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Geographical analysis of LULC in Nashik District (2024) of Maharashtra state

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ABSTRACT

The land is an essential natural resource that plays a vital role in human development and existence through the provision of food and shelter. Whatever human beings do is related to the land in some way, e.g. infrastructural development like buildings, roads, railway, and airport construction; recreational activities such as parks, gardens, and sports complexes and socioeconomic activities such as the establishment of hospitals, employment sector, and educational institutes. Hence, studying Land Use and Land Cover (LULC) change contributes to improving an understanding of the sustainable use of land resources for sound economic and social growth. This work aims to examine the land use and land cover changes in the Nashik District in December 2024 by using Landsat satellite images. Supervised classification method is used for generation of LULC maps for the selected time period. The image was classified into the five classes; Agriculture (4258.85 sq.km. or 27.43%), Barren Land (8265.16 sq.km. or 53.23%), Built up (222.17 sq.km. or 1.43%), Forest (2390.72 sq.km. or 15.40%) and Water body (389.62 sq.km. or 2.51%). The Barren land covers most of the area in study region. The confusion matrix and error matrix were used in this study to measure accuracy. The study's kappa coefficient was 0.82, and its total classification accuracy was 85.3%.

Because the kappa coefficient is nearly almost perfect, the categorized picture is deemed suitable for more study

Introduction:

The land is a significant natural resource that is essential to human growth and survival since it provides food and shelter. The development of infrastructure, such as buildings, roads, railroads, and airports; the construction of parks, gardens, and sports complexes; and socioeconomic endeavours, such as the construction of hospitals, employment sectors, and educational institutions, are all connected to the land in some way. Thus, research on LULC advances knowledge of the sustainable use of land resources for sound social and economic development. The assessment of land use and land cover change is critical for comprehending the human-nature relationship [2]. The ways in which people utilize the land cover are referred to as land usage [13]. The observed biophysical surface of the Earth, which includes water, forests, agricultural land, wetland, build-up, soil, topography, and surface water, is referred to as land cover ([12], [14]). Studies of land-use change at the local level, carried out over several time periods, aid in the discovery of broad principles that explain and forecast future changes in land-use [6]. The majority of LULC studies indicate that built-up areas are growing while forest and farmland areas are decreasing ([4], [5], [7], [9], [10], [11]). Information on land cover and use is necessary for administrative, business, and policymaking reasons. The data are also essential for spatial planning and environmental protection due to their geographic features [8].

Remote sensing and geographic information systems can detect and/or monitor features on the Earth's surface using satellite images with varying radiometric, spectral, spatial, and temporal resolutions. These technology resolutions offer various advantages in order to decrease time and expense in extracting land cover and land use [1]. In the processing of data from remote sensing, accuracy assessment or validation is an important stage. It tells a user how much information the resultant data is worth [8]. In image classification experiments, evaluating accuracy was not a top concern. But because digital photography increases the likelihood of inaccuracy, accuracy evaluation has become a crucial procedure ([3], [11]). Image classification accuracy is now commonly evaluated using the error matrix and kappa coefficient. Error matrices, which have been employed in many land categorization studies, were also an essential part of this study [8].

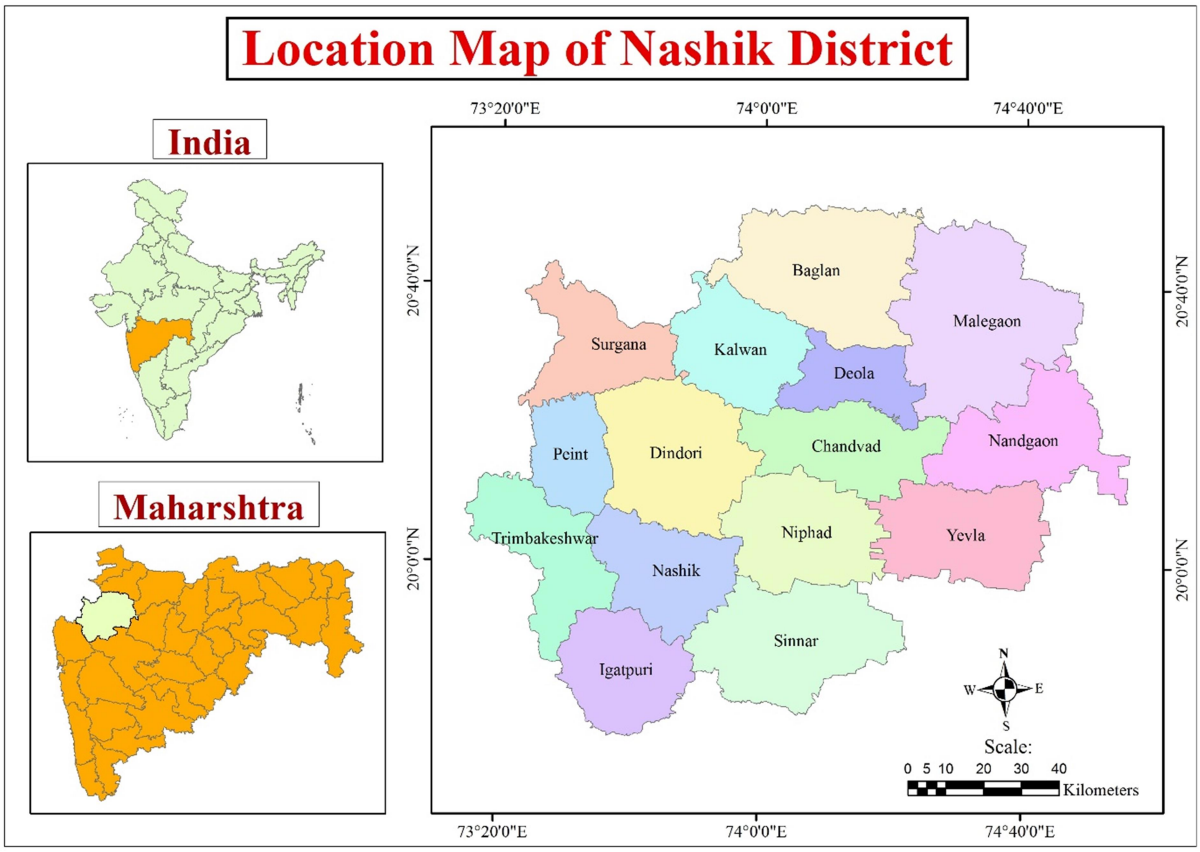
The main objective of this research was to classify the different Land Use Land Cover in Nashik District for the year 2024 by using remote sensing and Geospatial Information System (GIS) techniques

and also carry out accuracy assessment. In this study, we employed Landsat-8 satellite Images. These photographs are classified into five categories i.e. agriculture, Barren land, Built-up areas, Forests, and water body. The supervised classification method is used for study.

Objectives:

- To prepare Land Use Land Cover map of Nashik District of Maharashtra.
- To assess the accuracy assessment of the work.

Study Area:



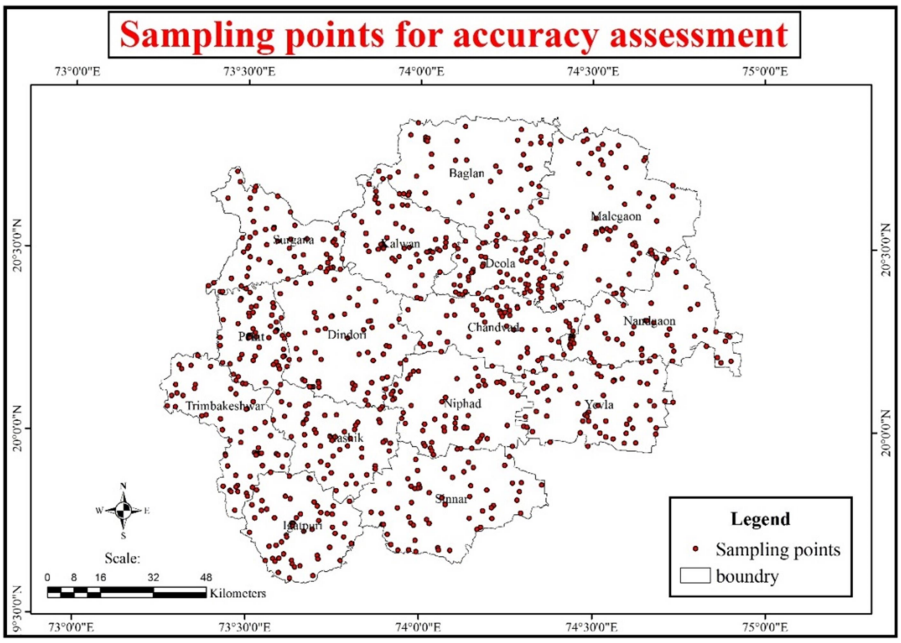
Nasik District is situated in north western part of Maharashtra. It lies between 19°35’ and 20°50’ north latitude and between 73°16’ and 74°56’ east longitude. It is surrounded by Dhule district in the north, Dangs and Surat district of Gujarat State in the northwest, Jalgaon in the east and northeast, Ahmednagar in the south, Aurangabad in the southeast and Thane in the west and southwest. The district covers a total area of 15,530 square kilometres. The district headquarters is located at Nasik Town. For administrative purpose four divisions have been formed namely Nasik, Niphad, Malegaon and Peth. The

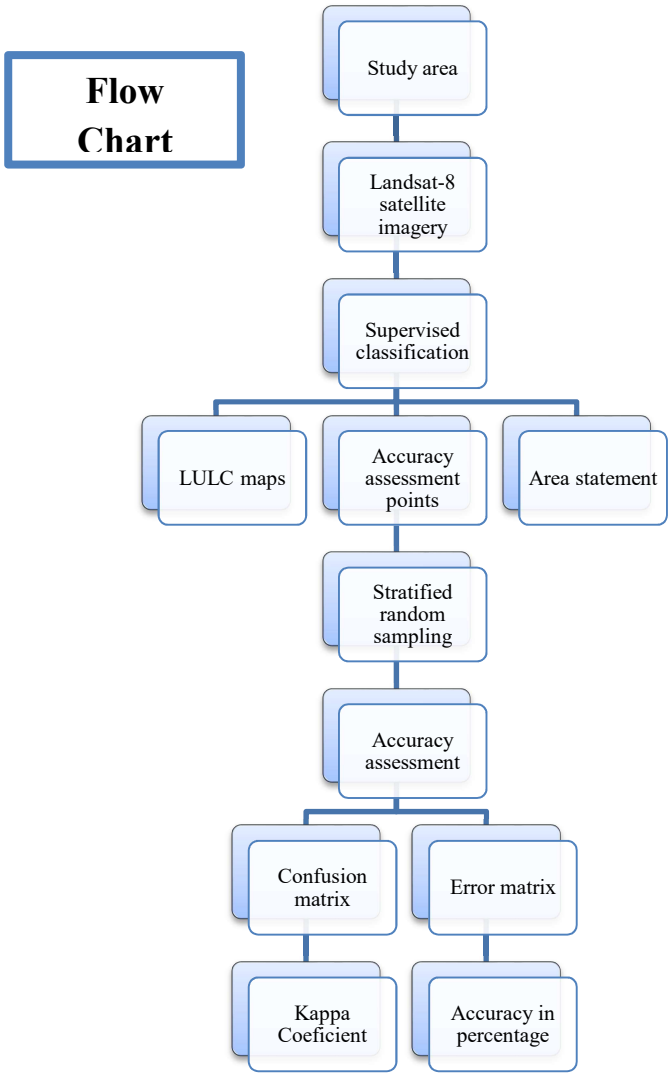
district is further subdivided in to 15 talukas viz., Nashik, Igatpuri, Dindori, Peint, Surgana, Deola, Satana, Kalwan, Chandwad, Niphad, Sinnar, Yeola, Malegaon, Nandgaon and Trimbakeshwar.

Data and Methodology:

Remotely sensed satellite data was used in this study as Landsat imagery. Landsat-8 satellite data was used for the December month of year 2024. The satellite images are downloaded from the USGS Earth Explorer website (earthexplorer.usgs.gov). The spatial resolution of Landsat is 30 meters. The GIS software plays an essential role in processing this data. The supervised classification is done through GIS software. The satellite imagery is classified into the five categories Agriculture, Barren land, Built-up areas, Forests, and water body. Different Training samples are selected for the different Land use and after that using image classification tool image is classified into the 5 categories. After Image classification was done the next step is to calculate area under different types of LULC categories. The area is calculated by using pivot table in the Microsoft excel sheet.

The accuracy assessment is the most important stage in this study. The aim of accuracy assessment is to quantitatively assess how effectively the pixels were sampled into the correct land cover classes [8]. For the accuracy assessment the 1st step is to create accuracy assessment points means sample points. In this study the stratified random sampling method is used for generating sampling points. About 857 samples points are taken throughout the district for accuracy assessment. Ground truthing was conducted using Google Earth Pro as a reference. The image from Google Maps served as a guide. Following the examination of every sample, a confusion matrix was produced for the outcomes. It was used to compute the kappa coefficient

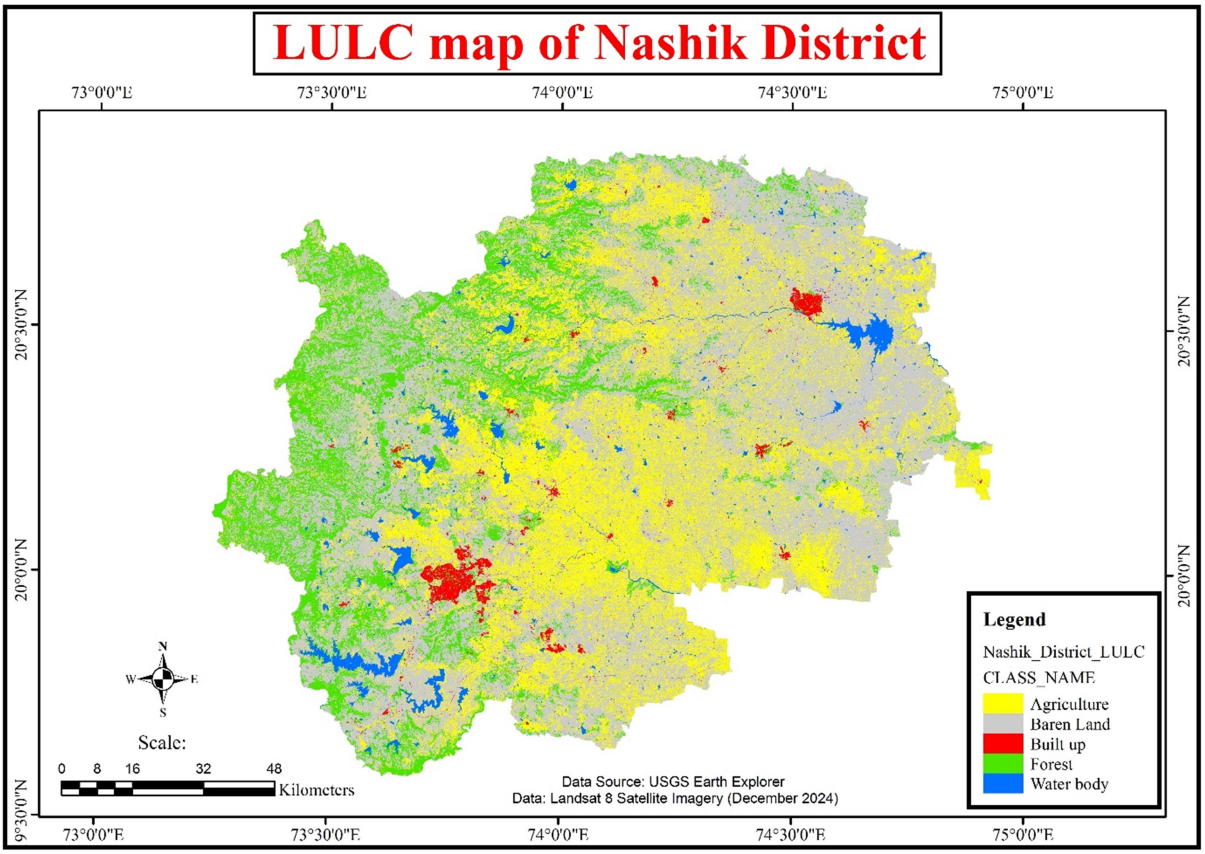




Category wise accuracy assessment statistical parameters for Kappa Coefficient: according to [8].

Sr. No.	Kappa statistics	Strength of agreement
1	<0.00	Poor
2	0.00 - 0.20	Slight
3	0.21 - 0.40	Fair
4	0.41 - 0.60	Moderate
5	0.61 - 0.80	Substantial
6	0.81 - 1.00	Almost perfect

LULC result and Accuracy assessment of Nashik District:



As seen in the above map, the land use and land cover for 2024 are divided into five groups. Agriculture, barren land, built-up areas, forests, and water bodies are the five categories. The region is under agricultural land, as indicated by the yellow colour. The majority of the district's centre and eastern regions are dominated by agriculture. The built-up region is indicated on the map by the colour red. Buildings and other man-made structures, commercial and industrial zones, mixed urban regions, and built-up lands are all considered built-up areas. Nashik City and Malegaon city are the two large populated places on the map. Small, dispersed clusters of built-up regions are seen, with a few dense zones perhaps denoting large towns or cities. The predominant land cover in Nashik District is barren land, shown in grey on the LULC map, occupying about 53.23% of the total area. It is mainly concentrated in the eastern and central regions, with a few patches in the south, and represents rocky, uncultivable, or degraded land with minimal vegetation. Barren land can be reduced through afforestation, soil and water conservation, and by promoting horticulture such as vineyards and orchards. It can also be utilized for renewable energy projects and eco-tourism, thereby transforming it into a productive resource. The Nashik District's forest area is shown by the colour green. The western portion of the district has a larger quantity of forest land, while the northern and north western parts also have

larger amounts. The western and southern areas are primarily forested. There are several large and small bodies of water in the research region but there are particularly apparent concentrations in the central and southern areas, all of which are blue in colour. Rivers, lakes, reservoirs, dams, and other bodies of water exist. Gangapur Dam, Darna Dam, Palkhed Dam, Ozarkhed Dam, Bhavali Dam, Upper Vaitarna dam area some major water bodies in study area.

Category wise Area statement			
Tehsil Name	**LULC type**	**Area (sq. km.)**	**Area (%)**
Nashik District	Agriculture	4258.85	27.43
	Barren Land	8265.16	53.23
	Built up	222.17	1.43
	Forest	2390.72	15.40
	Water body	389.62	2.51

The LULC area for each of the five categories is displayed in the above table both in square kilometres and as a percentage. Barren Land occupies the largest portion of the Nashik district, making almost over half of its entire size (8265.16 sq. km, or 53.23%). In Nashik District, the rise in barren land is driven by deforestation and agricultural expansion that reduce soil cover; unsustainable farming and over‑irrigation that degrade soil fertility; widespread topsoil erosion and poor soil health; rapid peri‑urban encroachment converting cropland into inactive land; climate-induced groundwater depletion and drought stress lowering productive moisture; and vegetation loss from over‑grazing and forest degradation, which accelerates overall land degradation. About 27.43% of the entire area is covered by agricultural land, ranking second in the research region's LULC. Additionally, the Nashik District has a sizable quantity of forest area roughly 2390.72 sq. km, or 15.40%. The scope for plantation is best in hilly areas with good rainfall, where the soil stays moist. Open or empty forest lands are also suitable for growing more trees. Riverbanks and wetland edges are ideal too, as the soil there is naturally wet and supports healthy vegetation growth. Water bodies make up 2.51% and built-up area 1.43%, respectively. The study region's predominant land use is barren land.

Confusion Matrix for Kappa Coefficient of Nashik District									
Sr. No.	**Class Value**	**Agriculture**	**Barren Land**	**Built up**	**Forest**	**Water body**	**Total**	**Users Accuracy**	**Kappa**
1	**Agriculture**	142	2	0	16	3	163	0.871166	0
2	**Barren Land**	54	179	1	1	0	235	0.761702	0
3	**Built up**	13	6	124	1	6	150	0.826667	0
4	**Forest**	13	1	0	145	0	159	0.91195	0
5	**Water body**	2	4	3	0	141	150	0.94	0
6	**Total**	224	192	128	163	150	857	0	0
7	**Producers Accuracy**	0.633929	0.932292	0.96875	0.889571	0.94	0	0.852975	0
8	**Kappa**	0	0	0	0	0	0	0	0.815478

The above table is confusion matrix for the classification this table is used to calculate Kappa coefficient value. The Kappa value for this work is 0.82, this shows that the strength of agreement is almost perfect. The kappa value is calculated using spatial analyst tool in the arc toolbox from Arc map software. There is tool Segmentation and classification in the spatial analyst tool and in that tool, there is tool compute confusion matrix.

Error Matrix for LULC accuracy of Nashik District								
Sr. No.	**Classified**	**Agriculture**	**Barren land**	**Built-up**	**Forest**	**Water body**	**Total**	**Correct Samples**
1	**Agriculture**	142	2	0	16	3	**163**	**142**
2	**Barren land**	54	179	1	1	0	**235**	**179**
3	**Built-up**	13	6	124	1	6	**150**	**124**
4	**Forest**	13	1	0	145	0	**159**	**145**
5	**Water body**	2	4	3	0	141	**150**	**141**
	Total	**224**	**192**	**128**	**163**	**150**	**857**	**731**

Accuracy in Percentage	85.29754959

The above table shows the relationship between the ground truth data and corresponding classification data. The above Table is confusion matric for LULC classification

The overall classification accuracy = No. of correct samples / Total Samples

= 731 / 857

= 85.30%

The total number of 857 samples are taken from overall study region, from that corrected samples are 731. The overall classification accuracy for the work is about 85.30%.

Conclusion:

The supervised classification performed on the satellite image. The image was classified into the five classes; Agriculture (4258.85 km^2 or 27.43%), Barren Land (8265.16 km^2 or 53.23%), Built up (222.17 km^2 or 1.43%), Forest (2390.72 km^2 or 15.40%) and Water body (389.62 km^2 or 2.51%). The Barren land covers most of the area in study region.

Before being utilized as input for any applications, categorized images must also be evaluated for correctness. To evaluate the model's performance with regard to a single category or class of interest for the research, individual accuracy evaluation parameters are helpful. The confusion matrix and error matrix were used in this study to measure accuracy. The study's kappa coefficient was 0.82, and its total classification accuracy was 85.3%. Because the kappa coefficient is nearly almost perfect, the categorized picture is deemed suitable for more study.

Sustainable land use in Nashik District means using land in a way that supports farming, forestry, and development while protecting natural resources like soil, water, and forests. The district has a mix of hilly areas, fertile plains, and forest zones, making it important to plan land use carefully. Practices like planting trees on degraded land, using drip irrigation, and promoting organic farming help keep the land healthy and productive. By balancing human needs with environmental care, sustainable land use in Nashik ensures that the land remains useful and fertile for future generations.

The land use potential of Nashik district reveals a clear spatial differentiation between plantation, agriculture, and industrial suitability. The western and southern zones, particularly Trimbakeshwar, Igatpuri, and Peth, demonstrate strong potential for plantation owing to their rainfall patterns and degraded forest landscapes. Plantation along the Godavari riverbanks can further support soil

conservation, while Niphad's dry areas are appropriate for agro-forestry. The central belt, including Niphad, Dindori, and parts of Sinnar, stands out as the agricultural core with fertile soils and irrigation facilities sustaining high-value crops such as grapes, onions, and pomegranates. Conversely, the eastern and northern regions, comprising Sinnar MIDC, Malegaon outskirts, Nandgaon, and the Dindori plateau, are largely barren or less fertile, making them more suitable for industrial expansion. This analysis highlights the importance of a balanced land-use strategy that integrates ecological restoration through plantations, sustains agricultural productivity, and accommodates industrial growth to ensure sustainable development in the district.

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