

AHP and GIS based Land Suitability Analysis for Built up in Bharatpur Metropolitan City, Nepal

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Abstract:- In Bharatpur Metropolitan City (BMC), rapid changes in socioeconomic conditions led to rapid urban growth, which in turn caused a number of environmental damages, including land fragmentation, unauthorized settlements, unchecked land use conversion, rising environmental pollution, and anthropogenic disasters. The rate of migration has been dramatically rising recently. These forecasts illustrated the gradual migration of people from rural to urban locations. Arable land fragmentation and erratic land use shifts are greatly impacted by rapid urbanization. They are significant concerns for property developers and urban planners. Urban planners and developers are unable to foresee city growth and modeling in the future using accurate management techniques due to unpredictable urban expansion. GIS based multi criteria decision making (MCDM) for land suitability analysis. Analytic hierarchy process (AHP) is a combination of qualitative and quantitative method used to calculate the weights of multi criterion by using pairwise matrices. By this method the biophysical and socioeconomic factors underlying the expansion has identified. Suitability maps had been prepared for several classes: highly suitable, moderate suitable, less suitable and restricted area and its percentage of area.

Keywords:- Analytical Hierarchy Process; GIS; MCDM; Pairwise Comparison Matrix; Suitability.

I. INTRODUCTION

Nepal has experienced a recent surge in urbanization. One of the 10 nations with the least urban population is Nepal [1]. It is, however, one of the ten nations with the fastest rate of urbanization. Recent years have seen a number of climate change-related issues in Nepal, including those related to precipitation patterns, glacial melt rates, and timing, all of which may have an impact on agricultural production, biodiversity, and hydroelectric energy generation [2]. A crucial topic for such regions' urban planners, policymakers, and environmentalists should be the effects of rapid urban growth on environmental challenges [3]. This study provides current scenarios for a variety of social, demographic, and economic factors; water supply, sanitation, and health factors; household characteristics, and housing patterns; and urban environmental infrastructure, accessibility to community facilities, awareness of public health, and other factors. Socioeconomic data, DEM, aspect, soil, geology, and other information gathered in conjunction with an urban base map, GIS, and ERDAS IMAGINE would offer priceless insight into the present and past land use patterns. Due to this city's uneven urban growth, there are difficulties with the environment, land use, socioeconomic imbalances, and land suitability. The analytic hierarchy process, a structured technique for dealing with complex decisions in the application of multi-criteria decision analysis [4]. Theoretically, the AHP aids decision makers in finding the solution that best suits their needs and understanding of the problem, rather than prescribing a correct decision [5]. The consequence is that AHP is a method of decision-making that is based on people's actual capacity for making important choices. The project's objective, in this case land use compatibility for present and future built up, should be determined before performing the AHP. A number of preset criteria or factors are graded in accordance. The analytical hierarchy process' general structure is depicted in the following Fig. 1: The general structure of AHP for MCDM, modified from [6].

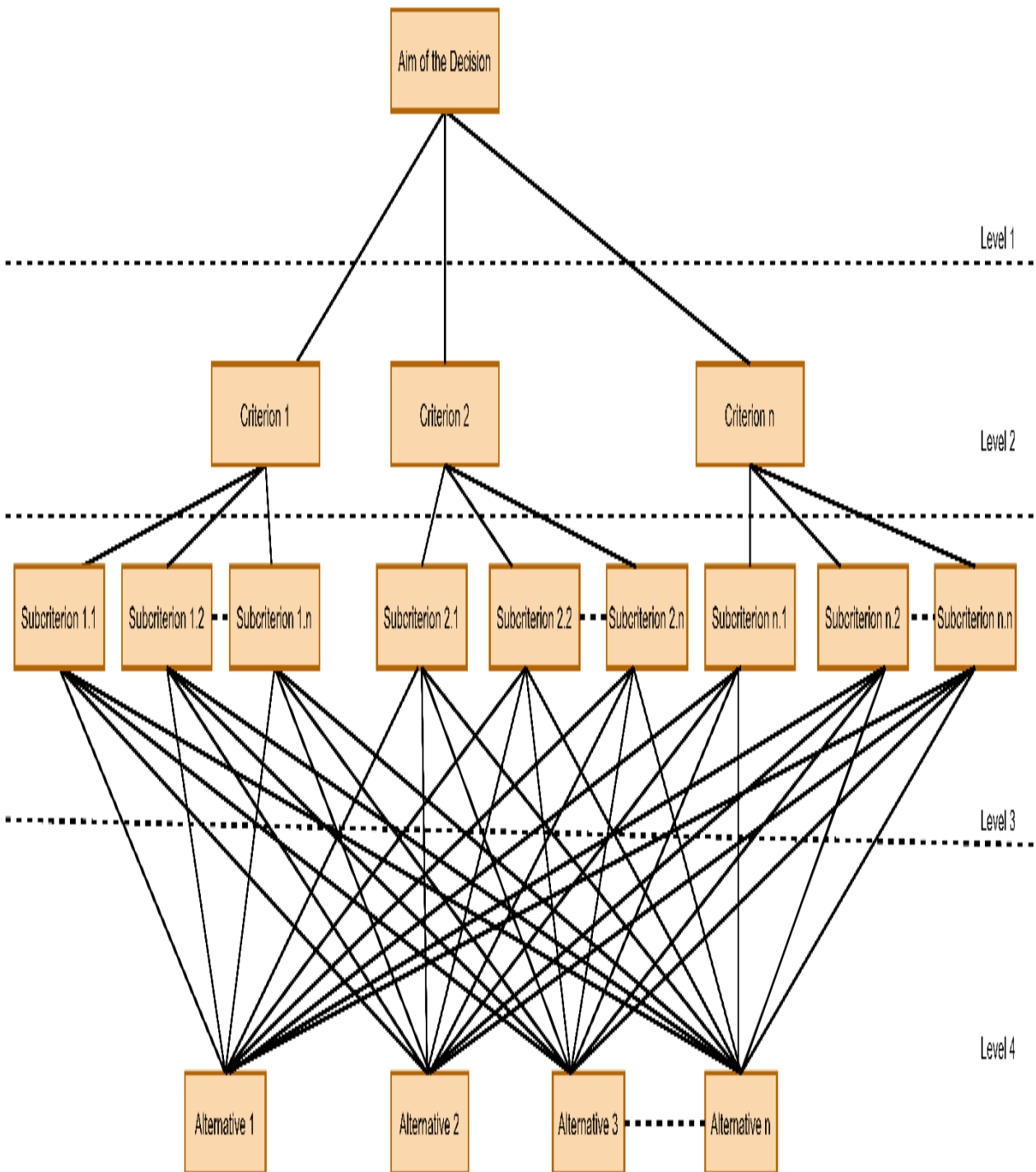


Fig. 1: The general structure of AHP for MCDM, modified from[6]

II. MATERIALS AND METHODS

A. Location of the Study Area

The city of Bharatpur is growing quickly in Nepal. It is a commercial centre for the Chitwan district and the central area of Nepal and is situated on the left bank of the Narayani River. On the Mahendra Highway, it is situated in the center of the Kathmandu-Birganj (North-South) traffic

corridor. The significance of this city's favourable geographic location has grown as a result of its proximity to Kathmandu (146 km), Pokhara (126 km), Butwal (114 km), Ghorahi (275 km), Birganj (128 km), Hetauda (78 km), and Gorkha (67 km). There are frequent flights from and to Bharatpur to Pokhara and Kathmandu. Fig. 1 presents a map of the study region.

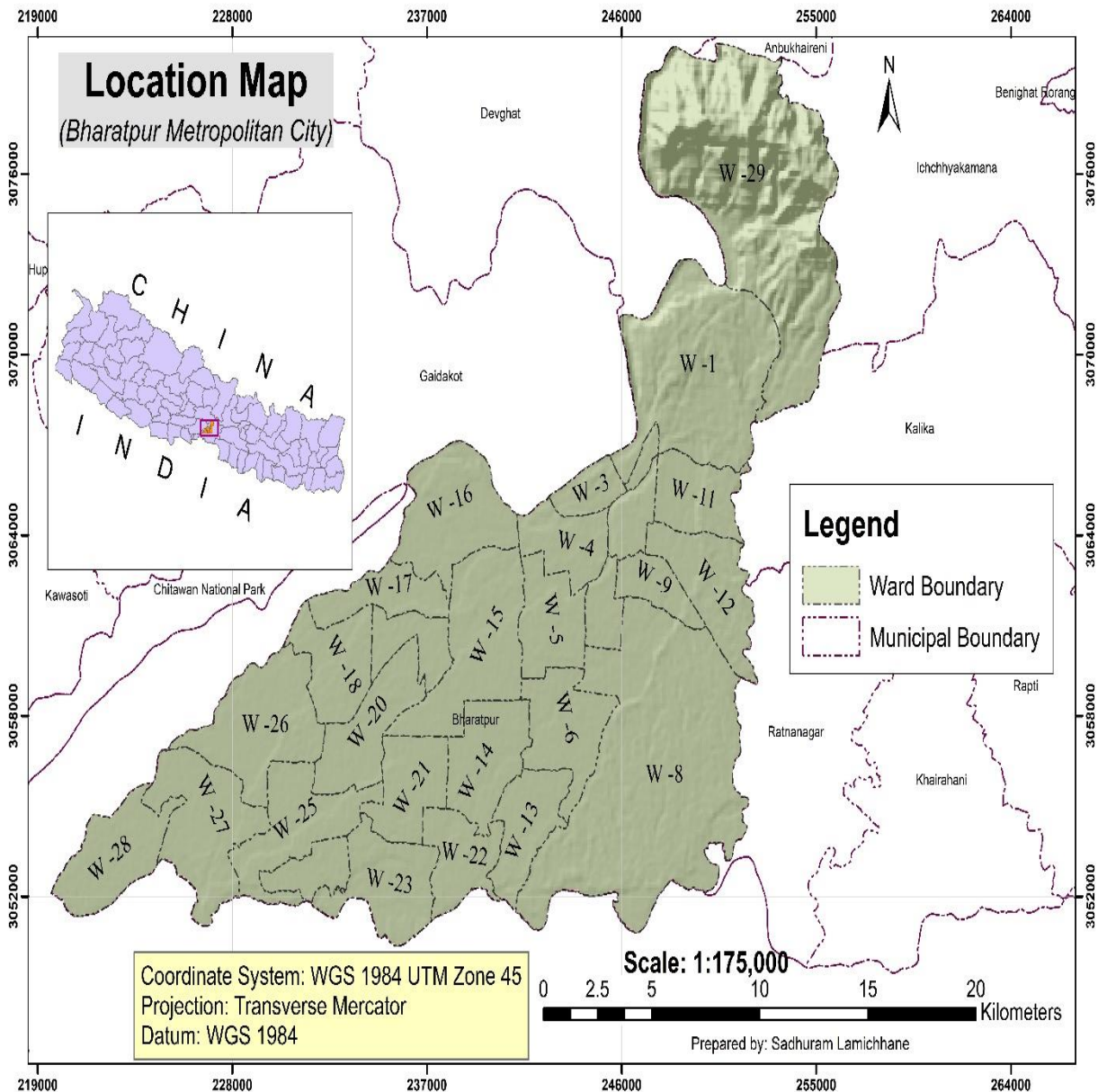


Fig. 2: Location map of Bharatpur metropolitan city

B. Selection of criteria

Nepal faces numerous challenges in urban planning, including where to locate public amenities like open space and parks. The assessment of land suitability is a foundation for maximizing the use of available land resources for sustainable agricultural production. There are different factors which plays crucial roles for land suitability analysis for built up area. These factors are: (i) Physical factor (ii)

Accessibility factor (iii) Social Factor (iv) Economic Factor (v) Environmental factor. The subsequent investigation for a suitable site was carried out using five major factors, and the combination of these five criteria has assisted in the identification of various possible locations for future development [7]. A flowchart showing the steps in the GIS-AHP-based methodology for finding suitable locations for built-up development is present below in Fig. 3.

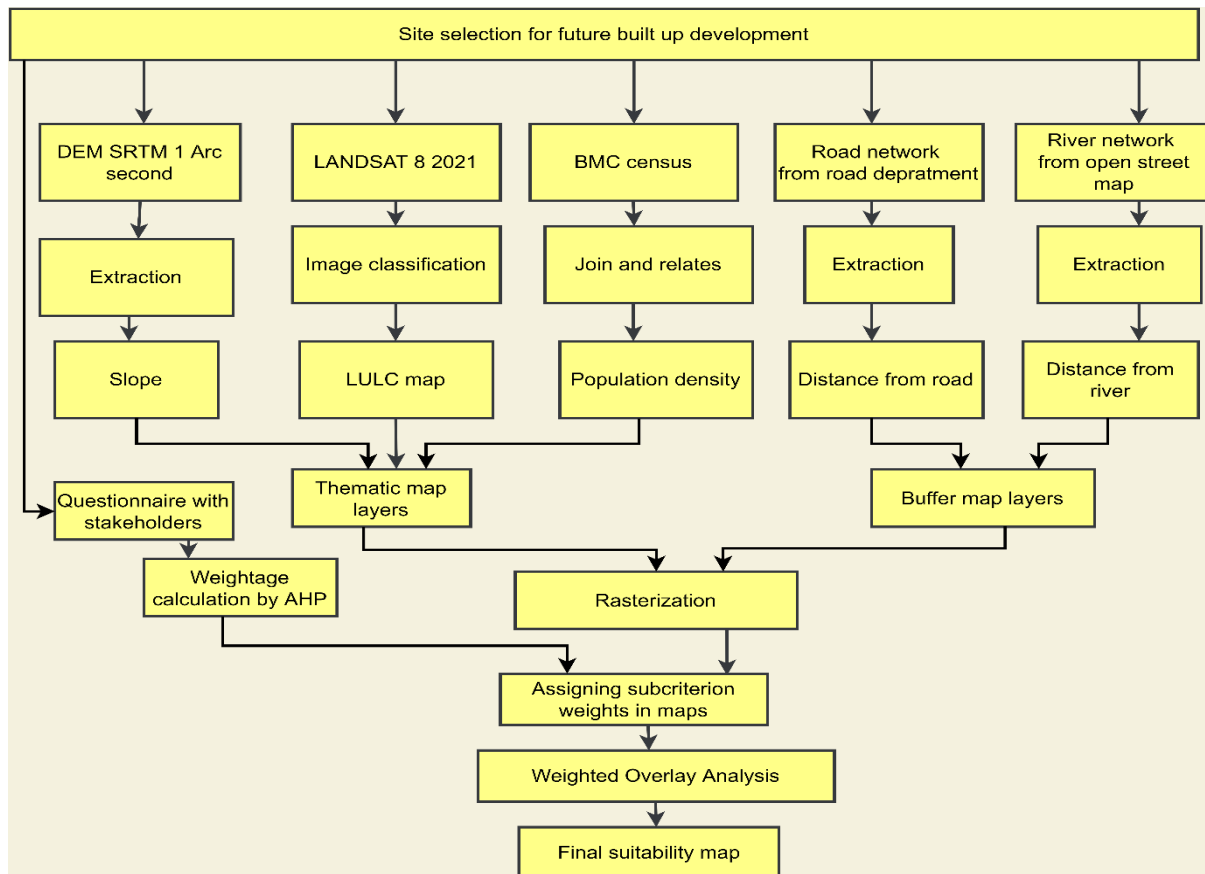


Fig. 3: Working methodology of AHP GIS based suitable places for built-up development

C. Calculating weightage by AHP

The expert(s) and participants use AHP to determine priorities for each node of the hierarchy after it has been built. It's a fantastic technique to simultaneously acquire and process information from participants and specialists. Priorities are allocated hierarchically in accordance with its architecture, and the values of those priorities are decided by the data submitted by process users, as indicated in the following table. The nine-level standardized comparison scale serves as the foundation for many pairwise comparisons in AHP. A person can compare and consistently score a maximum of nine objects at once,

according to psychologists. Decisions made in pairs are based on the finest information available as well as the decision maker's expertise and experience. The nine-level standardized comparison scale serves as the foundation for many pairwise comparisons in AHP. Psychologists choose to use nine items since a person may compare and rank up to nine items at once. The best information that is currently available and the decision maker's knowledge and experience are used to make pairwise decisions. The priority weight and relevance level for each of the chosen parameters are listed below in

Intensity of importance	Definition	Description
1	Equally important	Two factors contribute equally to the objective.
3	Moderately more important	Experience and judgement slightly favor one over the other.
5	Strongly more important	Experience and judgment strongly favor one over the other.
7	Very strong more important	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice.
9	Extremely more important	The evidence favoring one over the other is of the highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed.
Reciprocal of above	If an element I has one of the above numbers assigned to it when compared with element j, then j has the reciprocal value when compared with i	
Ratios (1.1-1.9)	If the activities(elements) are very close May be difficult to assign the best value, but when compared with other contrasting activities (elements) the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities (elements).	

Table 1: Priority weight for each selected parameters [8]

The AHP process consists of four steps: creating a decision tree, determining the relative weights of characteristics and sub-attributes, comparing each alternative to each attribute, and checking the consistency of the subjective assessments. Every alternative is weighed overall after evaluation [9]. Let $C_j = \{c_j \mid j=0,1, \dots, n\}$ be the set of criteria. The result of the pairwise comparison on n criteria can be summarized in an $(n \times n)$ evaluation matrix A in which every element $a_{ij} = \{i, j=0,1,2,3, \dots, n\}$ is the quotient of weights of the criteria, as given in

$$a_{11} \dots a_{1n} \dots a_{n1} \dots a_{nn} \dots \dots \dots \text{Equation 1.}$$

$$\begin{pmatrix} a_{11} & \dots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \dots & a_{nn} \end{pmatrix} \dots \dots \dots \text{Equation 1}$$

[10].

$$CR = CI / RI \dots \dots \dots \text{Equation 3}$$

The relative weights are given by the right eigenvector (w) corresponding to the largest eigen value $\max(\lambda)$ as in

$$Aw = \lambda_{\max} w \dots \dots \dots \text{Equation 2.}$$

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The final consistency ratio (CR), usage of which lets the user to conclude whether the evaluations are sufficiently consistent, is calculated as the ratio of the CI and the random index (RI), as expressed in

$$CR = CI / RI \dots \dots \dots \text{Equation 3}$$

The values of RI are tabulated in the following

Random index (RI) used to compute consistency ratios (CR) which is shown in below

N	1	2	3	4	5	6	7	8	9	10
Random index (RI)	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table 2: Random Index [8]

In this analysis maximum threshold of the CR is 10 percent, and in case of exceedance a three-step procedure is followed

- Look for the situation where the decision-judgment maker's is the most unpredictable.

's random index is created by averaging the CI of a randomly generated reciprocal matrix [9]. The measurement of consistency can be used to assess the consistency of decision-makers and the overall hierarchy [11].

D. AHP workflow

The following steps summarize the process of generating the normalized relative importance weights for the parameters at level 2, level 3 and creating the model.

- Step 1: Modeling the problem

The first step entails stating the issue, broadening the scope of the problem's objectives by taking into account all stakeholders, goals, and the resulting outcomes, and identifying decision elements such as alternatives and criteria or decision rules. In a hierarchical decision-making process, the decision elements are arranged into four categories: goal, criterion, sub-criterion, and alternative. This is considered the most critical step in the AHP process [12]. The overall goal (i.e., level 1) occupies the highest position in the hierarchy, such as the objective of selecting the best alternative. It's important to remember that the decision rules or criteria that help you achieve your overall goal are found at the second (i.e. level 2) level of the hierarchy. This level can be increased in complexity based on the level of detail considered for each decision rule or criterion. The alternatives that the decision analyst or maker will select are found at the lowest level (i.e. level 3).

- Ask the decision-maker to revise the judgment to a "fair value" after determining a range of values to which the contradictory judgment can be altered to decrease the related discrepancy.

- Step 2: Determining Priorities among the Decision Elements of the Hierarchy
This step involves using a pairwise comparison technique and a rating scale of relative importance to collect ratings for each of the criteria and alternatives. Using the pairwise comparison method presented in a matrix, this step solicits input from experts and/or stakeholders to determine the relative importance of one criteria or alternative to another [8]. The number of comparisons for the decision elements (i.e. criteria or alternatives) in a specific level is derived from (Number of comparisons = $n(n - 1)/2$) [13]. Each comparison (e.g., Criteria 1 versus Criteria 2 or Alternative 1 versus Alternative 2) is rated by a group of experts using the scale developed by [8]. for a pairwise comparison technique. It's common practice to use a questionnaire and geometric mean to arrive at an overall solution when reaching a consensus among a group [14].
- Step 3: Deriving the Overall Relative Weights of the Decision Elements
Using a pairwise comparison matrix for the criteria and for the alternatives, the relative importance of each criterion and the relative importance of each alternative to the criteria are determined in this step

(Step 2). For each criterion and alternative, normalized values are calculated and normalized principal eigenvectors or priority vectors are determined. This is accomplished by: (herein also referred to as relative weights). In order to arrive at the normalized values for each criterion and alternative in the matrices, the value of each cell is divided by the sum of the columns. For each criterion and alternative, this procedure yields a column total of one. Next, the weighted averages are computed for each matrix's rows. The resulting values show the relative importance of the criteria in relation to the goal, and the relative importance of the alternatives in relation to the criteria. The relative weights of the alternatives are calculated by multiplying the relative weight of each criterion by the relative weight of the alternative for that criterion [8]. If the expert opinions are in agreement, the decision makers can use the overall relative weights of the options to make their choice.

- Steps 4 and 5: Verifying the Consistency of Judgments and Making Conclusions Based on the Results

Before making a decision, these steps are essential for determining the consistency of the evaluation. Instead of computing overall relative weights for all alternatives, it would be preferable to first calculate CRs for all matrices (i.e., criteria and alternatives) before moving on to computing those overall relative weights. Calculate each criterion or alternative's maximum eigenvalue, consistency index, consistency

ratio, and normalized values. According to [8], if the ratio is greater than 0.1, the set of judgments may be too inconsistent to be relied upon. As a result, a CR of less than 0.1 percent (or 10 percent) is acceptable. When the results are inconsistent, the procedure is repeated until the CR falls within the desired range. The results are then used by decision makers to reach a decision.

III. RESULTS AND DISCUSSION

The identification of acceptable locations for adequate sustainable urban growth has become a vital and important activity for these cities as practically all of the cities in emerging nations are expanding haphazardly. Nine characteristics were used in the additional study to determine a viable site, and the combination of these nine criteria helped to identify many suitable locations for future development.

A. Physical factor:

Elevation, slope and aspect are the fundamental parameter for setting up urban and settlements in hilly and terai region. The land having steep slope is not suitable for settlements [7]. Due to land slide at rainy season and high construction costs steep lands are not suitable for built – up area. So plain regions are suitable for settlements. For most of the development projects like: road accessibility, water supply, sewer line, city hall, open space and parks, high rise buildings, shopping malls, hotels etc. are suitable for flat area and it should be examined properly.

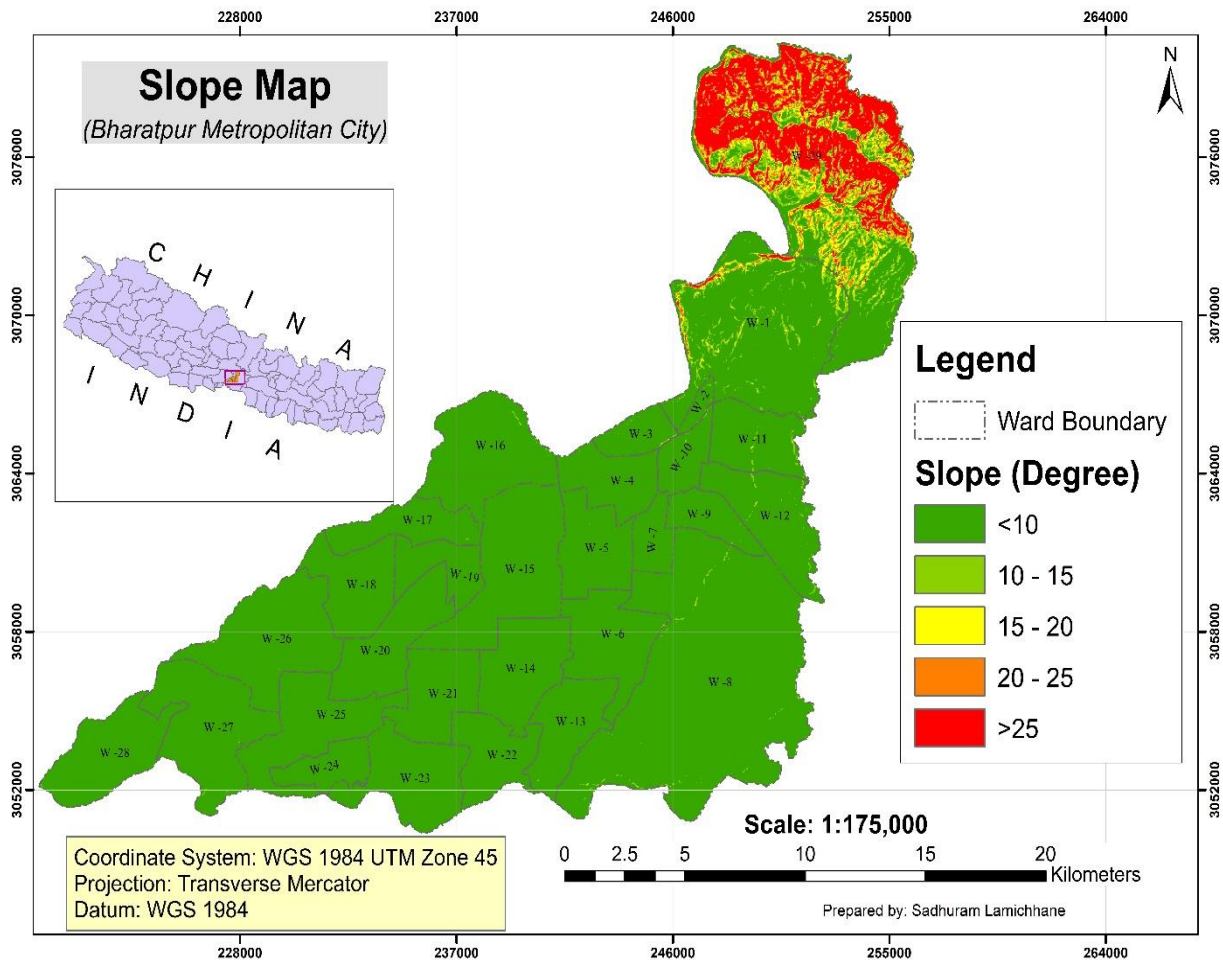


Fig. 4: Slope map identifying suitable sites of urban growth

B. Accessibility factor:

Better connectivity of transport network with the entire metropolitan city and other locations are the prime requirements of settlements commercial purposes. Proximity to the transport facilities (road, railways, airport) play vital

role to influence people who frequently use this service [7]. Road construction is costly, so the government builds new roads in areas where there are many settlements. This encourages residents to choose an area with good road connectivity before moving there.

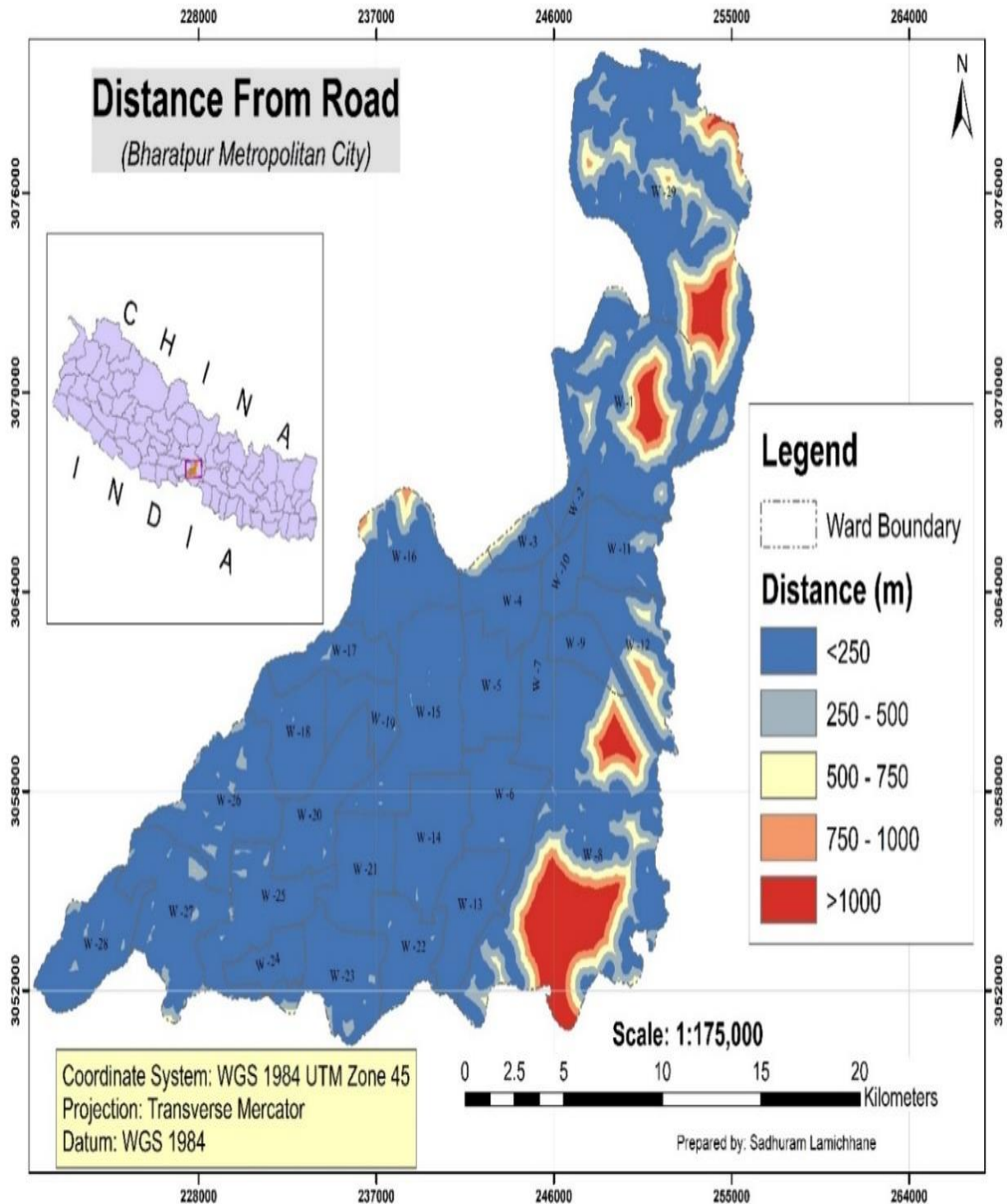


Fig. 5: Distance from the road map for identifying suitable site for urban growth

C. Social factor:

Every people's has wish to find out a residence where socially favorable for them. Also important in new built-up

development is the population and housing density, because people prefer to live in a less crowded area rather than one that is congested and congested.

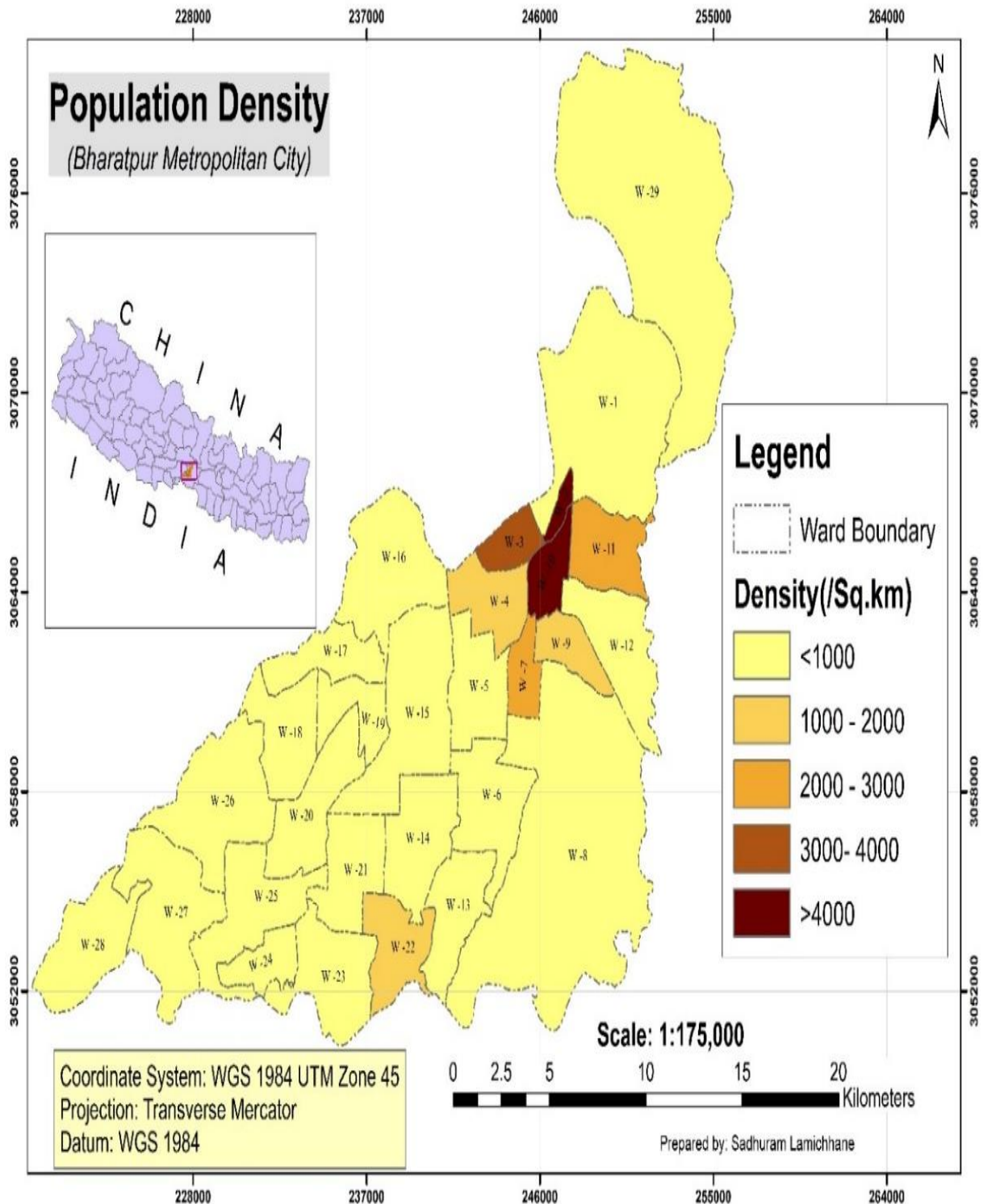


Fig. 6: Population density map or identifying suitable sites of urban growth

D. Economic factor

Many people wish to commercial center near to their residence in city area. Most people in these cities want to buy a plot for a lower price that is typically located outside of the city center, while only a small percentage want to buy

in the city for any price in order to take advantage of the city's civic amenities [7]. Nevertheless, for the general public, land price is an important determinant of new housing construction.

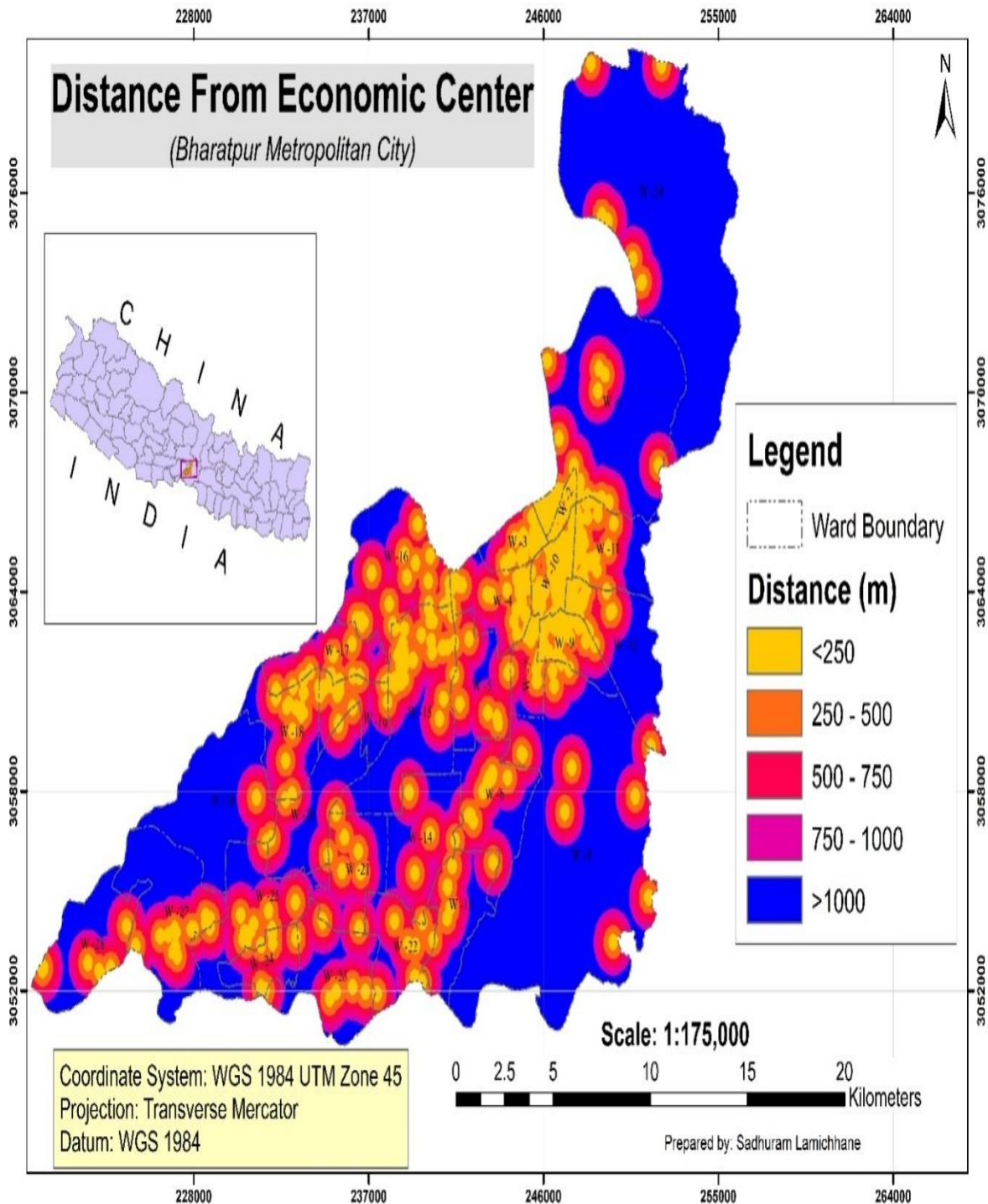


Fig. 7: Distance from the economic center map for identifying suitable site for urban growth

E. Environmental factor

it plays crucial role for identifying suitable locations for most of the development activities. Most of the construction projects have been implemented by preserving the environment. Builders and government entities should run

the development projects by protecting the forest, lakes and water bodies, valleys and mountains, natural heritages etc. So, land use land cover, distance from river and water bodies, distance from canals should be taken to identify the built – up suitability.

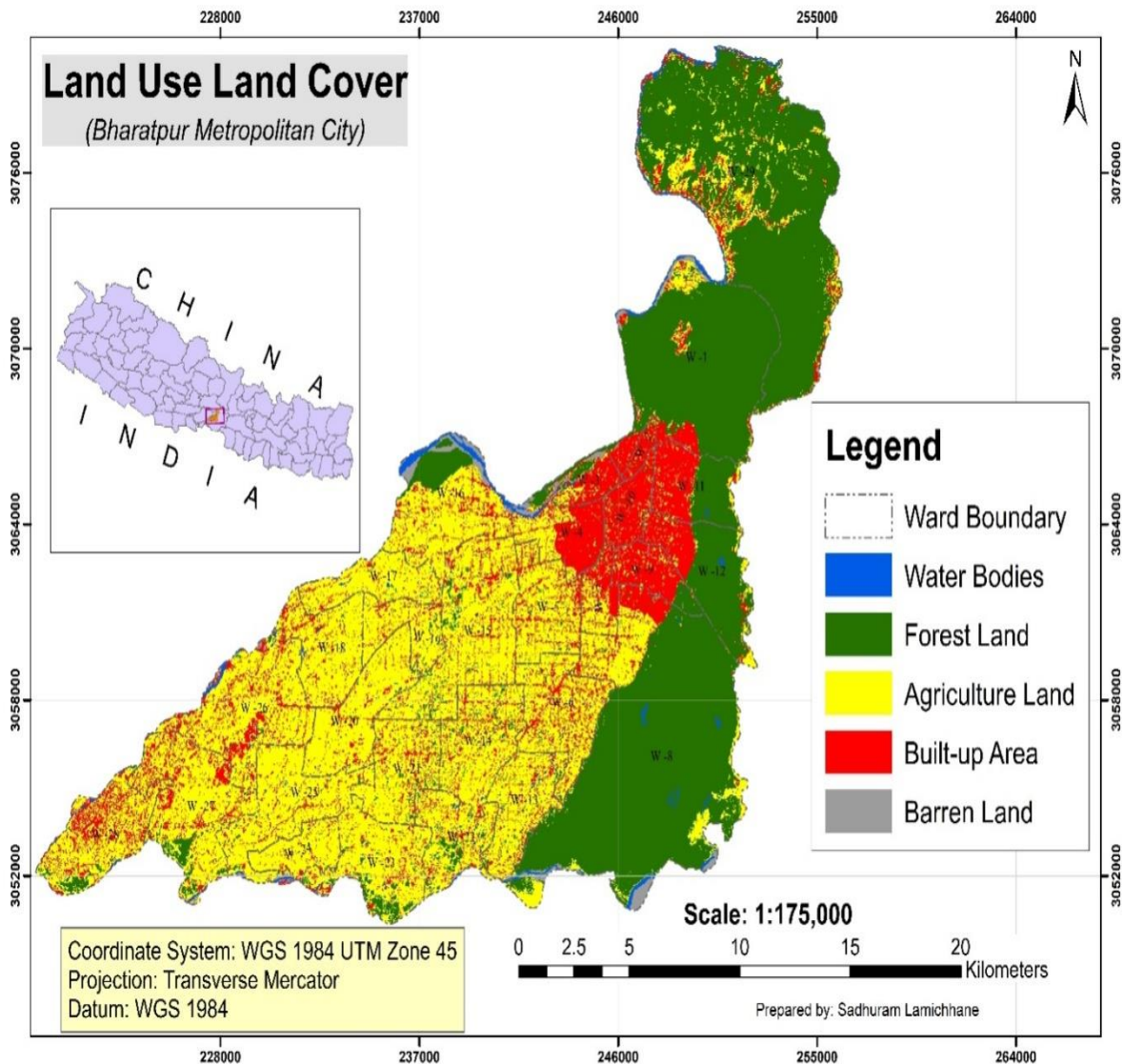


Fig. 8: Land use land cover map for identifying suitable sites of urban growth

F. Calculation of the consistency ratio

It is important to assess how consistent the judgments are. Prior to determining the value of CR, the consistency

index (CI) and values should be determined. The consistency vector's calculation is displayed in .NRIW for major factors are displayed in

Factors	Physical factor	Accessibility factor	Social factor	Economic factor	Environmental factor	Weight
Physical factor	1	0.33	1.1	1.3	0.33	0.126
Accessibility factor	3	1	1.5	1.3	.0.33	0.208
Social factor	0.90	0.66	1	0.5	0.5	0.125
Economic factor	0.76	0.76	2	1	0.5	0.164
Environmental factor	3	3	2	2	1	0.374
Sum	8.67	5.76	7.6	6.1	2.66	1

Table 3: Normalized pair wise comparison matrix and computation of criterion weightage $\Delta_{Max} \Rightarrow (8.68 * 0.13) + (5.77 * 0.21) + (7.6 * 0.13) + (6.1 * 0.16) + (2.67 * 0.37) = 5.25$, $CI \Rightarrow (5.26-5) / 5-1 = 0.0649$, $CR = CI/RI \Rightarrow CR \Rightarrow 0.06/1.12=0.0579739098205975= 5.79\% < 10\%$. In similar manner NRIW for parameter subclasses also identified iteratively.

Slope	$(2.18 * 0.45) + (4.08 * 0.25) + (6.67 * 0.17) + (12.5 * 0.08) + (17 * 0.05) = 5.0616$, CI => $(5.06-5) / 5-1 = 0.0154$, CR = CI/RI => CR => $0.02/1.12 = 0.01376 = 1.37\%$
Distance from road	$(3 * 0.34) + (3.6 * 0.27) + (5.36 * 0.19) + (8.41 * 0.1) + (13.1 * 0.08) = 5.04$, CI => $(5.05-5) / 5-1 = 0.0124$, CR = CI/RI => CR => $0.01/1.12 = 0.0111 = 1.11\%$
Population density	$2.28 * 0.44) + (4.88 * 0.2) + (7.1 * 0.16) + (8.71 * 0.11) + (11.5 * 0.09) = 5.11$, CI => $(5.12-5) / 5-1 = 0.0292$, CR = CI/RI => CR => $0.03/1.12 = 0.0261 = 2.61\%$
Distance from economic centers	$(2.28 * 0.44) + (4.88 * 0.2) + (7.1 * 0.16) + (8.71 * 0.11) + (11.5 * 0.09) = 5.11$, CI => $(5.12-5) / 5-1 = 0.0292$, CR = CI/RI => CR => $0.03/1.12 = 0.0261 = 2.61\%$
Land use land cover	$(4.2 * 0.26) + (3.98 * 0.3) + (4.14 * 0.28) + (8.33 * 0.12) + (23 * 0.04) = 5.44$, CI => $(5.44-5) / 5-1 = 0.1111$, CR = CI/RI => CR => $0.11/1.12 = 0.0992 = 9.92\%$

Table 4: Computation of consistency vector

Saha and Roy [7] classified nine sub-criteria for five classes. Summary of criteria, sub-criteria, suitability level, ranking of sub-criteria and weightage of criteria is shown below in Table 5. Among all the mentioned sub criterion for physical factor, I took slope for sub criterion. Slope was classified in to five classes.

Criteria	Sub - Criteria	Level of suitability	Ranking	Sub criteria weightage	Criteria weightage
Slope	<10°	Very Low	1	0.445	0.126
	10° - 15°	Low	2	0.251	
	15° - 20°	Medium	3	0.165	
	20° - 25°	High	4	0.082	
	>25°	Very High	5	0.054	
Distance from road	<250 m	Very Near	1	0.344	0.208
	250 m – 500 m	Near	2	0.273	
	500 m – 750 m	Medium	3	0.185	
	750 m – 1000 m	Far	4	0.114	
	>1000 m	Very Far	5	0.082	
Population density	<1000	Very Low	1	0.442	0.125
	1000 – 2000	Low	2	0.196	
	2000 – 3000	Medium	3	0.155	
	3000 – 4000	High	4	0.114	
	>4000	Very High	5	0.090	
Distance from economic centers	<250 m	Very Near	1	0.344	0.164
	250 m – 500 m	Near	2	0.273	
	500 m – 750 m	Medium	3	0.185	
	750 m – 1000 m	Far	4	0.114	
	>1000 m	Very Far	5	0.082	
Land use land cover	Barren land	Very High	1	0.299	0.374
	Built -up	High	2	0.275	
	Agriculture land	Moderate	3	0.257	
	Forest	Restricted	0	0.123	
	Water	Restricted	0	0.043	

Table 5: Summary of criteria, sub-criteria, suitability level, ranking of sub-criteria and weightage of criteria and sub criteria

G. Model Building

It was necessary to reclassify the parameter raster and compute their weights before creating the final model. We used GIS model builder with toolbox customization to prepare the model. A weighted sum tool is used to combine several rasters by multiplying their weights by each other and adding the results.

The tool has following usages:

- A useful way to add several rasters together is to input multiple rasters and set all weights equal to 1. Input raster can be integer or floating point.

- The weight values can be any positive or negative decimal value. It is not restricted to a relative percentage nor does it need to be equal to 1.0.
- The weight will be applied to the specified field for the input raster. Fields can be of type short or long integer, double or float.

In the model builder parameter were raster maps and their weight value, field for computation and weight are specified as shown in following in

Factor	Raster	Field	Weight
Physical factor	Reclassified slope	Value	0.126
Accessibility factor	Reclassified distance from road	Value	0.208
Social factor	Reclassified population density	Value	0.125
Economic factor	Reclassified distance from economic centers	Value	0.164
Environmental factor	Reclassified land use land cover	Value	0.374

Table 6: Weightage of specified factor for suitability analysis

After determining the weight for each factor, final model was prepared. Final output raster was prepared by using weighted overlay analysis in GIS. Which is presented below

$$Land\ suitability\ model\ for\ built - up = W_1 * slope + W_2 * distance\ from\ road + W_3 * population\ density + W_4 * distance\ from\ economic\ center + W_5 * LULC \dots \dots \dots Equation\ 4$$

In this model the coefficients W_1, W_2, W_3, W_4, W_5 are the computed from comparison matrix and Eigen vector using Analytic Hierarchy Process and the model parameters like precipitation, slope etc. are reclassified raster map of the respective parameter. Hence,

$$Land\ suitability\ model\ for\ built - up = 0.126 * slope + 0.208 * distance\ from\ road + 0.125 * population\ density +$$

$$0.164 * distance\ from\ economic\ center + 0.374 * LULC \dots \dots \dots Equation\ 5$$

Where the weights for the variables like slope, LULC etc. are also computed using AHP methodology. Their value ranges from 0 to 1 in general but their weight is converted to integer by multiplying each by thousand to avoid floating point value during reclassification as indicated.

H. Analysis of suitability map

The final suitability map is the major objective of this research. The map displays the various color compositions for each level of appropriateness. All selected raster was reclassified with cell size 30m×30m. Final suitability map was prepared with weighted overlay analysis in ArcGIS. Final suitability map for built – up is presented below in Fig. 9.

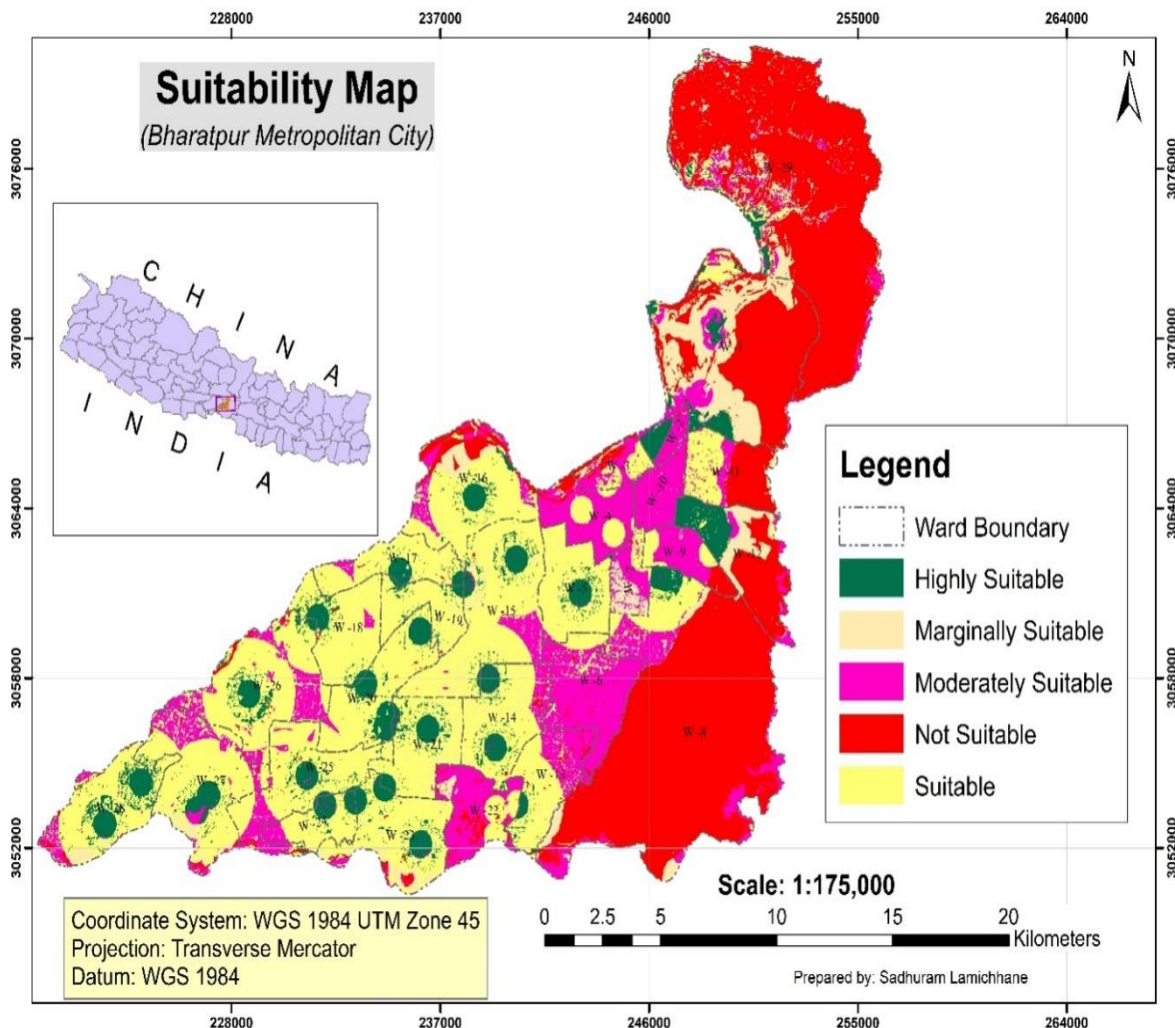


Fig. 9: Final suitability map for built-up development

Out of total area 142.25 km² obtained as not suitable for built – up, which is 32.86% of total study area. Mostly the not suitable area is located at and near water bodies, higher elevated land, near Narayanghat - Mugling Highway and most of the forest area. So, this area is restricted for new construction for settlements. Maximum villages of ward no 1, 3, 8, 11, 12, 16, 26, 29 have shown unsuitable land for built – up. Jugeedi, Dasdhunga, Bhorle, Thimura, Devghat, Tikauli forest area have shown not suitable for future settlement planning and development. 30.88 km² area was obtained marginally suitable area for built – up which is 7.13% of total study area. Most of the marginally suitable area is located at dense forest zone, this is not better choice for settlements. Maximum villages of ward no 1, 8, 12, 13, 16 and 22 have shown marginally suitable area. Further construction for built – up will harm and destroy the aesthetic area, dense forest and vegetated area. 66.39 km²

area was obtained as moderately suitable which is 15.33% of total area. Maximum villages of ward no 1, 2, 3, 4, 6, 7, 9, 11, 12, 13, 15, 22, 26, 27 and 29 have shown as moderately suitable class. But for these villages are located at moderately suitable category. Which is apart from the existing facilities and nearer to forest and river. 160.29 km² area was obtained as suitable for built – up which is 37.02% of total area. But most of the area covered by suitable category are agriculture/cultivated area and has better accessibility of road. Maximum village of shivanagar, patihani, meghauli, gitanagar, jyotinagar have shown suitable area for built – up and 33.14 km² area was obtained as highly suitable for built up which is 7.65% of study area. Most of the area of this category has already dense settlements. Total area covered by each suitability level is displayed in Fig. 10.

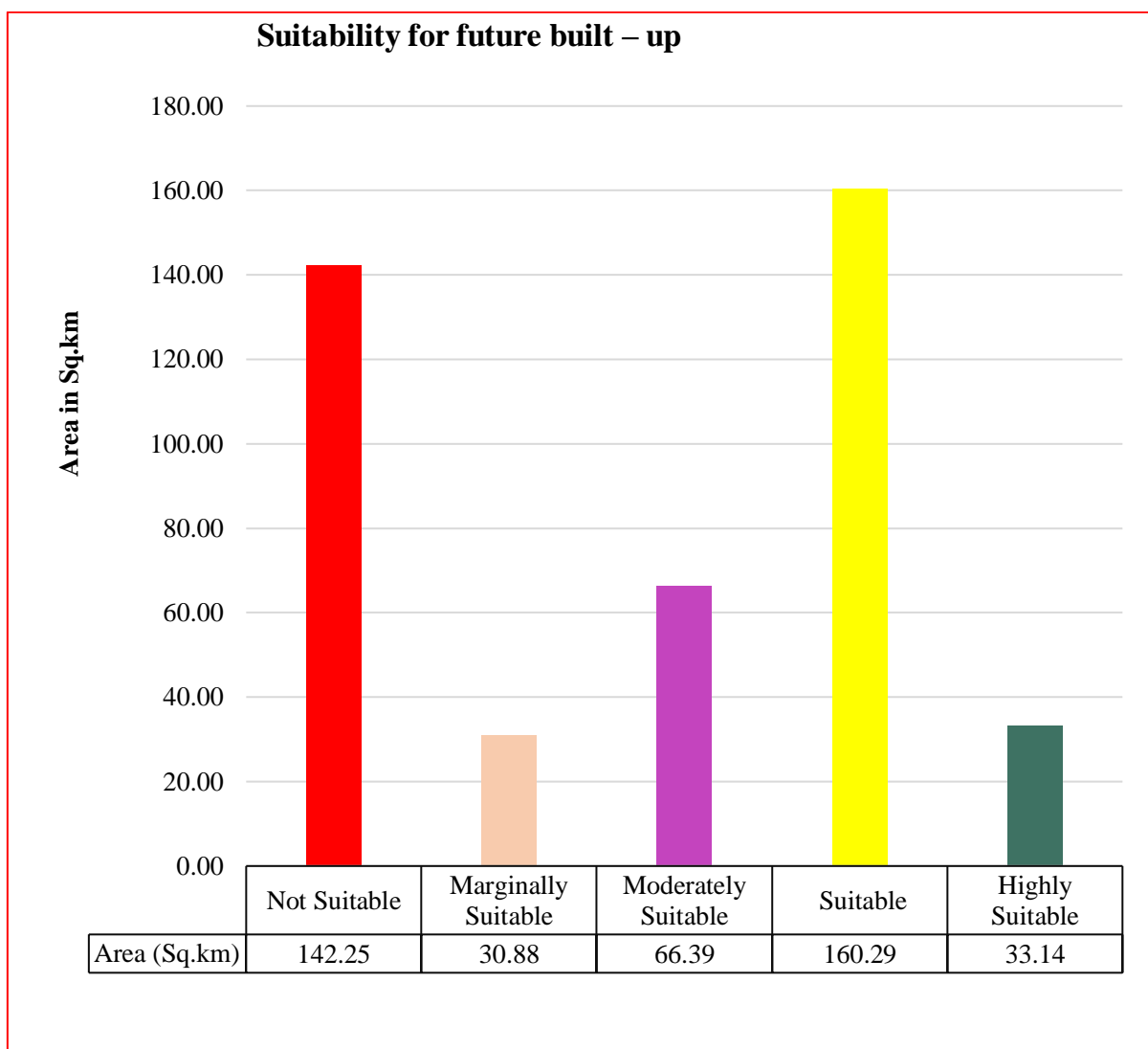


Fig. 10: Area covered by each suitability class for future built up

Spatial distribution of suitability levels determined by using geospatial analysis between administrative boundary and suitability map which is present below in Table 7.

Ward	Suitability category	Area (km ²)	Ward	Suitability category	Area (km ²)
1	Highly Suitable	3.10	11	Highly Suitable	0.01
	Marginally Suitable	11.69		Marginally Suitable	0.27
	Moderately Suitable	2.71		Moderately Suitable	1.05
	Not Suitable	17.25		Not Suitable	4.14
	Suitable	1.19		Suitable	3.56
2	Highly Suitable	0.01	12	Highly Suitable	3.08
	Marginally Suitable	0.03		Marginally Suitable	2.51
	Moderately Suitable	1.24		Moderately Suitable	0.97
	Not Suitable	0.05		Not Suitable	5.65
	Suitable	0.00		Suitable	0.19
3	Highly Suitable	0.00	13	Highly Suitable	0.49
	Marginally Suitable	0.28		Marginally Suitable	0.32
	Moderately Suitable	1.51		Moderately Suitable	3.25
	Not Suitable	0.89		Not Suitable	0.32
	Suitable	1.47		Suitable	5.33
4	Highly Suitable	0.01	14	Highly Suitable	1.92
	Marginally Suitable	0.11		Marginally Suitable	0.54
	Moderately Suitable	5.66		Moderately Suitable	1.19
	Not Suitable	0.59		Not Suitable	0.15
	Suitable	1.84		Suitable	8.28
5	Highly Suitable	1.15	15	Highly Suitable	1.79
	Marginally Suitable	0.21		Marginally Suitable	1.08
	Moderately Suitable	0.20		Moderately Suitable	1.60
	Not Suitable	0.01		Not Suitable	0.03
	Suitable	8.35		Suitable	16.02
6	Highly Suitable	0.00	16	Highly Suitable	1.25
	Marginally Suitable	0.02		Marginally Suitable	1.38
	Moderately Suitable	10.22		Moderately Suitable	1.83
	Not Suitable	0.35		Not Suitable	2.42
	Suitable	1.64		Suitable	10.02
7	Highly Suitable	0.00	17	Highly Suitable	1.06
	Marginally Suitable	1.59		Marginally Suitable	0.15
	Moderately Suitable	1.75		Moderately Suitable	0.31
	Not Suitable	0.06		Not Suitable	0.07
	Suitable	0.74		Suitable	6.21
8	Highly Suitable	1.19	18	Highly Suitable	1.18
	Marginally Suitable	1.48		Marginally Suitable	0.13
	Moderately Suitable	5.65		Moderately Suitable	0.21
	Not Suitable	53.99		Not Suitable	0.05
	Suitable	4.03		Suitable	8.74
9	Highly Suitable	0.01	19	Highly Suitable	0.54
	Marginally Suitable	0.03		Marginally Suitable	0.17
	Moderately Suitable	3.15		Moderately Suitable	0.01
	Not Suitable	0.88		Not Suitable	0.02
	Suitable	1.24		Suitable	5.57
10	Highly Suitable	0.00	20	Highly Suitable	2.80
	Marginally Suitable	0.03		Marginally Suitable	0.09
	Moderately Suitable	4.49		Moderately Suitable	0.16

	Not Suitable	0.07		Not Suitable	0.05
	Suitable	0.05		Suitable	8.75
21	Highly Suitable	1.88	26	Highly Suitable	1.69
	Marginally Suitable	0.48		Marginally Suitable	0.13
	Moderately Suitable	0.05		Moderately Suitable	3.57
	Not Suitable	0.00		Not Suitable	0.47
	Suitable	7.61		Suitable	12.67
22	Highly Suitable	0.01	27	Highly Suitable	1.45
	Marginally Suitable	0.51		Marginally Suitable	0.84
	Moderately Suitable	5.61		Moderately Suitable	3.07
	Not Suitable	0.93		Not Suitable	0.24
	Suitable	1.63		Suitable	12.08
23	Highly Suitable	1.97	28	Highly Suitable	2.77
	Marginally Suitable	1.13		Marginally Suitable	0.54
	Moderately Suitable	0.35		Moderately Suitable	0.93
	Not Suitable	0.34		Not Suitable	0.27
	Suitable	9.00		Suitable	8.05
24	Highly Suitable	1.06	29	Highly Suitable	1.02
	Marginally Suitable	0.04		Marginally Suitable	4.04
	Moderately Suitable	0.69		Moderately Suitable	3.12
	Not Suitable	0.01		Not Suitable	52.56
	Suitable	3.42		Suitable	1.66
Ward	Suitability category		Area (km ²)		
25	Highly Suitable		1.36		
	Marginally Suitable		0.21		
	Moderately Suitable		2.02		
	Not Suitable		0.25		
	Suitable		10.33		
Highly Suitable		1.36			

Table 7: Spatial distribution of suitability categories in BMC

IV. CONCLUSION

Most of the developing countries chaotic and unscientific rapid built – up growth. To solve the issue of unplanned expansion inside the small territory, suitable site selection has become essential. Any easy and cost – effective technique that can discover distinct appropriateness categories within a selected location is GIS – based MCA using analytical hierarchy process. As a result, BMC has been selected to identify the best locations for future built up development with the help of developers and experts. The maximum percentage of suitable and highly suitable area will be most helpful for further built – up development. This research will be very useful for planners and develop, those have right to decide whether the land should be developed.

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