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UTILIZING GIS AND REMOTE SENSING TO MAP LAND USE CHANGE AND URBAN GROWTH IN PUNE

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Abstract

Researchers may benefit from combining GIS with satellite remote sensing to learn more about what drives changes in land use and cover 2010 and 2018 and forecast its likely future expansion. To analyze urban land use class, Landsat TM and ETM+ satellite pictures from 2010, 2015, and 2018 were utilized. Using a maximum likelihood classifier and supervised classification techniques, urban classes were identified and mapped. The evaluation of accuracy was done for maps that were categorized. The total accuracy that was attained was 86.33%, and the Kappa figures were 0.76. Using several categorized pictures, the transition probability matrix and area change were determined. This research contributes to our knowledge of urban expansion and facilitates the planning, administration, and decision-making process for following infrastructure projects.

Keywords: GIS, remote sensing, land use change, urban growth, Landsat, supervised classification, infrastructure planning.

1. INTRODUCTION

In particular, studying the spatial example of land use change and urban extension is urgent to the investigation of urban geology. Numerous methods have been devised to simulate and predict the trends in land use changes and urban expansion. The two most popular ones are the statistical models based on multivariate analysis and the simulation models based on cellular automata (CA). The evolution of urban geography may benefit greatly from the analytical and theoretical insights offered by such models. Urban geography study has substantially benefited from the fast improvement of GIS and spatial scientific tools, as well as the accessibility of remote sensing information in ongoing many years. One popular trend in urban GIS/remote sensing research is using local analysis to look more closely at the spatial examples of urban extension. The main goal of earlier land use and urban development models was to show the pattern of urban expansion from a global or whole-map perspective. For example, the boundaries of the factual

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model's explanatory factors or the transition rules of CA models, which show how different causes affect the extension of urban land, are considered to be spatially invariant. Such models undoubtedly provide important information for comprehending the patterns, trends, and processes of urban development from a modeling and general viewpoint. The CA models' revelation of the complexity of urban dynamics, however, suggests that linkages between urban expansion and its underlying causes often exhibit a non-stationary rather than an invariant nature across space. Such possible non-stationarity in multivariate statistical analysis models suggests that the same collection of elements may produce different responses in various regions of the research field. Thus, comprehending, investigating, and simulating such possible spatial non-stationary linkages provide a different setting for more fully grasping the specifics of the urban development pattern.

The physical and biological cover that covers a piece of land, like water, plants, Land cover may refer to natural terrain or man-made structures. Land use, on the other hand, is what happens when land is put to use in accordance with certain social and economic goals and institutional frameworks, has a more intricate part as it incorporates the executives principles and sociologies. The material appearances of ecological and human elements and their interconnections interceded via land accessibility is changes in land use across various geographical and fleeting domains.

Changes in land use and land cover influence a significant number of the optional cycles that ultimately cause the world's ecosystems to crumble as well as altering the actual element of the classes' geographical region. Changes in land use and cover mostly reduce plant cover, one of the most. The loss of vegetation cover also has a cascade of other detrimental effects on the environment, such as altered hydrological regimes, reduced biodiversity, altered climate forcing, caused by pollution and changes in radiative forcing on other ecosystems in the natural world. Alterations in both land use and land cover may have a variety of effects that sets off a chain response of natural results that criticism into one another to additional influence changes in land use and land cover.Kumar &Kaur (2017) In Haryana, this article focuses on the crucial issue of food security and how it relates to climate change. It uses empirical data to show the difficulties farmers confront and how they affect food security. The significance of tackling climate change in the context of food security is well emphasized by this study. A thorough investigation of the effects of climate change on crop yield and food security in Haryana is provided by Verma and

Singh (2015). To make future projections, their study combines data from agriculture and climate models. They discovered that changing rainfall patterns and rising temperatures may result in lower crop yields, particularly for the region's staple crops of rice and wheat. Their study highlights the pressing need for Haryana to adopt climate-resilient agricultural practices and improve food security measures. In order to determine how much risk climate change poses to the agriculture industry, Kumar and Hooda (2017) perform a vulnerability assessment of the sector in Haryana. To evaluate the adaptability of farmers, they use vulnerability indexes and surveys. According to their analysis, Haryana's agriculture is extremely sensitive to climate change, especially because of water scarcity, erratic rainfall, and excessive temperatures. The study emphasizes the necessity of policy changes and farmer training to improve adaptive capacity. A case study on Haryana's agricultural adaptation to climate change is presented by Sharma and Yadav (2016). They look at the difficulties farmers confront and the methods they use to reduce climate threats. Crop diversification, better irrigation techniques, and awareness campaigns are among the study's highlighted adaptation strategies. It places a focus on how government structures and policies support these initiatives.

1.1. Changes in land use and cover detected remotely

Regarding this, satellite remote sensing has great promise for providing a comprehensive picture of the terrain at all scales, ranging from the local to the global. Additionally, the electromagnetic spectrum may be separated into several bands and captured at ranges outside of the visible spectrum using satellite-based remote sensing equipment. This makes it possible to extract data on the surface's variability caused by the planet's capacity to reflect light at various electromagnetic frequencies. GIS makes it possible to represent data on both naturally occurring and artificially created resources in geographical domains, which facilitates effective policy planning and implementation.

Because it takes into account perceptions over more extensive region of the World's surface than are reachable with ground-based perceptions, remote sensing is a crucial instrument in the field of land change research.

1.2. Need to estimate land use/cover change

In order to achieve equitable growth and development across several domains and sectors, it is imperative to address concerns arising from climate change and provide food and water security for the expanding population. Acknowledging the multipurpose needs of land, it is imperative to acknowledge the many aspects and interconnections of the various societal sectors. Planning and control of land use are seen as an intricately linked web structure in this context.

While India's metropolitan areas do have some contemporary planning and development technologies, the majority of the country's population lives in rural areas, which are home to 72% of the country's population and thus need scientific and technological contributions for overall socioeconomic development. A third of the nation's main energy use, or almost three-fourths of all families, are situated in country districts with restricted admittance to energy sources other than biomass. With an anticipated water demand of in excess of 980 billion cubic meters by 2050, water security will probably be one of the main issues in the following many years. India, a rural country, needs to ensure that water security is dealt with in the following a long time in request to take care of its growing population and sustain economic growth. To ensure the nation's water security, sustainable management of the nation's groundwater resources and efficient surface water use are required.

1.3. Modeling land use/cover change

Creating scenarios is the first step in simulating changes in land use and cover. This is due to the fact that people's interaction with the land stems from their shared evolutionary trait of being able to adapt their environment to fit their needs. Changes in land use are important ecological phenomena that are prevalent both locally and worldwide. Globally, throughout the last three centuries, around 1.2 million km2 of forest have been converted to other purposes, yet at the same time, agriculture has risen by 12 million km2. Significant amounts of the earth's land surface have been altered by people; now, 10–15% of it is dominated by urban industrial regions or agricultural, and 6–8% is pasture. These land use changes have significant effects on how the earth's climate will change in the future, which will significantly affect how land use and land cover will change later on. The land usage and land cover have a significant impact on the surface heat and moisture budgets, which in turn influence atmospheric instability. By simulating probable changes in the landscape caused by humans under various scenarios, it may be possible to identify key policies that need to be changed in order to enhance the environment.

Too far, there is no robust model with the capability to specifically address the land use and land cover aspects of a particular area, making it difficult for geospatial researchers to comprehend the spatial features of land use and land cover change. Land use patterns of the future are shown by combining cutting-edge technology with examples of past land planning. Specialist based change models are one kind of land use change model in which the drivers of land use change are explicitly modeled, and pattern examinations of historical information, for example, GEOMOD or CAMarkof, which estimate the speed and spatial example of land transformation in view of past land use change.

1.4. Research Objectives

1. Toproviding geographical insights assists urban planners in achieving sustainable development.
2. Toassessing the environmental effect of land use change, particularly vegetation loss, highlights sustainability problems.

2. STUDY AREA

Pune lies in the approximate coordinates of 19° 33" North latitude and 74° 52" East longitude. Pune is a city in the state of Maharashtra in western India. Located in what are sometimes called the Western Ghats, the Sahyadri range extends from the Deccan plateau to the east. The city itself has an area of 15,642 square kilometers. From Delhi, Pune is 1,125 km (689 mi) away, 723 km (567 mi) from Bangalore, 562 km (456 mi) northwest of Hyderabad and 158 km (84 mi) from Mumbai) in the Southeast.

Western India's Deccan plateau is where you'll find Pune, perched at an altitude of 450 meters (1,840 feet) above sea level. It is separated from the Arabian Sea by the Sahyadri mountain range, which is located on its leeward side. The city is located in a hilly region, with Vetal Hill rising to an altitude of 900 meters (3,500 feet) above sea level. The Sinhagad fort rises to a height of 1,300 meters (4,300 ft.). The Pune district, located between the coordinates 73°34′26.9177″E and 74°04′11.6946″E in longitude and 18°22′26.7042″N and 18°49′08.7726″N in latitude, is the major subject of this article.

Pune, India's ancient capital is situated where the Mula and Mutha rivers meet. Both the Mula's tributary Pavana and the Bhima's tributary Indrayani flow through the northwest Pune neighborhoods.

3. MATERIAL AND METHODS

The pictures were taken in 2010, 2015, and 2018 using data from the USGS. Because of cloud cover, satellite data for the analogous images from different time periods could not be gathered because of the wrong season. The specifics of the photographs utilized are shown in Table 1. Initially, all necessary satellite photos were acquired and piled. The upper left extents: Longitude 18d49'08.7726"N, Latitude 73d34'26.9177"E In the bottom right corner, latitude 74d04'11.6946"E and Longitude 18d22'26.7042"N were used to crop the research region and all of the photos.Using the maximum likelihood classifier technique for supervised classification, several time series photos were categorized.

Land usage and land cover were analyzed and predicted using the resulting categorized data. PCI Geomatica was the program used for this particular task. The following classifications were taken into consideration for classification: lakes, rivers, healthy vegetation, urban areas with vegetation, sparse vegetation, and no vegetation cover. Four categories were created by combining the number of classes: metropolitan, aquatic body, treeless, and vegetation.

Table 1: Satellite Images

Satellite Data	Spatial Resolution (m)	Date of Data Acquisition
Landsat 5 TM	20	02/03/2010
Landsat 7 ETM+	20	15/04/2015
Landsat 5 TM	20	30/04/2018

The classification report for each of the three photos was received after supervised classification, and it is shown in Table 2.

4. DATA ANALYSIS

Data categorized output for the years 2010, 2015, and 2018 are shown. Tables 2 and 3 include statistical data on land usage, land cover, and categorization accuracy, respectively. For qualitative (categorical) items, the Kappa statistic, also known as the Kappa Coefficient is a statistical measure of agreement amongst raters or annotators. Put another way, it expresses how far the categorized map deviates from reality. To comprehend the changes, a land use transition matrix was generated using the Molusce tool, a Quantum GIS plugin (Table 4, 5 and 6). This research area's urban area is growing, its vegetation is declining, and its lack of plant cover is expanding. Because of the temporal and geographical resolutions of satellite data, it is challenging to map, forecast, and determine the reasons of changes in the vegetation and absence of plant cover. Nevertheless, the focus of this current work is mostly on urban class.

Table 2: Report on classification

Land Cover	2010	2015	2018
Urban	43.15	134.56	221.36
Water Body	26.54	27.65	36.87
No-vegetation	1131.44	1173.38	1325.45
Vegetation	1444.25	1306.25	884.23
Null	42.26	39.62	23.65
Total	1362.26	2361.24	2317.15

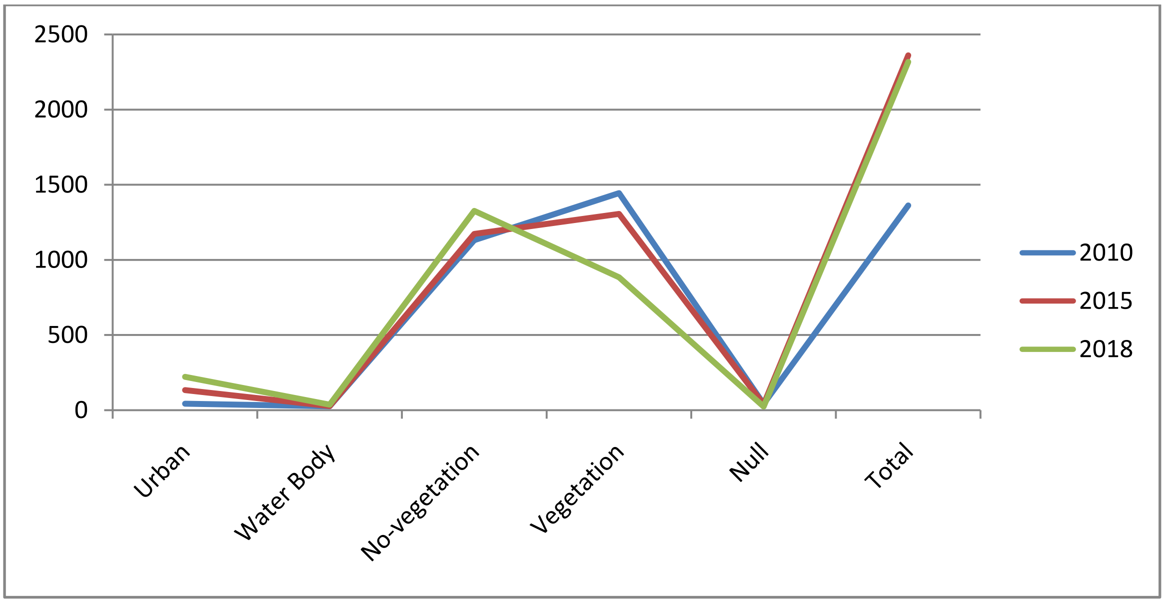

Figure1: Report on classification

Pune saw significant urban growth, expanding from 43.15 to 221.36 square kilometers between 2010 and 2018. The area covered by water bodies grew somewhat, from 26.54 to 36.87 square kilometers. Vegetation dropped from 1444.25 to 884.23 square kilometers, whereas no-vegetation areas constantly increased from 1131.44 to 1325.45 square kilometers. Accuracy was increased as unclassified regions decreased from 45.35 to 32.40 square kilometers. These patterns demonstrate Pune's rapid land use changes and urbanization.

Table 3: Evaluation of classification accuracy

Metric	Year 2011	Year 2015	Year 2018
Entire Accuracy	75.00%	76.00%	78.00%
Kappa Statistic	0.615	0.618	0.719

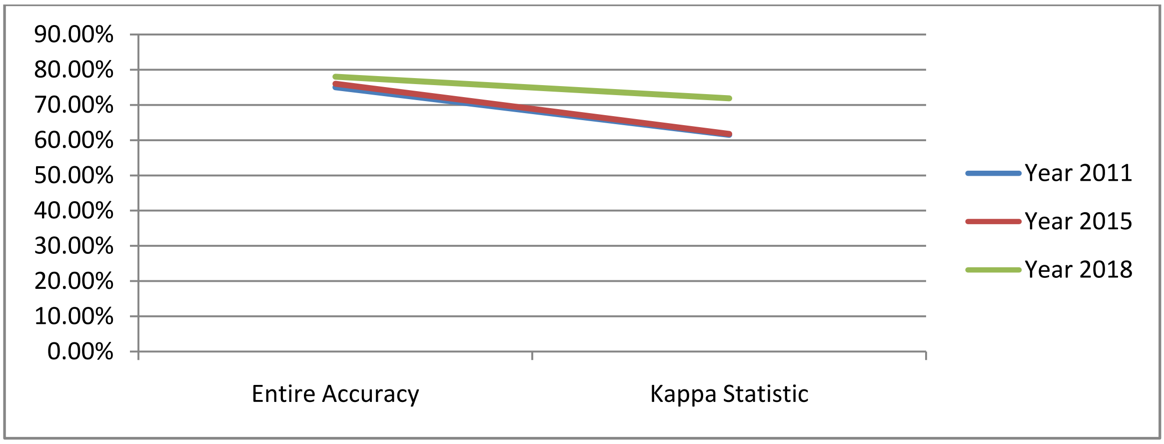

Figure 2: Evaluation of classification accuracy

Classification accuracy for the years 2010, 2015, and 2018 is compiled in Table 3. From 85.00% in 2011 to 88.00% in 2018, the overall accuracy rose, demonstrating an improvement in categorization precision.

Table 4: Transition matrix for 2010-2015

2010/2015	Null	Urban	Water Body	Vegetation	No Vegetation
Null	1.211	1.123	1.124	1.166	1.325
Urban	1.065	1.458	1.001	1.112	1.042
WaterBody	1.045	1.012	1.667	1.234	1.125
Vegetation	1.015	1.235	1.245	1.623	1.145
No Vegetation	1.017	1.025	1.001	1.478	1.458

Table 4 displays the transition matrix for the years 2010 to 2015, which emphasizes the major changes in land cover during that time. Urban development is shown by the fact that the class that was mostly identified as "Urban" in 2010 largely reverts to itself in 2015. The "No Vegetation" class also grows, which promotes urbanization, while the "Vegetation" class continues but also loses members to urban and non-vegetated regions. In general, water bodies continue to be steady. These results provide light on the dynamics of changing land cover, which is important for environmental management and urban development.

Table 5: Transition matrix for 2015-2018

2015/2020	Null	Urban	Water Body	Vegetation	No Vegetation
Null	1.187	1.444	1.125	1.365	1.114
Urban	1.016	1.657	1.002	1.232	1.117
Water Body	1.117	1.235	1.731	1.126	1.002
Vegetation	1.015	1.052	1.015	1.415	1.326
No Vegetation	1.007	1.145	1.004	1.214	1.751

Key changes in land cover are shown in Table 5's transition matrixes for 2015–2018. With very few exceptions, urban areas remained primarily urban. The water bodies stayed steady. Although isolated urbanization and forest loss occurred, vegetation areas remained constant. Expanding non-vegetated regions saw some conversion to urban settlements.

Table 6: Transition matrix for 2010- 2018

2010/2018	Null	Urban	Water Body	Vegetation	No Vegetation
Null	1.084	1.444	1.069	1.326	1.425
Urban	1.116	1.451	1.012	1.151	1.223
Water Body	1.045	1.008	1.517	1.126	1.002
Vegetation	1.114	1.052	1.015	1.415	1.326
No Vegetation	1.007	1.145	1.003	1.214	1.751

The transition matrices for 2010–2018 (Table 6) highlight significant changes in land cover. While there was considerable increase in urban areas, aquatic bodies were conserved. Though there was some isolated urbanization and deforestation, vegetation areas remained. Areas devoid of vegetation grew, with some developing into cities. The "Null" class saw an increase in classification precision. These understandings are essential for the investigated area's environmental management and urban development.

6. CONCLUSION

Integrating geographic information systems (GIS) and satellite remote sensing can help researchers better understand the factors that contribute to land use and land cover change. Therefore, urban planners and decision makers might save time and resources by doing this kind of study. Between 2010 and 2018, the metropolitan area of Pune is expected to expand further. The global and geographical focus of the satellite image, as well as the lack of ground truth information, are the only factors holding back improved outcomes. More research is needed, according to the results of the present study, to see how this change could affect the state of the land.

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