HOUSING GROWTH POTENTIAL BASED FUZZY SIMULATION ZONAL RANKING: A CASE STUDY OF INDIAN METROPOLITAN

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ABSTRACT

Population explosion, industrial development and urbanization are closely interknitted and as such forms a global phenomenon.India, being a third world country has been undergoing through this process in a significant way. The Class-I cities and the Metropolitan cities in particular are under rapid urbanization process. Therefore, these centers are experiencing tremendous pressure on resources and urban infrastructure. In Indian Urban system, the interplay of heterogeneous socio-economic groups, infrastructure system components and resources constraints are subjected to urbanization ambivalence. In this process, urban housing sector has been worst affected with clear cleavage between supply and demand, resulting in huge housing shortage. Therefore, the urgency to reduce the gap between housing requirement and supply can not be underscored.

The Indian metropolitan under study is an evolved city. It has recorded highest growth rate in the region as well as state. It has experienced one of the fastest growth rates even at the national level. With the rapid growth the city boundaries are increased. For the sake of administration the area under study is divided in seven zones, but for the purpose of technical study the metropolitan area is divided into twenty various study zones. The delineation was based on population distribution and aerial features.

Zonal housing growth potential can be defined as ability of a zone to attract the house demanding population to satisfy their actual demand in the varying affordable manner. The housing Growth Potential varies from zone to zone. It is a complex phenomenon and depends upon various varying parameters. On the basis of various pilot housing studies and correlation findings few major factors were found highly influencing.Therefore, the parameters involved are pertaining to land, where the land value plays the major role. Secondly road features like accessibility and road area network are significant. Thirdly the utility services provided to the people are also important. Apart from this, the ongoing Housing activities and the population density are also playing the major role.

The Urban area is dynamic in nature. The urban zones have built in potential to attract the people and thus influence the entire city also. Very surprisingly it can be stated that the zonal potential for housing growth varies with time and policies of the planners. It is a unique exhibition of manmade and natural interplay.

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This paper precisely highlights the Zonal Attraction Potential (ZAP) for housing through fuzzy composite modeling. The model incorporates number of influencing parameters to contribute residential attraction. The paper further describes the modeling approach and the Zonal Ranking process with respect to possible housing growth potential. This evaluation can have significant application in the field of urban planning. The urban planners wish to have a balanced and even city population growth to have scientific utilization of resources. The Zonal Ranking can become a powerful tool developed through the meaningful considerations.

KEY WORDS:

Zonal Attraction Potential (ZAP), Zonal Ranking, Housing, Land Accessibility, Urban, Growth, Development, Fuzzy

INTRODUCTION

Urban area is considered like an organic system, whereas the specific stages are experienced. The various zones are having inherent capacity to pull the people of need for their housing demands. If an urban area development is analyzed, a specific trend can be determined, which indicates a hidden factor of Zonal Attraction potentiality. As the urban area grows from its infant stage to a mature, the zonal development in terms of housing gives a direction and magnitude of zonal strength. This element of city growth can be termed as Zonal Attraction Potential (ZAP). Each urban zone is having a dynamic built in capacity to pull the people of migration and to attract the settled people through an intercity and intra-city shift respectively. The Zonal Attraction Potential (ZAP) is an outcome of interaction between natural and man made planning attempts. These indicators can be explained through descriptive variables. Finally as it is advocated by few researchers, they are fuzzy in nature. The practices and efforts of planners in the field of various urban zones are of subjective nature and not objective. This new notion of Zonal Attraction Potential (ZAP) will become an objective scientific tool. These strengths of zones can categorize the areas in considerable ranking. This will be surely helpful to the urban planners to foresee the possibilities of urban development. The zonal Attraction indicators, reflecting hidden potential of the fuzzy nature and a case study of a growing metropolitan city are presented here.

ZONAL ATTRACTION INDICATORS

The zonal attraction potential can be envisaged in two ways, as zonal potential and zonal development subterfuge. The zonal potential depends upon three indicators, land potentials, the infrastructure and accessibility. The first indicator comprises of land value, vacant land and residential land use in development plan. The most precious urban element is the land and its value added system, which is predisposed by its strategic sitting. The inter zonal accessibility portrays, the transportation facilities offered by a zone. Infrastructure of a zone, in terms of utility services like water supply, sanitary drainage, amenities of schooling, health, shopping, recreation and social environment matters much in zonal attraction for observable reasons.

Secondly the zonal development, which is a continuous phenomenon, is also playing role in dynamism of zonal attraction potential. These potentials are helpful to develop ranking instrument. The development process is viewed from Housing Growth Potentials and housing activities promoted. On the other hand the natural or man made constraints acting as a barrier between the zones is equally important. Flooding areas, river crossing, high railway embankments etc. are the examples in this regard. Finally population density is considered as one of the important parameters to reflect on settlement environment. Thus, zonal attraction is a unified function of zonal potential and development features. These zonal attraction potentials can be scaled in Zonal Ranking.

FUZZY COMPOSITE PROCEDURE

For decision making problems, where there are conflicting objectives with varied degree of importance and uncertain values of input indicators, Fuzzy Composite Programme is a proved and successful approach. This has been employed by Lee (1991) in his study on dredged material management. The Fuzzy Composite Procedure involves a step-by-step regrouping of a set of basic indicators to form a single composite indicator (Bogardi 1983). The fuzzy composite structure is shown in Fig. 1.0. The structure demonstrates the grouping adapted to the residential location decisions by the urban dwellers for zonal choices. The basic framework was designed on the basis of personal interview conducted for approximately 3115 urban dwellers. The set of deep-seated indicators initially form the ‘Level -I ’, which are of multivariate nature. These basic indicators are further grouped into five indicators designated as’ Level-II’. The Land potential, Accessibility and Service Potential are related to zones, while the growth and density potentials reflect the city state of affairs.

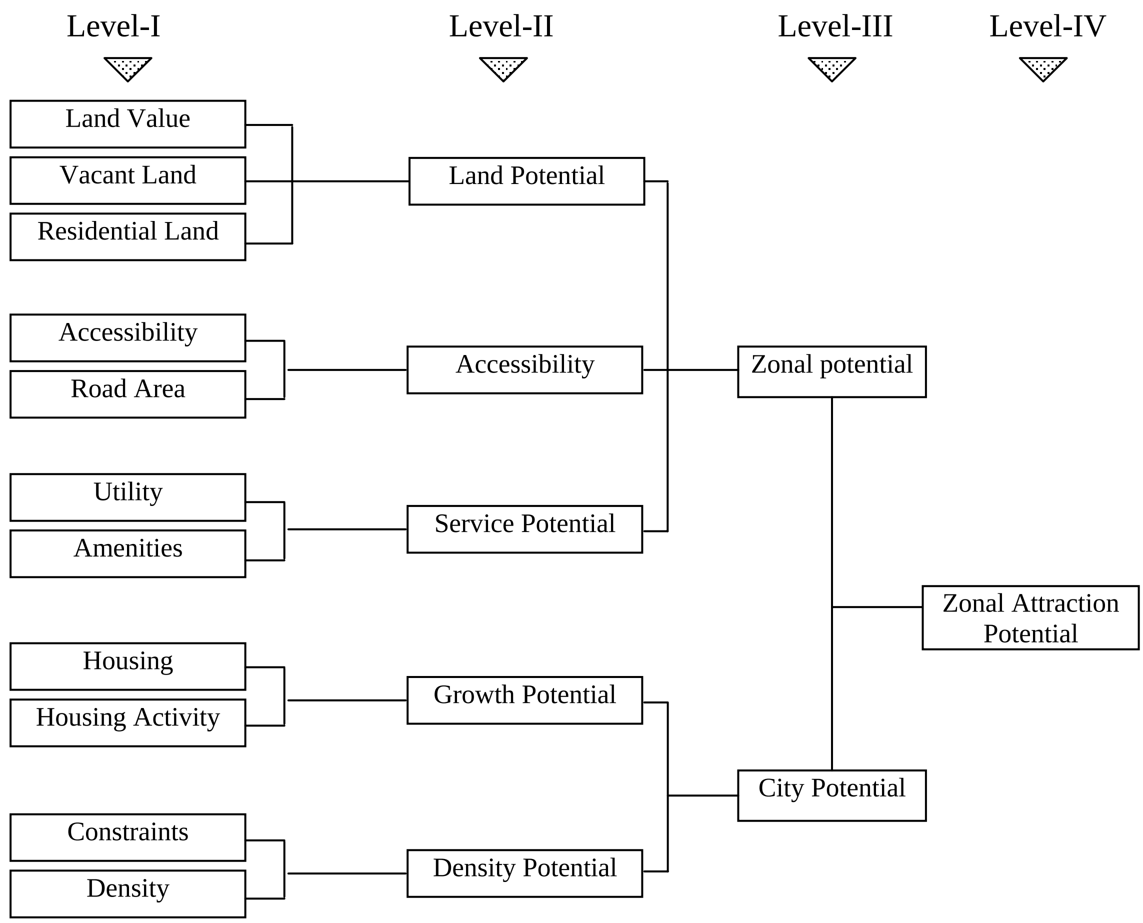

FIG. 1 ‘ZAP’ Fuzzy Composite Structure

Proceeding ahead the ‘Level-II’ indicators are further converted to ‘Level-III’ fuzzy indicators, showing zonal and relative urban potential considering the zone under study. These are later added to get Zonal Attraction Potential (ZAP) values which are the significant bases for Zonal Ranking process.

FUZZY COMPOSITE MODEL: ZAP

To evaluate the various indicators under uncertainly, let Zi(x) be a fuzzy value for the ith indicator and let its membership function be defined as μ [Zi(x)].As the units of each basic indicators are different they cannot be compared directly. Therefore, the basic indicators are transformed into an index in the range of 0 to 1 using the best value (BESZi) and worst value (WORZi) of Zi(x) for the ith indicator.

BESZi and WORZi values of the indicators of ‘Level-I’ are assigned by the housing decision makers judiciously. The composite model is in the form shown as follows:

$$Lijk_{(x)} = \left[\sum_{j}^{n} (W_{ij}[S_{ij}(x)]^{bj} \right]^{1/bj}$$

Where

L_{ij} : Index value of ith indicator at level ‘j’

n : The number of elements at level ‘j’

$S_{ij}(x)$: The index value of the ith basic indicator at desired level ‘j’

W_{ij} : The weight reflecting importance of each of basic indicator at the desired level

b_j : The balancing factor at level ‘j’

k : Factors in the next level

For each level the above step is repeated, and the final value may be obtained. The Zonal attraction Potential (ZAP) computer programme structure is shown in Fig.2.0. Three levels are set in the present model. Weight factors and balancing factors considerations in the model are as under.

Weight Assignment

Each indicator in the fuzzy composite procedure is assigned a specific weight to signify its bearing in the whole process. The urban zonal ranking process has been a complex phenomenon of housing market imperfections. In the decision support system, three weight assignment techniques are popular for evaluation. They are the direct assignment technique, the eigenvector method and entropy method. However first two techniques are explained over here.

The direct method of weight assignment is simple and effective. The basis of weight evaluation of each indicator depends upon the experts’ opinion. In order to evaluate the direct weights the descriptive variables are converted to digital variables. The descriptive variable and their values are given in Table No. 1.0. They are scaled between 0.1 and 1.0. In the decision process this approach has been adopted.

In the Eigen Vector approach the weights can be evaluated on pair comparison basis. For each level of composite programming all indicators of a sub set are compared and comparative values are assigned. In this way a square matrix is formulated, where the diagonal values are always unity. This matrix is solved and the maximum Eigen values are found through unit vector. These maximum Eigen values can be used as weights of each indicator in the fuzzy composite process. A computer subroutine has been used to workout Eigen value. Saaty (1988) has shown the eigenvector corresponding to the Eigen value of matrix. It is solved by A .W = λ max., Where W represents Eigen vector and A denotes the cardinal Ratio.

Table No:1 Descriptive Variables and Qualitative Values

Sr. No.	Descriptive Variables	Value
1	Very poor	0.2
2	Poor	0.4
3	Good	0.6
4	Very Good	0.8
5	Excellent	1.0
6	Intermediate Values	0.1, 0.3, 0.5, 0.7, 0.9

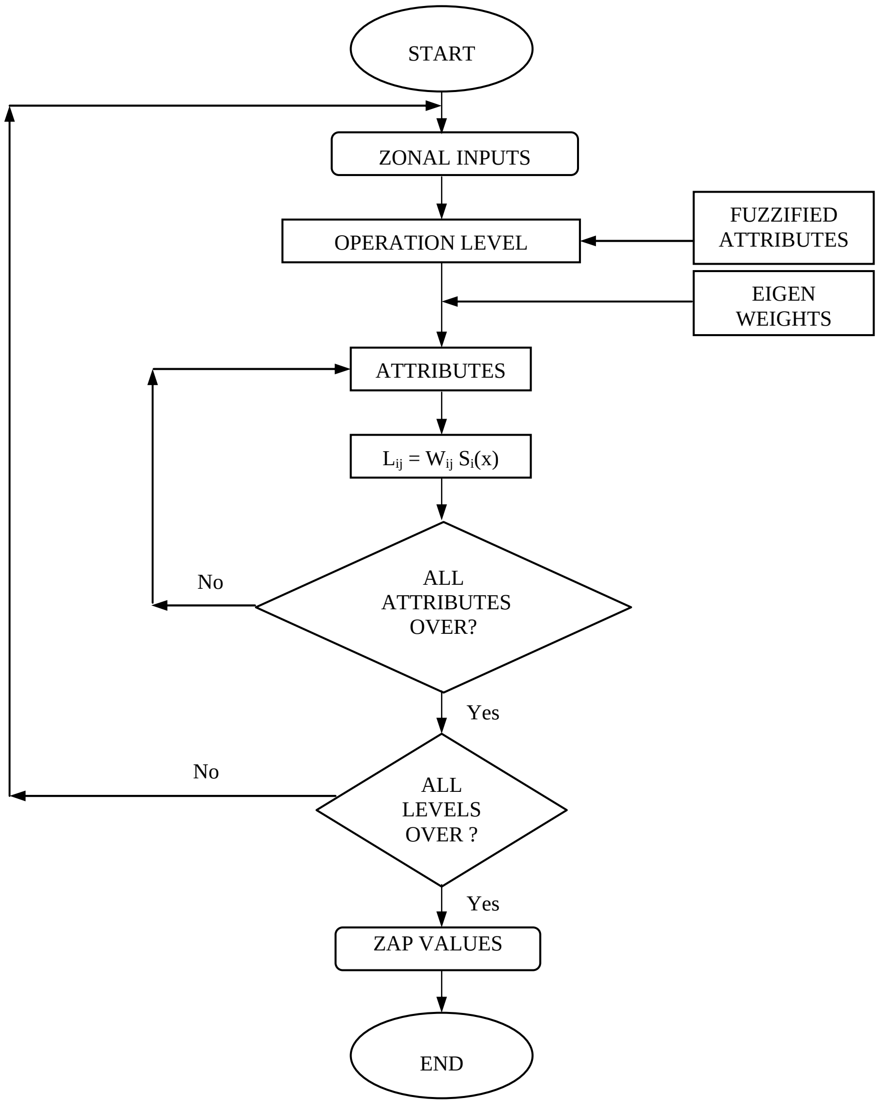

FIG. 2 ZAP Model Structure

Balancing Factors

The balancing factors b (b ≥ 1) is assigned to a group of indicators to reflect the importance of the maximal deviations. It is the maximum difference between an indicator value and best values. When b is “1”, all the deviations are equally weighted. Better values of b can be 1 or 2 (Bogardi 1983). Therefore, “b” has been assigned as 1 in the present work. In many fuzzy composite modeling, this approach is used for its straightforwardness.

ZONAL ATTRACTION POTENTIAL ANALYSIS (ZAP)

Computation of Zonal Attraction Values for the twenty study zones is carried through fuzzy Composite Modeling in line of the work of Bogardi (1983) and Lee (1991) as discussed already. Basic indicators which have swayed to rank the zone are identified and database has been developed through survey. Basic indicators are given in Appendix I and II. They are regrouped to get the updated indicators as shown in Fig. 1. The indicators are listed below.

a. Land Potential
b. Accessibility Potential
c. Service Potential
d. Housing Growth Potential
e. Density Potential.

The raw data of all the basic indicators are fuzzified with reference to the best and worst values as shown in Appendix I and II. Then, the values are brought to the common fuzzy index ranging between 0.1 and 1.0.

The pair wise comparison of indicators at level 1 is carried as shown in typical matrices given in Appendix III and corresponding Eigen value outputs are given in Table No:2. Fuzzy Composite Model output is given in Table No:3. The second level indicators are shown in columns 2 to 4, where as third level values are given in 6 & 7 columns. Third level attraction potentials are shown in 5^{th} and 8^{th} columns reflecting zonal and city level influences. Finally the evaluated Zonal Attraction Potential (ZAP) values can be seen in the 9^{th} column.

Table No:2 Eigen Values of Indicator Matrices

Matrix	Eigen Value	Matrix	Eigen Value
Matrix – I	0.595	Matrix – V	0.200
Matrix – II	0.308	Matrix – VI	0.333
Matrix – III	0.095	Matrix – VII	0.666
Matrix – IV	0.80	Matrix – VIII	0.614

The zonal attraction is due to urban land factor, accessibility and neighbourhood services prevailing, whereas housing growth potential and housing activities are related to the builders, which has major brunt in zonal ranking advance. At the same time the population density and major crossing barriers between the zones due to river or railway embankment speak of physical environment. Eventually the cumulative effect of all these indicators matters in shaping the zonal ranking based on attraction factor of the same. Thus, ZAP values are dynamic in nature and expected to vary with time.

Land Potential is very poor for CBD zones, but the outer fringe areas have quite high values because of the prospective area and low land values. This alone is not good enough to attract the people in absence of necessary accessibility, utility services and neighborhood facilities. This was recognised in the simulation process. The final 'ZAP' values of study zones are categorized in three levels A to C as shown in Table No: 4. with reference to the assumed ranges. Only five zones 8, 9, 10, 14 and 20 are having reasonable high values of 'ZAP' which are above 0.6. Six zones have B level and 9 zones are with C levels. Figure 3.0 shows the picture of Zonal Attraction Potential Values.

Table No: 3 Zonal ZAP Value Variations

Zone No.	Land Potential	Accessibility Potential	Services Potential	Zonal Potential	Growth Potential	Density Potential	City Potential	Zonal Attraction Potential (ZAP)	Zone
1	0.64	1.00	0.810	0.373	0.513	0.667	0.551	0.426	Saiudpura
2	0.56	1.00	0.810	0.368	0.238	0.333	0.262	0.337	Nanavat
3	0.294	1.00	0.810	0.515	0.200	0.556	0.289	0.448	Begampura
4	0.217	0.883	0.810	0.454	0.388	0.556	0.430	0.446	Sagrampura
5	0.358	0.459	0.476	0.401	0.438	0.222	0.384	0.396	Ashwaniku.
6	0.270	0.560	0.476	0.359	0.383	0.111	0.315	0.346	Angana
7	0.268	0.421	0.619	0.380	0.488	0.667	0.533	0.425	Nanpura
8	0.934	0.413	0.381	0.725	0.484	0.778	0.557	0.675	Umra
9	0.762	0.565	0.643	0.707	0.717	0.833	0.746	0.718	Katargam
10	0.739	0.352	0.857	0.725	0.700	0.667	0.691	0.715	Varachcha
11	0.497	0.301	0.143	0.379	0.308	0.111	0.259	0.344	Karanj
12	0.782	0.427	0.310	0.614	0.342	0.222	0.312	0.524	Dumbhal
13	0.715	0.131	0.438	0.572	0.291	0.667	0.385	0.517	Pandesara
14	0.756	0.291	0.667	0.678	0.537	0.556	0.542	0.637	Udhna
15	0.558	0.389	0.348	0.482	0.746	0.556	0.698	0.546	Adajan
16	0.885	0.037	0.390	0.653	0.063	0.667	0.213	0.523	J. Pura
17	0.655	0.328	0.214	0.49	0.000	0.444	0.111	0.384	Rander
18	0.703	0.331	0.538	0.615	0.063	0.444	0.158	0.486	Tadwadi
19	0.766	0.059	0.286	0.554	0.438	0.778	0.523	0.545	Magura
20	0.901	0.440	0.476	0.733	0.646	0.889	0.707	0.725	Siganpore

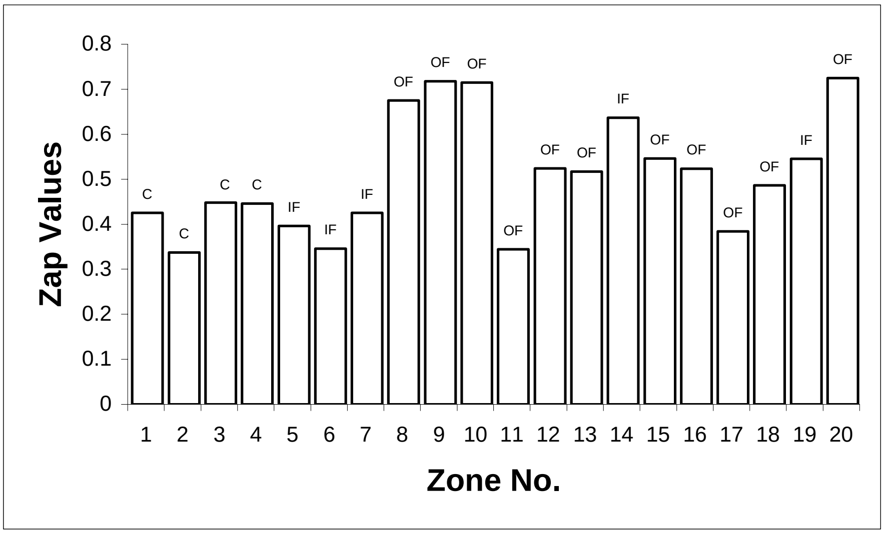

Fig. 3 Zonal Attraction Potential Values
C – C. B. D. Zones IF – Inner Fringe Zones OF – Outer Fringe Zones

Zonal Ranking

Zonal Ranking can be evaluated based on 'ZAP' values if there is any change in basic indicator. These 'ZAP' values have been found quite insightful for zonal ranking process in location observable facts of the urbanites. Thus, 'ZAP' model is one of major sensitive input provider.

Table No: 4 Zonal Attraction Potentials and Ranks

Sr. No.	ZAP Levels	Level Range	Zones	Total Zones	Zonal Rank
1.	Level A	> 0.6	8, 9, 10, 20, 14	5	High
2.	Level B	0.45 – 0.60	12, 13, 15, 16, 18, 19	6	Medium
3.	Level C	0.30 – 0.45	1-4, 5-7, 11, 17	9	Low

As shown in Table No :4, the zones can be divided into three ZAP levels. Level A shows high potentiality of the zones, where housing activities are decidedly concentrated. In order to have a balanced growth of the urban area, the zones falling in Level B and C can be attended to and the factors of attraction can be improved upon.

CONCLUSION

The Zonal Attraction Potential (ZAP) is a new concept in field of urban housing for Zonal Ranking process. Urban Development efforts were judgmental so far and not scientifically evaluative. The method and case study presented here have shown a new direction for the urban planners, developers and city managers in the field of urban housing and balanced sustainable development. The major regional metropolitan was divided in study zones at micro level and inherent quality of zonal ranks were evaluated, which can become a guiding path for city developers. The zonal development approach implemented on the basis of zonal ranks in the order of zonal attraction potential values may help in controlling the land values also. The notion may prove to be a boon.

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Appendix – I

Basic Indicators, Best and Worst Values (Zonal Level)

Zone	I	II	III	IV	V	VI	VII
1	10.0	1.0	6.0	8.0	8.8	10.0	6.0
2	8.4	2.0	5.5	9.1	9.9	10.0	6.0
3	5.6	0.0	5.5	10.0	10.0	10.0	6.0
4	6.3	2.0	5.0	6.9	10.0	10.0	6.0
5	5.4	3.0	5.0	3.6	5.3	5.0	4.0
6	5.6	2.0	4.0	4.5	5.5	5.0	4.0
7	6.3	3.0	5.0	2.6	7.9	9.2	4.0
8	2.1	8.0	4.5	4.0	2.0	3.0	4.0
9	2.8	6.0	4.5	5.0	3.7	4.5	6.0
10	1.5	4.0	4.5	2.4	6.1	7.0	7.0
11	3.4	2.0	4.5	2.4	4.2	2.0	2.0
12	1.0	5.0	4.0	3.3	5.3	3.5	3.0
13	1.1	4.0	3.0	0.8	4.2	4.2	4.0
14	2.1	5.0	3.0	2.7	2.6	7.0	5.0
15	4.0	4.5	4.0	3.4	3.5	4.3	3.0
16	0.3	7.0	4.0	0.2	1.9	3.2	4.0
17	1.0	3.0	2.5	3.0	2.8	2.5	2.5
18	0.3	3.0	5.5	2.8	3.7	4.3	5.0
19	1.1	5.0	3.0	0.8	1.5	3.0	3.0
20	0.3	7.0	5.0	4.0	3.0	5.0	4.0
Best Rating	2.0	8.0	8.0	8.0	8.0	8.0	8.0
Worst Rating	8.0	2.0	2.0	0.5	0.5	1.0	1.0

I – Land Value　II – Vacant Value　III – Resi. Land　IV – Accessibility
V – Road Area　VI – Utilities　VII – Amenities

Appendix – II

Basic Indicators, Best and Worst Values (City Level)

Zone	I	II	III	IV
1	6.1	0.0	3.0	6.0
2	3.9	0.0	5.0	10.0
3	3.6	0.0	3.0	10.0
4	5.1	0.0	3.0	10.0
5	4.9	3.8	7.0	6.0
6	3.3	7.3	8.0	6.0
7	5.9	0.3	3.0	6.0
8	5.7	2.5	3.0	4.0
9	6.3	6.3	3.0	3.0
10	5.6	9.6	5.0	2.0
11	3.8	4.0	7.0	8.0
12	4.4	3.0	8.0	4.0
13	3.0	6.0	4.0	4.0
14	4.6	7.1	6.0	2.0
15	6.4	6.7	6.0	2.0
16	2.5	0.9	5.0	2.0
17	2.0	1.5	7.0	2.0
18	2.5	1.5	7.0	2.0
19	5.5	1.5	4.0	2.0
20	6.5	4.0	3.0	2.0
Best Rating	8.0	8.0	2.0	2.0
Worst Rating	2.0	2.0	8.0	8.0

I – Housing Growth Potential　II – Housing Activity　III – Constrains　IV – Density

Appendix – III
Weights of Eigen Value Matrices

- **Matrix – I**

	Land Value	Vacant Land	Residential Land
Land Value	1.0	3.0	4.0
Vacant Land	0.33	1.0	5.0
Residential Land	0.25	0.20	1.0

- **Matrix – II**

	Accessibility	Road Area
Accessibility	1.0	3.0
Road Area	0.33	1.0

- **Matrix – III**

	Utilities	Amenities
Utilities	1.0	3.0
Amenities	0.33	1.0

- **Matrix – IV**

	Land Attrac.	Accessibility	Services
Land Attrac.	1.00	4.0	3.0
Accessibility	0.25	1.0	0.33
Services	0.33	3.0	1.00

- **Matrix - V**

	Housing Growth Potential	Housing Activities
Housing Growth Potential	1.0	3.0
Housing Activities	0.33	1.0

- **Matrix - VI**

	Constrains	Density
Constrains	1.0	2.0
Density	0.5	1.0

- **Matrix - VII**

	Housing Growth	Environmental
Housing Growth	1.0	3.0
Environmental	0.33	1.0

- **Matrix - VIII**

	Zonal Potential	City Potential
Zonal Potential	0.33	1.0
City Potential	1.0	3.0