Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 5, Issue 4; April-June, 2018, pp. 181-185

http://www.krishisanskriti.org/Publication.html

Application of Land Suitability Analysis to Enhance Planning Process: Case Study of Vizianagaram, Andhra Pradesh

Kanika Bimrah

School of Planning and Architecture, New Delhi
E-mail: kanikabimrah@gmail.com

Abstract—*Rapid urbanization and consequent slapdash growth of cities is a global phenomenon and India is no exception. The growing population and constant migration from rural to urban exerts tremendous pressure on natural resources like land, water and environment. Urban growth inevitably decreases the sustainability of land use and the ecosystem and gradually leads to the decline of natural and rural lands affecting the ecosystem in general. Given this situation, strategies and policies are needed to address and pre-empt this phenomenon before negative effects on the biosphere begin to increase. Thus, the application of innovative techniques is instantly essential to advance the concept of sustainable growth. Assessing the land use development problem has become an important task under the increasing aware of land resource conservation. Land use suitability assessment is a real-world tool to make decision on land use development.*

This study will focus on the importance of Land Suitability Analysis in Urban Development of Vizianagaram, Andhra Pradesh. Vizianagaram lies 60 kilometers away from Vishakhapatnam which is the IT Hub of Andhra Pradesh and one of the oldest port cities in India. It is evident that development potential of Vizianagaram is very high at regional level, hence certain parameters are to be assessed before allocation of land uses. To reduce the human effect on natural resources and to identify appropriate land uses, it is essential to carry out scientific land evaluations. The statistical and technical approaches along with the parameters are discussed and land suitability is carried out with Weighted Overlay Method using Geographic Information System (GIS).

Keywords*: Urban Development, Land Suitability Analysis, Planning Process, Land Use, Geographic Information System, Land Use, Land Characteristic, Regional Planning Approach, Urban Suitability, Regional Land Use Planning*

1. INTRODUCTION

Due to the increasing population and economic growth, human activities have unremitting impacts on land use. Those impacts might lead to serious complexities toward environment and land resources development. Population residing in urban areas in India, according to 1901 census, was 11.4%. This count increased to 28.53% according to 2001 census, and crossing 30% as per 2011 census, standing at 31.16%. Meanwhile, the emergent demand for urbanization, land resources used for a multiplicity of purpose will interact and contend with each other. Much of the increasing demand for land for the growing population in urban areas is met by the surrounding agricultural land. Population growth not only effects the development of rural areas but also the transition lands between the rural and urban continuum. Increasing population means increased demand for food, which makes it essential to utilize the most suitable land for agricultural purpose. Further the urban expansion in ecologically sensitive areas to be prohibited. [1]

Land-use planning is becoming multi-layered and multi-disciplinary as planners face abundant problems that need to be addressed within a single planning framework. Such problems include nonpoint-source pollution, water allocation, urbanization, ecosystem deterioration, global warming, poverty and unemployment, deforestation, desertification, farmland deterioration, and low economic growth. [2]

2. APPROACH AND DATA SYNTHESIS

Issues related to population and land being a limited resource emphasizes the need for more effective land use planning and policies. The increasing population and migration of population from rural areas to urban areas results in the high rate of urbanization. Population growth not only effects the development of rural areas but also the transition lands between the rural and urban continuum. [1]

Understanding the need for efficient land use planning, which is a multi-disciplinary field that faces numerous problems which needs to be dealt within a single planning framework; the aim of the study is *'To enhance the planning process of Vizianagaram with the application of land suitability analysis to ameliorate land use and spatial planning'.*

i. To understand land suitability analysis and its importance as a tool to enhance the planning process.
ii. To carry out Land Suitability analysis for Vizianagaram, Andhra Pradesh using Weighted

Overlay Method for Multi-Criteria Decision Analysis (MCDA) using Geographic Information System (GIS).

iii. Identification of suitable tracts of land for future development of the settlement.

3. INTRODUCTION TO LAND SUITABILITY ANALYSIS

The Land Suitability Analysis (LSA) is a GIS-based process applied to determine the suitability of a specific area for considered use, i.e. it reveals the suitability of an area regarding its intrinsic characteristics (suitable or unsuitable). [3]

Land suitability is the fitness of a given type of land for a defined use. The land may be considered in its present condition or after improvements. The process of land suitability classification is the appraisal and grouping of specific areas of land in terms of their suitability for defined uses. [4]

3.1 Food and Agriculture Organization (FAO) Framework Method

According to FAO framework for Land Evaluation (1976), the structure for suitability classification is composed of four categories:

I. Land Suitability Orders: reflecting kinds of suitability. S: suitable, N: non-suitable.

II. Land Suitability Classes: reflecting degrees of suitability within orders such as S1(highly suitable), S2(moderately suitable), S3 (marginally suitable) and N (not suitable).

III. Land Suitability Subclasses: reflecting kinds of limitation or main kinds of improvement measures required, within classes (e.g. S2m, S2e, etc.).

Land suitability Classes reflect degrees of suitability. The classes are numbered consecutively, by arabic numbers, in sequence of decreasing degrees of suitability within the Order. Within the Order Suitable the number of classes is not specified. There might, for example, be only two, S1 and S2 which is shown in Table 1.

Table 1: Qualitative Classification of Suitability

Class S1 Highly Suitable:	Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.
Class S2 Moderately Suitable:	Land having limitations which in aggregate are moderately severe for sustained application of a given use; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on Class S1 land.
Class S3 Marginally Suitable:	Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, that this expenditure will be only marginally justified.

Source: (FAO Organisation, 2018) [6]

IV. Land Suitability Units: reflecting minor differences in required management within Subclasses such as S2e-1, S2e-2. [5]

3.2 Multi-Criteria Decision Analysis

Multi-Criteria Decision Analysis, or MCDA, is a valuable tool that we can apply to many complex decisions. MCDA involves the basic steps which are:

i. Set the goal/define the problem

ii. Determine the criteria (factors/constraints): How much details are needed in the analysis affects the set of criteria to be used and the criteria should be measurable.

iii. Standardize the factors/criterion scores: Set the suitability values of the factors to a common scale to make comparisons possible

iv. Determine the weight of each factor: There are several methods (i) Ranking i.e. 3 factors: rank the factors with 1, 2, & 3, where 1 is the least important while 3 is the most important (ii) Rating i.e. 3 factors: rate the factors using percentile – Factor 1 with the lowest percentage as the least important & Factor 3 with the highest percentage as the most important

v. Aggregate the criteria: Weighted Linear Combination is the most commonly used decision rule

Formula: $S=\sum wixi \times \Pi cj$

Where: S – is the composite suitability score

xi – factor scores (cells)

wi – weights assigned to each factor

cj – constraints (or Boolean factors)

$\sum$ -- sum of weighted factors

$\prod$ -- product of constraints (1-suitable, 0-unsuitable)

vi. Validate/verify the result: To assess the reliability of the output (a) Ground truth verification i.e. conduct a field survey to verify sample areas (b) Sensitivity analysis [7]

4. STUDY AREA

Vizianagaram is the district headquarters of Vizianagaram district in the Indian state of Andhra Pradesh. It is a municipality and also Vizianagaram Mandal headquarters. It is located (18.4059° N, 83.3362° E) 18 km inland from the Bay of Bengal and 42 km to the northeast of Visakhapatnam which is shown in Fig.1.

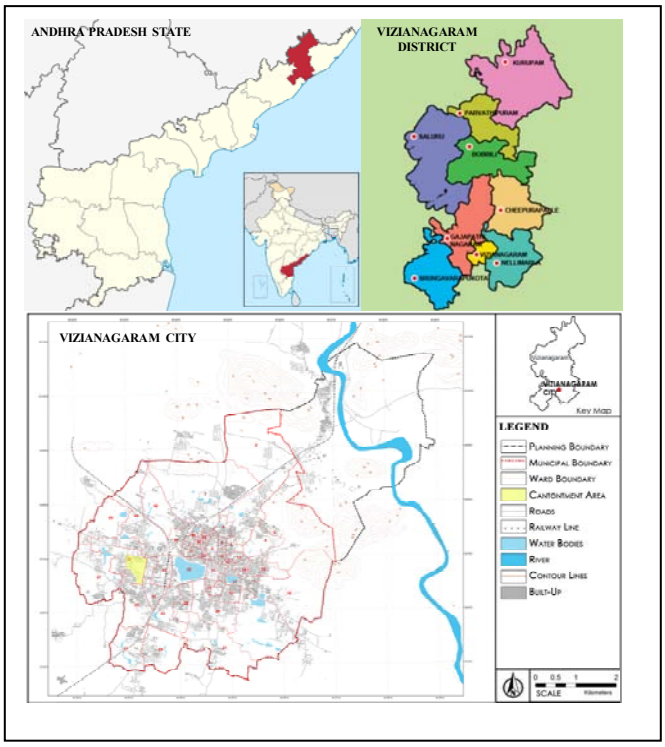

Fig. 1: Location Map of Vizianagaram, Andhra Pradesh

5. APPROACH FOR LAND SUITABILITY ANALYSIS

The approach adopted for carrying out Land Suitability Analysis (LSA) in Vizianagaram is as follows:

1. The parameters used for LSA are selected and classified.
2. The shapefiles of the above selected parameters are generated with the help of Geographic Information System.
3. The parameters are allotted ranks and weightage based on the vision for development of Vizianagaram.
4. Analysis is carried out through Multi-Criteria Decision Analysis by raster reclassification and weighted overlay method through GIS. Finally, a suitability map is generated.

Fig.2. shows the approach adopted for Land Suitability Analysis of Vizianagaram.

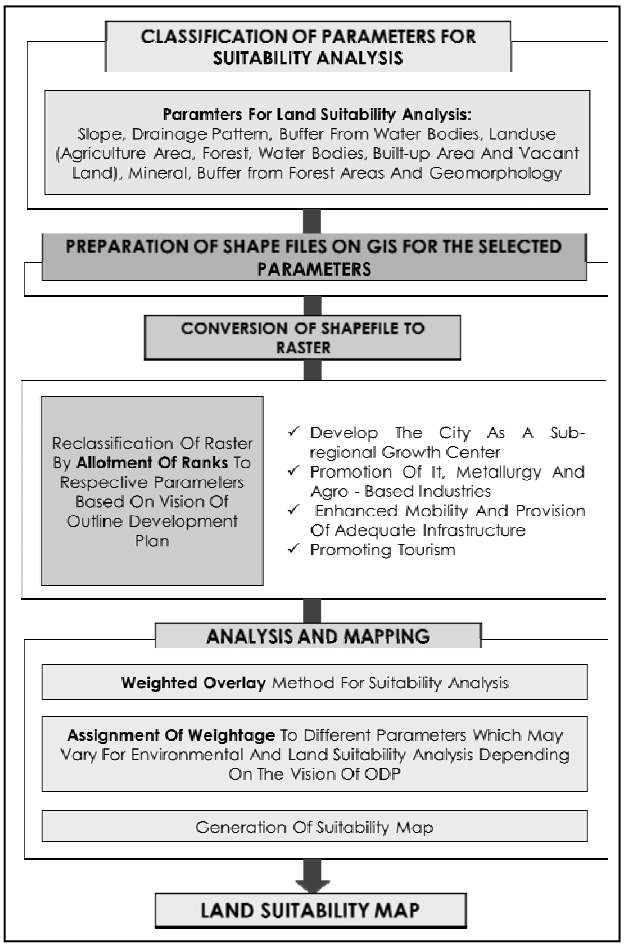

Fig. 2: Approach adopted for Land Suitability Analysis of Vizianagaram, Andhra Pradesh

5.1 Assumptions

1. Forest areas have been considered unsuitable for development as they are reserved forests. They act as growth constraints. Buffer area of 100 meters has been marked.
2. Buffer areas around water bodies have been marked which are considered to be unsuitable for development.

Land Suitability analysis have been carried out after demarcating the above areas.

5.2 Parameters for Land Suitability Analysis

The parameters considered for Land Suitability Analysis are slope, geomorphology, land use, mineral mapping, drainage pattern, buffer from water bodies and reserve forests. Table 2 shows all the above-mentioned parameters along with their allotted ranks and weightage.

Table 2: Parameters for Land Suitability Analysis

S.NO.	PARAMETER	RANK	TOTAL WEIGHTAGE
1	SLOPE		
1.1.	Gently Undulating (0-5%)	5	
1.2.	Undulating (5-15%)	3	15
1.3.	Moderately Steep (15-30%)	2	
1.4.	Steep (30-60%)	1	
2	GEOMORPHOLOGY		
2.1.	Pedi plain	4	
2.2.	Flood Plains	1	10
2.3.	Older Flood Plains	2	
3	LANDUSE		
3.1.	Forest Area	0	
3.2.	Agriculture	1	
3.3.	Water Bodies	0	25
3.4.	Built-up Area	3	
3.5.	Vacant Land	5	
4	MINERAL MAPPING		
4.1.	Khondalite	4	10
4.2.	Charnockite	3	
5	DRAINAGE PATTERN		
5.1.	Buffer up to 10 meters	1	
5.2.	Buffer up to 20 meters	2	15
5.3.	Buffer up to 30 meters	3	
6	BUFFER FROM WATER BODIES		
6.1.	Buffer up to 50 meters	1	
6.2.	Buffer up to 100 meters	2	15
6.3.	Buffer up to 150 meters	3	
6.4.	Buffer up to 200 meters	4	
7	BUFFER FROM RESERVE FORESTS		10
7.1.	Buffer up to 100 meters	0	
	TOTAL		100

6. LSA FOR VIZIANAGARAM, ANDHRA PRADESH

Suitability maps are generated for the above-mentioned parameters which are shown in Fig.3. (1) Slope Map (2) Geomorphology Map (3) Land use (4) Mineral Mapping (5) Buffer from Water Bodies (6) Buffer from Reserve Forests. The suitability maps are generated based on the increasing suitability of each parameter according to the rank allotted to them.

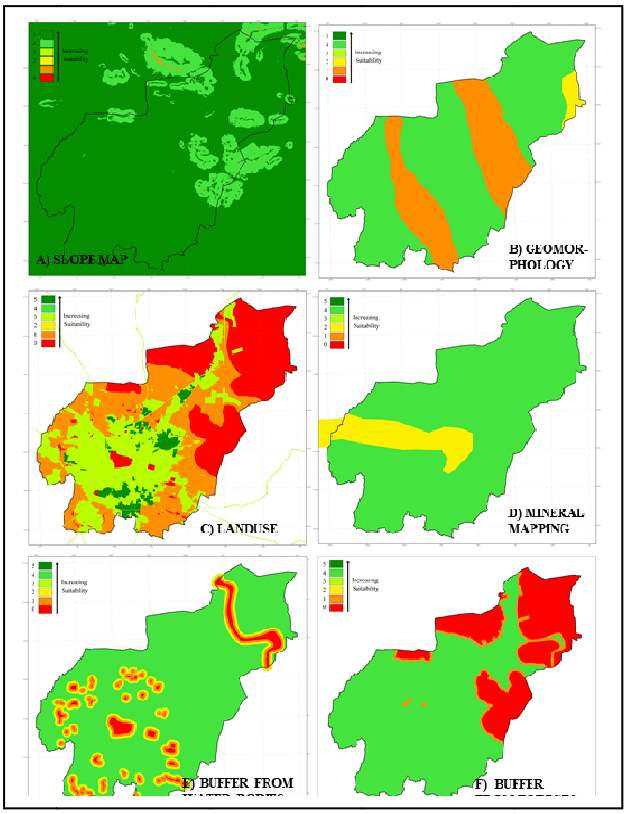

Fig. 3: Suitability Map (A) Slope Map (B) Geomorphology Map (C) Land use (D) Mineral Mapping (E) Buffer from Water Bodies (F) Buffer from Reserve Forests.

Using the above parameters, a suitability map is generated which uses the following formula

Suitability map= Σ [criteria map * weight]

Fig.4. shows the Land Suitability Map for Vizianagaram.

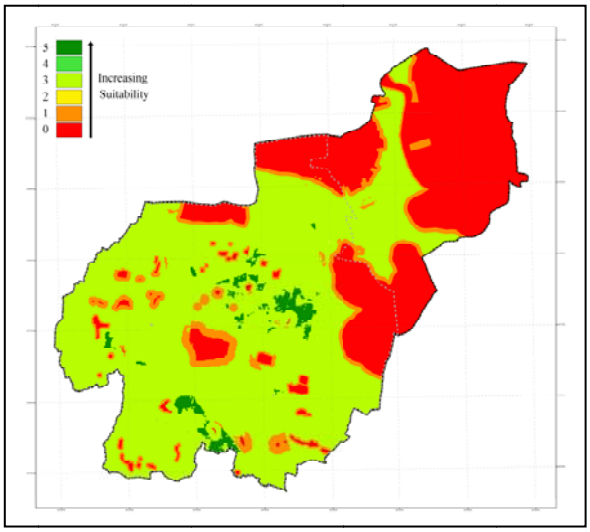

Fig. 4: Land Suitability Analysis for Vizianagaram, Andhra Pradesh

7. INFERENCES

The inferences drawn from the analysis are discussed as follows:

1. The suitability map is generated by weighted overlay method by considering the discussed parameters is shown. Hilly and forest areas along with water bodies and mangrove plantation covers 30 % of the entire area which is not at all suitable for development. Around 8% of the area is least suitable for development. It can be observed that around 60% of the area is moderately suitable land for development. Remaining 2% of the area is most suitable for development.
2. It is observed that the most suitable land for development is vacant land. Hence for residential development, priority will be given to the vacant land and later agricultural land may be utilized, if required.
3. The location of residential pockets will be strategically placed within the proximity of industrial areas such that employed people will have housing near the work place.

8. CONCLUSION

The suitability analysis makes urban planning decision-making more rational, thus the planning outcome is can be easily communicated, understood, and accepted by the public, which means less resistance in the implementation process; 2) the overlay analysis includes data from multiple sources and aspects including geographical, social, economic, etc., and 3) the weighted overlay allows manipulation of the overlay process by assigning different weights for different input layers, so that the factors playing a more important role will have larger influence in shaping the result of the overlay analysis. [8] With land suitability being one of the primary objectives of the land use planning process, a GIS based approach for land use suitability assessment will assist land managers and land use planners to identify areas with physical constraints for a range of nominated land uses and will result in efficient land use planning.

9. ACKNOWLEDGEMENT

It gives me immense pleasure and satisfaction in submitting this paper. My profound gratitude and deep regard to the faculties of Department of Architecture and Planning, Maulana Azad National Institute of Technology, Bhopal, India, and School of Planning and Architecture, New Delhi for their exemplary guidance, valuable feedback and constant encouragement throughout the duration of this research work.

REFERENCES

[1] J. Chan, "GIS-based multi-criteria analysis for land use suitability assessment in City of Regina," *Environmental Systems Research,* 2014.

[2] Water Encyclopedia, "Science and Issues: Water Encyclopedia," 09 April 2018. [Online]. Available: http://www.waterencyclopedia.com/La-Mi/Land-Use-Planning.html.

[3] S. Jafari, "Land Suitability Analysis using Multi Attribute," *International Journal of Environmental Science and Development,* 2010.

[4] M. M. Wanjohi, "Land Suitability Analysis for Tea Cultivation: Case Study of Kirinyaga West District," 2008.

[5] M. Mokarram, *LAND SUITABILITY EVALUATION FOR WHEAT CULTIVATION BY FUZZY THEORY APPROACHE AS COMPARED WITH PARAMETRIC METHOD.*

[6] FAO Organisation, "A Framework for Land Evaluation-FAO," 20 April 2018. [Online]. Available: http://www.fao.org/docrep/x5310e/x5310e04.htm#chapter%203:%20land%20suitability%20classifications.

[7] R. C. Estoque, *GIS-based Multi-Criteria Decision Analysis,* 2011.

[8] S. Chen, "Land-use suitability analysis for urban development in Regional Victoria: A case study of Bendigo," *Journal of Geography and Regional Planning,* vol. 9, no. 4, pp. 47-58, 2016.