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Analysis of Land Use and Land Cover of Nashik City

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Abstract: *This study employs Geographic Information System (GIS) techniques to comprehensively analyze the dynamic landscape of Nashik city focusing on land use and land cover changes and alterations. Utilizing a combination of satellite images, topographical maps, land use data and GIS data with tools, we conduct a multi-temporal assessment spanning several years. The methodology involves images and data pre-processing, classification schemes, supervised classification of the LULC maps. The research delves into the identification and qualification of land cover classes, emphasizing the detection of changes over time. Additionally, the study employs spatial analysis to discern relationships between land use pattern and various environmental factors. Zonal statics and overlay analysis offer insights into the distribution of land use type, while temporal analysis provides a nuanced understanding of evolving trends. Furthermore, the research extends to land suitability analysis, integrating diverse spatial datasets to assess the appropriateness of different areas for specific purpose such as agriculture, urban development and conversation. The results of this geospatial investigation contribute to informed decision-making in land management and policy planning. The study conclude with comprehensive visualization, including thematic maps and graphs, enhancing the communication of findings. By documenting the methodology, data sources, and key outcomes, this research aims to serve as a valuable reference for policymakers, researchers and stakeholders involved in sustainable land use planning and management in Nashik city.*

Keywords: LULC Maps, GIS, GPS, Classification Using QGIS

I. INTRODUCTION

Land Use and Land Cover (LULC) Mapping: Importance and Applications

Land Use and Land Cover (LULC) mapping is crucial for understanding the ways in which land is utilized and how its surface features change. Land Use refers to the purpose for which land is employed, such as agriculture, residential, commercial, industrial, and recreational areas. Land Cover, on the other hand, refers to the physical and biological features covering the earth's surface, including vegetation, water bodies, and urban infrastructure.

LULC maps provide vital data to analyze the relationship between land use patterns and environmental changes. These maps are composed of various components, such as natural vegetation (forests, grasslands, wetlands), agricultural lands (croplands, pastures), urban areas (residential, commercial, industrial), water bodies (rivers, lakes), and barren lands (rock, sand). They are created using technologies such as Remote Sensing, Geographic Information Systems (GIS), and Field Surveys.

Remote Sensing involves using satellite imagery and aerial photography to collect data about land cover from a distance. It utilizes different sensors like optical, radar, and LIDAR to gather information. GIS plays an essential role by integrating spatial data with other datasets for analysis. Field surveys further enhance accuracy by ground-truthing remote sensing data. These combined techniques create comprehensive maps used for various applications, including land use planning, ecological studies, agricultural monitoring, disaster management, and climate change research.

Tools like ArcGIS, QGIS, and Google Earth Engine are commonly used for LULC map creation and analysis.

Geographic Information Systems (GIS): Key Components and Applications

GIS is a powerful tool for analyzing and visualizing spatial data, linking geographic data with real-world features. It integrates hardware, software, and data to capture, manage, analyze, and display geographically referenced information. GIS consists of four main components: Hardware (computers, GPS units, servers), Software (ArcGIS, QGIS), Data (both vector and raster formats), and People (analysts and decision-makers).

Spatial data in GIS can be represented as Vector Data (points, lines, polygons) or Raster Data (grid of pixels with attributes like temperature or elevation). The system performs various functions, including data input, manipulation, analysis, and presentation. GIS enables better decision-making, resource management, public engagement, and supports interdisciplinary research.

Applications of GIS span across urban planning, environmental management, transportation, public health, and emergency responses. GIS helps improve organizational efficiency by integrating datasets from different departments, allowing shared access to data, and eliminating redundancy. Additionally, GIS is not only used for making maps but also for analyzing complex data and aiding decision-making processes.

Remote Sensing: Overview and Benefits

Remote Sensing is the technique of gathering information about the earth's surface from a distance, using platforms such as satellites, aircraft, or drones. The system uses electromagnetic radiation (EMR) to collect data about physical objects or phenomena, such as land cover, geology, or vegetation. It allows for large-scale data collection without direct physical contact with the objects or areas of interest.

One of the primary benefits of remote sensing is that it offers a bird's-eye view of large regions, enabling quick assessment of natural disasters (e.g., floods, wildfires). This technology is especially useful for areas that are difficult to access, such as remote forests or disaster zones. Additionally, remote sensing provides multi-spectral data, allowing the monitoring of environmental changes over time.

The technology is also beneficial for studying natural hazards, such as earthquakes, landslides, and land subsidence. An ideal remote sensing system would feature uniform energy sources, advanced sensors, and real-time data handling systems.

There are three primary types of platforms used for remote sensing:

- Ground-borne platforms – used mainly for laboratory work or small-scale experiments.
- Airborne platforms – such as balloons and aircraft, used for collecting weather data and generating aerial photographs.
- Spaceborne platforms – satellites in orbit that can cover vast areas of the earth's surface, providing valuable data for environmental monitoring and land use analysis.

Challenges and Limitations of Remote Sensing

While remote sensing provides significant advantages, there are certain limitations. For example, aerial photographs and satellite images may lack the ability to identify specific areas or objects clearly, unlike traditional maps. Ground-truthing is often required to verify the accuracy of remote sensing data. Moreover, the technology requires skilled personnel for data collection and analysis, making it a resource-intensive process.

The data processing involved in remote sensing is also time-consuming and costly. Unlike traditional maps, which are often easier to interpret, remote sensing data requires careful analysis and integration with other systems like GIS. Despite these challenges, remote sensing remains an invaluable tool for spatial analysis, environmental monitoring, and disaster management.

In conclusion, LULC mapping, GIS, and remote sensing are powerful technologies that provide critical insights into land use patterns, environmental changes, and spatial data analysis. They have widespread applications in urban planning, environmental monitoring, and disaster response. As these technologies continue to evolve, they will enhance our ability to manage natural resources, address climate change, and make informed decisions for sustainable development.

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II. LITERATURE REVIEW

Ashish Khemnar et al. explained that encroachment refers to inefficient and dispersed urban growth. The study focuses on various critical land resources and their impacts on encroachments, as well as indicators that measure per capita land consumption. Some consequences of urban sprawl include the loss of vegetation cover, the reduction of prime agricultural land, and increased population density. Using retrospective data from 1991 to 2011 on land use, land cover, and population growth statistics from Nasik city, the study evaluates the impact of land resources. After thorough analysis, it was found that Nasik city expanded in a clustered manner during this period, leading to significant urban encroachment.

Rajnor V. B. et al. highlighted the use of advanced data collection technologies such as remote sensing and GIS-based software. Remote sensing allows for data acquisition without physical contact with objects, but the data comes in raw form and needs software to make it interpretable. GIS software like QGIS and ARCGIS simplifies handling large data sets. In their study, data from Landsat satellites for Nasik district were processed and analyzed for land use and land cover (LULC), considering six classes: vegetation, water bodies, barren land, and others. They compared the LULC data from 2016 and 2021, observing significant changes across the different classes.

Mukesh B. Patil and Shaileshkumar A. Wagh et al. examined land use and land cover as one of the most valuable natural resources of a nation. They distinguished between human activities, such as residential, commercial, and agricultural land, and natural land cover like vegetation, water bodies, and hilly areas. Their study used data extracted from the Bhuvan website for Jalgaon district and categorized it according to LULC and rural-urban distinctions. The analysis, aided by software tools such as MS Excel, revealed a sharp increase in developed land and a corresponding decline in agricultural and vegetative cover within the district.

Bisworanjan Behuria and Manoj Kumar Meher et al. explored the relationship between land use and land cover (LULC) changes and their direct impacts on food security, human health, urbanization, biodiversity loss, and environmental degradation. Their study focused on the Golamunda block of Kalahandi district in Odisha, an area rich in natural vegetation, where notable changes in LULC were observed. Using Landsat imagery from 2001, 2009, and 2016, they conducted a spectral-based supervised classification of the images. The results showed a decrease in agricultural land, deciduous forests, and water bodies, while barren land, scrub forests, and settlements increased. The study highlighted the need for better planning and enforcement to protect forests and manage the growing barren land, which contributes to desertification.

III. MATERIALS AND METHODOLOGY

Study Area

Nashik is among one of the rapidly growing cities in Maharashtra State in India. It is the third largest urban area, covering an area about 259.10 sq.km. The administrative division of NMC are divided into 06 divisions and 61 general wards. It lies between 19^{o}53' to 20^{o}08' North latitude and 73^{o}38' to 73^{o}55' longitude at 536 metres above sea level, situated on banks of river Godavari. The city has become the Centre of attraction because of its surrounding and cool and pleasant atmosphere. Temples and Ghats on the bank of Godavari have made Nashik one of the holiest places for Indians all over the World. Nashik is one of the places in India where the Kumbh Mela is held once in 12 years and also the wine capital of India. The city is divided into several zones, such as residential, commercial, industrial, and agricultural areas, with prominent neighbourhoods including Panchavati, Nashik Road, and Sinnar. The city also contains forested and hilly regions, particularly towards the outskirts, contributing to its varied topography, which plays a crucial role in LULC (Land Use and Land Cover) studies.

This project employs a comprehensive methodology for analysing the Land Use and Land Cover (LULC) in Nashik City. The primary steps include data collection, processing, mapping, and validation, which are further detailed below. GIS (Geographic Information System) and remote sensing software such as QGIS, ArcGIS, Google Earth Pro, and Carto were essential tools for visualizing, analysing, and mapping land use patterns.

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Data Collection

Data was collected to support comparisons between 2005-06 , 2011-12, and the present 2022 enabling a analysis of land use changes and urban development trends in Nashik City. To develop an accurate LULC map following data sources were used:

- **Topographic Maps:** These are used in data collection to represent the elevation, relief, accuracy in delineating urban and rural boundaries, and slope of terrain, providing detailed information about the physical features of a geographic area. They also show the land's contours, allowing to determine features of landscape such as plains, mountains, valleys, canyons, and hillsides.
- **Satellite Images:** These are fundamental in collecting data for LULC analysis due its ability to provide consistent, large scale, and up-to-date observations of the Earth's surface. They allow for mapping, detecting land cover changes over time assessing land degradation as well as deforestation, and monitoring agricultural areas.
- **Land Use Data:** Previous LULC maps of Nashik from government databases and studies provided historical references for comparison.
- **GIS Data and Tools:** These include vector and raster data layers for vegetation, water bodies, and built-up areas that enhance the analytical depth and spatial accuracy of LULC maps.

Data Processing

- Satellite Image Downloading
- Raster Data Opening in QGIS
- Data Conversion DN To Reflectance
- Change The Band Combination
- Adding Data to The Band Set
- Data Clipping
- Create The Training Input File
- Training Sample Extraction
- Image Classification

Data Pre-Processing

After we have downloaded the data, the next action is Data pre-processing done using QGIS. QGIS is a geographic information system that supports viewing, editing and analysis of geospatial data.

The steps in this section can be described as trimming the data downloaded and extracting the data relevant to mapping land cover change.

Loading Vector Data into QGIS:

Open QGIS Desktop with GRASS, and do the following:

- Click on "Layer"
- Go to "Add Layer"
- Select "Add Vector Layer"

Extracting Shape File for Chosen Area

- On the toolbar, click the button "Select"
- In the map that appears on the Map Panel of the QGIS Interface, click on your chosen region to highlight it.
- In the left bottom panel (called the layer panel) of the QGIS interface, right click on the file.
- Select "Export"
- Select "Save Selected Feature As"

- Next, select "Browse" and open the folder
- Name the File with a name of your choosing.
- Click "OK"
- In the Layer Panel, right click on file.

Land Use and Land Cover (LULC) Classification

Classification Scheme:

The classification categories included:

- **Forest:** Areas with dense tree cover.
- **Water Bodies:** Rivers, Lakes, and other natural or artificial water features.
- **Grasslands:** Open, grassy areas primary outside urban zones.
- **Urban/Built-up Areas:** Residential, commercial, industrial, and infrastructural zones.
- **Agriculture:** Cropland lands, identified by crop rotation patterns and field boundaries.

Supervised Classification:

A supervised classification approach was used, where training samples were taken for each land cover type, ensuring accurate categorization. This method involved defining clear boundaries for each class based on field knowledge and historical data.

Comparison of LULC Maps:

Historical maps from 2005-06, 2011-12 were overlaid and compared with 2022 LULC map, identifying significant changes in land use. This comparison highlighted areas of urban expansion, loss of green spaces, and increased built-up areas, which were then quantified and analysed for trends.

Final Map Layout and Visualisation:

The processed and classified LULC data was compiled into a visually appealing map layout with clear labels and symbology. Key features, including urban growth boundaries, green spaces, and water bodies, were color-coded for intuitive interpretation. The map was designed to be both informative and accessible to policymakers, urban planners, and environmental agencies.

IV. CONCLUSION

The Land Use and Land Cover (LULC) analysis of Nashik City shows patterns in the city's urban growth, land transformations, and environmental shifts. From the LULC analysis, it is clearly seen that there is major reduction in agricultural land, barren or unculturable, and wastelands, as well as there is a major increase in forest areas, built-up areas, and wetlands and water bodies such as rivers, lakes, and streams. By analysing the changes occurred from 2005-06 to 2011-12, this study reveals that in some advantageous, beneficial changes has occurred which are good for development of city socially and economically, but some changes are not good for the growth, improvement and development of city. Hence, data obtained from LULC analysis help to identify the various land cover types and then make it easier for decision making about growth, future planning, and overall development of city.

LULC data provides information regarding urbanization, infrastructure development, agricultural development. As a result this guides to face upcoming challenges, make necessary preparedness for disaster, as well as various measures can be implemented to prevent losses and damages occurred due to changes in land cover types over time. Environmental protection can be done after getting an idea about tracking deforestation, soil erosion, urban sprawl, impact on ecosystem and resources.

After knowing the reasons responsible for changes in land cover types, it becomes easier to look forward for development and growth of city by minimizing the factors responsible for losses and damages. To maintain the relevance and utility of LULC data, regular updates, advanced classification techniques, and public engagement are essential.

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With continued monitoring and collaboration among stakeholders, Nashik can achieve a balanced approach to development that ensures environmental sustainability and conservation, and improved quality of life for its residents. This analysis serves as a foundation for informed decision making, for the growth, development, and smart Nashik City

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