GEOGRAPHICAL ANALYSIS

ORIGINAL ARTICLE

Site Suitability Analysis for Urban Growth in Himalayan District of Jammu, India Using AHP Technique

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Abstract

The urbanization surge poses significant challenges to sustainable urban development globally, necessitating innovative approaches for site suitability analysis and planning. This research focuses on Jammu, India, using the Analytical Hierarchy Process (AHP) integrated with Geographic Information Systems (GIS) to assess suitable areas for urban growth. Considering nine key parameters including land use, population density, infrastructure, and environmental factors, we constructed criteria maps and weighted them using AHP's pairwise comparison matrix. The study area, Jammu district, spans 2342 sq.km. and hosts a diverse landscape ranging from agricultural lands to dense forests, presenting a complex scenario for urban expansion. Our findings reveal that approximately 38.72% of the area is highly suitable for urban development, primarily peripheral zones with agricultural and forested lands. Moderately suitable zones, covering 46.42% of the area, indicate potential transformation into built-up and commercial areas. However, a restricted zone of 1.8% prohibits new constructions due to environmental and infrastructural limitations. The accuracy assessment, employing the Kappa coefficient, yielded a satisfactory overall accuracy of 85.23%, validating the suitability classification. The results offer valuable insights for city planners, emphasizing the need for balanced development strategies that preserve environmental integrity and promote sustainability. This study contributes to the discourse on sustainable urbanization, showcasing the effectiveness of GIS-AHP integration in site suitability analysis. By guiding decision-making in urban planning, it lays the foundation for creating liveable and resilient cities amidst rapid urban growth challenges.

Keywords: Site suitability analysis, Urban expansion, Multi-Criteria Decision Making (MCDM), Analytical Hierarchy Process (AHP), Shiwalik Himalayas, Land use planning

1 Introduction

The term "sustainable city" refers to the physical manifestation of sustainable urban evolution. Furthermore, a sustainable city should have blended functions, a condensed form, a good standard of living, and great service accessibility. According to Taghizadeh-Mehrjardi *et al.*[45] (2020), land suitability and sustainability are related. Due to regular settlement patterns and relatively constant populations, urban development rates are fixed or modest in the developed world. It is undeniable that all continents have experienced rapid urbanization. According to the UN, this pace will gradually decline over the next 50 years, with the exception of Africa, where growth will continue. According to the Revised World Urbanization Prospects 2018, cities will house 68 percent of world population by

2050. Asia and Africa will contribute for 90% of global urban population growth between 2015 and 2030. The problem of urbanization and its detrimental impacts on social, economic, and environmental issues have received a lot of attention. Both industrialized and poor nations must practice sustainable development. India's census data indicates that the number of people living in cities increased by around 17 times between 1901 and 2021. Since 1980, the industrialized urban economy has caused an enormous spike in urban dwellers, which has resulted in rural migration[21]. As a consequence, issues associated with random, unplanned, and unsystematic urban growth has been plaguing Indian cities[20, 22]. For sustainable urban planning, it is therefore vital to assess the potential area for future urban growth[44].

Evaluation of the land's suitability is the essence for land-use planning. Land suitability is a geographically integrated process, and the suitability analysis can be carried out using GIS with particular attributes connected to the end goal[47]. According to Jamil *et al.* 2018 and Purnamasari *et al.* 2019[15, 34], the land suitability technique identifies the most appropriate land use by taking account of the wants and requirements of the user and attributes of the land. All the attributes or benchmarks have varying degrees of significance which have been established by a variety of approaches. Since 1960, scholars have been preoccupied with the problem of figuring out how to integrate various datasets into a single assessment index[49]. In numerous instances, a blend of GIS techniques and Multi-Criteria Decision Making (MCDM) is a better option than using regular map overlay approaches[11, 23]. GIS software enables users to conduct geospatial research and manage data to generate outputs in the form of graphs or maps. According to Malczewski (2006)[24], one of these methods for solving land suitability issues is GIS-MCDA. There are multiple techniques for MCDA, such as the ELECTRE Method by Bernard Roy, TOPSIS, PROMETHEE, and AHP[29]. Saaty (1980)[39] originally proposed the AHP multi-criteria decision-making framework for suitability analysis. Using a pairwise comparison matrix and expert opinions and local knowledge, AHP determines the weights of the criteria. Numerous applications of the AHP approach have been identified, including the most suitable areas for sustainable urban development[6]; evaluating the land's suitability for the purpose of urban growth and development[1] analyzing potential landfill sites for waste management[13], building site locations[3], and agricultural land use sites[33, 42]. MCDM analysis techniques are able to provide adequate tools for complex planning in terms of setting priorities, weighing and selecting alternatives, and allocating resources across competing activities. Numerous studies have been conducted in the past to find the best location for urban development utilizing geospatial technology and AHP, with positive outcomes[9]. Site suitability analysis based on the Analytical Hierarchy Process provides a structured approach for directing urban growth in Jammu district also. Urban development in the district is largely driven by proximity to transport networks, educational and commercial centres, while being constrained by flood susceptible rivers plains, unstable Shiwalik slopes, and heterogeneous lithological conditions. In this context, GIS integrated AHP is particularly effective as it combines multiple physical and socio-economic factors within a transparent decision-making framework, converting expert judgment into spatially defined suitability zones for future urban expansion. Therefore, the aim of the present study is to analyze the suitable site for the urban growth in Jammu using GIS along with the Analytical Hierarchy Process (AHP) based on Saaty's 9-point-scale.

2 Study Area

Jammu district, situated in an area of 2342 sq.km. between 32° 50" to 33° 30" N and 74° 24" to 75° 18" E [Fig. 1]is the winter capital city of the union territory of Jammu and Kashmir, which host population of 1.53 million[12]. The district is bounded by Shiwalik range of lesser Himalayas to the north. It shares its border with north and northeast by Reasi and Udhampur district, southeast by Samba, northwest by Rajouri district and also share international border with Pakistan by west and southwest[5].

Jammu district has sub-humid to sub-tropical climate type and receives mean annual rainfall of about 1246mm which is mainly from southwest monsoon. Temperature of the district varies from winter low as 4°C to summer high 46°C. Jammu city is the main economic hub of the whole administrative Jammu division, enriched with number of small-scale industries and also famous for the Basmati rice grown in R.S Pura region which is exported throughout the country. As a capital city of the Union territory, it attracts the surrounding district's population thus, population growth rate was 12.74% in 2011. Jammu city saw the exponential growth in the urban structure due its enormous population growth. Among all the districts of

the Union territory, Jammu is the second largest urbanised district with the 43.98% of urban population after the Srinagar which constitutes 82.80% of urban population[12]. If the city is not built in a planned way it can indulge in many socio-economic problems hence, in order to overcome such problems, we assessed the suitable site for the expansion of Jammu city using the Analytical hierarchy process and GIS method which would be helpful for the city planners to plan the city expansion in a proper way following the mentioned suitable sites of the region.

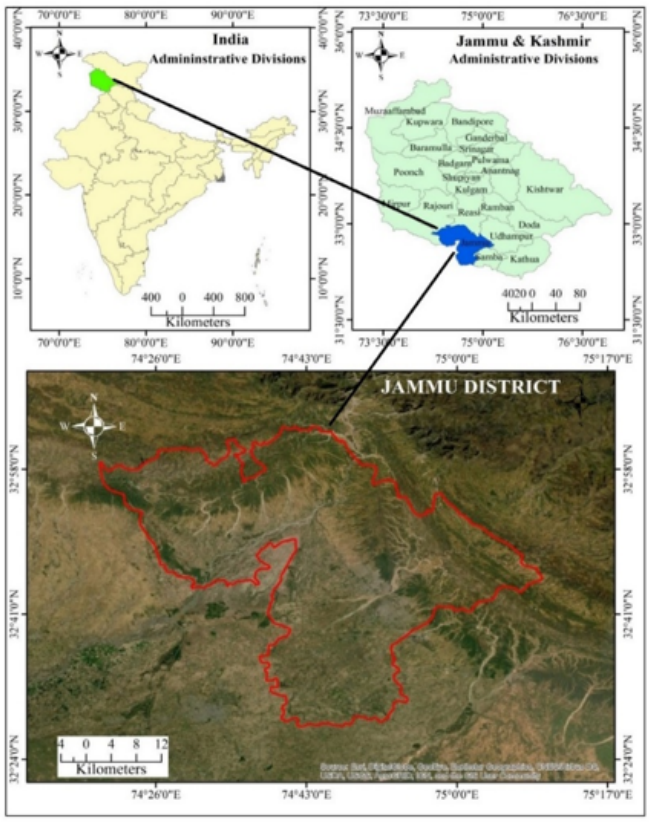


Fig. 1: Study Area

3 Data and Methods

3.1 Selection and preparation of criteria maps:

Nine parameters were selected to carry out the study. The principal criteria used for the land suitability analysis are land use land cover change, population density, river, road, railway station, educational institution, slope, lithology and commercial area. All these criteria were used for the preparation of maps. The data used in the study is shown in [Table. 1].

3.2 Data:

Table 1: Dataset used in the study

S. NO	Map Layer	Data Sources
1	ASTERDEM	United States Geological Survey (USGS)
2	LANDSAT-8	United States Geological Survey (USGS)
3	Lithology	Geological Survey of India
4	Population Density	Census of India, 2011
5	Road, Railway lines, Rivers, Educational institutions, Commercial areas	Google Earth image

3.3 Weightage calculation by AHP:

This study used AHP along with the GIS technique to determine the site's suitability for the outward expansion of Jammu city. The pair-wise comparison analytical hierarchy process (AHP) developed by T.L. Saaty in the early 1970s is a set of multiple criteria method which is used to solve complex decision-making problems involving socio-political, economic and technological matters[38, 41], Assigns weights to each criterion according to the relative importance[40]. AHP is a flexible and powerful technique that can be used to solve decision-making problems according to the set of priorities and help to make the best decision when both the qualitative and quantitative aspects are taken into consideration[48].

Saaty introduced the four steps methodology comprising modelling, valuation, prioritization and synthesis. At the early stage, a hierarchy is constructed where the goal of the study is placed at the top level and then other relevant variables are placed below at different levels according to the preferences and relative weight of each variable[32]. Pairwise comparison method was used to generate a matrix and to provide weights and scores to variables. The study used the 9 scale Saaty's method [Table. 2] which ranges from 1-9 where 1 represents the lowest and 9 as the highest suitability respectively[39].

Table 2: Saaty's 9-point weighing scale for pairwise comparison

Degree of importance	Description	Suitability class
1	Equal importance	Lowest suitability
2	Equal to moderate importance	Very low suitability
3	Moderate importance	Low suitability
4	Moderate to strong importance	Moderately low suitability
5	Strong importance	Moderate suitability
6	Strong to very strong importance	Moderate high suitability
7	Very strong importance	High suitability
8	Very strong to extremely importance	Very high suitability
9	Extremely importance	Highest suitability

Source: Saaty 1980[39].

Table 3: Random Index (RI)

Matrix size	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I	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	1.58

Source: Saaty 1980[39].

3.4 Computation of consistency ratio (CR):

After the completion of pairwise comparison matrix and normalised pairwise comparison matrix, Consistency ratio (CR) has been calculated using the equation 1 and 2 to determine the consistency level of the matrix. If the computed value of CR < 0.10 then the comparison is said to be consistent and if CR ≥ 0.10 then the value ratio of judgement indicates inconsistency[13]. CR can be calculated as:

$$CR = CI / RI \quad (1)$$

Where, RI is the random index which is average of consistency index depending on the size of matrix formulated by T.L Saaty[38], [Table. 3] and consistency index (CI) can be calculated as:

$$CI = (\lambda - n) / (n - 1) \quad (2)$$

Where, 'λ' is the average value of the consistency vector and consistency index and 'n' represents the no. of values in the matrix.

$$CI = (10.11 - 9) / (9 - 1) = 0.14 \quad (3)$$

$$CR = 0.14 / 1.45 = 0.096 \quad (4)$$

Above **equation 4**, depicts that Consistency ratio (CR) is = 0.096 < 0.10 indicates reasonable level of consistency in the pairwise comparison matrix, which reflects that the results obtained satisfy the condition and the weights assigned are satisfactory. The pairwise comparisons were prepared using Saaty's 9-point scale and were based on expert judgement informed by the regional planning context of the study area. While reviewing the matrix, particular attention was given to closely related infrastructure criteria in order to address small local inconsistencies that can arise due to the limited range of the scale. In a few cases, very strong preferences were slightly moderated to improve internal consistency, while keeping the overall importance ranking of the criteria unchanged.

3.5 Land use land cover classification:

Several methods have been employed in recent years for Land Use and Land Cover (LULC) classification, including the Maximum Likelihood Classifier, Indices Overlay Method, Neural Networks, and K-means Clustering[17, 43]. In the present study, the Maximum Likelihood Classification technique was utilized to perform the LULC classification. Six major LULC categories were identified: scrub land, agricultural land, vegetation, gullies and dense forest. Following statistical equations used to calculate the

overall accuracy and kappa index for the raster layers of the LULC classification.

$$\text{Overall accuracy} = \sum_{i=1}^{r} Xii \qquad (5)$$

Where, X_{ii} is the diagonal value in the error matrix

X is the total no. of samples

$$\text{Kappa index } \hat{k} = \frac{n\sum_{i=1}^{r} Xii - \sum_{i=1}^{r}(Xi+X+i)}{n^2 - \sum_{i=1}^{r}(Xi+X+i)} \qquad (6)$$

Where r is the no of rows in the error matrix; x_{ii} is the no of observations in a column *i* and row *i* ; x_{i+} and x_{+I} are the marginal total of row *i* and column *i* ; and n is the total no of observations.

3.6 Overlay analysis:

In this study, the weighted linear combination (WLC) approach has been applied to integrate multiple criteria and determine the suitability index. The WLC method was preferred over the Boolean intersection (BI) and ordered weighting average (OWA) techniques due to its simplicity and widespread use[23]. In this approach, the suitability index was obtained by calculating the sum of the products of each criterion's weight and its standardized score, as expressed in equation below.

$$\text{Suitability index} = \Sigma Wi * Xi \qquad (7)$$

Where, Wi indicates weight of each criteria and Xi is standardized score of each criteria (0-10).

4 Results and Discussion

Nine parameters (land use land cover, population density, river, road, railway station, educational institute, slope, lithology and commercial area) were taken into consideration for assessing the suitable site for the growth of Jammu city. After an extensive literature review and expert opinions, a pairwise comparison matrix [Table. 4] was formed based on Saaty's 9-point weighing scale [Table. 2], weights were given to the parameters by comparing them in the matrix and according to their relative importance.

Subject expert opinions were gathered through a structured Analytic Hierarchy Process (AHP) questionnaire. The evaluation involved four domain experts, including: Two faculty members from the Department of Geography, University of Jammu, specialization in urban planning and geomorphology. One senior town planner from the Jammu Development Authority (JDA). One GIS analyst engaged in a government mapping initiative. Each expert completed an AHP questionnaire comprising 36 pairwise comparisons among the nine criteria. These comparisons were rated using Saaty's 1–9 scale based on their professional judgment. The individual assessments were consolidated by calculating the geometric mean which is a standard method for integrating multiple expert inputs in AHP[39]. The resulting geometric mean values formed the final pairwise comparison matrix [Table. 4].

A normalised pairwise matrix [Table. 5] was formed by dividing each value of the pairwise comparison matrix with the sum of their respective column value. To find out the criterion weight average of each row in the normalised matrix has been computed. It is observed that road is the highest influencing parameter in the study as the weightage value is 29.9% followed by the educational institution (18.7%), and land use land cover (16.4%). Similarly, lithology is the least influencing factor in the study area as the weightage value is (1.9%).

4.1 Land use land cover (LULC):

Land use land cover is the key aspect for urban planning[35] which is the product of natural as well as socio-economic factors, utilised by humans over a period of time[13]. LULC of Jammu district in the present study has been categorized as scrub land, agricultural land, vegetation, gullies and dense forest. In this study, scrub land is classified as "highly suitable" for future development of city, vegetation as "moderately suitable" while dense forest considered as "least suitable" [Table. 6].

4.2 Slope:

Slope is an important criterion which contributes to the development of any region. Slope degree is the main factor which determines the rate of erosion, usually amount of material carried away increases with the increase of slope degree and vice versa[9]. Thus, steeper slope increases the construction cost due to erosion during the construction process and subsequent usage and also limits the maximum floor size[19]. Generally, slope degree less than 10 considered as highly suitable for urban development

and slope exceeding 20 degree has been classified as unsuitable [Table. 6][19, 36].

4.3 Road proximity:

The presence of roads increases the suitability of the region. connectivity is essential for the transportation of raw material and finished goods[19]. In this regard, preference given to locate the site nearer to road because construction of new roads usually expensive[42]. Also, road is the highest influential factor in the study region [Table. 4].

4.4 Lithology:

It is important to examine the lithology of the region in order to develop any kind of settlement. The study area contains the mountainous area of Shiwaliks and plains of Sirowali and Kandi region. Shiwaliks are the least suitable zone as shown in the [Table. 6] because it is difficult to develop the settlement in the hilly region compared to the plains, also Himalayas lies in the seismically active zone. Hence, plains lying below the Himalayas i.e., Sirowali and Kandi have been given more weightage for future urban development.

4.5 River:

Area located near to any surface water body develops more rapidly compared to the areas located away from the water bodies. Two main rivers identified in the present study- (a) 'Tawi river' which flows through the centre of the Jammu city and (b) 'Chenab River' which flows from the periphery of the city, both are the tributaries of the river Indus. The proximity map has been reclassified into five classes- <500m, 500-1000m, 1000-1500m, 1500-2000m and >2000m [Table. 6]. Accordingly, more weight was given for the highly suitable region i.e., area located less than 500m of distance and Low weightage was given for the region lying more than 2000m away from the river.

4.6 Population density:

There is corelation between comfortability and population density of an area. Various Studies showed the negative psychological effects in adults like, aggression, loneliness, stress, less responsive parent behaviour etc. associated with crowd housing conditions[14]. Hence, the population density is an important factor determining urban land suitability analysis.

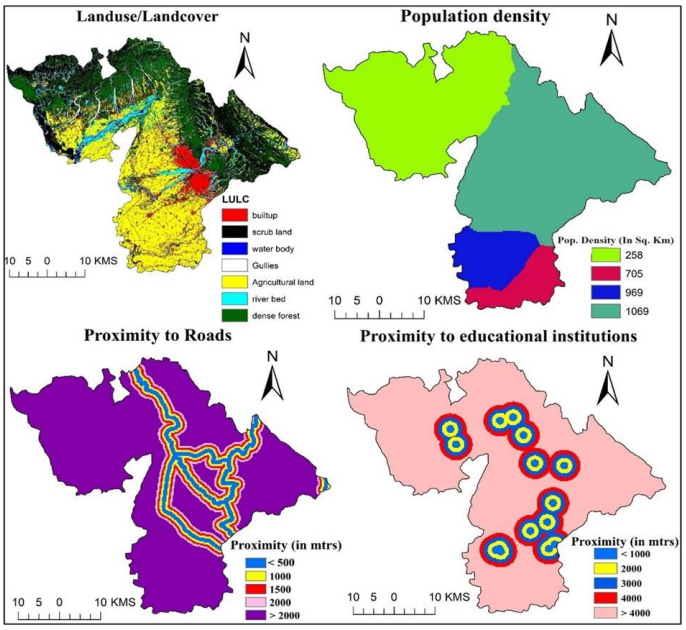


Fig. 2: Shows map of LULC, Population density, Proximity to roads and Proximity to Educational intuitions

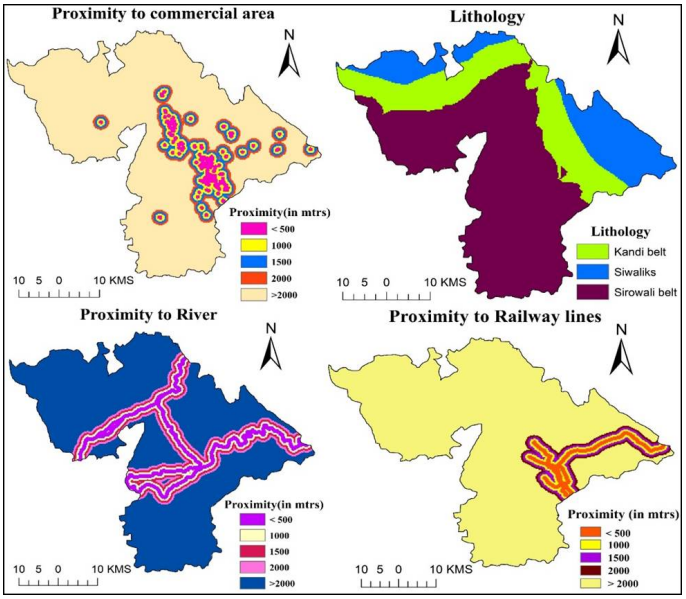


Fig. 3: Shows Proximity to Commercial areas, Lithology, Proximity to River and Proximity to Railway lines

4.7 Infrastructure:

Besides all other factors urban site suitability also incorporate the infrastructure facilities such as distance from roads, railway stations, educational centres, existing

urban centres, and medical facilities[8]. As a result, we have identified educational institutes, distance from railway station and distance from existing commercial areas as shown in [Fig. 2]. and [Table. 5] which provides an opportunity for urban development.

4.8 Preparation of land suitability map:

All the nine criteria maps were converted into raster data format to determine the pixel wise score. Final suitability map was prepared by integrating and overlaying all the criteria maps.

Table 4: Pairwise comparison matrix and normalised pairwise comparison matrix

Criteria	LULC	PD	RV	RD	RS	EI	SP	LT	CA
LULC	1	2	4	0.33	4	0.5	4	6	5
PD	0.5	1	4	0.33	0.5	0.5	1	7	6
RV	0.25	0.25	1	0.14	0.25	0.17	0.5	1	0.5
RD	3	3	7	1	5	3	2	7	7
RS	0.25	2	4	0.14	1	0.33	1	7	4
EI	2	2	6	0.33	3	1	4	6	5
SP	0.25	1	2	0.5	1	0.25	1	8	5
LT	0.17	0.14	1	0.14	0.14	0.17	0.12	1	0.25
CA	0.2	0.17	2	0.14	0.25	0.2	0.2	4	1
Sum	7.62	11.56	31	3.05	17.14	6.12	13.82	47	33.75

LULC- Land use/ Land cover, *PD*- Population Density, *RV*- River, *RD*- Road, *RS*- Railway Station, *EI*- Educational Institutions, *SP*- Slope, *LT*- Lithology, *CA*- Commercial Areas.

Table 5: Normalized pair-wise comparison matrix and computation of criterion weightage

	LULC	PD	RV	RD	RS	EI	SP	LT	CA	Criterion weight	Weighted sum value	Ratio	Rank
LULC	0.13	0.17	0.13	0.11	0.23	0.08	0.29	0.13	0.15	0.16	1.71	10.8	3
PD	0.07	0.09	0.13	0.11	0.03	0.08	0.07	0.15	0.18	0.1	1	10.01	4
RV	0.03	0.02	0.03	0.05	0.02	0.03	0.04	0.02	0.02	0.03	0.27	9.96	8
RD	0.39	0.26	0.23	0.33	0.41	0.49	0.15	0.15	0.21	0.29	3.05	10.53	1
RS	0.03	0.17	0.13	0.05	0.06	0.05	0.07	0.15	0.12	0.09	0.94	10.16	5
EI	0.26	0.17	0.19	0.11	0.18	0.16	0.29	0.13	0.15	0.18	1.93	10 .56	2
SP	0.03	0.09	0.07	0.16	0.06	0.04	0.07	0.17	0.15	0.09	0.93	9.99	6
LT	0.02	0.01	0.03	0.05	0.01	0.03	0.01	0.02	0.01	0.02	0.2	9.48	9
CA	0.03	0.02	0.07	0.05	0.02	0.03	0.01	0.09	0.03	0.04	0.35	9.5	7
Sum	1	1	1	1	1	1	1	1	1	1			

4.9 Accuracy assessment:

The accuracy assessment of the LULC map and urban growth suitability map has been performed using ground truthing by kappa index. Kappa index can be used as a measure of agreement between reality and predictions model or to examine if the values present in error matrix shows the result significant than random[26]. The Kappa coefficient for the present LU/LC classification is 0.880 with an overall accuracy of 90.4% which is reasonable and acceptable.

Whereas for the accuracy assessment of site suitability map 400 randomly distributed sample points have been taken for ground truthing. These points were converted into KML format and overlaid on Google Earth imagery. The overall accuracy of the classified map is 87%, which is considered acceptable according to literature standards indicating that accuracies above 85% are satisfactory[31].

Table 6: Suitability ranking

Intensity of importance	Land use land cover	Population density	Distance from river	Road proximity	Distance from railway station	Distance from educational institute	slope	Lithology	Distance from commercial area
Very high				<500m			<10°	-	
	Scrub land/Wasteland.	<258	<500m		<500m	<1000m			<500m
High	Agricultural land	258–705	500m-1000m	500m–1000m	500m–1000m	1000m–2000m	10°–15°	Sirowali	500m–1000m
Moderate	Vegetation	705–969	1000m–1500m	1000m–1500m	1000m–1500m	2000m–3000m	15°–20°	Kandi	1000m–1500m
Low	Gullies	969–1069	1500m–2000m	1500m–2000m	1500m–2000m	3000m–4000m	20°–25°	Shiwaliks	1500m–2000m
Very low	Dense Forest	>1069	>2000m	>2000m	>2000m	>4000m	>25°	-	>2000m

LULC- Land use/ Land cover, *PD*- Population Density, *RV*- River, *RD*- Road, *RS*- Railway Station, *EI*- Educational Institutions, *SP*- Slope, *LT*- Lithology, *CA*- Commercial Areas

Table 7: Area under different suitability classes

Suitability Classes	Area (In sq.km)	Percentage (area)
Highly suitable	893.84	38.72
Moderately Suitable	1071.38	46.42
Less suitable	301.36	13.06
Not suitable/Restricted	41.71	1.80

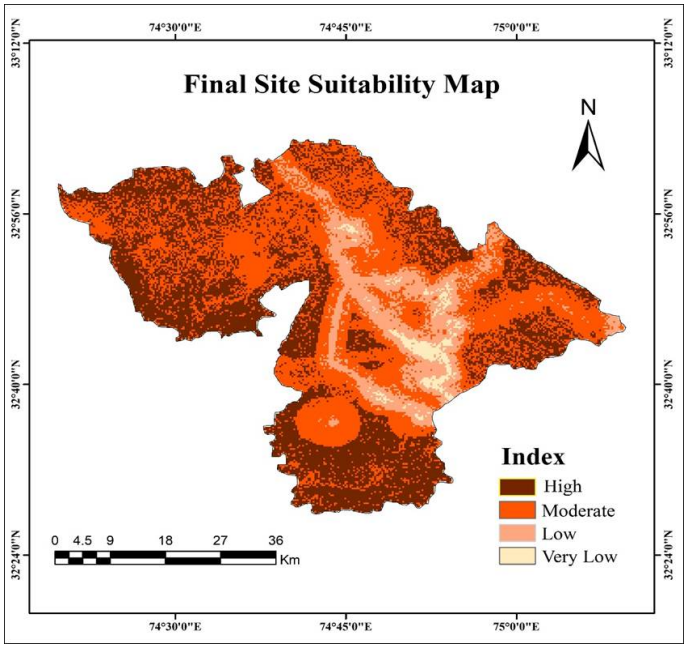


Fig. 4: land suitability map

4.10 Site suitability analysis:

To identify the most suitable site for the sustainable development of city, GIS based multicriteria decision evaluation approach along with AHP was used to evaluate and analyse the scores given to each criterion. All the maps were prepared and pre-processed in the ArcGIS using spatial analysis tool. To derive the suitability map, weighted values of each class obtained using AHP were used. The final suitability map has been grouped in four classes namely highly suitable, moderately suitable, less suitable and restricted or least suitable.

The allocation of land in each category is outlined in [Table. 7]. Specifically, the region classified as highly suitable constitutes approximately 38.72% (equivalent to 893.84 sq.km), representing areas that meet all predetermined criteria. These locations are predominantly situated in the peripheral zones of the study area, featuring agricultural land, cultivated vegetation and forested area. It

is crucial, however, to approach development in these regions with caution, as excessive urbanization could negatively impact both productivity and environmental conditions, given the role of vegetation as a natural carbon sink. Hence, a balanced and prudent approach to further development is recommended, with a focus on sustainability. Moderately suitable zone comprised of 46.42 % of the total area which is the highest. It can be projected that if the current trajectory of population growth persists; a substantial transformation is anticipated in the near future within the majority of zones. These areas are expected to undergo conversion into built-up and commercial zones, subsequently exerting an inevitable influence on the agricultural sector. Because the moderate zones primarily encompass agricultural fields, with the cultivation of rice and wheat being particularly susceptible to adverse effects.

Among all, a minimal area, accounting for merely 1.8% of the total, falls within the restricted zone, indicating that no new construction is permissible in this particular area. Expanding urban infrastructure in these regions is deemed unsuitable due to their existing overcrowded nature and their positioning within the floodplain of the Tawi River.

Areas marked as highly suitable are mainly located along the city's periphery, a large part of these zones overlaps with existing agricultural land. This pattern brings out a clear planning trade-off, as urban expansion in easily accessible fringe areas can place increasing pressure on productive farmland that supports local food needs. The results do not suggest that these lands will inevitably be converted. Instead, they indicate locations where development pressure is likely to be higher because physical conditions and infrastructure access are favorable, highlighting the need for careful planning to balance urban growth with the protection of agricultural land.

Similarly, zones classified as moderately suitable should be seen as transitional spaces rather than future urban areas by default. In these locations, accessibility benefits coexist with environmental or physical constraints, and actual land-use outcomes will depend on policy choices, infrastructure provision, and regulatory controls. The suitability analysis therefore provides a way to reflect on possible trade-offs and guide planning decisions, rather than a model that predicts how the city will expand.

4.11 Policy recommendation:

Following policy measures recommended:

1. Zones classified as unsuitable especially those located in the Shiwalik hill ranges near Nagrota, Jhajjar–Kotli, Dansal, and the Tawi River proximity should continue to be restricted to reduce environmental risks and potential hazards.

2. Regions falling under moderate suitability like Akhnoor, Samba road corridor, and Ghou-Manhasan need gradual upgradation in transportation links, drainage networks, and essential services to enhance their capability for future development and to limit unregulated expansion.

3. Any conversion of agricultural or vegetated land lying in R S Pura, Bishna and Marh region within suitable categories should follow a controlled and phased approach to preserve ecological functions.

4. Urban planners should emphasise accessibility-driven development by reinforcing major transport corridors and promoting secondary urban centers to ease pressure on the primary city core.

5 Conclusion

In conclusion, the study highlights the critical importance of site suitability analysis using GIS and the Analytical Hierarchy Process (AHP) in the context of urban growth in Jammu, India. The rapid urbanization and population growth in India, especially in regions like Jammu, necessitate careful planning to ensure sustainable development and alleviate socio-economic challenges.

The research underscores the significance of sustainable urban planning, emphasizing the need for blended functions, condensed forms, good living standards, and accessible services in creating sustainable cities. The World Commission on Environment and Development's emphasis on growth that meets current needs without compromising future generations' requirements further underscores the importance of sustainable development strategies. The application of GIS and AHP techniques in land suitability analysis has been thoroughly discussed, showcasing their effectiveness in identifying the most suitable areas for urban expansion. By considering multiple criteria such as land use, population density, infrastructure, and environmental factors, the study provides a comprehensive framework for decision-making in urban planning.

The results of the study reveal that certain areas within Jammu are highly suitable for urban growth, while others

require careful consideration due to environmental constraints or infrastructural limitations. The findings offer valuable insights for city planners and policymakers, enabling them to make informed decisions to support sustainable urban development. Overall, the research contributes to the broader discourse on sustainable urbanization and offers practical solutions for addressing the challenges posed by rapid urban growth. By integrating geospatial technology with decision-making frameworks like AHP, the study provides a robust methodology for guiding future urban development initiatives in Jammu and similar regions, ultimately contributing to the creation of more liveable and resilient cities.

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