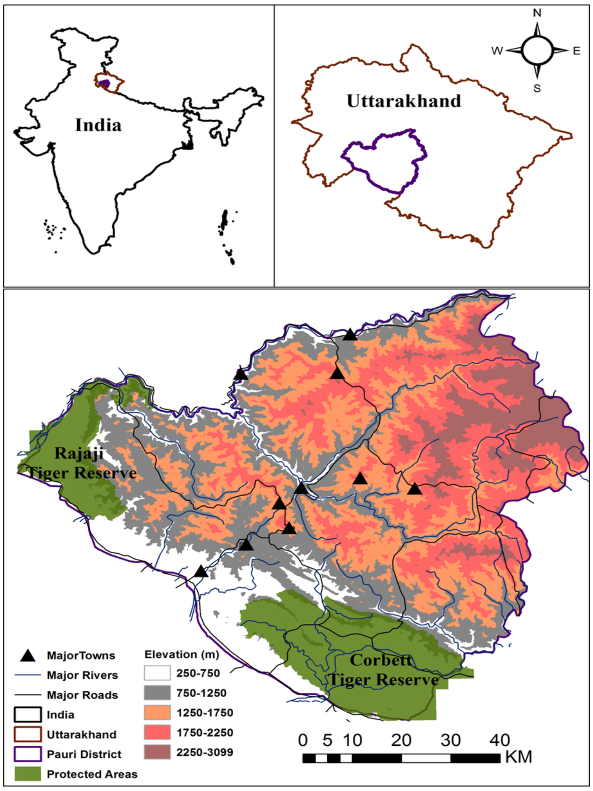

Fig 1. Study area (Pauri Garhwal District, Uttarakhand, India) is the study region.

B. Data used

The USGS Earth Explorer provided the LANDSAT 5 ("TM") image from 2010, the LANDSAT 7 ("TM") image from 2015, and the LANDSAT 8 ("OLI+TIRS") image from 2020 for the month of January. These images were put in Google Earth Engine (GEE) for LULC classification.

III. METHODOLOGY

Fig. 2 illustrates a flowchart. USGS (http://earthexplorer.usgs.gov/) provided LANDSAT photos for the years 2010, 2015, and 2020. Subset (study area) was made using the Indian administrative district wise boundary table. These photos were categorised into five different LU/LC classes in Google Earth Engine using a machine learning Random Forest classifier, including water bodies, urban areas, barren land, agricultural, and forests. In random forest, training was done on 70% of the training samples, and testing was done on 30%.By calculating the kappa coefficient (KC) and overall accuracy (OA), accuracy was evaluated. To identify LULC changes over various time periods, a post classification change detection approach was applied.

A. Classification

The classification method reveals the numbers of pixels in a picture are properly identified by a classifier. Using a random forest classifier, March LANDSAT images from the years 2010, 2015, and 2020 were separated into five distinct land use and land cover groups. For the purpose of training machine learning models, which we generated practise data for each Google Earth land cover type. It is determined how accurate the model is by using the testing data, and its efficiency is evaluated using the simulated data.

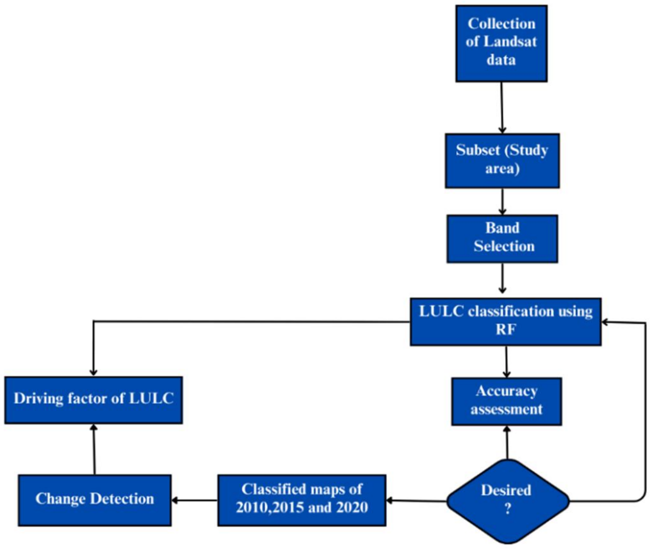

Fig 2. Research methodology employed in this investigation.

IV RESULTS AND DISCUSSION

A. Classification of land use and cover

Supervised and unsupervised categorization, as well as other standard land cover classification systems, has been found to be affected by a number of problems, including the fact that each classification is area-dependent and has a distinct precision for specific land cover class [15].Using the Random Forest classifier, LANDSAT images from 2010, 2015, and 2020 were sorted into five land cover groups with the use of the incredibly powerful online cloud computing tool Google Earth Engine (GEE). Urban, water, barren, forest, and agricultural areas are the five types of land cover. Fig. 3 depicts simulated maps of classified output for the years 2010, 2015, and 2020.

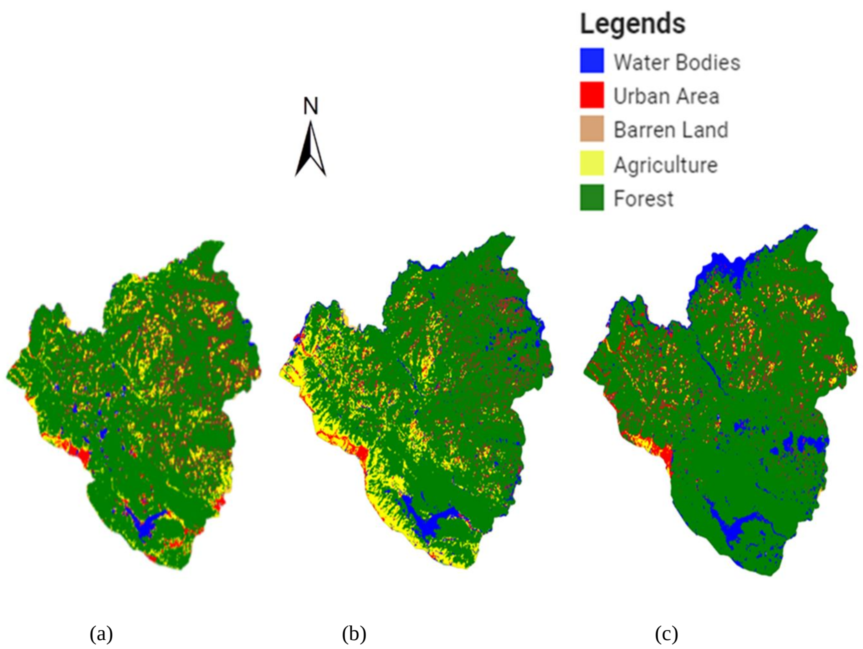

Fig. 3. Classified maps (a) 2010, (b) 2015 & (c) 2020

The confusion matrix was used to determine OA. OA in all three successfully categorized images was higher than 93%, indicating almost accurate categorization. OA was 97.75% in the 2010 image, 98.72% in 2015, and 98.54% in 2020. Kappa coefficients of 0.97, 0.98, and 0.98 were discovered for images from 2010, 2015, and 2020, respectively.

B. Map classification-based area estimation

The results in Table I show that the area of water bodies in the examined area decreased by -23.97% from 2010 to 2020, from 32371.18 ha in 2010 to 31121.01 ha in 2015 to 24611.36 ha in 2020. Urban area has undergone major alteration from 11575.74 ha in 2010 to 15952.02 in 2020 ha showing a substantial rise in urban area by 37.80% from 2010 to 2020. The area used for agriculture fell from 2010 (14312.05 ha) to 2015 (13664.48 ha) and increased in 2015 to 2020 (14210.11 ha). Overall, agriculture area is decreased by -0.71 % from 2010 to 2020 (Table1). Forest area is increased by 0.18 % from 2010 to 2020. Barren land was 143800.05 ha in year 2010, 145520.03 ha in 2015 and in 146523.02 ha 2020. In Fig. 4, the percentage of each LU/LC class's covered area in each of the years 2010, 2015, and 2020 is depicted.

C. What influence does urbanization have on different types of land cover?

People relocating from rural to urban regions as a result of economic progress is known as urbanisation. People relocate from a village to a city in quest of better social and cultural opportunities, better transit, better employment opportunities, and better health and education. Forest regions, water bodies, and arid land are moving into populated areas as a result of urbanisation. In contrast to advanced nations, the degree of LULC changes brought on by urban sprawl are more severe in developing countries [16].In the northern region of India, in the state of Uttarakhand, is the district of Pauri Garhwal. The district has seen a significant change in the built-up areas; it is one of the thirteen districts of Uttarakhand and is situated in the Garhwal region of the state. In the study region, the total area of forest has expanded by 0.18 percent, the area of bare land has increased by 28.01 percent, and the area of water bodies has decreased by-23.97 percent between 2010 and 2020 as a result of these significant built-up extension. Over a ten-year period (from 2010 to 2020), built-up expanded in the study area along National Highway NH-58. The study area's growing population, new schools and universities, and the upgrade of the national highway have all contributed to these changes [17].

D. What is the LULC change's direction, and what are the reasons that are fueling it?

There are significant increases in food demand in addition to socioeconomic changes as a result of economic operations conducted in different geographic areas and the ever-increasing population. In order to forecast how LULC will alter in the future, it is imperative to map out the changes that have already occurred. The total area of water bodies and agricultural land has decreased throughout a ten-year period (from 2010 to 2020), whilst urban and arid land have expanded in the research areas. Along the national highway NH-58 at this segment, urbanization increases have taken place owing to the efforts of the people and administration of India's Uttarakhand state. The fastest expanding capital in terms of populace, higher education, industrial development, food, and transit was once comprised of forest, barren land, water bodies, and agricultural land. urbanisation is thus recognized as the key driving force underlying the perceive commute in the studied region.

TABLE I. ESTIMATED AREA IN THE STUDY REGION FOR EACH LU/LC CLASS.

Land cover classes	2010		2015		2020		Area change in %
	Area in Ha	Area in %	Area in Ha	Area in %	Area in Ha	Area in %	2010-2020
WaterBody	32371.18	6.18	31121.01	5.95	24611.36	4.70	-23.97
UrbanArea	11575.74	2.21	11851.1	2.26	15952.02	3.05	37.80
BarrenLand	143800.05	27.49	145520.03	27.82	146523.02	28.01	1.89
Agriculture	14312.05	2.73	13664.48	2.61	14210.11	2.71	-0.71
Forest	321060.05	61.38	320931.02	61.36	321640.12	61.49	0.18

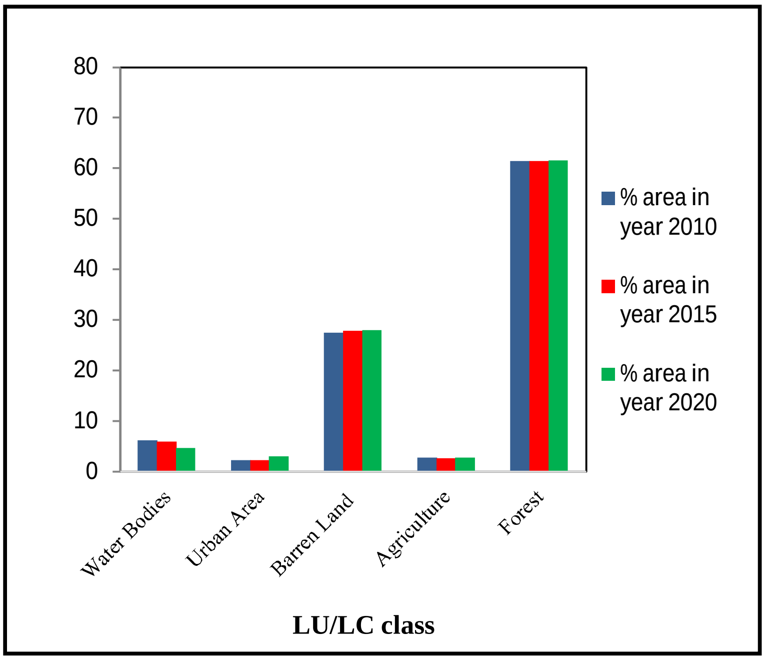

Fig 4. Percent coverage in year 2010, 2015 and 2020.

V. Conclusions

According to this study, Remote sensing (RS) and GIS techniques are very beneficial in determining the consequences for the effectiveness of land use. The water body in the examined area fell by 23.9 percent during the course of ten years due to urbanization. Urbanization has found to be substantially increased by 37.8 percent from 2010-2020, along National Highway NH-58. The study area's growing population, new schools and universities, and the upgrade of the national highway have all contributed to these changes. Also agriculture area has decreased from 2.73 percent to 2.71 percent due to the relocation of non-agricultural activities such as contruction of buildings, road and transportation networks. Barren land area was increased from 27.49 percent to 28.01 percent from 2010 to 2020. Between 2010 and 2020, the research area's forest cover increased from 61.38 to 61.49 percent. Thus the results show that there is a sudden increase of urban/ built-up area, barren land and forest area whereas reduction in agriculture area and water body area within the study area.

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