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Generation of Hierarchy Ranking Model to Strengthen Decision Making Parameters

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Abstract-Prediction models are gaining popularity amongst the scientists and researchers from different domain. Till date, the utility of prediction models has been proved in majority of sectors to name a few, land use changes, growth pattern, population and infrastructure, city development plans, resources management, disaster prone areas etc. Most of the prediction models are based on multi criteria decision support system where various causative parameters are identified and suitable weights are assigned to them. The suitability of weights allotted is calculated by different methods namely Normalized Mean Value (NMV), Geometric Mean Method (GMM) and Eigen Vector Method (EVM). The computed weights assigned to causative parameters strengthen the accuracy and validity of prediction model. In present research the combination of NMV and EVM is made to calculate the most suitable weights for three land use categories namely fallow, barren and agricultural land which play key role of decision parameters in the land use prediction model. Generated output of hierarchy ranking model is further utilized as an input for decision support system based model. This design module also helps assigning the most suitable weightages to different decision support system based models.

Keywords-Weight estimation techniques, Normalized Mean Value, Eigen Vector Method, prediction model

I. INTRODUCTION

Urban growth prediction model can assist city developers, planners or decision makers to foresee impacts of their development plans, actions and policies [1, 2, 3]. Till date, various urban growth models are developed referring the simple versus complex, aspatial versus spatial, sustainable versus non sustainable and diffused version location based parameters of urbanization phenomena.

To overcome haphazard growth of the cities or unorganized city expansion problem, there is a need to understand the demand, availability and scarcity of resources, which will be useful for predicting the future growth of the city [4,5]. Prediction model generated by processing the spatial data with attributes based on population, infrastructure, current land use pattern, availability and demand of resources would strengthen the sustainable development of the metropolitan cities in India [6, 7].

The work flow of any model starts with reading input data, processing it as per the programming and generate the results/output. Based on basic assumptions of model, proposed design module uses input data in the form of preferences of decision making parameters [8]. Using different weight estimation techniques the input parameters are

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getting processed and output is generated in the form of most suitable weightage readily assigned to those parameters. AHP is a powerful and flexible decision making process that helps in setting the priorities amongst the causative factors and support in making the best decision [9, 10].

Present research work demonstrates the generation of most suitable weight for fallow land, barren land and agricultural land which are used as decision making parameters to predict urbanization of Pune Municipal Corporation.

II. MATERIALS AND METHODS

The accuracy of prediction models is based on the selection of causative factors, assign appropriate weights to those parameters and decide the hierarchy, therefore it is necessary to apply a suitable mathematic model for weight calculation. To compute the most suitable weights for selected decision parameters, three weight estimation techniques are in vogue. The details of these techniques are as follows:

- Normalized Mean Value (NMV)
- Geometric Mean Method (GMM)
- Eigen Vector Method (EVM) / $\lambda \max$ Method (LMM)

Normalized Mean Value (NMV) / Sum Method

Let A = (A_{ij}) is n× n judgment matrix.

Procedure:

I. Normalize each column vectors in the judgment matrix

II. Add normalized matrix in rows using the formula give below:

$$Wi = \frac{1}{n}\sum_{i=0}^{n}\frac{Aij}{\sum_{k=1}^{n}Akj} \quad (i = 1, 2, 3\ldots n)$$

Geometric Mean Method (GMM)

Procedure:

I. Normalize the column vectors in the judgment matrix.

II. Compute the geometric mean of each row using the formula:

$$\mathbf{Wi} = \sqrt[n]{\prod_{i=1}^{n} Aij}$$

Eigen Vector Method (EVM) / $\lambda \max$ Method (LMM)

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The eigenvector is defined by

$$AW = \lambda \max W$$

Where $\lambda \max$ = largest Eigen value of A
W = weight

Eigenvector solution is normalized $\Leftrightarrow \sum_{1=1}^{n} Wi = 1$

Weight assigning is based on two separate parts namely local priority and overall priority. In this research land use layer has been developed to show how it works for each category. By this way hierarchy ranking approach is an efficient help for exact calculation of weights where it is not possible only based on expert opinion. For this purpose, first a hierarchical framework is proposed to select the weight for submitting it in the model structure.

Computation of weights

Three different weight estimation techniques are studied to judiciously assign the weightages for land use layer. In this research weights are computed for following factors by considering equal importance of each factor.

TABLE 1. DETERMINING THE RELATIVE FACTOR WEIGHTS

Factors	**Step I**			**Step II**			**Step III**
	BL	OL	AL	BL	OL	AL	Weights
Barren Land	1	1	1	0.33	0.33	0.33	(0.33+0.33+0.33)/3=0.33
Open Land	1	1	1	0.33	0.33	0.33	(0.33+0.33+0.33)/3=0.33
Agricultural land	1	1	1	0.34	0.34	0.34	0.34+0.34+0.34)/3=0.34
Sum	3	3	3	1.00	1.00	1.00	1.00

The values shown in Table 1 will differ as per the value of different pair wise comparison values, which are based on preferences/judgments provided by the researchers, experts, decision makers or planners.

Determination of Consistency Ratio (CR)

TABLE 2. DETERMINING THE CONSISTENCY RATIO (CR)

Factors	**Step I**	**Step II**
Barren Land	0.33*0.33+0.33*0.33+0.33*0.34=0.99	0.99/0.33=0.33
Open Land	0.33*0.33+0.33*0.33+0.33*0.34=0.99	0.99/0.33=0.33
Agricultural land	0.33*0.33+0.33*0.33+0.33*0.34=0.33	0.102/0.34=0.34

Two steps are used to calculate Consistency Ratio (CR):

1. Determine the weighted sum vector by multiplying the weights for their corresponding values of the original pair wise comparison matrix, sum values over the rows
2. Determine the consistency vector by dividing the weighted sum vector by the factor weights determined in step1(Table 2)

Lambda ($\lambda \max$) and CI calculation

CR values are depending upon the values of lambda and consistency index (CI). Lambda is simply average of consistency vector.

$$\lambda = (3.39+3.34+0.33)/3 = 3.105$$

To calculate CI, lambda should always be greater than or equal to the number of factors considered in urban growth prediction model.

$$CI = (\lambda - n)/(n-1) = (3.105-3) = 0.105$$

$$CR = CI/RI$$
$$CR = 0.105/0.52 = 0.201$$

Random Index (RI), the consistency index randomly generated pair wise comparison matrix. RI depends on the number of elements (n) being compared. The consistency ratio is designed such a way that shows a reasonable level of consistency in the pair wise comparisons if CR > 0.10. It means preferences provided by decision makers and planners in urban growth prediction model are consistent in nature.
CR consistent results proved that, provided judgments/preferences for each factor are correct using pair wise comparison method.

Pair wise comparison method

For weight estimation module, high level pair wise comparison method is used to read the preferences for each factor selected from decision makers and planners. While providing the preferences for each factor, decision makers, researchers or planners have to rate the relative preferences for causative factors by providing the values mentioned on the comparison scale provided by Saaty [11]. This scale consists of 9-points on intensity of importance basis so that an individual can simultaneously compare and consistently rank the parameters (Table 3).

TABLE 3: SCALE FOR PAIR WISE COMPARISON USED FOR HIERARCHY RANKING MODEL

Intensity of Importance	**Definition**	**Explanation**
1	Of equal value	Two factors i & j are of equal importance
3	Slightly more value	Factor i is slightly important than factor j
5	Strong Value	Factor i is slightly important than factor j
7	Very strong value	Factor i is more important than factor j
9	Extreme value	Factor I is most important than factor j
2, 4, 6, 8	Intermediate values between two adjacent judgments	When compromise is needed
Reciprocals	If factor i has one of the above numbers assigned to it when compared with factor j, then factor j has the reciprocal value when compared with factor i	

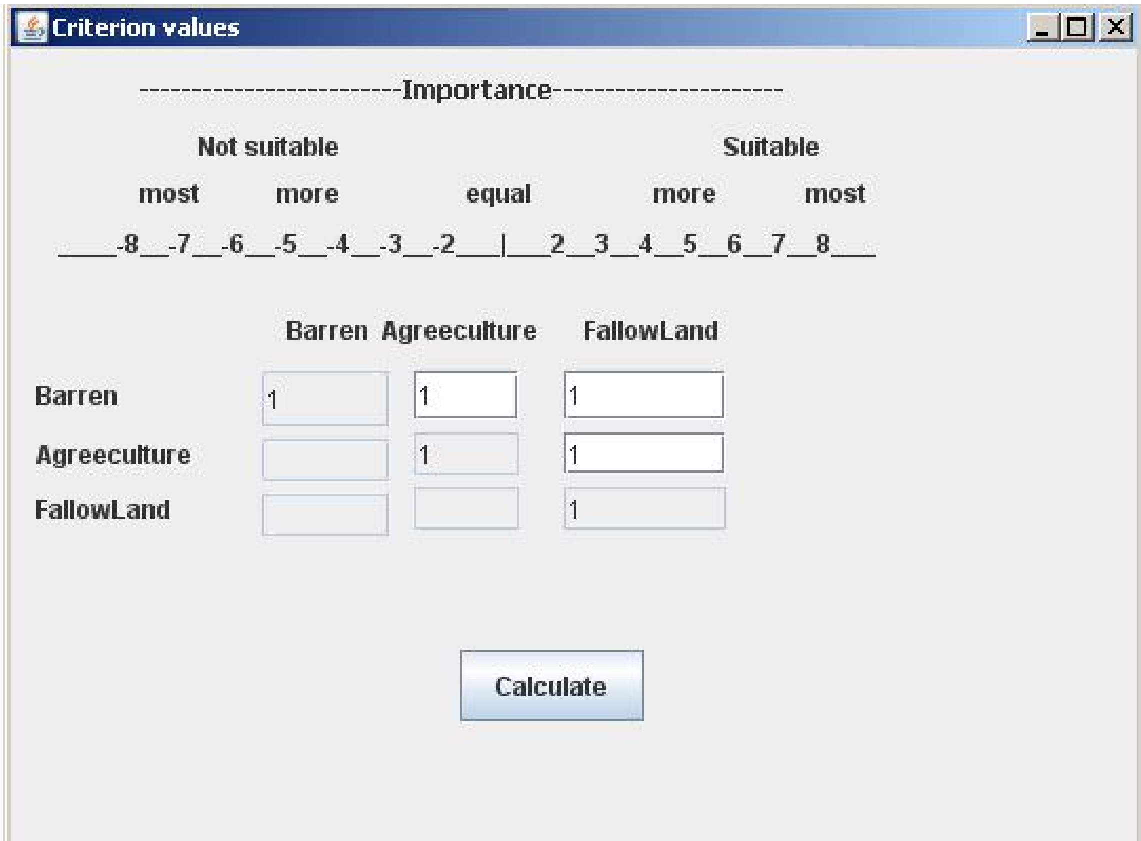

Fig. 1. Tool developed for Pair wise comparison matrix.

III. CONCLUSION

From the present research work , it has been concluded that the, combination of Normalized Mean Value (NMV) and Eigen Vector (EV) methods give better results as compared to Geometric Mean method (GMM) to assign the most suitable weightages to the decision making parameters in MCDM / AHP technique. Hence for the present research work combination of NMV and EV methods is used to provide consistent results readily available for decision maker's judgments. Generated output of design module will be applicable as an input database for any decision support system based model to predict urban growth of any fast growing city.

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