Industrial Land Suitability Analysis for Aligarh District Using GIS-Based Multi-Criteria Evaluation (MCE) Technique

Umang Sharma[1], **Sanjeev Maheshwari**[1], **Mohammad Arif Kamal**[2,*]
[1] Dept. of Architecture, Aligarh Muslim University, Aligarh, India
[2] Architecture Section, Aligarh Muslim University, Aligarh, India
[*] Corresponding Author: architectarif@gmail.com

Abstract: This paper presents a comprehensive GIS based Multi-Criteria Evaluation (MCE) framework for prospective regions suitable for industrial development in District Aligarh (Uttar Pradesh), India. The research concerns the increasing pressure of industrial expansion on land resources and seeks to integrate technological tools for strategic planning. Geographic Information Systems (GIS) and the Analytical Hierarchy Process (AHP) are combined to provide effective site selection model. Six critical factors influencing industrial site suitability — land cover, railway accessibility, road accessibility, proximity to built-up areas, distance from water bodies, and soil typology — were assessed through expert surveys and analyzed using AHP to determine their relative weight. The resulting spatial layers were processed through weighted overlay analysis in GIS to produce a comprehensive suitability map. The analysis identifies highly suitable zones primarily along major transportation corridors such as Delhi Road, Khair Road, and Agra Road. This integrated methodology aids policymakers and urban planners in promoting sustainable industrial development while minimizing ecological and social disruption.
***Keywords*:** Industrial development, GIS, Multi-Criteria Evaluation (MCE), Analytical Hierarchy Process (AHP), Land suitability Aligarh, Spatial analysis, Urban planning.

1. Introduction

Industrialization has long been considered as an essential driver of economic success and societal advancement. It encourages employment creation, technical innovation, and regional development. However, unplanned industrial expansion can have negative impacts, especially in underdeveloped countries. The unplanned expansion of industrial units in cities and peri-urban areas frequently leads to the loss of productive agricultural fields, environmental damage, and the relocation of rural inhabitants. As a result, it is critical to take a comprehensive approach to land use planning that balances industrial development with environmental protection and social welfare. This study uses GIS and MCE tools to examine whether land in Aligarh District is suitable for industrial development. The study impartially establishes the relative importance of several land suitability criteria by using the Analytical Hierarchy Process (AHP). The main objective is to offer an evidence-based framework for determining the best industrial locations that complement regional planning plans and the Sustainable Development Goals (SDGs).

2. Literature Review

In urban planning, the idea of land suitability analysis has become more popular, particularly in light of growing industry and urbanization. According to Farooq and Ahmad (2008), the unplanned industrial growth results the negative impact on agricultural output and land quality. Saran and Ramana (2018) emphasized how GIS may be used to monitor land use changes and guide decision-making. As per Weerakoon (2014), MCE as a decision-support tool that considers many competing factors, which is especially useful in land allocation tasks. Mohammed et al. (2016) and Rikalovic and Cocic (2014) demonstrated how GIS-MCE approaches were successfully used to find potential areas for urban growth and industrial parks in a variety of geographical contexts. Saaty (1980) created the AHP approach, which measures expert opinions to make it easier to compare criteria in a systematic manner. Its reliability and consistency checking method make it a popular choice for spatial decision-making. In urban and regional planning, land suitability research has grown in importance, especially as regions deal with the combined demands of urban development and industrialization. The combination of GIS and MCE techniques offers a logical framework for making spatial decisions that strike a balance between sustainability and development.

2.1 Role of GIS in Land Use Planning

Geographic Information Systems (GIS) enable the visualization, analysis, and modeling of spatial data, thereby improving the accuracy of land suitability assessments. Urban planners increasingly rely on GIS to integrate diverse datasets, monitor urban growth, forecast land use changes, and engage communities in participatory planning processes. GIS enables the analysis of environmental impacts, optimization of transport systems, disaster management planning, and development of smart cities. Furthermore, the integration of multiple-criteria decision-making (MCDM) with GIS has improved the evaluation of complex urban planning scenarios. The integration process of GIS with MCE changes geographic data (input) to a result decision (output). Thus, GIS is not merely a tool for analysis but a core strategic instrument in shaping future urban environments.

2.2 Multi-Criteria Evaluation (MCE) in Spatial Planning

Multi-Criteria Evaluation (MCE) is a powerful decision-support tool used in spatial planning to analyze and solve complex problems where multiple, often conflicting, criteria must be considered simultaneously. It helps planners assess and prioritize different land areas based on a set of chosen factors and constraints. Weerakoon (2014) defined MCE as a methodology for evaluating complex decision problems that involve multiple conflicting objectives. In the context of land suitability analysis, MCE enables planners to assign importance to various spatial criteria. Chuvieco (1993) and Chen et al. (2001) also advocate MCE's role in urban planning, as it can handle heterogeneous data types and provide decision-makers with prioritized outputs.

2.3 Multi-Criteria Evaluation Process

A typical MCE process involves four main steps:

Identification of Criteria: These can range from environmental factors such as slope, elevation, and water availability to socio-economic factors like population density, land value, and accessibility to services.

Weighting the Criteria: Using techniques like the Analytical Hierarchy Process (AHP), the relative importance of each criterion is determined.

Standardization: Since the criteria often have different units of measurement, they need to be standardized for comparison.

Combining Criteria: The weighted criteria are combined using GIS software to generate a final map that highlights the most suitable areas for urban development. (Mohammed et al., 2016)

2.4 Analytical Hierarchy Process (AHP) for Weight Assignment

The Analytical Hierarchy Process (AHP), was developed by Saaty (1980), is widely employed to determine the relative importance of criteria in a structured, hierarchical format. It converts subjective expert opinions into quantifiable weights and includes a consistency ratio to validate the judgments. Malczewski (1996) supports the integration of AHP in GIS-based planning as it ensures logical coherence in multi-criteria analysis.

2.5 Calculation of Consistency Ratio

To assess the consistency of the pair-wise comparison matrix, an arithmetical index called Consistent Ratio (CR).

$CR = CI / RI$

$CI = (\lambda max - n)/(n-1)$

where,

CR	is Consistency Ratio
CI	is Consistency Index
RI	is Random Index
λmax	is Consistency vector
n	is number of criteria

Here, λmax signifies the maximum value, and the number of influences is expressed by n, while RI represents the mean average consistency index, which is shown in Table 1.

Table 1. RI mean average consistency index values

RI mean average consistency index values															
n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Consistency ratio (CR) from random mediums is provocatively minor, carefully specified to be about 10% or less (Saaty, 1990).

2.6 Applications of GIS-MCE and AHP in Industrial Site Selection

Several studies highlight the effectiveness of combining GIS and AHP for industrial land use planning. Mohammed et al. (2016) demonstrated its application in Penang, Malaysia, where urban growth zones were identified using weighted criteria such as proximity to roads and population centers. In the Indian context, Johar et al. (2013) conducted a suitability analysis in Banda, Uttar Pradesh using GIS-MCE and found that road and railway accessibility were crucial determinants of industrial viability. Baghel (2022) replicated a similar study in Raipur and Nava Raipur, employing a weighted overlay model to prioritize zones based on existing infrastructure and land use.

3. Research Context: The Aligarh District, Uttar Pradesh, India

3.1 Geographic Location and Extent

Aligarh District is located in the western part of Uttar Pradesh, India. It lies between latitudes 27.8974° N and longitudes 78.0880° E. The district spans an area of approximately 3,781 square kilometers with an average elevation of 178 meters above sea level. It is bordered by the districts of Bulandshar in the north, Hathras in the east, Etah in the southeast, and Mathura in the south. This strategic location within the Indo-Gangetic plain gives Aligarh a geographical advantage due to its flat terrain, fertile soil, and proximity to major regional markets and urban centers (Figure 1).

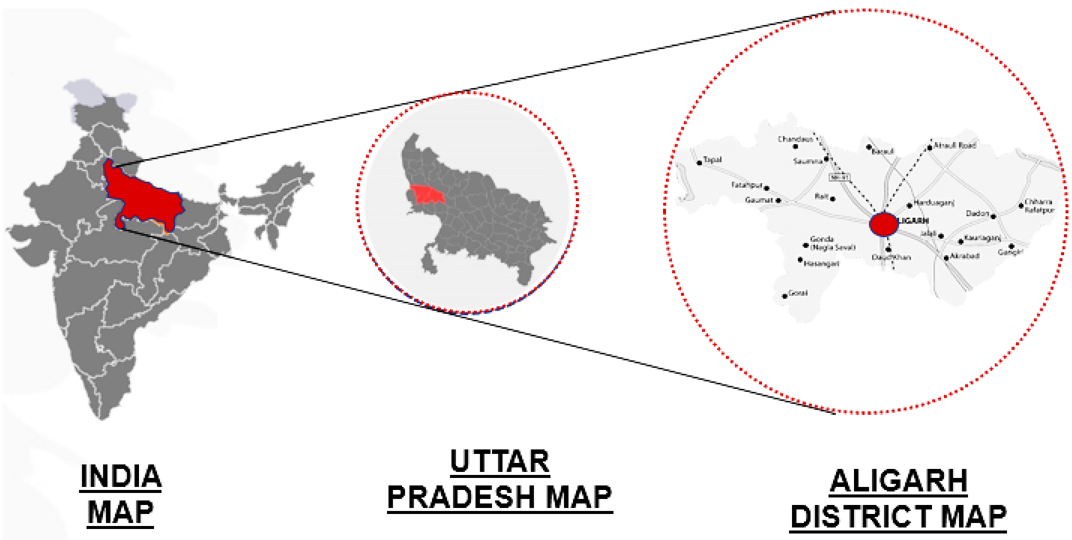


Figure 1. Location of Aligarh in the state of Uttar Pradesh in North India

3.2 Demographics and Urbanization

As per Census 2011, Aligarh District has a total population of 3.67 million. The urban population comprises a significant portion of this total, with Aligarh city being the primary urban center. The city has grown rapidly in recent decades, driven by its educational institutions, small and medium-scale industries, and improved transport infrastructure. Aligarh's expanding urban footprint is characterized by a mix of planned colonies and informal settlements, especially in the peripheral zones.

3.3 Transportation and Connectivity

The district boasts excellent connectivity via road and rail networks. It is traversed by several national and state highways including NH-91 (linking Aligarh to Delhi and Kanpur), NH-334D, and NH-509. These highways facilitate the efficient movement of goods and labor, enhancing Aligarh's industrial potential. The Aligarh Railway Junction lies on the Delhi–Kanpur route and serves as a major node in northern India's railway grid. The city is also in proximity to two major airports: Indira Gandhi International Airport in Delhi and Agra Airport, further amplifying its regional connectivity.

3.4 Existing Industrial Landscape

Aligarh's industrial landscape includes both formal and informal sectors. Major industrial estates such as Tala Nagri Industrial Estate, ITI Industrial Estate, and Numaish Ground Industrial Area serve as hubs for manufacturing and trade. The city also has a thriving household industry sector located in areas such as Sasni Gate, Bhujpura, Upper Fort, and Naurangabad-Etah Chavni. These industries are primarily engaged in hardware manufacturing, especially locks, hinges, and door accessories.

3.5 Land Use Patterns and Environmental Characteristics

The district's land use is predominantly agricultural, with vast tracts devoted to the cultivation of wheat, rice, sugarcane, and vegetables. Built-up areas are expanding steadily, primarily along major road corridors. Water bodies, including rivers and ponds, are scattered across the district and influence both land use and ecological patterns. The soil profile of Aligarh is largely alluvial, loamy, and silty-loamy, which supports diverse agricultural and construction needs. However, environmental concerns such as waterlogging, waste disposal, and air pollution in industrial pockets need to be addressed through integrated land use planning.

3.6 Significance for Industrial Development

Aligarh's proximity to the National Capital Region (NCR), strong road and rail networks, availability of semi-skilled labor, and existing industrial base make it a prime candidate for further industrial expansion. The district's inclusion in state-led development schemes and its designation as part of the Delhi–Mumbai Industrial Corridor (DMIC) further enhance its attractiveness for investment. By using scientific tools like GIS and MCE, planners can capitalize on these strengths while ensuring the sustainable use of land and environmental resources.

3.7 Planning Considerations

The Master Plan for Aligarh (2021) outlines spatial zoning for residential, commercial, and industrial development. However, the rapid pace of urbanization demands a dynamic, evidence-based planning approach. GIS-based land suitability analysis offers a powerful means to supplement conventional planning by identifying zones that align with infrastructure, environmental, and socio-economic priorities. The current study, thus, situates itself within this planning context to provide actionable insights into optimal industrial site allocation.

3.8 Research Methodology

The research methodology involves a systematic sequence of steps integrating GIS-based spatial analysis with AHP-driven MCE. The research process is outlined in Figure 2.

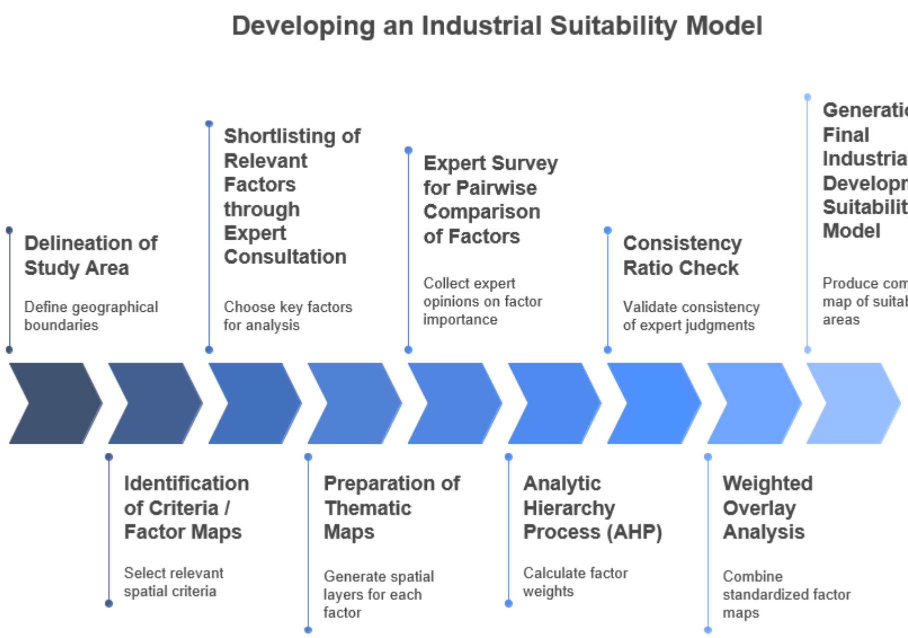


Figure 2. Industrial Development Suitability Process

4. Data Collection & Analysis

Data were obtained from both primary and secondary sources. Primary data collection involved expert surveys to rank the importance of selected criteria. Secondary data included satellite imagery; topographic maps, land use and land cover (LULC) data, road and railway networks, and soil maps. Identification of Criteria: Based on expert survey and URDPFI

Guidelines (2015), six criteria were selected:

- Existing Land Use / Land Cover
- Distance to Railway Accessibility
- Distance to Road Accessibility
- Proximity to Urban/Built-up Areas
- Distance from Water Bodies
- Soil Typology

The expert survey is conducted for the prioritization of criteria/factors in the Industrial Land Suitability Analysis for Aligarh, with a sample size of 80 respondents (Figure 3).

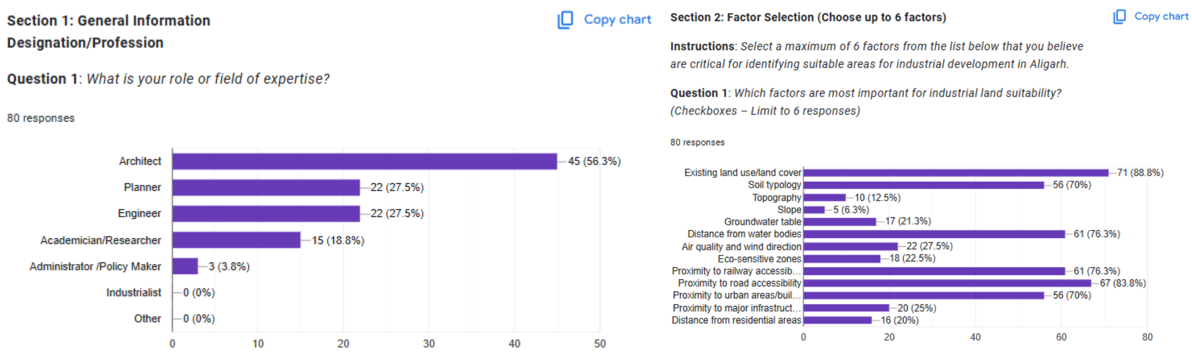


Figure 3. Expert survey of six factors selected as critical for Industrial land suitability in Aligarh

4.1 Analytical Hierarchy Process (AHP)

Expert responses (n=80) were compiled into a pairwise comparison matrix. AHP was used to compute the relative weights for each criterion. The consistency ratio (CR) was calculated to validate the reliability of the expert judgments. A CR value of 0.0604 (< 0.10) was achieved, indicating acceptable consistency (Table 2).

Step 1: Pairwise Comparison Matrix (Filled Based on Survey of 50 Respondents)

Table 2. Pairwise comparison matrix

PAIRWISE COMPARISON MATRIX Comparison of the relative importance of each factor for industrial land suitability by AHP scale. AHP Scale: 1- Equal Importance, 3- Moderate importance, 5- Strong importance, 7- Very strong importance, 9- Extreme importance (2,4,6,8 values in-between).						
Criteria/ Parameters	Landuse/ Landcover	Distance to Rail Accessibility	Distance to Road Accessibility	Proximity to Built-up Areas	Distance from water body	Soil Typology
Landuse/Landcover	1	4	3	4	5	4
Distance to Rail Accessibility	0.25	1	3	4	3	3
Distance to Road Accessibility	0.33	0.33	1	4	3	4
Proximity to Built-up Areas	0.25	0.25	0.25	1	3	3
Distance from water body	0.2	0.33	0.33	0.33	1	4
Soil Typology	0.25	0.33	0.25	0.33	0.25	1
	2.28	6.25	7.83	13.67	15.25	19

Step 2: Calculate the Normalized Matrix, as shown in Table 3.

Table 3. Normalized matrix

Criteria/Parameters	Average Criteria weights (W)	Criteria weightage (in %)	Rank
Landuse/Landcover	0.38	38	1
Distance to Rail Accessibility	0.22	22	2
Distance to Road Accessibility	0.17	17	3
Proximity to Built-up Areas	0.10	10	4

Criteria/Parameters	Average Criteria weights (W)	Criteria weightage (in %)	Rank
Distance from water body	0.08	8	5
Soil Typology	0.05	5	6
		100	

Step 3: Calculate the Weightages (Priority Vector), as shown in Table 4, Table 5 and Table 6.

Table 4. Important parameters for weightage calculations

Criteria/Parameters	Sum of Normalized values	Weightage (%)
Landuse/Landcover	2.292	38
Distance to Rail Accessibility	1.2998	22
Distance to Road Accessibility	1.0269	17
Proximity to Built-up Areas	0.6092	10
Distance from water body	0.484	8
Soil Typology	0.2882	5

Table 5. Suitabilty parameters for the location of Aligarh

Criteria/ Parameters	Landuse/ Landcover	Distance to Rail Accessibility	Distance to Road Accessibility	Proximity to Built-up Areas	Distance from water body	Soil Typology
Landuse/ Landcover	0.438	0.640	0.383	0.293	0.328	0.211
Distance to Rail Accessibility	0.109	0.160	0.383	0.293	0.197	0.158
Distance to Road Accessibility	0.146	0.053	0.128	0.293	0.197	0.211
Proximity to Built-up Areas	0.109	0.040	0.032	0.073	0.197	0.158
Distance from water body	0.088	0.053	0.043	0.024	0.066	0.211
Soil Typology	0.109	0.053	0.032	0.024	0.016	0.053
	1	1	1	1	1	1

Table 6. Weightage calculations for different parameters of Aligarh

Criteria/ Parameters	Landuse/ Landcover	Distance to Rail Accessibility	Distance to Road Accessibility	Proximity to Built-up Areas	Distance from water body	Soil Typology
Landuse/Landcover	1	4	3	4	5	4
Distance to Rail Accessibility	0.25	1	3	4	3	3
Distance to Road Accessibility	0.33	0.33	1	4	3	4
Proximity to Built-up Areas	0.25	0.25	0.25	1	3	3
Distance from water body	0.2	0.33	0.33	0.33	1	4
Soil Typology	0.25	0.33	0.25	0.33	0.25	1

Step 4: The consistency check is analyzed. It is shown in Table 7.

Table 7. Consistency vector calculation

Criteria/Parameters	Average Criteria weights (W)	[C] x W=Ws	Consistency Vector ʎmax. = Ws x 1/W
Landuse/Landcover	0.38	2.77	7.29
Distance to Rail Accessibility	0.22	1.62	7.34
Distance to Road Accessibility	0.17	1.21	7.12

Criteria/Parameters	Average Criteria weights (W)	[C] x W=Ws	Consistency Vector ʎmax. = Ws x 1/W
Proximity to Built-up Areas	0.10	0.68	6.83
Distance from water body	0.08	0.52	6.49
Soil Typology	0.05	0.31	3.18
	6.37		

Consistency Check

- Lambda Max (λmax) = 6.37
- Consistency Index (CI)= (λmax - n) / (n - 1)= (6.37 - 5) / (6-1) =0.074924012

Step 5: Calculate of Consistency Ratio (C.R.)

- Random Consistency Index (RI) for n=6 is 1.24 (for 6 criteria or parameters)
- Consistency Ratio (CR)= CI / RI = 0.07492 / 1.24 = 0.06042 → 6.04% (< 10%)
- Hence Consistency is O.K.

Step 6: Final Weightages

- Landcover : 38 %
- Distance to Railway : 22 %
- Distance to Road : 17%
- Proximity to Built-up : 10 %
- Distance from Water Body : 8 %
- Soil Typology : 5 %

Step 7: Weighted Overlay for Industrial Suitability

The above weightages will be used in ArcGIS for the weighted overlay analysis to generate the final Industrial Suitability Map of Aligarh District with the defined factor hierarchy and survey-based AHP methodology (Table 8).

Table 8. Data source for LULC map preparation

Parameters	AHP weightage (in %)	Category	Scoring
Land Use	38	Waste land	5
		Agriculture	3
		Exiting Built-up Areas	0
		water body	0
		Vacant land	4
Railway Accessibility	22	0-2000 m	5
		2000-5000 m	4
		5000-10000 m	3
		10000-20000 m	2
		>20000 m	1
Road Accessibility	17	0-200 m	5
		200-500 m	4
		500-1000 m	3
		1000-2000 m	2
		>2000 m	1
Distance from water body	10	>2000 m	5
		1000-2000 m	4
		500-1000 m	3
		250-500 m	2
		0-250 m	1

Parameters	AHP weightage (in %)	Category	Scoring
Proximity to Built-up Areas	8	>2000 m	5
		1000-2000 m	4
		500-1000 m	3
		250-500 m	2
		0-250 m	1
Soil Typology	5	Loamy soil	5
		Alluvial soil	4
		Silty Loamy soil	3

4.2 Data Sources for Thematic maps Preparation

Each criterion was represented through thematic maps generated using ArcGIS. These maps were standardized using reclassification and buffered where necessary (Table 9). For example, proximity to roads and railways was categorized into buffer zones (e.g., 0–500m, 500–1000m, etc.) with decreasing suitability scores.

Table 9. Selected criteria and data sources for thematic maps preparation

S. No.	Criteria/Parameters	Data Types	Sources
1	Existing land use / landcover	Raster Data	Esri Living Etlas Land Use/Land Cover Data
2	Proximity to Railway accessibility	Polygon Data	BBBike Open Street Map & Google earth pro
3	Proximity to Road accessibility	Polygon Data	BBBike Open Street Map & Google earth pro
4	Proximity to built-up areas	Polygon Data	Esri Living Etlas Land Use/Land Cover Data
5	Distance from water bodies	Esri Living Etlas Land Use/Land Cover Data	Esri Living Etlas Land Use/Land Cover Data
6	Soil Typology	Polygon Data	Digital soil Map of the world Food and Agricultural Organization (FAO)

4.3 Landcover Map of Aligarh District

The land cover used to describe the physical characteristics of the Earth's surface. It simply means the use of land. Figure 4 shows the Landcover map of Aligarh district. Table 10 shows the different landcover area distribution of Aligarh district (in sq.km.).

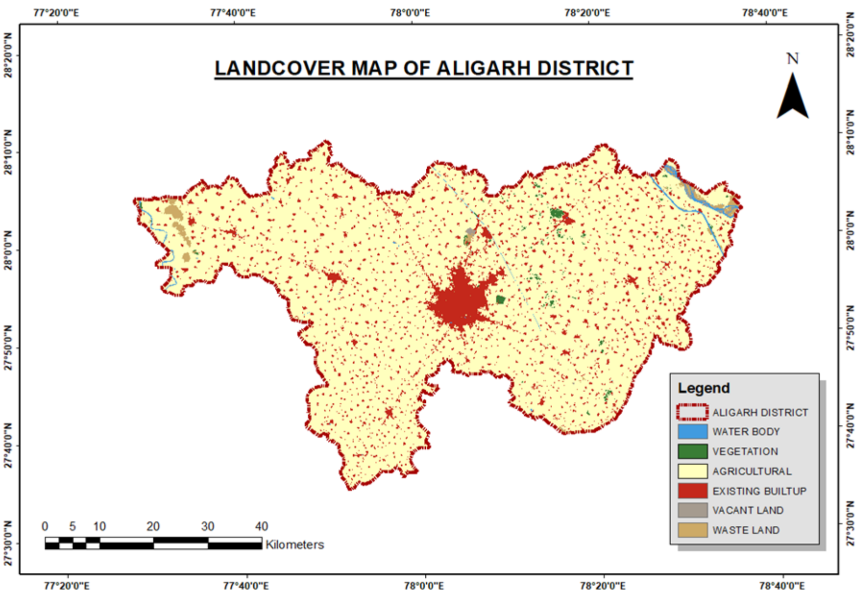
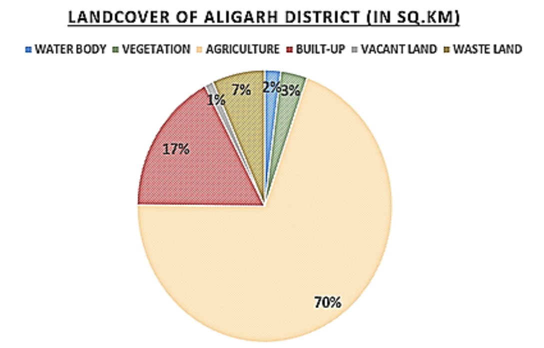


Figure 4. Landcover Map of Aligarh District

Table 10. Different Landcover Area distribution of Aligarh district (in sq.km.)



Landcover Type	AREA (sq.km)
Water Body	70.88722
Vegetation	117.885461
Agriculture	2442.002443
Built-Up	598.800003
Vacant Land	37.250553
Waste Land	234.141539

4.4 Road Network of Aligarh

Figure 5 shows the road network of Aligarh.

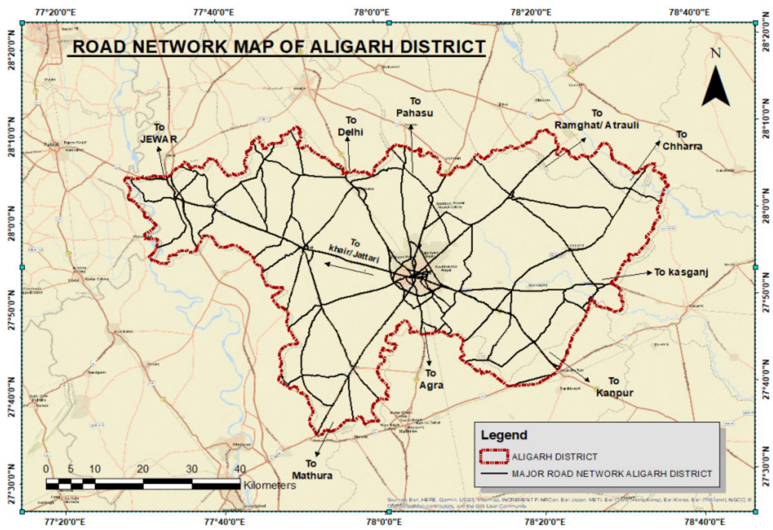


Figure 5. Road network of Aligarh

4.5 Distance to Road Network of Aligarh District

Figure 6 shows the distance to road network of Aligarh.

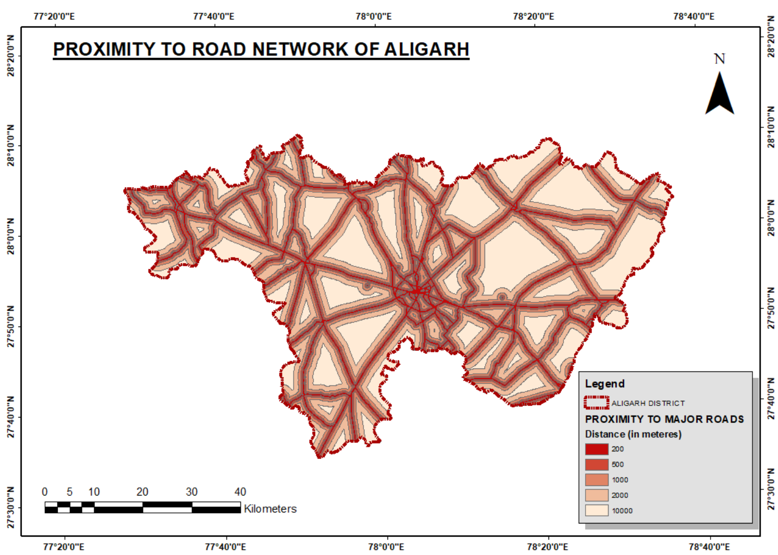


Figure 6. Distance to road network of Aligarh

4.6 Railway Network of Aligarh

Figure 7 shows the railway network of Aligarh road accessibility.

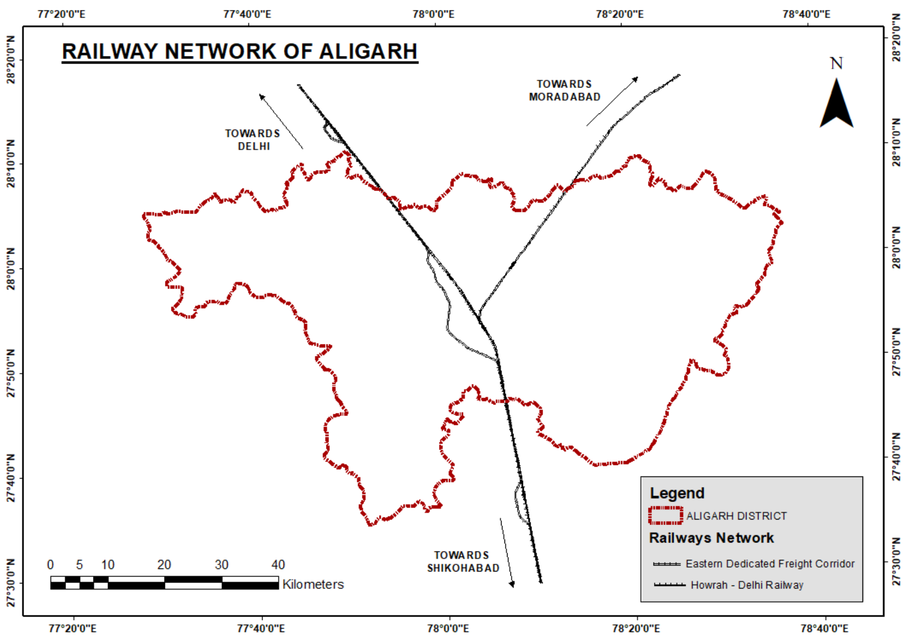


Figure 7. Railway network of Aligarh road accessibility

4.6.1 Distance to Railway network map of Aligarh

Figure 8 shows the distance to railway network of Aligarh.

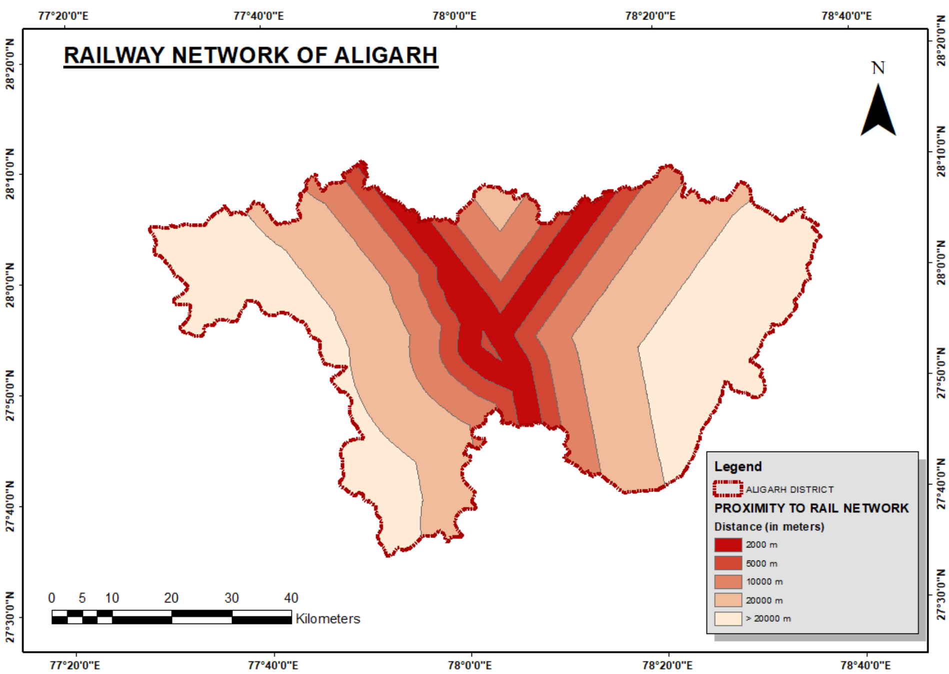


Figure 8. Distance to railway network of Aligarh

4.7 River /Water Body Map Aligarh District

Figure 9 shows the river/ water body map of Aligarh district.

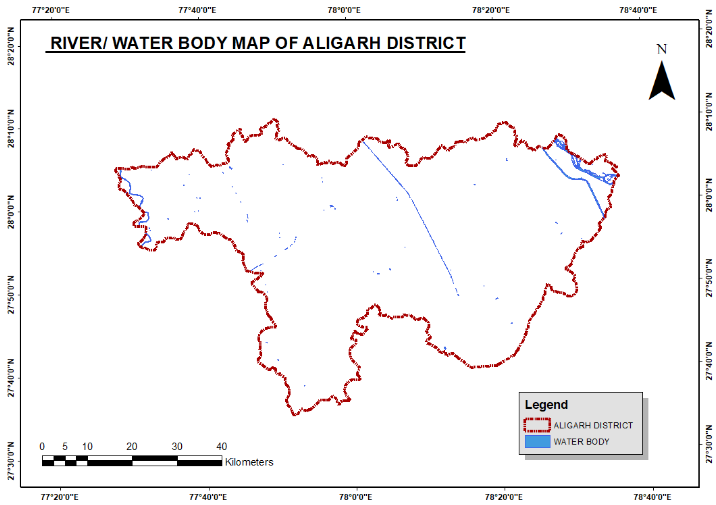


Figure 9. River/ water body map of Aligarh district

Figure 10 shows the distance from river/water body map of Aligarh district.

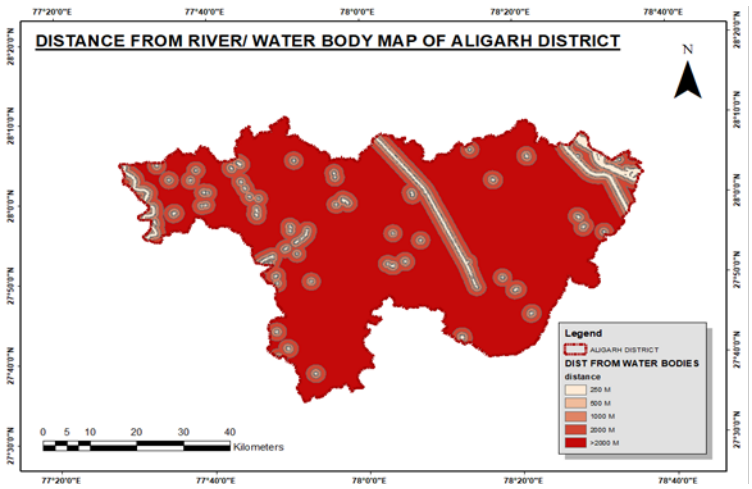


Figure 10. Distance from river/ water body map of Aligarh district

4.8 Existing Built-up Area of Aligarh District

Figure 11 shows the existing built up land of Aligarh district.

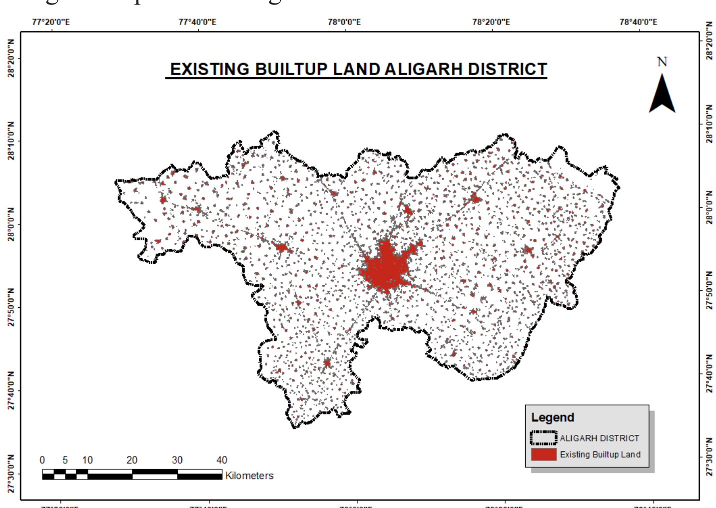


Figure 11. Existing built-up land Aligarh district

Figure 12 shows the proximity to existing built up land of Aligarh district.

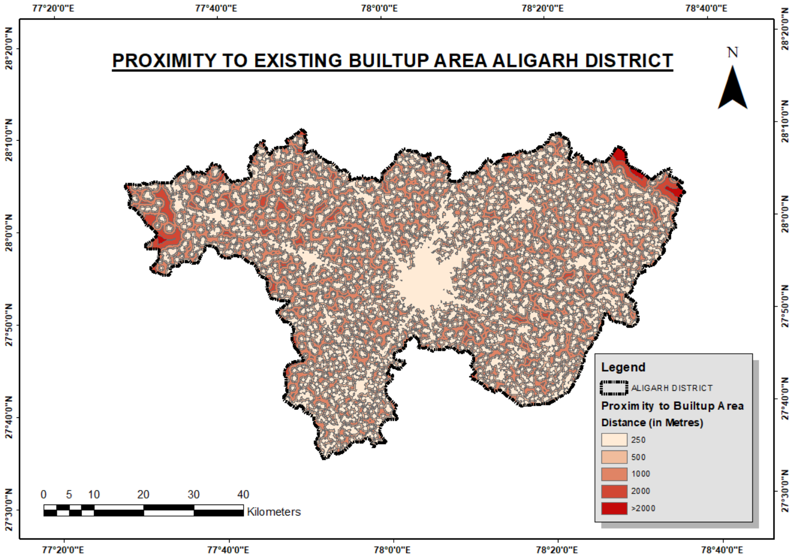


Figure 12. **Proximity to existing built-up area Aligarh district**

4.9 Soil Typology

Soil typology plays a crucial role in determining the suitability of land for industrial development, especially when it comes to factors like load-bearing capacity, drainage, ease of construction, and risk of erosion or flooding. Figure 13 shows the soil typology map of Aligarh district.

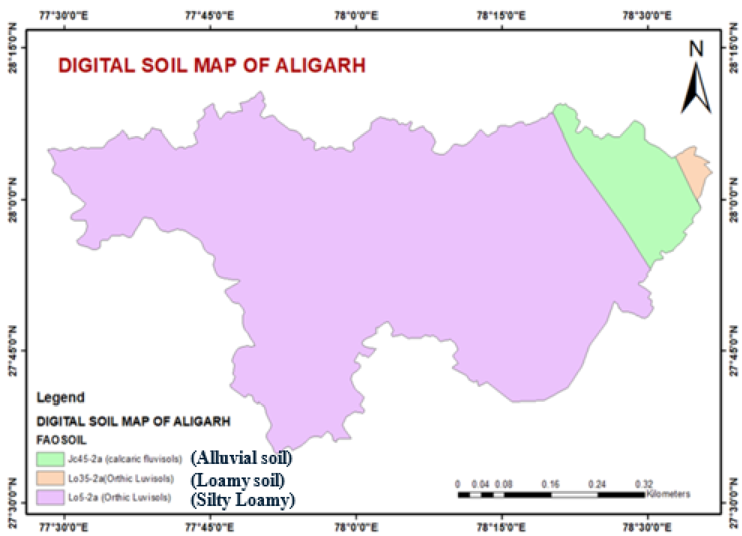


Figure 13. **Soil Typology map of Aligarh district**

In the context of Aligarh district, the three main soil types are:

- Alluvial Soil
- Loamy Soil
- Silty Loamy Soil

Table 11 shows the ranking for the soil type class for industrial land suitability.

Table 11. Ranking for Soil type class for industrial land suitability

Soil Type	Industrial Suitability	Reason	Importance Criteria
Loamy soil	High	• Excellent for foundations and infrastructure. • It offers the best mechanical strength and drainage properties, making it ideal for factory foundations, warehousing, and road building.	5
Alluvial soil	Medium	• Formed from river deposits; fertile and fine-textured. • Good for agriculture, but for industries: Often lacks compactness, especially in deep layers. • High water table in some areas can affect deep foundations. • May require soil treatment or reinforcement for heavy construction.	4
Silty Loamy soil	Low	• High silt content makes it: Poor in drainage; Prone to erosion and waterlogging; Unstable under load • Requires significant engineering intervention for stable industrial development.	3

4.10 AHP Pairwise Comparison Questionnaire

Data of expert survey on industrial land suitability assessment for Aligarh using AHP. Figure 14 shows the professional background of respondents of the expert survey for Industrial Land suitability. Figure 15 shows the experience of respondents in their field of expertise.

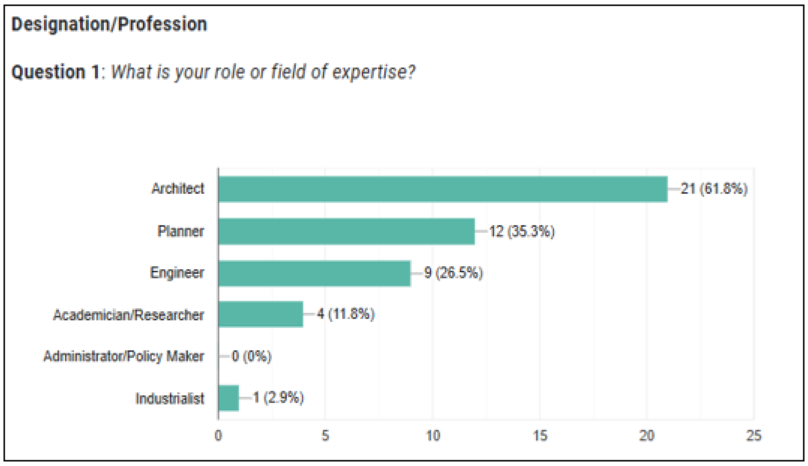


Figure 14. Professional background of respondents of the Expert survey for Industrial Land suitability

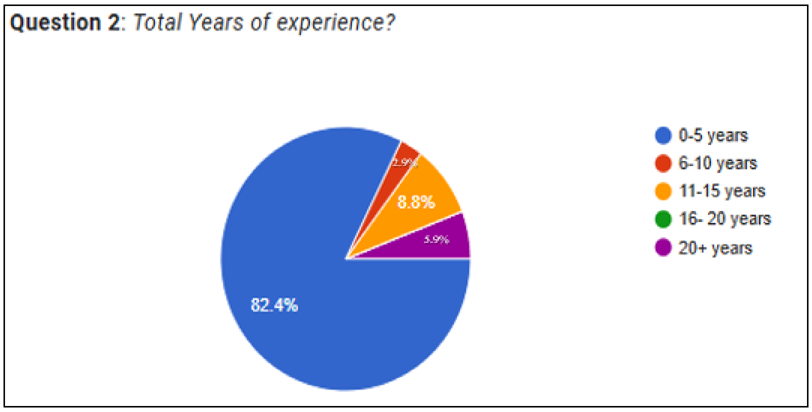


Figure 15. Experience of respondents in their field of expertise

4.11 Industrial Land Suitability Map of Aligarh along with Existing Industrial sites

Figure 16 shows the final suitability map for Industrial development.

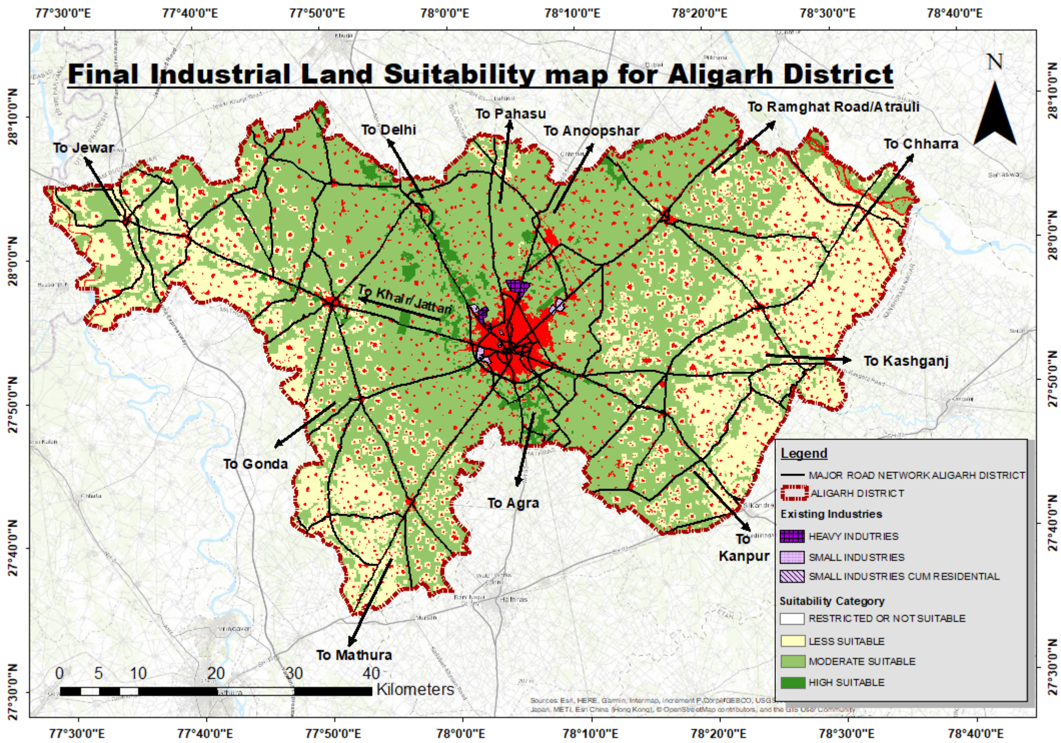


Figure 16. Final suitability map for Industrial development

Table 12 shows the existing Industrial sites with their areas in sq. kms. Table 13 shows the land use suitability category and Table 14 shows the high suitable areas along major roads in Aligarh sites.

Table 12. Existing Industrial sites with their areas (in sq. km.)

S. No.	Existing Industrial sites category	Areas (in sq.km.)
1	Heavy Industry	6.1933
2	Small Industry	5.1266
3	Small Industry cum Residential	0.18836
	11.50826	

Table 13. Land use suitability category

S. No.	Land suitability category	Areas (in sq.km.)
1	Restricted/ Not suitable	393.0538
2	Less Suitable	1140.094
3	Moderate Suitable	2244.396
4	High Suitable	93.453
	3871	

Table 14. High Suitable Areas Along Major Roads in Aligarh sites

S. No.	Road Corridors	Areas (in sq.km.)	% of Total High suitable Area
1	Delhi Road	36.354	38.90 %
2	Khair/Jattari Road	14.315	15.32 %
3	Agra Road	12.710	13.60 %
4	Anoopshar Road	5.007	5.36 %
5	Ramghat Road	2.672	2.86 %

5. Weightage Assessment through AHP

The following weights derived through the AHP process:

- Landcover : 38%
- Distance to Railway : 22%
- Distance to Road : 17%
- Proximity to Built-up Areas : 10%
- Distance from Water Bodies : 8%
- Soil Typology : 5%

Each factor was analyzed spatially to assess its influence on land suitability. The overlay results showed the spatial distribution of suitable zones across Aligarh. Areas with low population density, minimal ecological sensitivity, and strong infrastructure connectivity scored highest.

6. Results and Findings

The standardized maps were combined using the AHP-derived weights in the GIS environment. This resulted in a composite Industrial Suitability Map for Aligarh District, categorizing land into four classes: Not Suitable, Less Suitable, Moderately Suitable, and Highly Suitable through weighted overlay process.

The final suitability map revealed the following land distribution:

- Not Suitable : 393.05 sq. km
- Less Suitable : 1140.09 sq. km
- Moderately Suitable : 2244.39 sq. km
- Highly Suitable : 93.45 sq. km

High-suitability zones were clustered along major transportation corridors, specifically:

- Delhi Road : 36.35 sq. km (38.10%)
- Khair Road : 14.32 sq. km (15.00%)
- Agra Road : 12.71 sq. km (13.32%)
- Anoopshar Road : 5.01 sq. km (5.25%)
- Ramghat Road : 2.67 sq. km (2.80%)

These five corridors account for over 76% of the highly suitable zones, indicating the centrality of transportation in industrial site suitability. Areas near water bodies and residential zones were classified as low suitability due to risk factors like flooding, pollution, and social conflict. The study underscores the critical role of accessibility and existing land use in industrial site selection. While vacant and wasteland offer high development potential, preserving agricultural and ecologically sensitive zones is equally important. Integration of stakeholder perspectives through AHP ensured the realism and applicability of the weight assignments. The findings also stress the need for infrastructure augmentation in moderately suitable zones to elevate their potential.

7. Conclusions

This study comprehensively explored the industrial land suitability of Aligarh District using a GIS-based Multi-Criteria Evaluation (MCE) approach, enhanced by the Analytical Hierarchy Process (AHP). The results underline the efficacy of combining spatial analysis tools with expert-driven decision-making methodologies to support sustainable urban and industrial development. The analysis of industrial land suitability in Aligarh has identified key factors that significantly influence the potential for industrial development. The study emphasizes the importance of existing land use, proximity to railway and road accessibility, closeness to urban areas, distance from water bodies and soil typology as critical criteria. Based on the findings of the study, it is evident that the most suitable areas for industrial growth in Aligarh District are primarily located along Delhi Road, Agra Road, and Khair/Jattari Road. These locations offer excellent connectivity to the National Capital Region (NCR), which enhances logistical advantages and trade opportunities for industries. The GIS-based weighted overlay analysis, conducted using ArcGIS and the Analytic Hierarchy Process (AHP), categorized the district into four levels of suitability: Not Suitable (393.05 sq. km), Less Suitable (1140.09 sq. km), Moderately Suitable (2244.39 sq. km), and Highly Suitable (93.45 sq. km).

A further analysis of the Highly Suitable category revealed that a significant portion is concentrated along major road corridors. Specifically, Delhi Road accounts for 36.35 sq. km, which represents 38.90% of the total highly suitable area. Khair/Jattari Road contributes 14.32 sq. km (15.32%), and Agra Road adds 12.71 sq. km (13.60%). Smaller yet notable portions are also located along Anoopshar Road (5.01 sq. km or 5.36%) and Ramghat Road (2.67 sq. km or 2.86%). Collectively, these five corridors encompass approximately 76.03% of all highly suitable land identified in the study. This distribution underscores the critical role of transportation infrastructure in shaping the spatial pattern of industrial suitability and supports strategic planning for future industrial development in Aligarh. The AHP analysis assigned the following weights to the criteria, based on a consistency ratio (CR) of 0.0604:

- Land Cover : 38%
- Distance to Railway : 22%
- Distance to Road : 17%
- Proximity to Built-up Areas : 10%
- Distance from Water Bodies : 8%
- Soil Typology : 5%

The findings emphasize that optimal industrial site allocation is not merely a function of available land but a multidimensional assessment involving environmental, socio-economic, and infrastructural parameters. This aligns with broader sustainable development goals, ensuring that growth does not come at the expense of ecological degradation or the displacement of agricultural functions. By leveraging underutilized lands—such as vacant (37.25 sq. km) and wastelands (234.14 sq. km)—this approach minimizes land use conflicts while maximizing economic returns. Moreover, the study's methodological framework has broader implications for regional planning beyond Aligarh. The GIS-AHP model demonstrated here can be replicated and tailored to other districts facing similar developmental pressures. It offers planners, policymakers, and investors a practical tool to identify strategic areas for industrial expansion that align with long-term land use planning objectives and policy frameworks.

It is also crucial to note the importance of continually updating datasets and incorporating dynamic variables such as demographic trends, environmental impact assessments, and evolving infrastructure developments. Industrial planning must be flexible and responsive to external changes, such as government policy shifts or technological advancements. In conclusion, Aligarh's strategic location, industrial legacy, and connectivity infrastructure position it as a viable hub for sustainable industrial growth. The findings of this study provide a robust foundation for data-informed planning decisions and underscore the critical need for integrating advanced geospatial tools into mainstream urban and regional planning processes. Future planning initiatives should build on this framework, incorporating stakeholder participation, environmental stewardship, and economic foresight to shape resilient and inclusive industrial landscapes in Aligarh and beyond.

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