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Spatio-Temporal Change of Landscape and its Impact on Agriculture Development in Ghaziabad District

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Abstract

In the past two decades, rapid urbanization and population growth have led to significant land use and land cover (LULC) changes in the Ghaziabad district, impacting its natural ecosystem and agricultural development. This study investigates the spatio-temporal dynamics of LULC and its effects on agricultural development during the period 2000 to 2020. Various factors, including human encroachment, industrialization, and excessive resource utilization, have contributed to altering the district's landscape. The research employs multispectral datasets from Landsat satellites, specifically Landsat 5, Landsat 7, and Landsat 8, utilizing Thematic Mapper (TM), Enhanced Thematic Mapper (ETM), and Operational Land Imager (OLI) data to analyze LULC patterns for the years 2000, 2010, and 2020. The analysis was conducted using ERDAS-Imagine 2013 software to process the satellite images and perform accuracy assessments for each period. The results reveal a continuous decline in agricultural land due to the expansion of built-up areas. The increasing urban sprawl and infrastructure development have encroached upon previously cultivated regions, reducing the availability of agricultural land and threatening the sustainability of local farming practices. These findings underscore the challenges faced by agriculture in the district, where urban growth has led to competition for land and resources. Furthermore, the study highlights the ecological consequences of LULC changes, including the disruption of natural habitats and reduced ecosystem services. As the study primarily focuses on understanding the spatio-temporal changes in LULC and

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their impact on agricultural land, the organic farming sector emerges as a critical aspect of the evolving agricultural landscape. This research also serves as a critical resource for sustainable land management strategies in Ghaziabad, emphasizing the importance of mitigating the adverse effects of LULC changes on agriculture and the broader environment.

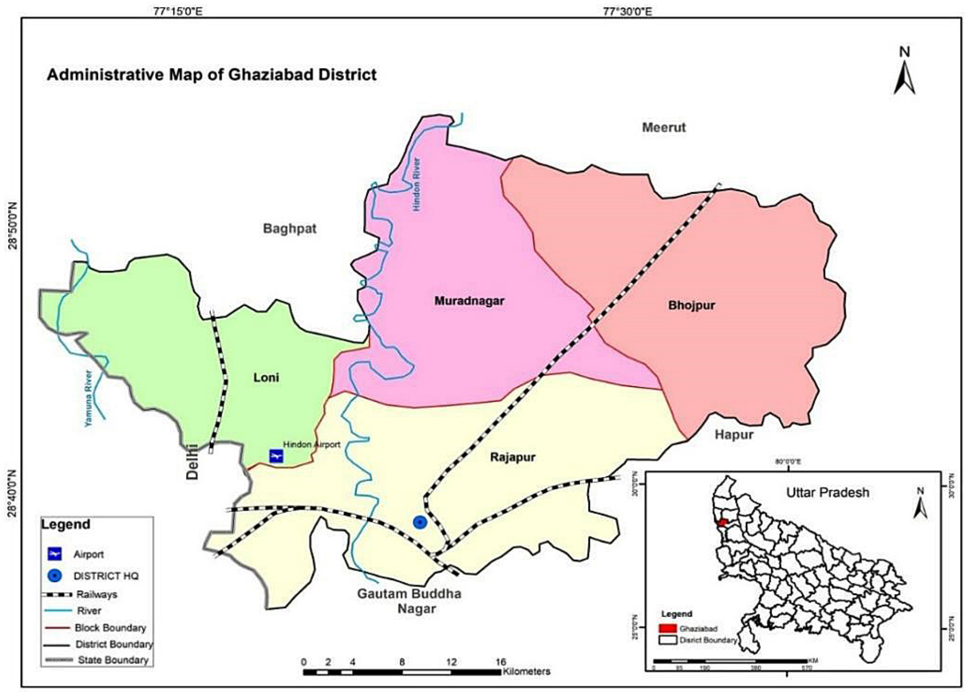
Introduction

Changes in land use and land cover are the result of human exploitation of resources for varied purposes over time and space. These modifications may also be the result of natural processes. To understand the human interference in the natural pattern this method becomes relevant or viable to trace various feature that have been changed.[1] The information of the area of interest collected through optical satellite imageries provides us an edge to understand the human activities and its utilization of the space for various purposes.[2] The different uses of land are result of interaction among several factors of that region such as physical, social, economic and institutional.[3] Land has been used for agriculture, forestry, recreational activities, industries, urbanization, grazing, etc. Land use change always occurs under certain circumstances and these circumstances affect the whole ecosystem of that region.[4] The variables responsible for changes in land use and land cover can be divided into direct and indirect factors. Some activities or circumstances, such as agricultural development, industrialization, urbanization, etc. are known to directly affect or alter the proportion of land that is utilized.[5] Physically, the direct variables are more significant than the indirect elements, but the indirect factors are responsible for affecting the direct factors, resulting in landscape changes.[6] These indirect influences have extremely intricate structures that govern the transformation of land use and human activities. Population growth and economic shifts frequently influence land usage and land cover changes.[7] Changes in land cover are mostly influenced by human activity.[8] Changes in land use and land cover are complementary to one another.

The utilization of land in a region of an agricultural network always reflects, on the one hand, the geographical setting of the site and, on the other, the socio-cultural status and economic activities of the inhabitants.[9] One of the districts where urbanization, industrialization, and agriculture are advancing is the district of Ghaziabad. The land is categorized as requiring special training due to the fact that it has undergone a number of alterations that have resulted in both positive and negative transformations as a result of the land's real nature and qualities.[10] In India, land is divided into five classes according on its intended use. It was decided that this categorization was insufficient, particularly within the framework of agricultural planning. It does not provide a complete picture of the real sample of land use that may be evaluated for necessary adjustments in use. Therefore, in March 1950, the Government of India approved every other type in accordance with the advice of the Food and Agriculture Organization's status Advisory Committee on statistics.[11] Consistent with this classification, India's land was divided into nine groups. The nine types of land are forest, uncultivated land, land used for non-agricultural purposes, cultivable waste land, permanent pastures and other grazing lands, land beneath diverse tree species, fallow land other than contemporary fallow, modern fallows, and internet-sown land.[12] Ghaziabad district of Uttar Pradesh reveals a varied land use sample with massive spatio-temporal variations. There has been latest incidence observed full-size transformation in land use of numerous categories of the district because of the pressure of population and growing their needs. Therefore, detailed analysis of adjustments of fashionable land use and agricultural land use inside the district is highly vital before reading the transformation of cropping sample and agricultural improvement within the district.

Study Area

Ghaziabad district extend from longitude 77°12’ to 78°13’ and latitude 28°26’ to 28°54’ and is underlain by Quaternary sediments (Fig. 1). It is located in the middle of Ganga Yamuna doab. On the north it is bound by the district of Meerut on the south by that of Bulandshahar and Gautam Budh Nagar and on the South West by the national capital Delhi State and on the East by the district Jyotiba Phule Nagar.[13]



Source: Prepared by Authors

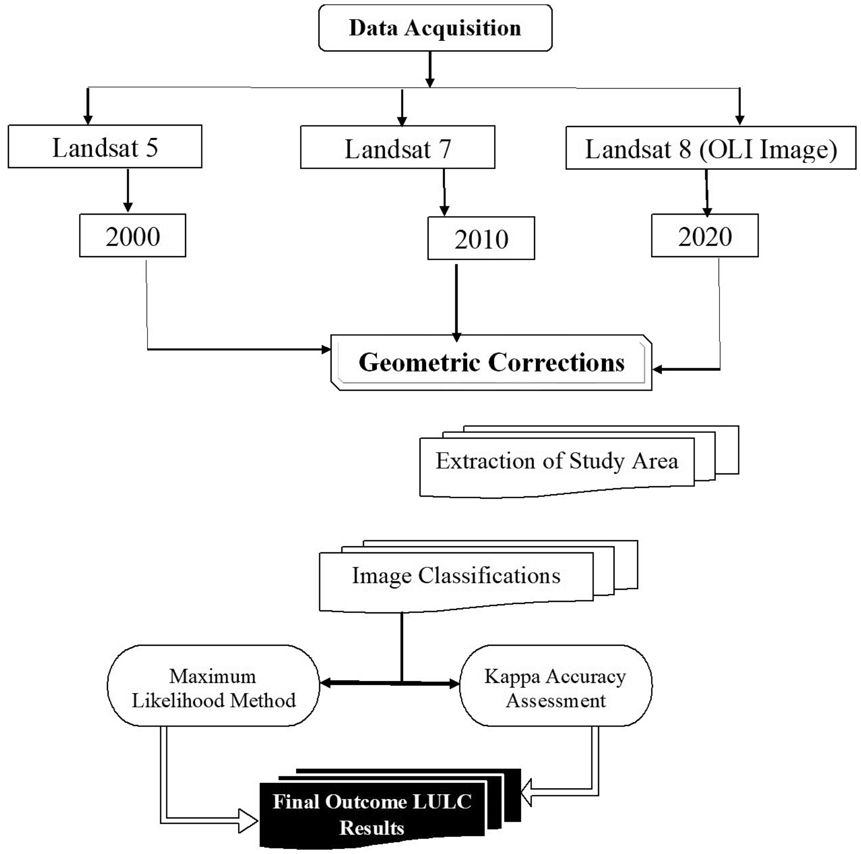
Fig. 1: Study Area

The district[14] is administratively divided into 3 tehsil and is further divided into 4 development blocks. The total population as per 2011 census[15] is 33, 14,070. The density of population is 1995 per sq. km. It is drained by Hindon river one of tributary of Yamuna River. The area represents almost a monotonous flat plain dissected by drainage of different order. Ghaziabad town is situated almost in the old flood plain of river Hindan.

Data Sources and Methodology

Recognizing the significance of LULC monitoring in the management and planning of land resources, this study focused on mapping LULC changes in the Ghaziabad district of Uttar Pradesh, India, using GIS to process topographic sheets and LANDSAT satellite data from different years.[16] The research was conducted based on three scenarios corresponding to the years 2000, 2010 and 2020. The overall land use is also divided into two categories: satellite image-based land use and statistical dataset-based land use. The study required topographical maps, satellite images, and secondary data for its completion. In order to examine the change in LULC, different layers of maps were generated using LANDSAT data (2000-2020). GIS and RS techniques were used to gather spatio-temporal data on the LULC and its evolution. The study required topographical maps, satellite images, and secondary data for its completion. In order to examine the change in LULC, different layers of maps were generated using LANDSAT data (2000-2020). GIS and RS techniques were used to determine spatial-temporal data on the LULC and its changes (Fig. 2).

A set of LTM and ETM multispectral images acquired in 2000, 2010, and 2020 were utilized for the identification of various LULC classes and the creation of a LULC map. These datasets were generated by the United States Geological Survey (USGS) with a spatial resolution of 30m x 30m (path 146 and row 40) and are freely accessible via USGS Earth (Table 1). TM, ETM and OLI imageries were chosen for this research due to its rich spectral information, the stability of data availability and the fact that the imagery is available at no cost. The technical specification of Landsat ETM sensor and Band specifications are as follows:



Source: Prepared by Authors

Fig. 2: Methodology of Land Use and Land Cover

Table 1: Technical Specifications of Satellite Images

Type	**Mechanical Scanner**
Spatial Resolution	30 meters
Spectral Range	0.45 µm to 12.5 µm
No. of Bands	08
Temporal Resolution	16 days

Year	**Path and Row**	**Spatial Resolution**	**Description**	**Satellite Sensor**
2000	146/40	30 m	Landsat-5	Thematic Mapper (TM)
2010	146/40	30 m	Landsat-7	Enhanced Thematic Mapper (ETM)
2020	146/40	30 m	Landsat-8	Operational land Imager (OLI)

Source: Prepared by Authors, 2020

Data Analysis

It comprises analysis of all the data related to the study with the help of various tools and methods. This included sorting of data, digitization of various layers, preparation of maps, merging, area calculation and change detection analysis. In case of Landsat sensor, it collects information in the form of different bands in Tagged Image Format File (TIFF) format which is needed to obtain multi spectral imagery from the raw data obtained from USGS. For getting the detailed information from remotely sensed images, multi spectral data has extracted from the imagery. For this layer, layer stacking of seven bands out of eight was done except thermal band since it has no application in LULC process and then based on the requirement, one of the classification techniques was applied for the preparation of the maps. This technique aids in improving the quality of the image and thereby, increasing the chances of image interpretation. It deals with the individual pixel values in an image. The purpose of spectral enhancement is to increase the contrast of an image in order to make specific aspects more prominent.

Land Use and Land Cover Classifications

The basic requirement for the construction of a land use and land cover map is satellite data. Landsat 5, Landsat 7, and Landsat 8 satellite pictures were used to obtain satellite data with TM, ETM, and OLI forecasts relating to agriculture trends in 2000, 2010, and 2020. For the classification of the satellite images, the unsupervised classification has been used in the study. Classification of images can be labeled into supervised and unsupervised categories. It is defined as the process by which pixels are assigned to their respective classes.[17] Typically, each pixel is viewed as a unique unit consisting of data from multiple spectral bands. Supervised classification is the process of classifying an image based on the known identity of distinct sites within remotely sensed data that provide homogeneous examples of land cover types. In unsupervised image classification method, the pixels of the image are separated into clusters or classes by the image interpreting software which is based upon their reflectance values without user interference. The user needs to perform quality check on the results. Several spectral classes can be allocated to a small number of land cover categories using this method.[18] The advantages of this classification are: faster analysis of results, user friendly, user independent, repeatable.

Maximum Likelihood Methods

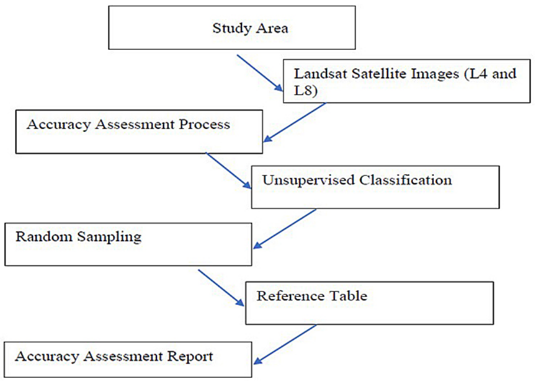
Maximum Likelihood (ML) is a supervised classification method derived from the Bayes theorem. In this method, each pixel is assigned to the class with the highest likelihood or labelled as unclassified

if the probability values are all below a threshold set by the user. The general procedures in ML are as follows:

1. The number of land cover types within the study area is determined.
2. The training pixels for each of the desired classes are chosen using land cover information for the study area. The outcome of maximum likelihood classification after assigning the classes with suitable colours, is shown vegetation (green), water bodies (blue), agriculture (yellow), open land (brown) and settlements (red). The areas in terms of percentage and square km. were also computed.

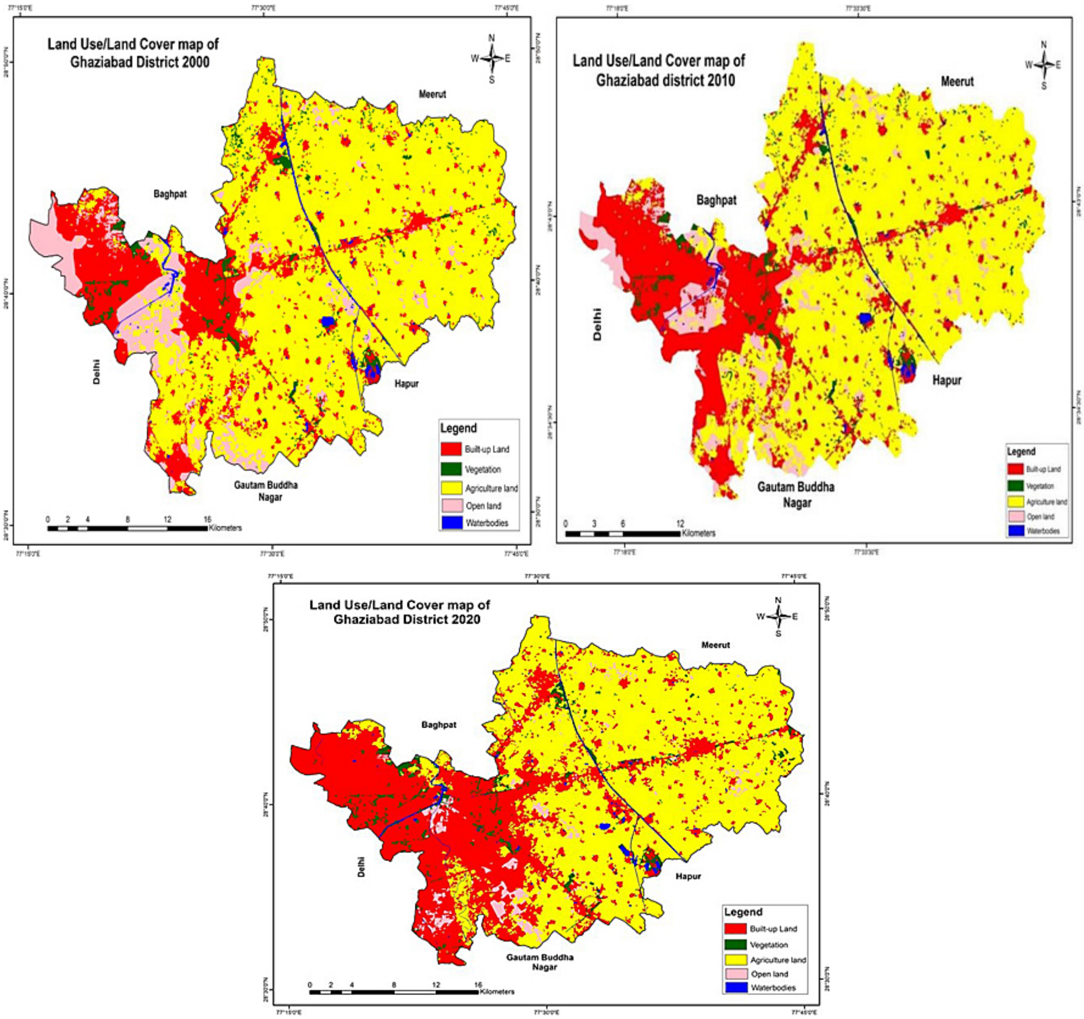
LULC Accuracy Assessment

Evaluation of accuracy is a crucial step in the processing of remote sensing data.[19] It ensures factual data to the users. The complete accuracy of the classified image relates to actual land cover conditions.[20] Accuracy assessment of LULC is carried out for both regimes using Earth Resources Data Analysis System. The Fig. 3 shows steps involved accuracy assessment using ERDAS Imagine 2013.



Source: Prepared by Authors

Fig. 3: Steps Involved in Accuracy Assessment



Source: Prepared by Authors based on USGS, 2020

Fig. 4: Land Use Land Cover Map of Ghaziabad, 2000, 2010, 2020

Results and Discussions

Land Use Land Cover Change Detection

Changes on the surface with the passage of time are a description of the change detection analysis. The Landsat analysis of land use and land cover change detection provides an accurate and reliable description of the research region. Landsat Enhanced Thematic Mapper (LETM) spatial data used as the basis for base maps compiled with the assistance of the United States Geological Survey.

Land Use Land Cover for the Year 2000

Land usage land cover change offers information about the utilization of resources for particular purposes. These modifications are made to the map in order to accurately depict the surface's reality. In 2000, the agriculture has occupied highest land area in Ghaziabad with 605 sq. km of area. These were mostly concentrated in eastern part of district and open land is associated with agriculture as well as built up area. This region had less vegetation cover and it occupied only 2 per cent area (Fig. 3). The built-up area concentrated in western part in the map, which is adjoined with Delhi. Built up has occupied 18 per cent of land in the study area in 2000. The structure is the second highest land use in the study area. The major land use in the study region was agricultural land, which constituted 68 percent of the total area. Together, agriculture and construction have consumed over 85 percent of the total study area (Table 2). Open land lies in the western section of the area due to redevelopment process. The water bodies are less and these mostly drains or small river. Therefore, agriculture land is visible in across the map with small built-up patches.

Land Use and Land Cover for the year 2010

Land use land cover change 2010, show major change in agriculture and built up land areas. These changes are produced in map to understand the reality of surface accurately. In 2010, the agriculture have occupied largest area in Ghaziabad with 564 sq. km of area. These were mostly concentrated in eastern part of district and open land is associated with agriculture as well as built up area. This region had less vegetation cover and it occupied the 3.09 per cent area. Agriculture area has reduces in this period and built up area occupied the agriculture land.

The built up area concentrated in western part in the map with 25.06 per cent of land. Agriculture is still has highest share of land use in this period. The built up land is second highest land occupancy in the study area. Followed by open land with 6.70 per cent of share of land. The water bodies shares only 1.07 per cent of land. Overall, agriculture and built up have occupied the almost more than 87 per cent of total study area together. Open land lies in the western section of the area due to redevelopment process. The water bodies are less and these mostly drains or small river. Therefore, agriculture land is visible in across the map with small built up patches.

Table 2: Land Use Land Cover Classes for Ghaziabad, 2000,2010,2020

S. No.	LULC Classes	Area (in Sq. Kms)	Area (in Per cent)
1	Water bodies	9.47	1.08
2	Vegetation	23.44	2.6
3	Agriculture land	605.37	68.79
4	Built-up area	162.41	18.46
5	Open land	79.39	9.63
Total		**880.01**	**100**
S. No.	**LULC Classes**	**Area (in Sq. Kms)**	**Area (in Per cent)**
1	Water bodies	9.35	1.07
2	Vegetation	27.16	3.09
3	Agriculture land	564.00	64.09
4	Built-up area	220.50	25.06
5	Open land	59.00	6.70
Total		**880.01**	**100**
S. No.	**LULC Classes**	**Area (in Sq. Kms)**	**Area (in Per cent)**
1	Waterbodies	9.33	1.07
2	Vegetation	25.54	2.9
3	Agriculture land	516.91	58.74
4	Built-up area	302.92	34.42
5	Open land	25.31	2.88
Total		**880.01**	**100**

Source: Prepared by Authors based on USGS, 2020

Land Use and Land Cover for the year 2020

Land use and Land cover change 2020, show major change in agriculture and built up land areas. Agriculture land changed into built up land in this time period over the map. These changes are produced in map to understand the reality of surface accurately.

In 2020, the agriculture have occupied largest area in Ghaziabad with 516 sq. km of area. These were mostly concentrated in eastern part of district and open land is associated with agriculture as well as built up area. This region had less vegetation cover and it occupied the 2.9 per cent area. Agriculture area has reduces in this period and built up area occupied the agriculture land. The built up are concentrated in western part in the district with 18.46 per cent of land. Agriculture is still has highest share of land use in this period. The built up land is second highest land occupancy in the study area. Followed by open land with 2.88 per cent of share of land. The water bodies shares only 1 per cent of land. Overall, agriculture and built up have occupied the almost more than 92.9 per cent of total study area together. The agriculture land share 58.74 per cent of total land area that is highest among the all categories. Open land lies in the western section of the area due to redevelopment process. The water bodies are less and these mostly drains or small river. Therefore, agriculture land is visible in across the map with small built up patches.

Comparative Analysis of Land Use Change Assessment of 2000-2020

As of the year 2000, the Built-up area occupies 162.41 hectares of land, which is greater than 18.4 percent. The category of vegetation, which includes the forest occupies 2.6 per cent or 23.44 per cent of land in the research area. The majority of the district of Ghaziabad consists of agricultural terrain. 68.7 percent of the district's total geographical area is occupied by this category, which occupies 605.3 percent hectares.

Table 3: Change between different classes in Ghaziabad District (2000 and 2020)

S.No.	Class	Area in Hectare in 2000	Area in Per cent in 2020	Area in Hectare	Area in Per cent	Change detection between 2000-2020
1.	Water bodies	9.47	1.08	9.33	1.07	-0.14
2.	Vegetation	23.44	2.6	25.54	2.90	2.1
3.	Agriculture land	605.3	68.79	516.91	58.74	-88.39
4.	Built-up area	162.41	18.46	302.92	34.42	140.51
5.	Open land	79.39	9.63	25.31	2.88	-54.08
Total		**880.01**	**100**	**880.01**	**100**	

Source: Prepared by Authors based on Landsat 5 and Landsat 8, 2021

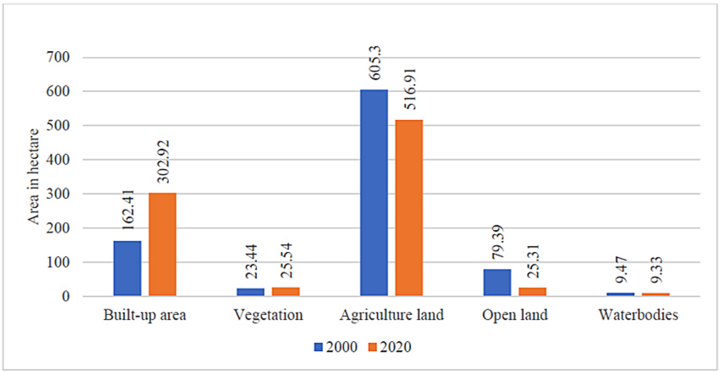


Fig. 5: Land Use Land Cover Change of Ghaziabad 2000-2020

The category of open land occupies 79.39 hectares, indicating that only 9.63 percent of the entire geographical area occupied by this category is agricultural land. All rivers and tributaries, as well as lakes, marshes, and reservoirs, are classified as water bodies. This category of land use accounts for 9.47 hectares, or less than 9.33 per cent of the total land area (Fig 5). The majority of the district of Ghaziabad consists of agricultural terrain. This category accounts for 68.79 per cent of the district's total land area and occupies 605.3 hectares.

LULC Change in Particular Class

Vegetation

Area under forests comprises any areas that are really wooded or controlled as forests under any statute pertaining to forests, whether state or privately held. After 20 years, the district's forest cover decreased from 3.542 percent of its total geographical area in 2000 to 1.453 percent. For the needs of a growing population, forest land was primarily converted to inhabited areas, particularly homestead areas, and agricultural land during this time period. In addition, a portion of forest land has been converted to non-agricultural uses, as evidenced by a minor increase in the proportion of non-agricultural land from 1.49 per cent in 2000 to 1.56 percent in 2020 in the study region.

Open Land

The non-cultivable land consists of land used for non-agricultural purposes, open land, and uncultivated land. In 2000, the non-cultivable land accounted for 21.38 percent of the total land area, a percentage that decreased to 17.45 percent after 20 years. Open and uncultivated land is difficult to use for productive purposes since it requires a thorough assessment of the property's potential and a high cost-benefit ratio. The area under other uncultivated land, excluding fallow land, consists of permanent pastures and other grazing land, as well as a variety of crops and groves that are not included in the net area planted and cultivable waste land.

Agriculture

The district has loss of 2.08 sq. km. of vegetation land from 2000 to 2020. It is decreased to 1.45 sq. km in 2020 from 3.54 sq. km in 2000. It consists of tree crops and groves, the orchards surrounding the homestead, bamboo groves, betel nut groves, and other areas where useful trees are located. In 2000, there were 21.38sq. km.of open space in the district by 2020, that number will have decreased to 17.45 sq. Km (Table 4).

Table 4: Land under Agriculture and related Activities

S.no	Land use Categories	2000 (area in sq. km)	2020 (area in sq. km)	Change in area sq. km
1.	Vegetation	3.542	1.453	-2.089
2.	Open land	21.38	17.45	-3.93
3.	Organic Farming area	8.61	9.53	0.92
4.	Agriculture	132.82	144.684	11.86
	Total	165.819	173.112	7.293

Source: District Census Handbook Ghaziabad, 2000 and 2020

The organic farming was 8.61 sq. km in 2000 which has been increased to 9.53 sq. km in 2020. The increase area between this year was 0.92 sq. km. the agriculture land was 132. 82 sq. km in 2000 and that has been increased to 144. 68 sq. km. the increased area in between 11.86 sq. km. In some areas of the district, there is a dearth of water for irrigation, and climatic conditions fluctuate. Therefore, farmers leave their land fallow for a time before cultivating it.

Organic Farming Area

The analysis of the organic farming practices in Ghaziabad district, spanning from 2000 to 2020, is crucial in understanding the evolving agricultural landscape amidst the broader context of Land Use Land Cover (LULC) changes. Over the two-decade period, organic farming in Ghaziabad expanded from 8.61 sq. km in 2000 to 9.53 sq. km in 2020. Although the increase is modest, it reflects a growing trend towards sustainable agricultural practices, which hold the potential to mitigate some of the negative impacts of LULC changes on agriculture. This trend, although limited in extent compared to the overall agricultural land, highlights a shift towards more environmentally conscious farming methods that prioritize soil health, biodiversity, and the reduction of chemical inputs. The rise in organic farming demonstrates that despite the decline in total agricultural land due to the encroachment of built-up areas, there are efforts to enhance agricultural productivity through sustainable approaches.

Organic Farming in the Context of Agricultural Land Decline

The study indicates that agricultural land in Ghaziabad has continuously decreased, with 605 sq. km in 2000 reducing to 564 sq. km in 2010, and further down to 516 sq. km in 2020. This decline, primarily driven by the expansion of built-up areas, presents a significant challenge to the sustainability of agriculture in the district. Despite this overall reduction in farmland, the growth of organic farming represents a critical adaptation strategy. Organic farming practices, which emphasize crop rotation, natural pest management, and soil fertility enhancement, allow farmers to maximize yields on shrinking arable land without relying on chemical inputs that could degrade the soil over time.

Spatial Distribution of Organic Farming

The distribution of organic farming in Ghaziabad is concentrated in the Rajapur, Bhojpur, Loni, and Muradnagar blocks, areas that have seen significant spatio-temporal changes in land use patterns. These regions have been at the forefront of agricultural transformations, with organic farming providing a sustainable alternative to conventional practices. As LULC analysis for the years 2000, 2010, and 2020 indicates, the eastern part of the district continues to be dominated by agricultural land, while the western region has seen rapid urbanization. The adoption of organic farming in these blocks suggests a proactive response by farmers to changing land conditions, seeking to preserve soil health and long-term productivity despite increasing pressures from urban expansion.

Organic Farming and LULC Impact Analysis

The study's LULC analysis for the years 2000, 2010, and 2020 reveals a growing trend of urbanization and industrialization, with built-up areas increasing from 18% in 2000 to 25.06% in 2010, and 18.46% in 2020. This encroachment has resulted in the conversion of agricultural land, reducing the overall area available for farming. In response, the incremental increase in organic farming represents an adaptation to these challenges, as it allows for the efficient use of limited agricultural land. In addition, organic farming aligns with the global trend towards more sustainable land management practices, which is essential for balancing urban growth with agricultural needs.

By the year 2020, the share of agriculture in the total land area of Ghaziabad had decreased to 58.74%, yet organic farming continued to grow, indicating that farmers are increasingly recognizing the value of sustainable practices amidst land scarcity. This resilience is particularly important as the study highlights the competing demands for land from urbanization, infrastructure development, and agriculture.

Organic Farming's Role in Land Use Optimization

One of the key objectives of this study is to explore how agriculture can adapt to the rapid LULC changes and maintain productivity. The expansion of organic farming serves as a crucial component of land use optimization. As urbanization spreads, the need to maximize the productivity of remaining agricultural land becomes paramount. Organic farming, with its emphasis on soil health and reduced chemical input, offers a pathway to achieve this goal without further degrading the environment. In regions like Ghaziabad, where 67% of the population is directly or indirectly involved in agriculture, the adoption of organic practices is essential for ensuring food security and sustainable livelihoods.

The increase in organic farming from 8.61 sq. km in 2000 to 9.53 sq. km in 2020, while small in absolute terms, signals a positive trend towards sustainability in an era where agricultural land is increasingly under threat from urban expansion. Organic farming helps maintain soil fertility, reduces dependency on external inputs like chemical fertilizers and pesticides, and promotes biodiversity, all of which are critical to sustaining agricultural output in shrinking farmlands.

Kappa Accuracy Assessment

The Kappa accuracy assessment is used to check the quality of map output after completion of map. This process used by various scientists and scholars for assessment of accuracy of the maps. It is used through reality check of actual positioning of features and element which plotted or identified on the maps and on the basis of Geographical Control Points (GCP) it has been cross checked with pixels. It was introduced by Cohen in 1960s.The Kappa provides the reader as quantitative measure for the agreement between observers. Kappa assessment has been done with very simple formula

Sum of the observations on which the class occur /Total number of observations X 100

Table 5: Accuracy Assessment by Kappa Coefficient from 2000 to 2020

Year	Overall Accuracy (in per cent)	Kappa Coefficient
2000	89.05	0.82
2010	90.25	0.84
2020	91.10	0.86

Source: Prepared by Authors, 2020

The overall accuracy and Kappa Coefficient represent the level of accuracy of maps in the research area. The accuracy rate 2000, 2010 and 2020 map are 89.05, 90.25 and 91.10 with 0.82, 0.86 and 0.86 Kappa coefficient respectively (Table 5).

The accuracy of the maps is calculated with the help of putting the value on the map and cross marking or point to identify the exact element identification by which proper accuracy assessment can be done.

Agricultural Land Use Pattern in Ghaziabad

Land is exploited for agricultural production of various crops in a certain unit of space at a specified point in time during the agricultural year. Agricultural land use pattern refers to the proportion of land devoted to different crops at a given period, as it varies in space and time. A region's cropping patterns are heavily influenced by its physiographic, climatic, socio-cultural, economic, historical, political, and technological characteristics. The significance of man in the cultivation of particular crops cannot be overstated. The decision-making ability of farmers is a significant factor in determining the regional agricultural pattern (Fig. 6).

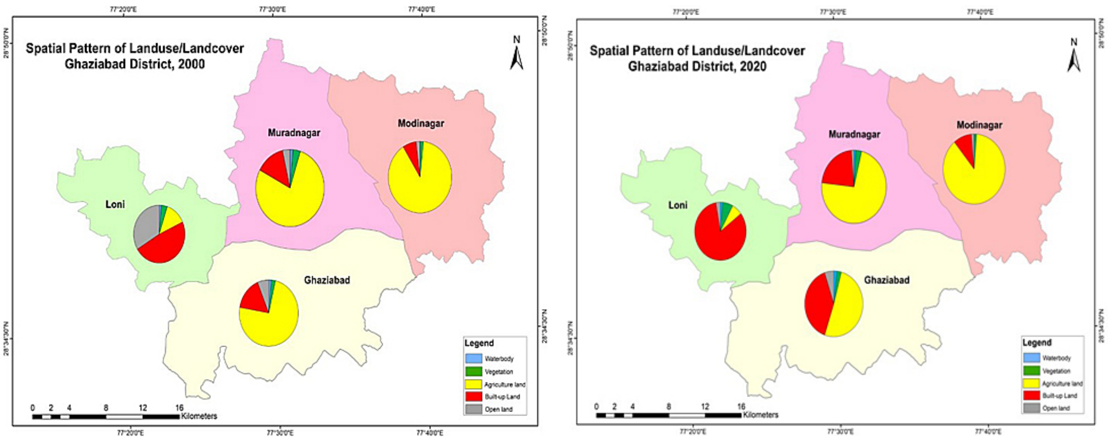


Fig. 6: General Land use/Land cover of Ghaziabad District 2000, 2020

An efficient cropping pattern is one that maximizes the utilization of arable land by the application of water resources, bio-chemical inputs, methodical cultivation etc. Consequently, it is a dynamic idea as no cropping pattern can be appropriate for all future eras. In Ghaziabad, 67 per cent of the population is directly or indirectly involved in agriculture. As population increases, so does the burden on agriculture and eventually the government will take actions to increase food production. Attempts are undertaken to boost the output by enhancing conventional techniques and utilizing HYV seeds, chemical fertilizers, and modernization and advanced irrigation techniques. Therefore, new cropping may emerge in a place if an alternative crop that is more productive than the present ones becomes available.

The cropping pattern of different crops in the Ghaziabad area is dependent not only on physical and agro-climatic conditions, but also on socio- economic and infrastructural facilities. For the analysis of the cropping pattern in the research area, public government records utilise the data of the area under different crops. To comprehend the modifications in agricultural practises, a detailed analysis of agricultural land use is done.

The obtained agricultural land use and cropping data is tabulated, organised in the correct format, and statistical methods are used to obtain the results. The trends in agricultural land usage cropping for specific crops are comprehended by graphical analysis. Consequently, an effort is made to comprehend the state of agricultural change in the research area.

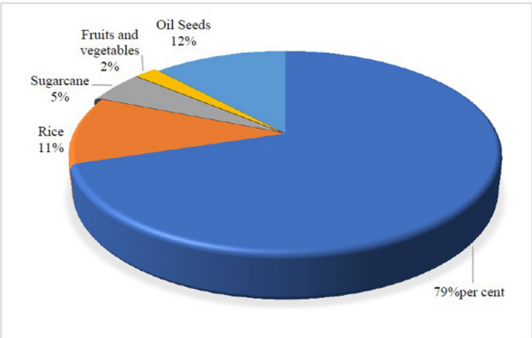
Cropping Pattern of the Study Area

Cropping pattern refers to the proportion of land under different crops at a given moment. Throughout the district, the cropping pattern is incredibly irregular. In the district as a whole, food crops, which generally dominate agricultural land to a great extent, predominate the cropping pattern. Generally, the distribution of food crops adapts to the physical environment and dietary preferences of the farming population. Wheat is the most important crop because it is the staple food of the district's inhabitants. The performance of the various crops demonstrates substantial diversity. Table 6 and Fig. 6 make it very evident that grains are the predominant crops in the district. It comprises the largest amount of the district's overall cultivated land.

Table 6: Study of Cropping Pattern in 2000-2020

Crops	Area in 2000 (Kg/Ha.)	Area in 2020 (Kg/Ha.)
Cereals	7503.56	6865.67
Rice	2234.45	2769.34
Sugarcane	1690.67	1259.56
Fruits and vegetables	648.89	1209.66
Oil Seeds	206.56	320.77

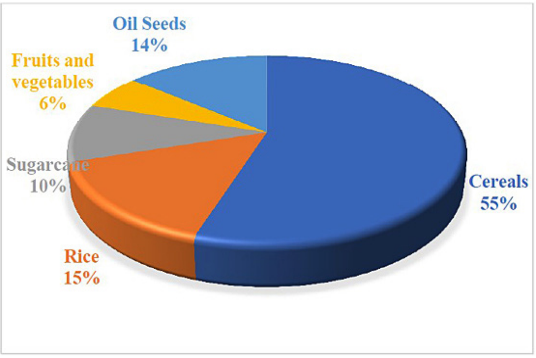
Source: District Census Handbook of Ghaziabad 2020



Source: Prepared by Researcher based on District Census Handbook of Ghaziabad 2000

Fig. 7: Cropping Pattern in Study area in 2000

In 2000, cereal crops were grown on 79 percent of the districts land but by 2020, this proportion will have decreased to 55 percent of the districts total cropped area. Rice is also one of the most important crops grown in the Ghaziabad area. In 2000, 10 percent of the total planted land was devoted to rice. By 2020, this proportion will have climbed to 15 percent. In contrast, fruits and vegetables and oil seeds occupy the smallest proportion of farmed land. In 2000, their percentages were 2 percent and 14 percent but in 2020 they will be 6 percent and 14 percent.



Source: Prepared by Authors based on District Census Handbook of Ghaziabad 2020

Fig. 8: Cropping Pattern in Study area in 2020

Correlation Matrix for organic Agriculture Elements

The output indicates that land cultivation and land area have a Pearson correlation coefficient of r = 0.370 at p 0.01. The Pearson correlation analysis shows a significant relationship between land size and the use of organic seeds, with a correlation coefficient of **r = 0.370** at a **p-value of 0.01.** This suggests that as the area under organic farming expands, there is a 37% increase in the use of organic seeds in the region. In other words, larger organic farms are more likely to adopt organic seeds, reflecting a positive relationship between farm size and the use of sustainable farming inputs. On the other hand, the analysis also reveals a notable correlation between land size and the use of organic pest control methods. The Pearson correlation coefficient for this relationship is **r = 0.300** at a **significance level of 0.01,** indicating a some-what weaker, yet still meaningful, association. Interestingly, this correlation is negative, suggesting that larger land areas under organic farming tend to use less organic pest control. This may be due to economies of scale, where larger farms might rely more on preventative measures or integrated pest management strategies that reduce the need for frequent organic pest control interventions. The Pearson correlation coefficient between organic pest control and organic fertilisers is r = 0.21, and it is significant at the p 0.05 level of confidence. A positive correlation between neem coated and land area suggests that adopting agro forestry as a land conservation and management tool in the region would make it possible to increase the land available for grazing animals, as intensive farming would be reduced. Lastly, the result reveals a positive, significant, linear link between neem-coated pests and earthworm compost in the region, as indicated by a Pearson correlation value of r = 0.335 at a confidence level of p 0.01.

Table 7: Correlation Matrix between Organic Farming Elements and ?

	Land Size	Organic Seeds	Organic Fertilizers	Organic Pest Control	Neem Coated Urea	Earthworm Compost
Land Size	1					
Organic Seeds	.370	1				
Organic Fertilizers	0.167	0.228	1			
Organic pest control	.300	0.213	0.105	1		
Neem coated urea	0.037	0.048	0.037	0.122	1	
Earthworm compost	0.19	0.1	-0.088	.335	-0.089	1

Source: Prepared by Authors, 2020

This positive link between the two variables suggests that households in Ghaziabad that engage in organic farming or organic tree planting are more likely to embrace organic compost practises as supplementary means of boosting productivity. The results of the correlation analysis between land size and organic matter are summarised in Table 7. With land size as the independent variable and organic farming and its components as the model's predictor variables, a positive association has been shown between land size and farming components. These findings highlight that as the scale of organic farming increases, there is a higher tendency to adopt organic seeds, which could be linked to the need for better yield and sustainability practices. However, the inverse relationship with organic pest control suggests that larger farms may focus more on broader, ecosystem-based pest management strategies rather than intensive organic pest control methods. This dual trend reflects the evolving dynamics of organic farming in the region.

Conclusion

The study reveals significant land use and land cover (LULC) changes in Ghaziabad between 2000 and 2020. A major finding is the continuous decline in agricultural land, which reduced from 605 sq. km in 2000 to 516 sq. km in 2020, primarily due to urban expansion in the western part of the district. Concurrently, built-up areas saw considerable growth, increasing from 18% in 2000 to 25.06% by 2010, reflecting rapid urbanization trends. Despite this reduction in agricultural land, organic farming expanded modestly, growing from 8.61 sq. km in 2000 to 9.53 sq. km in 2020, highlighting a gradual shift towards more sustainable agricultural practices. Land use/land cover (LULC) mapping is essential for development planning, and Ghaziabad's diminishing agricultural land due to urban expansion highlights the need for sustainable solutions. Organic farming emerges as a key strategy, helping to maintain agricultural productivity and ecological balance amidst ongoing urbanization. By promoting resilience in the agricultural system, organic practices counteract the adverse effects of land use changes, ensuring farming remains viable. Despite the reduction in agricultural land due to urban growth and infrastructure development, the district remains largely suitable for organic farming, with many people still engaged in agriculture. The cropping pattern is influenced by physical, agro-climatic, socioeconomic, and infrastructural factors, reflecting the dynamic nature of land use change in the area. Additionally, the study found a positive correlation between farm size and the adoption of organic inputs, with larger farms exhibiting a 37% increase in the use of organic seeds, while relying less on organic pest control, likely due to a preference for ecosystem-based pest management. These findings emphasize the need for sustainable farming practices in response to the pressures of urbanization and land scarcity.

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Conflict of Interest

The authors do not have any conflict of interest.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Author Contributions

All authors equally contributed in writing and editing the final manuscript.

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