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Site Suitability Analysis for Urban Development in Krishnagiri Taluk, Tamilnadu

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ABSTRACT: The rocketed hike in urban development has profound effect on economic, ecological and social aspects. Identification of potential sites for urban development is mandatory for sustainable environment. The study illustrates the use of geographic information system (GIS) and numerical multi criteria evaluation (MCE) techniques for identification of suitable site for urban development in Krishnagiri taluk of Tamilnadu state. LISS IV satellite images, ASTER DEM products, and Survey of India topographical maps were utilized in the study. Five thematic maps such as land use/ land cover, geology, road network, aspect and slope map were generated. These maps were used for analytical hierarchy processing by using pairwise comparison matrices (Saaty's method, 1994). The results showed that 39% of the total area falls under highly suitable category, 40% under suitable category and remaining 17% is not suitable. The study indicates that east, middle and north eastern parts are potential sites for urban development due to gentle slope, good road network and no forest cover.

KEYWORDS: Pairwise comparison, AHP, Site suitability

I. INTRODUCTION

Urban expansion has become a common issue in most of the developing countries due to uncontrolled migration from rural regions to the developed regions, which results in increased population. It exerts a tremendous pressure on social, economical and ecological parameters.

Sustainability can be defined as an ability or capacity of something to be maintained or to sustain itself. It's about taking what we need to live now, without jeopardizing the potential for the people in the future to meet their needs. If an activity said to be sustainable it should be able to continue forever. Using the principle of sustainable development, the environment, social and economical impacts can be managed to maximize positive impacts while minimizing negative effects. The conventional method of finding suitable urban development is tedious and time consuming process.

In the advancement of remote sensing and GIS the identification of potential zone became very easy and economical. The identification of potential sites for urban development using GIS based Multi Criteria Evaluation Technique (MCET) has been carried out by several researchers (Kumar and Biswas (2013), Effat and Hagazy (2013))

II. STUDY AREA

The study area, Krishnagiri taluk, is one among the seven taluk of Krishnagiri district of Tamilnadu state. It geographically lies between 12°19'12"N & 12°49'12"N latitudes and 78°2'60"E & 78°21'1"E longitudes. It covers an area of 1737.26 sq km.

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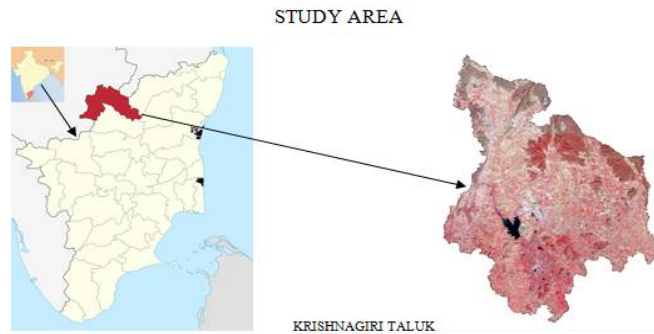


Fig 1. Study area

The area receives the rain fall under the influence of both southwest and northeast monsoons. The normal annual rainfall varies from 750 to 900mm. The climate is pleasant due to general dryness of atmosphere during summer and an appreciable drop in temperature during monsoon season.

Geologically the area consist of granite, charkonite, quartzite, epidote hornblend gneiss and ultra basic complex lithologically uniques. The landform of the area includes denudational landforms, pediments, inselbergs and plateaus etc.

III. MATERIALS AND METHODS

LISS IV satellite images (2015), ASTER DEM (2011) products and survey of india topographical geological map were utilized in the study. All the satellite images/ products were geocorrected UTM projection and WGS 84 datum.

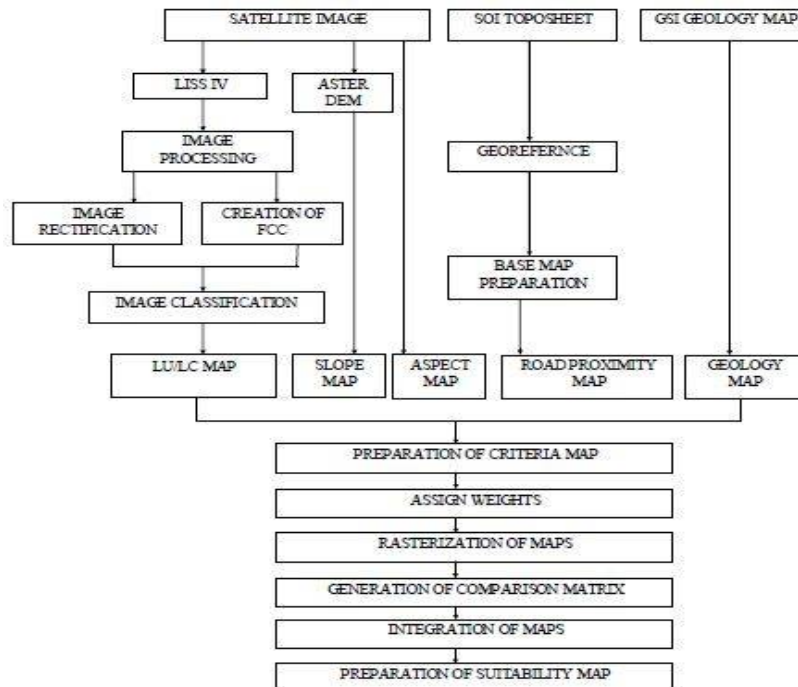


Fig 2 .Methodology

Thematic maps such as land use/ land cover, geology, slope, aspect and road proximity maps were generated and weightages were assigned to map in GIS domain.

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Intensity 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 to extreme strong importance	Very high suitability
9	Extremely importance	Highest suitability

Table 1 Saaty's pairwise comparison matrix

The maps were subjected to analytical hierarchy process by using pairwise comparison matrices (Table 1) based on Saaty's method, 1994. Subsequently the total area was categorized into 3 classes, namely highly suitable, moderately suitable and not suitable development.

Order matrix	RI	Order matrix	RI
1	0.0	6	1.24
2	0.0	7	1.72
3	0.58	8	1.41
4	0.90	9	1.45
5	0.12	10	1.49

Table 2 Random index matrix for analyzing consistency of pairwise matrix

IV. RESULTS AND DISCUSSIONS

A. Site suitability analysis

Five spatial maps i.e., LU/LU, road network, geology, slope and aspect provided basic inputs for identifying suitable sites for urban development using multi criteria evaluation technique (MCET). The results of various thematic maps are as follows.

A.1. Slope map

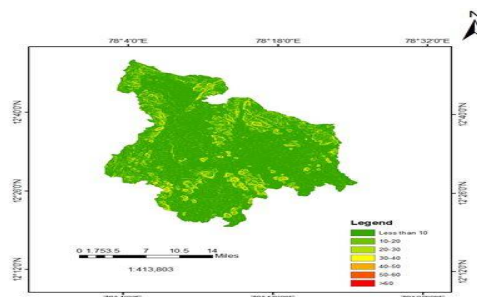


Fig 3. Slope map

Slope map is an important criterion for site suitability analysis. Slopes greater than 10° are considered as steep slope, which are vulnerable to erosion and are not suitable for construction purpose. Slope less than 10° is generally suitable

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for urban development. Slope map of the study area is given in fig 4. It can be observed that east, middle and north western parts have gentle slopes. The maximum slope value in the study area is 45°.

A.2. Road proximity map

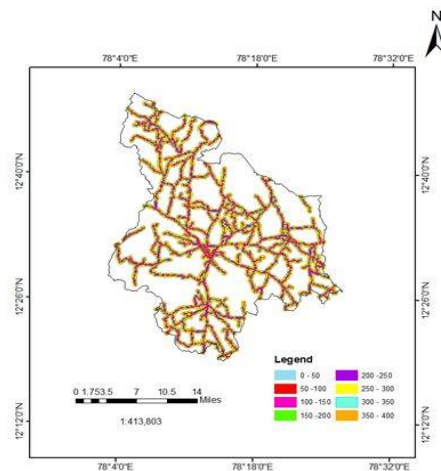


Fig 4. Road proximity map

Road network plays an important role in urban planning and development as it connects different settlements and also important for conveying goods and services. In the present study buffer zones have been created for the road network covering 50m, 100m, 150m, 200m, 250m,300m, 350m and 400m width on both sides of the roads. The buffer zone falling within 100m is considered as highly suitable for urban development. The north, east and southern parts of the study area have good road connectivity.

A.3. Land use/land cover

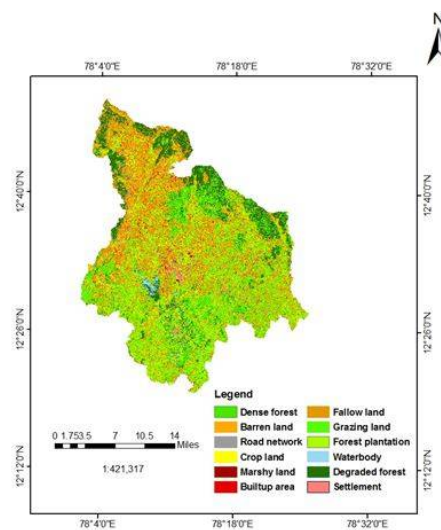


Fig 5. land use/land cover map

Barren land, uncultivable land and cultivable waste land are generally used for rising settlement and amenity facilities.

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Description	Area in Square kilometer	Area percentage in
Dense forest	138.13	8.00
Barren land	133.73	7.70
Road network	22.27	1.28
Crop land	142.41	8.20
Builtup area	38.76	2.23
Marshy land	0.31	0.02
Fallow land	436.24	25.11
Grazing land	280.52	16.15
Forest plantation	256.83	14.78
Water body	8.67	0.50
Degraded forest	249.15	14.34
Settlement	30.25	1.74

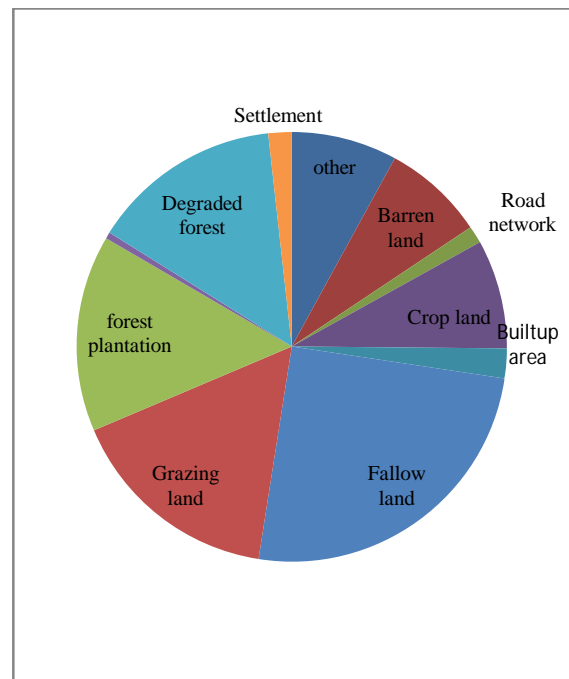


Table 3 distribution of land use land cover pattern

Fig 6. land use land cover distribution

Among the different land use land cover classes, forest occupies 37% of the total area followed by cultivable land (crop and fallow) i.e., 33%. Barren land occupies 8%, builtup and settlement occupies 6%. The remaining area is covered by other classes like marshy land, grazing land, waterbody etc. The distribution of land use land cover details are furnished below (table3 & fig 1)

A.4. Geology map

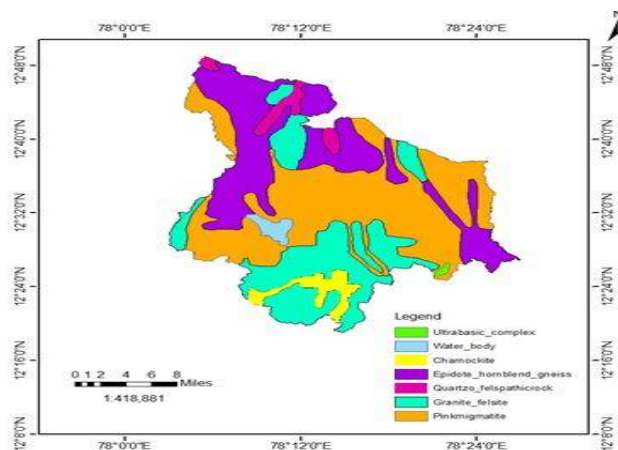


Fig 7. Geology map

The study area consists of geological formations such as quartzite felspathic rock, charnockite, granite felsites, pink migmatite, epidote hornblend gneiss and ultra basic complex. In the present study highest ranking given to the geological formations, which have high ground water potential and good resistance to erosion. In this present study charkonites have given maximum priority, whereas migmatites have less priority.

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A.5. Aspect map

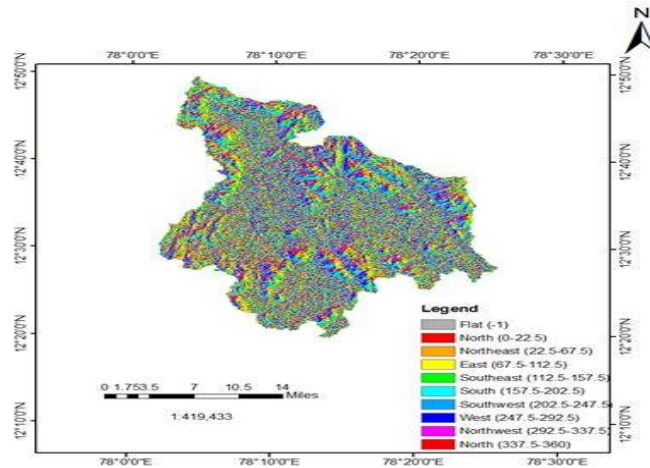


Fig 8.Aspect map

Aspect map generally refers to the horizontal direction to which a mountain slope faces. The south portion is highly suitable and north is less suitable for residential buildings based on the amount of sunlight available in these parts.

B. Calculation of consistency ratio

The calculation of comparison matrix is necessary to check whether the comparisons are consistent or not.

Criteria	Pairwise comparison matrix					Normalized pairwise comparison matrix					Computation of criteria weights (a+b+c+d+e)/5
	Slope (a)	Road proximity (b)	Lu/lc (c)	Geology (d)	Aspect (e)	a	b	c	d	e	
Slope	1	3	4	8	9	0.55	0.64	0.47	0.49	.36	0.50
Road proximity	0.33	1	3	4	8	0.18	0.12	0.35	0.24	0.32	0.26
LU/LC	0.25	0.33	1	3	4	0.14	.07	.12	.18	.16	.13
geology	0.125	0.25	0.33	1	3	.07	.05	.04	.06	.12	.07
Aspect	0.11	0.125	0.25	0.33	1	.06	.03	.03	.02	.04	.04
Total	1.815	4.705	8.58	16.33	25	1	1	1	1	1	1

Table 4 Pairwise comparison matrix

Weightages are given to the physical parameters by comparing with each other. The computed weightage values are represented in table 4

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Criteria	Weighted sum vector	Consistency index
Slope	$(1 \times 0.5) + (3 \times 0.26) + (4 \times 0.13) + (8 \times 0.07) + (9 \times 0.04) = 2.72$	$2.72 / 0.50 = 5.44$
Road proximity	$(0.33 \times 0.5) + (1 \times 0.26) + (3 \times 0.13) + (4 \times 0.07) + (8 \times 0.04) = 1.415$	$1.415 / 0.26 = 5.44$
LU/LC	$(0.25 \times 0.5) + (0.33 \times 0.26) + (1 \times 0.13) + (3 \times 0.07) + (4 \times 0.04) = 0.71$	$0.71 / 0.13 = 5.46$
Geology	$(0.125 \times 0.5) + (0.25 \times 0.26) + (0.33 \times 0.13) + (1 \times 0.07) + (3 \times 0.04) = 0.36$	$0.36 / 0.07 = 5.14$
Aspect	$(0.11 \times 0.5) + (0.12 \times 0.26) + (0.25 \times 0.13) + (0.33 \times 0.07) + (1 \times 0.04) = 0.18$	$0.18 / 0.04 = 4.50$

Table 5 Computation of consistency vector

The consistency index were calculated (Table 5) for checking the reasonable consistency of the pairwise comparison matrix.

C. Check consistency of pairwise matrix

Average consistency vector (λ)

$$\lambda = 5.44 + 5.44 + 5.46 + 5.14 + 4.5 = 5.196$$

Condition 1

$\lambda \geq$ no of criteria

$$\text{Consistency index (CI)} = (\lambda - n) / (n - 1) = (5.196 - 5) / (5 - 1) = 0.049$$

Consistency ratio (CR)

$$\text{CR} = \text{CI} / \text{RI} \quad \text{RI} = 1.12 \text{ (from table 2)}$$

$$\text{CR} = 0.049 / 1.12 = 0.043$$

Condition 2

$$\text{CR} = 0.043 < 0.10$$

It indicates reasonable consistency in pairwise comparison.

D. Preparation of site suitability map for urban expansion

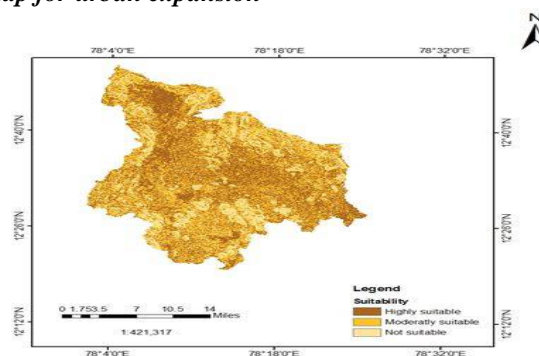


Fig 9. Site suitability map

All the criteria maps have been converted into raster format, in order to assign value for each pixel. Later site suitability map has been generated using the suitability model.

$$\text{Suitability map} = \sum [\text{criteria map} * \text{weight}]$$

$$\text{Suitability index} = [(slope * 0.5) + (road proximity * 0.26) + (LU/LC * 0.13) + (geology * 0.07) + (aspect * 0.04)]$$

Using this equation, integrate all the criteria maps to develop site suitability map (fig 9).

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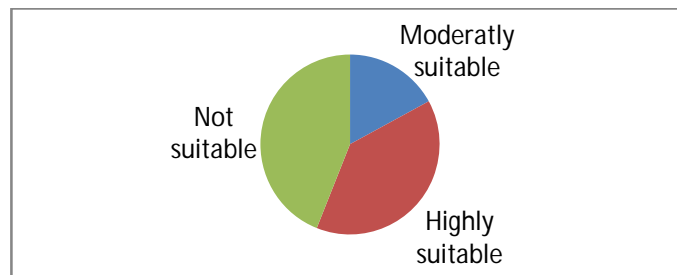


Fig 10. site suitability diagram

The results showed that (Fig 10) 39% of the total area falls under highly suitable category, 40% under suitable category and remaining 17% is not suitable for urban development.

V. CONCLUSION

It can be concluded that remote sensing products play vital role in the preparation of suitable urban development plans. GIS based Analytic Hierarchy process (AHP) helps in deriving rankings for each thematic map individually as well as integrated ranking as a whole for the entire area under investigation. Study reveals that presently built-up land and settlement occupy 6% of the total study area and there is a good scope for urban expansion. It is estimated that totally 973 sq.km area is available for urban expansion in which 678 sq.km is highly suitable.

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