Remote Sensing and Machine Learning Techniques for Development of Smart City and LULC Classification: A Case Study

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ABSTRACT

Every government in the world desires smart cities since they have a direct impact on their country. The smart city requires not only that the people of the city be smart, but that the city's facilities be handled by technology in order to become smart. It uses numerous technologies such as Information and Communication Technology (ICT), Internet of Things (IoT), Remote Sensing, and GIS to make cities and governments smart. In this research work we concentrated on Remote Sensing GIS and Machine Learning approaches for the design and implementation of an E-Governance System for Municipal Corporations and Citizens, as well as how this technology aids in the establishment of a Smart City. Finally we choose Aurangabad City, Maharashtra, India as case study for development of Land Use Land Cover (LULC) Map by using Machine Learning techniques for classification of Land in various classes. For the years 2013, 2016, 2019, and 2022, the LULC utilizing MLC has overall accuracies of 87.71%, 88.50%, 86.30%, and 86.06%, respectively. With an overall accuracy of 87.14% in classifying land use and land cover classes from remote sensor data, these accuracy results show that the categorized maps satisfied the USGS's classification criteria. Additionally, all four classified maps obtained kappa coefficient values larger than 0.78 in 2013, 2016, 2019, and 2022, demonstrating that the classification is noticeably improved. These values were 0.85, 0.76, 0.75, and 0.79, respectively.

Keywords: Remote Sensing and GIS (RSGIS), Global Positioning System (GPS), Land Use Land Cover (LULC), Maximum Liklihood Classification (MLC), E-Governance, Smart City, LANDSAT-8.

I. INTRODUCTION

Nearly every nation on Earth is attempting to plan and create smart cities. Planning and building smart cities aims to improve people's quality of life while also reducing time and effort spent on various tasks [1]. The first smart city in the world is referred to as Amsterdam. The world's other smart cities are Singapore and Dubai. It is worthwhile to travel to destinations like Hong Kong, London, Copenhagen, New York, Boston, Barcelona, and Oslo. Over 300 smart cities are to be planned and developed in China. Based on this, the Indian government announced plans to build 100 smart cities, with a budget of 720,000 crore given for this purpose. The Indian government's Smart Cities Mission seeks to improve people's quality of life and economic development by encouraging local area development and utilising cutting-edge technology that yields Smart results. Planning and building smart cities involves participation from governmental organizations, academic institutions, and private sector organizations [2, 3]. Every country wants to develop smart cities because they want to strengthen basic things like, (i) Transportation (ii) Health Care Sectors (iii)Standard of Peoples Living (iv) Smart Services in every sector[4,5]. These fundamental four elements are dependent upon their nation being recognised internationally and having a stronger economy. Technologies are needed to build "smart cities" for a variety of reasons. The core technologies include "huge network connectivity," "cloud storage," "data mining and analytics," "Internet of Things," "machine learning and artificial intelligence", "remote sensing and geographic information systems", and so on[6,7]. The primary goal of e-governance is to provide citizen-centric services facilitated by information and communication technology (ICT). Regardless of the level of smartness pursued by a city, E-Governance deliverables are seen as critical for a nation. Smart cities are also anticipated to be policy-driven and to have a well-defined architecture. Today's e-governance activities are focused on collaboration across groups such as businesses, civil society, government, and people [8, 9]. Remote Sensing and GIS techniques combine with machine learning algorithms not only use for satellite image analysis but this can also be useful for development of hyperspectral data from satellite images and also using Spectroscopic devices [10,11]. The hyperspectral data can be collected through NIR Spectroscopy for various applications like Identification and Counterfeiting in pharmaceutical products, Honey adulterating [12, 13]. It can also be useful for agricultural purpose like Soil analysis and Vegetation analysis. From soil analysis it is use for finding the available contents in the soil like Nitrogen, Phosphorous, Salt, etc. [14, 15]. From Vegetation analysis it is use for finding the available contents in the vegetable and also it is useful for disease analysis and yield prediction [16, 17]. The Remote Sensing and GIS Land Use Land Cover approach helps for classifying large area according to the classes. It may help for designing and planning the city. Classification of Land Use and Land Cover (LULC) is a critical step in urban planning and development, especially when developing smart cities. Smart cities use data and technology to optimise resource use, raise sustainability, and enhance resident quality of life. Accurate LULC classification is essential to attaining these objectives because it offers information on current land uses, identifies possible development areas, and aids in making well-informed decisions [18].

LULC classification can help for development of smart city through the following:

- Environmental Management
- Infrastructure Development
- Traffic and Mobility Planning
- Economic Development and Real Estate
- Urban Planning and Zoning
- Resource Allocation
- Preparation for Disasters and Resilience
- Monitoring and Evaluation

The LULC classification assists city planners in identifying various land uses such as residential, commercial, industrial, recreational, and green spaces. This data is critical for developing zoning boundaries, evaluating the best places for particular activities, and striking a balance among development and preservation of the environment. Managing environmental concerns requires an understanding of different land cover types, such as vegetation, aquatic bodies, and impervious surfaces. It aids in the creation of green spaces, the preservation of natural ecosystems, the control of stormwater runoff, and the reduction of the impact of the urban heat island. Infrastructure for smart cities must be carefully developed and include utilities, public services, and transportation systems [19]. The LULC categorization helps to identify places that require new infrastructure, including public transportation routes, utility installations, roads, and bridges. The LULC categorization offers information on patterns of resource use, such as energy use, water use, and waste creation. Cities may apply sustainable practises and optimise resource allocation by examining these trends. The goal of smart cities is to reduce traffic and encourage effective mobility. With the use of LULC categorization, heavy traffic zones may be identified, facilitating improved transportation planning, the installation of intelligent traffic control systems, and the creation of pedestrian-friendly locations. For determining vulnerability to natural catastrophes like floods, landslides, and wildfires, accurate LULC data is essential. Cities can create early warning systems, evacuation plans, and disaster preparedness plans using this information. LULC data is useful for assessing real estate prospects and figuring out how much a property is worth depending on its location and land use. By providing direction for decisions involving mixed-use developments, shopping malls, and housing complexes, it aids economic growth [20]. Regular LULC updates give a way to analyse changes over time, evaluate the effects of development projects, and keep tabs on the advancement of smart city efforts. Policymakers may use this information to gauge the success of their plans and make any necessary revisions. Satellite photography, geographic information systems (GIS), remote sensing, and machine learning techniques can all be used to improve the precision and effectiveness of LULC classification. These technologies can automate the process of classifying and recognising different forms of land cover, making it simpler for city planners and decision-makers to acquire the data they require for the creation of smart cities [21]. The proposed study focuses on how remote sensing, geographic information systems, and machine learning approaches can help improve the administration of smart cities' transport systems, road networks, identification items, mapping of buildings, open spaces, stores, and properties using Remote Sensing and Geographic Information Systems using LULC technique and the MLC Supervised Machine Learning algorithm.

II. LITERATURE REVIEW

Road networks are a crucial component of the smart city, and they must be robust in order to provide better travel, transport, the simple movement of products and materials, tourism, and other economic ventures. The traditional method of road monitoring is physical inspection; it is time-consuming, labor-intensive, and expensive, requiring a significant number of employees and materials. It also endangers the monitoring personnel, among other things [22]. This outdated technique can no longer fully achieve the desired purpose as more roads are built. Even in places where reasonably sophisticated alternatives have been created, roads still transport the majority of commodities and services exchanged globally along with people. From the point of manufacture to the point of sale, a product may or may not be carried by ship, train, or aeroplane; it will almost certainly be delivered by lorry, van, or people or animals by road at some point [23]. Roads need to be closely managed to make sure that they don't deteriorate to a point where they become severe or unmanageable because they require a significant investment and are essential to the economy. Modern techniques and technology are therefore needed to keep an eye on our roads. The authors Lagunzad and Mcpherson explain how the implementation of a common Location based Reference System (LRS) that will integrate all data on road and bridge inventories will aid in managing the highway network using the Global Positioning System (GPS), Geographic Information System (GIS), and conventional database applications. In order to undertake studies on the role of transport planning in establishing sustainability in the transport sector, several research teams performed structured interviews and questionnaires [24]. Hence, the study or choice of GIS and Remote Sensing in road monitoring is a better option.

One of India's smart cities, Ludhiana uses GIS and remote sensing technology to collect property taxes through municipal corporations. Property taxes are the main source of income for each city, and they are gathered by the municipal corporation of that city. The city of Ludhiana's officials identified properties using high-resolution satellite photos. It is simple to identify illegal properties and their linkages with the use of GIS methods. The study's findings demonstrated how the use of Worldview-II satellite high-resolution photos, ground truthing through door-to-door surveys, and ICT technologies increased accuracy and helped businesses make money [25, 1]. Surat Municipal Corporation created a GIS-based web application for citizens and Surat Municipal Corporation department employees. This project has a total budget of 3.5 crore. They purchased high-quality pictures with 0.6-meter resolution from two satellite images taken in 2006 and 2012. The data was collected physically, and a geo-corrected base map was created. Ground control points, property survey, digitization and geo-referencing, coding and testing for GIS data rectification and software, testing and validation of the model provide hands-on training for Surat Municipal Corporation personnel. Citizens can use the interface to search for plot/property owner information and valuation, plot print with appropriate layers and information, building authorization, and so on. Surat Municipal Corporation's interface provides services such as town planning, building planning, property tax, water supply, sewerage, storm water, road and transportation, bridge, slum and so on. This application provides significant benefits to the Surat government's many agencies, including the Town Planning Department, Property Tax Department, and Town Department. Remote sensing and GIS techniques are at the heart of this [26]. Bhopal, Madhya Pradesh, is one of India's recognised smart cities. According to the study, remote sensing and GIS techniques are employed to construct a rooftop solar photovoltaic system and household-level rainwater collecting. To extract the total and available roof area of Bhopal City, the CARTOSAT-1 Stereo pair in eCognition Developer (V.10) and a technique of segmentation followed by rule-based classification, an automated object-oriented approach is utilised. The removed roof space is decreased further to get usable roof space for solar photovoltaic installations [27]. Md. Omar Sarif and Rajan Dev Gupta carried out the research on LULC and its change pattern, thermal dynamics, and their role in exploring the ecological state over Prayagraj city and its surroundings in summer and winter duration using multi-temporal Landsat (1987–2018) and MODIS Terra data (2007–2018) at both diurnal and nocturnal scenarios. Maximum Likelihood Classifier (MLC) was used for LULC classification. Using the Urban Thermal Field Variance Index (UTFVI), the ecological vulnerability status has been assessed during the day and at night in the summer and winter of 1987–2018 and 2007–2018, respectively. According to author, during the period 1987–2018, built-up land rose the highest, by 18.25 percent, which led to a significant growth in urbanisation. Forest land, on the other hand, fell by 2.22% between 1987 and 2018. Regardless of the season, agricultural land was the most vulnerable class, followed by forest land. Mean LST increased thermal state by 1.25 °C in the summer and 0.58 °C in the winter during the day. However, the mean LST increased by 1.86 °C in winter and 6.64 °C in summer at night. In north-western regions, the excellent ecological class with no SUHI effects decreased in summer from 1988 to 2018 by 1.59% but increased in winter from 1987 to 2018 by 12.33%. However, at night, the excellent ecological class with no SUHI effects significantly decreased in summer and winter from 2007 to 2018 by 11.1% and 1.32%, respectively [28].

Remote Sensing and GIS LULC approach is useful for planning the city because it helps to identify the land classes available in the particular area. ArcGIS, ENVI, ArcMap, QGIS software helps for analysis of satellite image and classify it according to its uses. As per the previous work done in this domain shows that the Remote Sensing and GIS techniques combine with machine learning approach helps to do this. We can identify the Green Spaces, Barred Land, Build up areas, Empty spaces for efficient Land management. Also it helps to identify the Invasive and Non Invasive things in the particular area of land. This can be directly help for smart city development [29, 30]. Swapan Talukdar, Pankaj Singha and its co-authors conducted a survey related to accuracy of different machine-learning algorithms for LULC mapping for satellite data. After that the authors applied six machine learning algorithms on Landsat 8 (OLI) data for classification. Assessment of accuracy was undertaken by Kappa coefficient, an index-based technique and empirical observations. According to the author as per the previous work done in this domain, the RF and ANN is best classification algorithm. As per the result given by RF in this study, the author concluded that the RF is best algorithm for LULC and classification for satellite data. Author also said that according to the geomorphic condition and morphoclimatic condition the LULC accuracy is vary as per the time and location [31]. According to the literature review, Remote Sensing and GIS, Machine Learning, and ICT approaches have played and continue to play major roles in the development of smart cities in India. Previous research has shown that without this technology, an E-Governance system and smart city planning are not feasible.

III. Technologies for Development of Smart Cities and E-Governance System

A. Remote Sensing and GIS

The study of obtaining an area's physical characteristics without physically visiting it is known as remote sensing. It gives users the ability to photograph, observe, and research things and features on Earth's surface. By accumulating the photos, we may classify them according to land cover and perform various types of analysis. We can view much more than we can from the ground because to images taken by satellite and aircraft cameras, which cover large areas of the Earth's surface. Photographs of marine temperature changes may be taken using satellite cameras. The study demonstrated that the development of an e-government system and the creation of a smart city both benefit from remote sensing and geographic information systems (GIS) [32, 33]. Satellite photos with high resolution make it possible to identify any object on Earth. Today, earth resource mapping and urban settlement studies use a number of GIS and remote sensing techniques collectively referred to as geo-informatics [34]. Satellite remote sensing is important because it can give a broad area synoptic view at several scales and on various dates, which conventional methods might not be able to [35]. Table 1, showed the high-resolution satellites that can be useful for Smart city planning.

Table 1: High Resolutions Satellites

Satellite Name	Resolution (in Meter)	Applications
WorldView	0.5 (minimum)	Creation and update of topographic maps, Creation of maps for urban planning purposes, Monitoring of the crops' state, yield forecasting,Mining, Smart City planning , Creation of Digital Terrain Models (DTMs), construction works of oil and gas, Inventory of forests and forest management and so on.
GeoEye-1	0.5	Defence and Security, Engineering and Construction, emergency preparedness, air and sea transportation, exploration for oil and gas, Environment Management, production and development of mines, mapping of remote areas, location-based services, insurance and risk management, crop management, and so on.
IKONOS	1	It is usefull where we want high resolution images like mapping, agricultural monitoring, resource management and urban planning, Cartographic, photogrammetric, and various remote sensing applications ,and so on.
QuickBird	1.6	Engineering and Construction, Environmental Research, Oil and Gas exploration and production (E&P), Analyses of changes in land usage, agriculture, forest climates and so on.
CARTOSAT	2.5 (minimum)	Urban and Rural Infrastructure Development and Management, Land Information System (LIS), Cartography, coastal studies, mineral prospecting, military purposes, weather mapping, forest surveys and so on.

A geographic information system (GIS) is a computer system that gathers, stores, validates, and presents information about specific geographic locations on the surface of the Earth. Streets, buildings, and even plants can all be represented on a single map using GPS. GIS is used by hundreds of thousands of businesses throughout the world to produce maps that communicate, analyses, exchange information, and solve complex problems [36]. The previous study demonstrates that several organizations, researchers, and government agencies from all nations are engaged in various types of initiatives linked to this field using remote sensing and GIS techniques. Various Indian towns, including Bhopal, Ludhiana, Surat, and others, are growing their cities and working to become E-Governances systems using the RS-GIS technique as part of the Indian government's smart city development effort. The software for processing and analyzing data from remote sensing and GIS is listed in Table 2 as both free and paid options.

By collecting Ground Control Points (GCP) and digitizing high-resolution satellite photos, GIS technology is utilized to create georeferenced maps. Municipal Corporations can use GIS systems to manage a variety of tasks, including property taxes, birth and death registrations, property valuations, property searches, construction permissions, town planning, water supply planning, bridge development planning, and others. The E-Government system created by this technology shown tremendous advantages for both people and municipal businesses. Benefits include centralizing all departmental data, facilitating effective planning and decision-making, enhancing the collection of real estate taxes, promoting public health, and more[37,11].

Table 2: Remote Sensing and GIS Software

Software Name	Manufacturer	Applications
ArcGIS Pro	ESRI	Visualize and Analyze Data, Exploration of Data, Creation of 2D, 3D Maps and Scenes, Share work to ArcGIS Online or ArcGIS Enterprise portal.
ArcGIS Desktop	ESRI	Create maps, perform spatial analysis, and manage data.
ENVI	L3Harris Geospatial	Visualization, Analysis, and Management of Geospatial Imagery and Scientific Data
QGIS	QGIS Development Team	The viewing, Editing, Printing, and Analysis of geospatial data.
GRASS GIS	Grass Development Team	Geographic Information System (GIS) Software packagesare used to store and analyse geographic data, model topography and ecosystems, visualise raster and vector data, and process satellite and aerial photos.
GeoMedia	Hexagon Geospatial	GeoMedia is a unified map view that allows for quick data processing, analysis, presentation, and sharing, as well as simultaneous access to Geospatial Data.
MapInfo Pro	Precisely, Pitney Bowes	Data visualisation, analysis, editing, interpretation, and output. The use of map symbols, themes, and labels aids in improving your understanding and ability to visualise data.
Global Mapper	Blue Marble Geographics	It offers a wide range of spatial data processing capabilities to both new and seasoned geospatial experts. There are more than 300 spatial data formats supported by Global Mapper.

B. Machine Learning

High-resolution satellite photos are crucial for the creation of Municipal Corporations' E-governance system. The photos encompassed a vast region, making it impossible to identify each object, structure, property, etc. from the image using standard techniques such visual inspection and picking out each object one at a time. Therefore, we must utilize the Machine Learning technique to select all homogenous and heterogeneous objects from satellite photos. In today's technology age, machine learning techniques are applied extensively practically everywhere. It is frequently utilised in video surveillance, automated navigation systems, object recognition, image processing, and other applications [38, 39]. Unsupervised learning and supervised learning are the two subcategories of machine learning. Machine learning algorithms combined with remote sensing and GIS help to performing a number of tasks for the development of the E-Government system as well as for the creation of smart cities [40, 41]. Buildings and other objects are mostly classified using supervised learning techniques. The Support Vector Machine (SVM) algorithm is used to identify and recognize items, while the K-Means Clustering technique is used to group different objects [42]. Classification algorithms such as Logistic Regression, Linear Discriminant Analysis (LDA), and SVM are used to extract buildings with and without rooftops. The datasets utilized as Worldview-II high-resolution satellite photos and Sentinel satellite images are used in the majority of the study. Vegetation indices are used to identify the greenery and shadows of trees. According to the author, SVM classification algorithms provided higher accuracy [43, 44]. Machine learning techniques aid in the development of smart cities, governmental institutions, and every area of research. In comparison to other available methods, remote sensing and GIS software has good accuracy since it uses machine learning techniques like SVM and Random Forest (RF). When we are careful with the input information and algorithmic settings, the algorithms operate effectively [45, 46].

C. Basic Flow for Analysis of Satellite Images

Through the use of multispectral, infrared, and hydrological data, we can perform urban vegetation analysis, thermal condition forecasting in urban areas, and hydrography geospatial analysis for flooding hazard detection in urban areas using remote sensing and GIS technologies [47]. Land Use Land Cover (LULC) is a highly fundamental application in Remote Sensing and GIS and a key stage in doing comprehensive city analyses [48, 49]. E-government system development is a component of the creation of a smart city, and it requires a variety of approaches and planning depending on the project's goals. The required essential and fundamental processes are depicted in Figure 1. In which first we must obtain the high resolution satellite picture in accordance with our purpose, perform preprocessing on it for noise reduction and feature improvement, and utilize suitable remote sensing and GIS software in accordance with the requirements as indicated in the Table.2. In order to provide the necessary outcomes, the Remote Sensing and GIS software can apply Machine Learning and Deep Learning techniques to satellite photos.

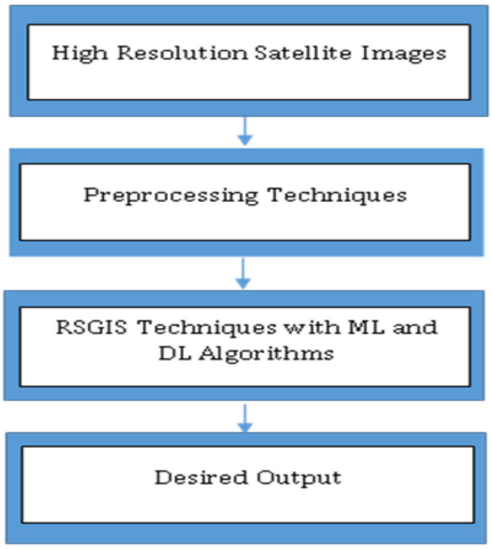


Figure1: Steps of RSGIS

IV. LULC Classification using RSGIS and Machine Learning

Urbanization is a global phenomena with far-reaching consequences for the environment, society, and economy. Rapid urbanization has resulted in the transition of natural landscapes into built-up regions, resulting in a variety of environmental challenges such as air and water pollution, biodiversity loss, and climate change. Urbanization also has an impact on society's social and economic fabric, resulting in challenges such as inequality, poverty, and urban sprawl. Effective urban planning and administration are required to meet these difficulties. We chose Chatrapati Sambhaji Nagar City (formerly Aurangabad) as a case study for our research because it is undergoing rapid expansion, necessitating a detailed examination of land use and land cover. We use Remote Sensing, GIS, and Machine Learning approaches to do this. According to the previous study done in LULC through ENVI, ArcGIS software shows a good accuracy for detailed examination and land classification in the city.

A. Study Area

Chatrapati Sambhaji Nagar (formerly Aurangabad) is a city in the Indian state of Maharashtra. It is noted for its rich historical and cultural legacy and serves as the administrative seat of the Sambhaji Nagar district. The city is located on the banks of the Kham River and is home to various historical landmarks, including the UNESCO World Heritage Sites Ajanta and Ellora Caves. It is located at latitude 19.8762° N, longitude 75.3433° E.

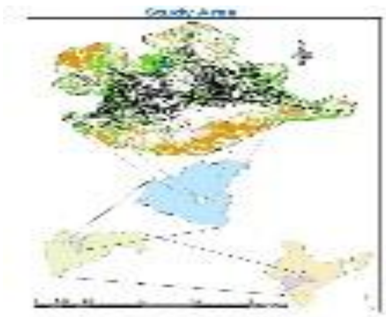


Figure 1. Study Area Map

B. Land Use Land Cover Classification Data

Insightful information about the spatial patterns and changes in land cover types in the research area from 2013 to 2022 was obtained from the LULC classification data produced from Landsat 8 satellite imagery. The information can be used to help urban planning and management tasks such locating high urban development and expansion locations, tracking changes in agricultural and natural areas, and evaluating the effects of urbanisation on the environment and society. The high level of classification accuracy shows that Landsat 8 imagery is suitable for LULC analysis in urban areas.

C. Image Processing and Analysis

Image processing and analysis play a crucial role in remote sensing and Geographic Information Systems (GIS). Remote sensing provides a wealth of information about land cover, land use, vegetation health, urban growth, natural disasters, and more. In this research work the ArcMap software package from ArcGIS Pro was used to process the Landsat 8 satellite images. The data of Landsat 8 satellite images was processed with the steps shown in figure2. In the first step the Landsat 8 satellite images was downloaded from USGS website. After that we preprocessed that images for radiometric and geometric correction, atmospheric correction, and sensor calibration [50]. These processes ensure that the images are ready for analysis by removing distortions and artifacts. LULC classification process involves categorizing pixels or regions in an image into classes, such as water bodies, forests, urban areas, etc. Supervised and unsupervised classification methods are commonly used for this purpose. The Maximum Likelihood supervised classification algorithm was used for mapping the satellite images class wise. By comparing images acquired at different times, changes in land cover, urban expansion, deforestation, etc., are identified and analyzed through the developed classified maps and its statistics data. This all process was done through ArcGIS Pro Remote Sensing and GIS complete software package[51].

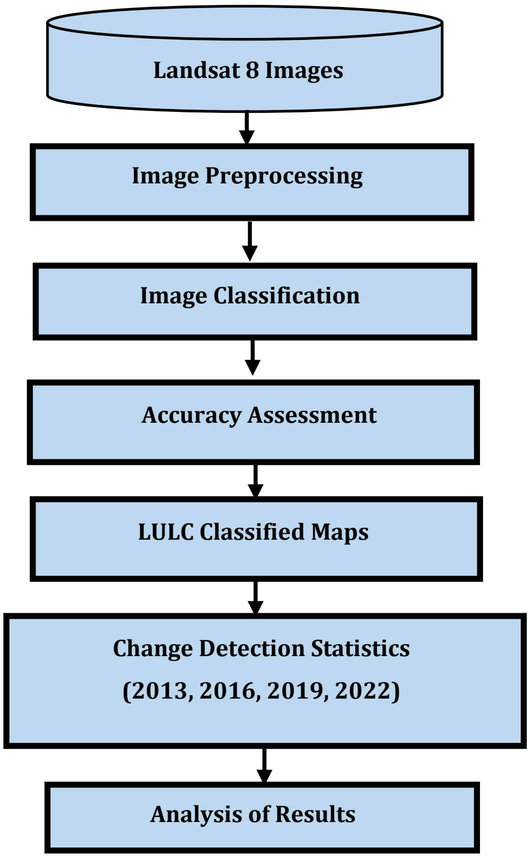


Figure2: Satellite Image Analysis

D. Image Classification

The technique of image classification is used to assign land cover classes to pixels within a picture. The image can be segmented into clusters representing distinct land cover types by analyzing the digital values of each pixel and grouping them together based on similarity. For our investigation, we began with Land Cover and Land Change data from 2013 to 2022, making small adjustments as needed. Built-up areas, bare land, forested areas, agricultural land, herbaceous land, and water bodies were all classified under the chosen classification scheme [52].

Table2: land use land cover classes category list

LULC class	Description
Green Area	Green spaces play a vital role in both nature and human existence. It is a vital aspect of both natural and urban landscapes. It can reduce emissions and pollutants, enhance tourism, increase biodiversity in urban wildlife, and provide cleaner air and streets.
Buildup Area	The assessment of built-up areas as part of land use and land cover mapping is highly relied on in urban and regional planning, environmental management, and sustainable development activities.
Road Area	Road area mapping is an important aspect of land use and land cover analysis because it provides essential data for choices on transportation infrastructure design and management, as well as environmental impact assessments.
Water Bodies	The areas are permanently covered by water, which includes man-made dams and ponds. The dams are useful for storing water and use for farming, daily use etc. The ponds can be useful for fishing and tourism.
Barren Land	Those situations in environment where there is less than one-third of the land covered with vegetation or other types of cover. Typically, thin soil, sand, or pebbles make up barren land. Examples of barren landscape include arid salt, flats, sand dunes, deserts, beaches, strip mines, exposed rock, gravel pits and quarries.

The MLC classifier was employed in the study, which is a supervised classification strategy in ArcMap that relies on the selection of sample pixels in an image that represent different classes. These training examples serve as guidance for classifying the remaining pixels in the image [53]. To train the classifier, uniformly distributed Regions of Interest (ROI) for all class categories were selected in the research region using visual interpretation of Landsat 8 images. To enhance feature visualization and make it simpler to identify between LULC classes in the image, true and false color composites were used. The categorized maps were tested and trained using images from the Google Earth collection. There were a total of 6210, 4230, 3560, and 5102 training samples used for the images from 2013, 2016, 2019, and 2022, respectively. The separability of the samples was assessed using a spectral separability test utilizing the M-statistic approach before the training samples were used in the classification procedure [54]. The images were categorized into the six LULC categories previously mentioned using spectral signatures created using the MLC approach, which can perform supervised learning via backpropagation.

$$f(i,j) = \max[R(i,j),G(i,j),B(i,j)]$$

The equation $f(i,j) = \max[R(i,j), G(i,j), B(i,j)]$ represents a simple method for calculating the maximum value of the Red, Green, and Blue bands for each pixel (i,j) in an RGB color image.

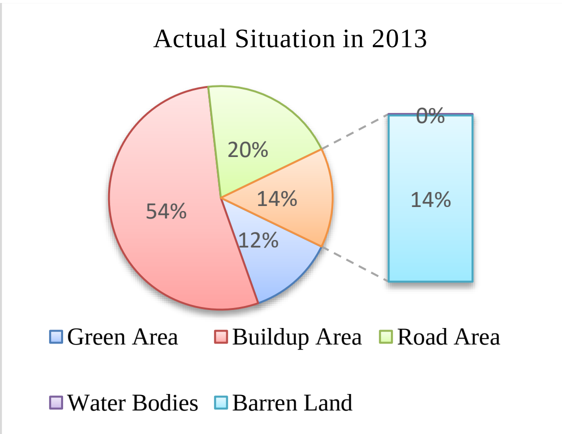
E. Accuracy Assessment

An assessment was carried out to determine the accuracy of four classified maps and to check that the mapped information corresponded to what was found on the ground. The classification accuracy was evaluated using the error matrix. For the four categorized maps, the error matrix was utilized to calculate a variety of accuracy metrics, including overall accuracy, kappa coefficient, user accuracy, and producer accuracy [55].

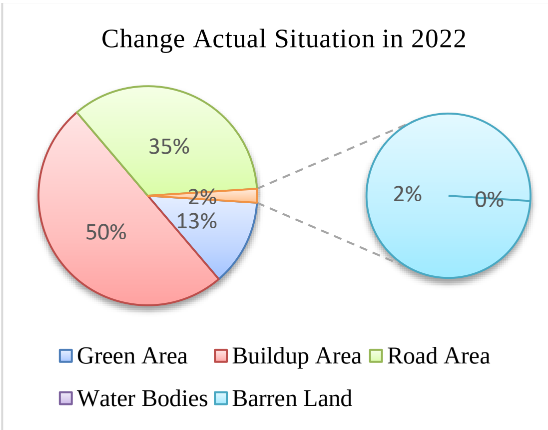
The overall accuracies for the years 2013, 2016, 2019, and 2022 were 87.71%, 88.50%, 86.30%, and 86.06%, respectively, according to the evaluation results. These accuracies show that the categorized maps satisfied the USGS classification requirement of 87.14% overall accuracy in classifying land use and land cover classes from remote sensor data. Furthermore, in 2013, 2016, 2019, and 2022, all four classified maps attained kappa coefficient values of 0.85, 0.76, 0.75, and 0.79, which are greater than 0.78, showing that the classification is much improved.

Table3: Land Use Land Cover Classes Areas in Km2

Sr. No	Land use Land Cover Classes in 2013 and 2022					
	Land use category	Area In 2013 km^2	%	Area in 2022 km^2	%	Change in km^2
1	Green Area	14014	12.41%	17731	18.00%	+ 5.59%
2	Buildup Area	117	53.63%	31265	31.70%	-21.93%
3	Road Area	19300	19.63%	34544	35.07%	+15.44%
4	Water Bodies	52830	0.12%	115	0.12%	No change
5	Barren Land	12275	14.22%	14881	15.11%	+0.89%
	Total Area	**98536**	**100%**	**98536**	**100%**	



Graph X



Graph Y

The study examined how each land cover class had evolved over time and discovered (Table 3 and Graph X and Graph Y) that the area of Green Area had increased by 5.59%, the area of Buildup Area had reduced by 21.93%, the area of Road Area had increased by 15.44%, the area of Water Bodies had stayed stable, and the area of Barren Land had increased by 0.89%. When making decisions about land use and conservation in fast growing cities like Chatrapati Sambhaji Nagar (Aurangabad), urban planners, land managers, and policymakers can use these findings as vital insights into the LULC patterns of the study area.

F. LULC Classification Analysis

According to the categorised maps, the research area's primary land use and land cover classes are green areas, road buildup areas, water bodies, built-up areas, and barren land. Due to urbanisation and other reasons, the proportion of each land use and land cover class has varied over time. While the area classified as built-up regions has grown, the area classified as green areas has shrunk. The effects of urbanisation have also been felt by the forest and water bodies, as seen by the study area map, which displays the results of the study before and after classification using a divide-by-class bar graph.

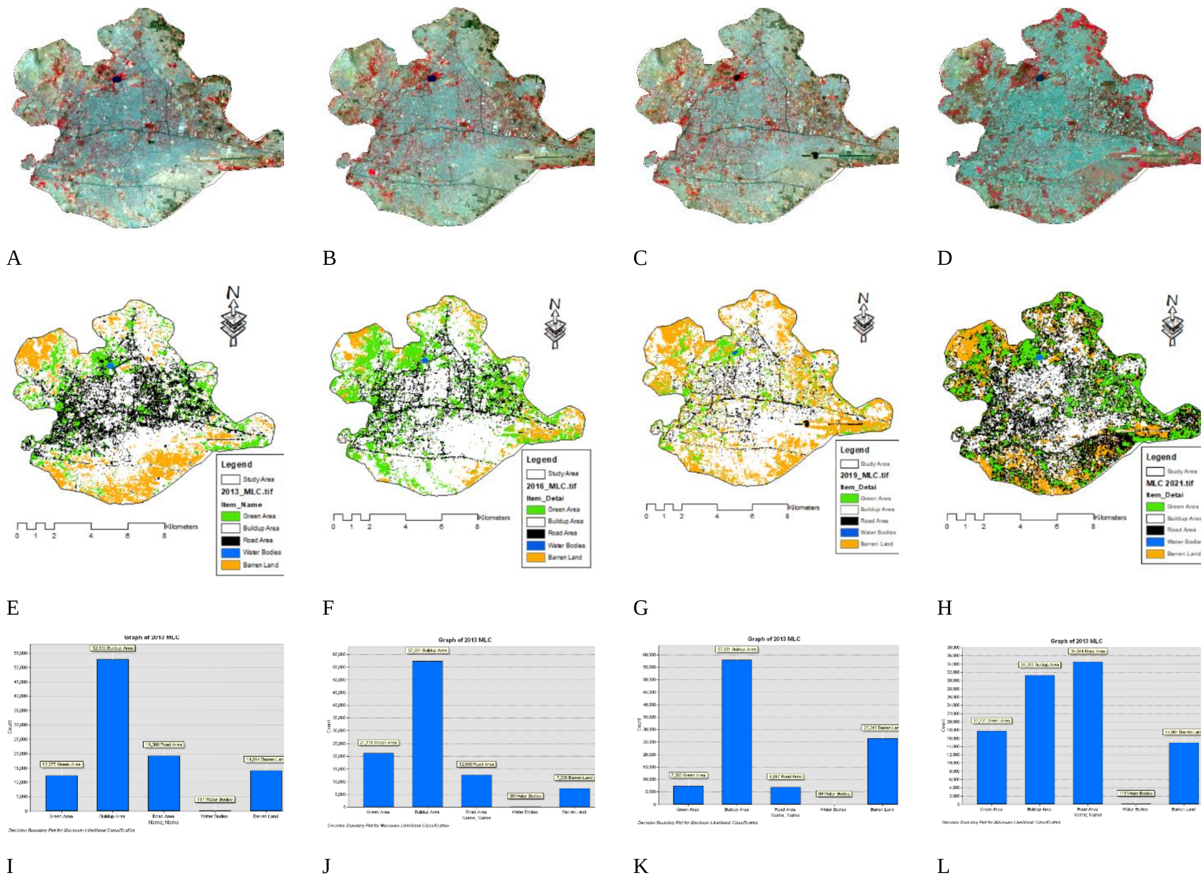


Figure 3. False Color Image (A) 2013, (B) 2016, (C) 2019 and (D) 2022, LULC map (E) 2013, (F) 2016, (G) 2019 and (H) 2022 and LULC Class wise Bar Graph (I) 2013, (J) 2016, (K) 2019 and (L) 2022.

V. Conclusion

Machine learning techniques combined with remote sensing and GIS have a huge impact on the design and development of e-government systems and the growth of smart cities. The previous study and research work done in this paper demonstrated that high-resolution satellite images, such as Worldview-II, Sentinel, IKONOS, Quick Bird, and others, aid in the recognition and identification of various types of objects, buildings, empty places, playgrounds, greenery, and other items from a large area of the city, and this can aid in the design of E-Government systems with the aid of Remote Sensing and GIS software as well as Machine Learning algorithms. Various things are present in the satellite image; to extract and identify those objects, supervised machine learning methods are extensively utilized due to their accuracy and tremendous benefits. This study found that Machine Learning techniques and Worldview-II high-resolution satellite photos are useful for the development of the Smart cities and also useful for contributing to the development of E-Governance system as a part of Smart cities in the form of technology. The use of Maximum Likelihood Classification (MLC) to map the Land Use and Land Cover (LULC) of the Chatrapati Sambhaji Nagar district using USGS satellite imagery has proven to be an effective approach. The Chatrapati Sambhaji Nagar case study demonstrated the excellent accuracy of MLC for multi-spectral imaging data of the study region, with overall accuracies reaching the USGS classification criterion and kappa coefficient values indicating considerable increases. Our research has uncovered important information on the LULC trends in the study area that might assist urban planners, land managers, and politicians in making wise choices regarding land use and conservation in quickly growing cities like Chatrapati Sambhaji Nagar.

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