

Integration of GIS and Fuzzy MCDM approach for Real Estate Investment analysis

Keyur Kapadia¹, Somya Agarwal²
^{1,2} (Department of civil engineering, BITS-Pilani, India)

Abstract: Real estate is one of the fastest growing sector nowadays in our country. With increasing population, demand and foreign investments and flexibly in rules and regulations by various organizations e.g. housing bank loans schemes etc. have further added to its growth rate. Today most of the cities are facing non-uniform growth. If one wants to invest in real estate then, where to invest? , how much to invest? Are some of the few questions that comes to our mind at first glimpse. So this project mainly focuses on the growth and point of investment in any city. Further it includes site selection for new real estate development with uniform growth of the city. This includes the use of GIS based software for the same which will be followed by decision making tool for obtaining the optimum location for investment.

Keywords: GIS, Real estate, Investment analysis, Fuzzy AHP, Fuzzy TOPSIS.

I. Introduction

Real estate is the combination of natural and artificial resources at any place. The buying and selling takes place for the real property takes place to generate income source. It majorly consists of residential and commercial places. The residential real estate is type of property containing individual or multiple families available for non-commercial purpose. Similarly, commercial real estate are the type of property which are available for business purpose to single or multi-occupant. The real estate plays a major role in overall development of any city. It also plays a major role in generating GDP for the country. In India the real estate contributes 20.54 % of total GDP of country. It is one of the most growing sector in India. Generating income through real estate has become a major source of income for many people, for some it is the only source. The money earned from other industries are sometime invested in real estate for future source of income. The investment in real estate are in terms of selling, buying, and leasing of residential, commercial or land type property.

I.1 why investment analysis needed?

As it is one of the highest growing field and higher GDP contributing Field the investment analysis becomes a major need so that invested money does not become dead investment or its value doesn't decrease. A proper investment analysis is needed in order to prevent the above mentioned situation.

The value of real estate property highly depends on the location of the property and the facilities that are available nearby. The location plays a major role as for a land situated far away from the city its value will not increase high rate due to less developed area and also no other facilities would be available so people try to prevent investment at such location. The return on investment may be high at such location but at slow rate. This type o location may be helpful if money is to be invested for a longer period of time. This shows the importance of the location in real estate investment.

Many techniques have been developed recently for investment analysis purpose. MCDM tools are gaining much focus due to its decision based on multiple criteria making it reliable. But it lacks in considering the location condition and situation as manually surveying the area is a difficult task to be done to collect data. This situation can be overcome by incorporating the use of Geographic information system for extracting location based information electronically just by means of Computers. The major similarity in GIS and real estate is its requirement of location based information for analysis. This study describes the incorporation GIS and MCDA tool in order to obtain the best location for investment in real estate. The data extracted from GIS is been used in MCDM tool to reach the decision for real estate investment location. The analysis has been carried out considering 3 areas of the Surat city that are being developed most recently. The study area is been defined in detail in the next section.

II. Methodology

The whole project is divided into two parts. First includes use of GIS technology and the second part includes use of multi-criteria decision making tool to select appropriate site for real estate investment. GIS is used to find out the fallow land and built-up areas available in the selected three areas of study area. Then the calculated area is used to find out the growth rate.

MCDM tool is used to analyze all parameter for the three alternatives i.e. three developing areas taken in this study of the Surat city. Results from the two methods fuzzy AHP and fuzzy TOPSIS are compared. The overall project work methodology adopted is as below.

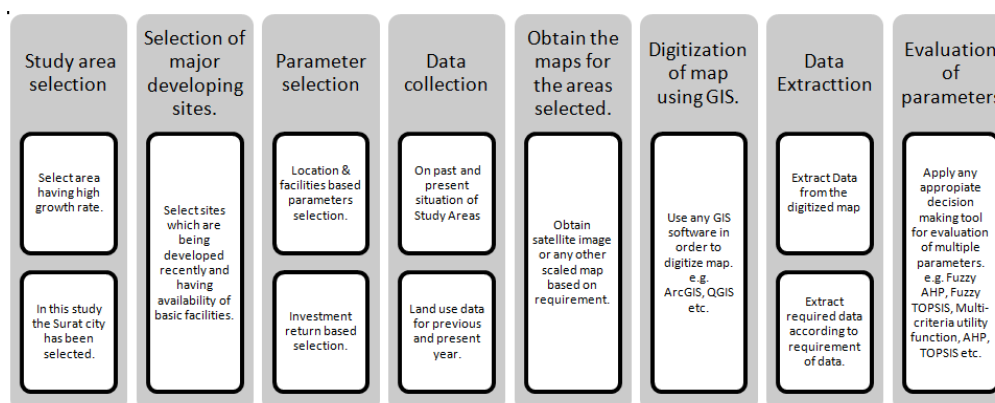


Figure 1 Methodology

II.1 Study Area

In this study, Surat city of Gujarat is considered due to emerging growth in real estate as study area. It is one of the top most growing city in the world and is ranked 2nd as the most developing city. Surat city is also known as the diamond hub of the world and is the one of the major textile hub of India. Due to both the trades, the money flow in the city is very high. Recently Surat city and its adjoining areas have started developing to great extent in terms of infrastructure and overall growth. Real estate investment is one the major ongoing trend of investment in the city. Continuously growth in the adjoining areas has further added to the same. The considered study, consists of three newly developing areas for the analysis i.e. Vesu, Pal & Unn. These newly developing areas are considered as good alternative for investment as the return on investment is high due to rapid growth rate.

Though these developing areas have high rate return on investment but they to some extent they lack in basic facilities. For example, Unn has poor public transport facility thereby leading to poor accessibility to the central business district of city even though investment in real estate is high. These developing areas does not have high return on investment in current situation but on forecasting future, high rate of return is expected. Further in the study, areas are considered on the basis of the recent development and fallow land availability.

Second study area of the Surat city taken for study is vesu. It is one of the fastest growing area with maximum growth rate, high return on investment, maximum number of facilities available (commercial complex, hospitals, school) in the vicinity of residential areas.

At last, pal located on the opposite side of the river Tapi. It is also the developing area and is considered as the good option for real estate investment. Though the development in public transport facility is going on, still it is considered as the good option for investment

II.2 Parameter selection:

Selection of parameters for any study is one of the most important factor as the result may vary a lot on the basis of the parameters considered.

According to the ideal real estate site, it should have all the lowest values of input and the highest values of outputs. It is noted inputs and outputs can be spatial criteria as well as economical criteria. Hence observable criteria, such as facilities available (commercial complex, school, hospital) in the vicinity of the residential areas, growth rate, return on investment, public transport facilities available etc. are used.

Parameters selected for study are:

- Growth rate
- Land value
- Return on investment
- Public transport available
- Basic facilities (market, hospital etc.)

II.3 Data Collection:

Data for different areas is collected by surveying the area, contacting the contractors for land rate, using Google earth and GIS for calculating the areas of built-up land and fallow land etc.

II.4 GIS (Geographic Information System)

GIS and Real estate can be much related as both are based on location. Real estate investment depends very much on location due to different parameters such as land use, transport facilities, commercial space available etc.. for this reason GIS can be successfully incorporated in Real estate investment procedure, as all the data can be represented by means of map and also the data regarding the above parameters can be easily extracted. GIS helps reduce the effort of physically visiting the site and analysing the situation of any area. Instead with help of GIS the data regarding the development at any location can be observed electronically and can be used for evaluation. The growth rate for any site can be obtained by means of GIS. The effort required for collecting and analysing data can be narrowed down effectively. Performance of any site regarding the real estate can be evaluated in terms of growth for the site.

GIS is used in this study for the purpose of digitization of real estate data and the data regarding fallow land available, total built up area were extracted and used to obtain the growth rate of a particular location in city. For this purpose GIS based software Esri’s ArcGIS was used to obtain data.

The procedure followed to extract data is as described below.

1. Obtain satellite map for the site required for analysis.
2. Geo-reference the map image using geo-referencing tool in ArcGIS.
3. Further form required polygon shape files.
4. Form polygonal map using by drawing polygon and digitize the map.
5. Obtain the data regarding the area from the polygon formed by area option in attribute table for the shape file.

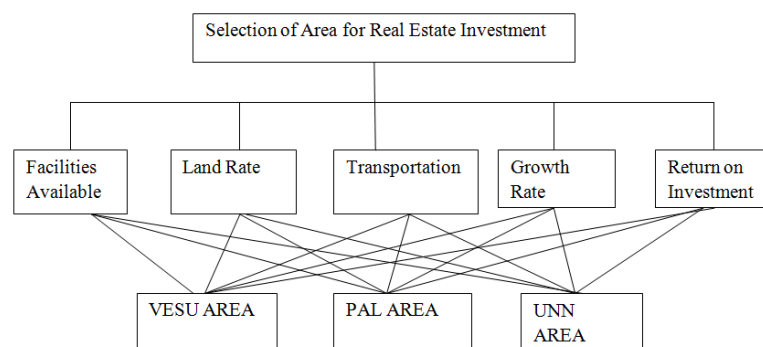
II.5 MCDM (Multi-criteria decision making Methods):

MCDM is concerned with structuring the decision and planning problem. It helps in obtaining the decision through mathematical manipulation in the structured problem. MCDM takes the decision makers individual criteria priorities and provides the overall ranking or priority.

MCDM is general term used for different techniques used for obtaining priorities in different ways. Some of the different methods of MCDM includes Weighted sum, PROMTHEE (Preference ranking organisation method for enrichment of evaluation), ELECTRE (Elimination and choice expecting reality)- I, II, III, IV, AHP (Analytical Hierarchy process), Fuzzy sets, Multi-attribute analysis, Multi-criteria utility theory, Cluster analysis, TOPSIS (technique for order of preference by similarity and ideal solution, DEA (Data Envelope analysis), VIKOR, further may of this techniques has been merged and applied in order to overcome the limitations and disadvantages of each other.

II.5.1 Fuzzy Analytical Hierarchical Process

The present study includes evaluation of criteria for investment in real estate in the Surat city on the basis of various factors i.e. facilities available, land rate, transportation, etc by fuzzy AHP method i.e. Buckley and by the Fuzzy TOPSIS method. Five vital parameters for investment in real estate are considered. The whole study is decomposed into various hierarchical levels. The topmost level shows selection of the most effective area for real estate investment in the newly developed area of the city Surat while next level deals with the criteria for selection and the third level deals with the alternatives.



In this study Buckley’s method of Fuzzy AHP and Fuzzy TOPSIS has been effectively applied for a case study of selection of area for real estate investment in the Surat City .The proposed methodology of fuzzy AHP approach using triangular fuzzy numbers which are used to perform the pair-wise comparison among criteria on the basis of their relative importance and the areas available on the basis of each criteria. Second methodology includes Fuzzy TOPSIS. Relative weights obtained from the Buckley’s method of criteria-criteria matrix are used as used in Fuzzy TOPSIS to form weighted fuzzy normalized decision matrix.

II.5.1.1 Buckley’s method of Fuzzy AHP:

Normal Fuzzy does not includes pair-wise comparison and hence relative importance of criteria cannot be found whereas normal AHP does not takes into account the uncertainty associated with the mapping of human decision into numerical form. But integrated Fuzzy AHP includes pair-wise comparison and the triangular fuzzy number for mapping of human decision more accurately.

Step by step procedure for Buckley’s method is given below:

1. Weights of the matrix among criteria is determined and the weights of different alternative(areas for investment) on basis of each criteria are also determined to find out the overall weights for real estate investment in three different areas of Surat city.
2. The normalized weights for each investment area and criteria are determined by the sum of weights obtained from Buckley’s method and then dividing each weight from the sum.

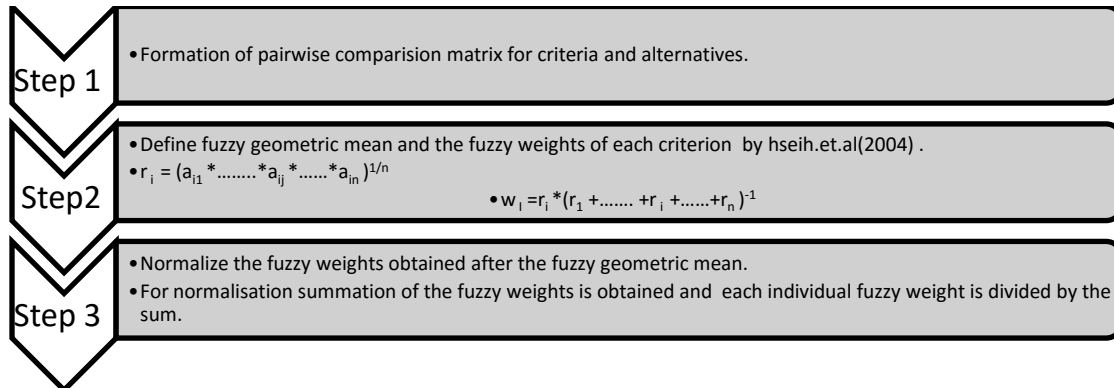


Figure 2 Hierarchy for Fuzzy AHP

II.5.2 Fuzzy TOPSIS:

In this study, Fuzzy TOPSIS was also used as the merit of using a fuzzy approach to the TOPSIS is to assign the relative attributes using fuzzy numbers instead of precise numbers for suiting the real world in fuzzy environment. The method is based on the concept that the chosen alternative should have the shortest distance from the positive- ideal solution (i.e. minimal gaps in each criterion from ideal situation) and for the negative ideal solution, criteria has maximum gaps in each criterion.

Step wise procedure is shown below:

1. Using fuzzy AHP to determine weights of criteria
2. Construct the performance matrix among criteria and areas selected for investment.
3. Find normalized decision matrix
4. Find weighted fuzzy normalized decision matrix.
5. Determine the distance from positive ideal solution and negative ideal solution.
6. Obtain degree of satisfaction and degree of gap.

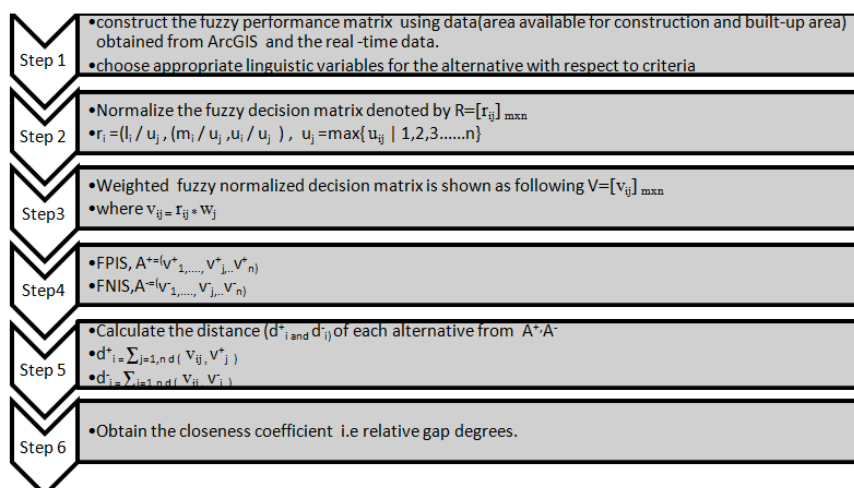


Figure 3 Hierarchy for Fuzzy TOPSIS

Case Study:

The steps described were used to extract data using ArcGIS. Step wise procedure with example is show below.

STEP 1:

Obtain the satellite image of the study area (in this case Google maps was used). A sample satellite image file is shown below.

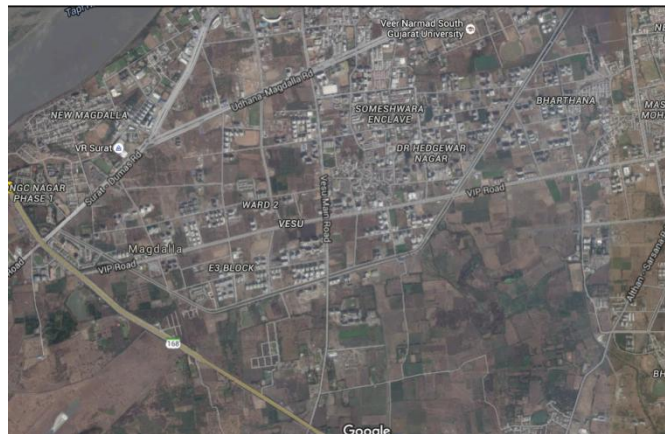
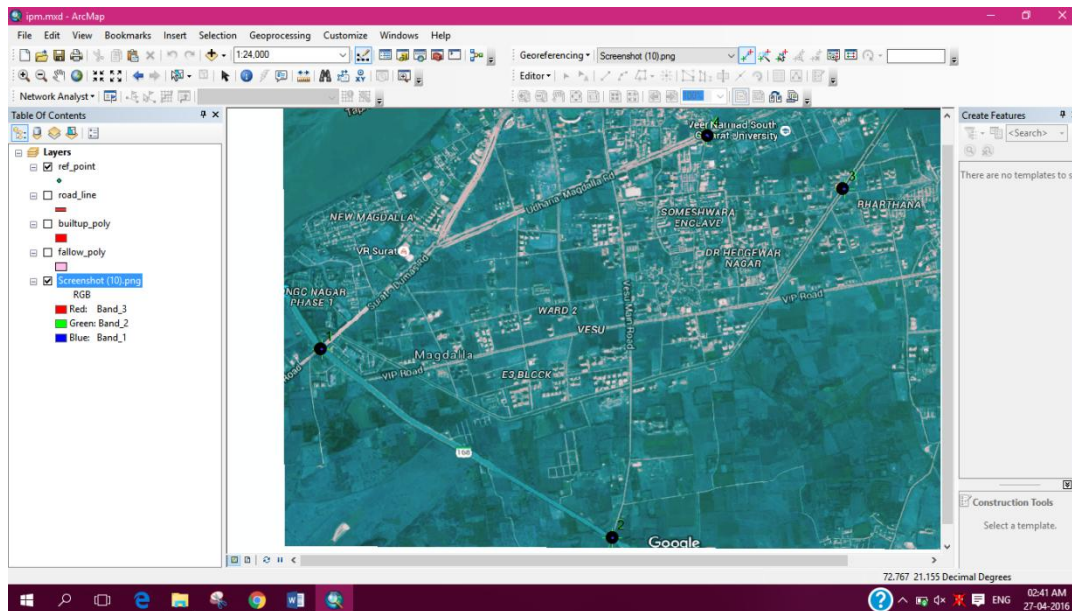


Figure 4 satellite image for vesu Figure 5 Geo-referencing using ArcGIS

STEP 2: Geo-referencing:

The Latitude and longitude at 4 points were obtained from the Google maps. It is as described below.

The control points were drawn initially and the control point were connected to the exact point on map and the maps were geo-referenced. The geo-referenced map image is as shown below for the same.



STEP 3: Create Polygon shape file for Built-up and Fallow land.

After the shape file has been created create polygon for the built up and fallow land area. The image for the same is shown below for single area.

After successful formation of polygon according to the specified area in map the polygon map, similarly for other two areas of study area polygon maps were formed. The maps obtained are shown in result.

Fuzzy AHP:

The fuzzy triangular numbers are used to express linguistic variables into numerical form. Further these triangular numbers reduces uncertainty associated with the human decision mapping. FTN (fuzzy triangular number) used in this study are shown in table 1.

Table 1 Fuzzy linguistic rating variable

Linguistic Variable	Triangular Fuzzy Number	Triangular Fuzzy Number
Equally important	$\tilde{1}$	(1,1,3)
Weakly important	$\tilde{3}$	(1,3,5)
Weakly important	$\tilde{5}$	(3,5,7)
Very strongly important	$\tilde{7}$	(5,7,9)
Absolutely important	$\tilde{9}$	(7,9,9)

Graphical representation of FTN

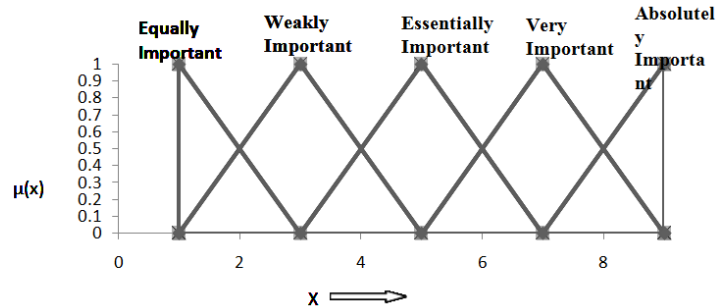


Figure 6 Graphical fuzzy representation of Fuzzy number

Response matrices:

Response matrices were formed for the criteria and alternative. The real value matrix formed for criteria and alternatives are shown in table 2. This values were used to rate the alternatives w.r.t the parameters (table 3). Also pairwise comparison matrix (table 4) was formed in order to obtain weights of each criteria by means of Fuzzy AHP.

Table 2 Real value matrix

	Vesu	Pal	Unn
Growth rate	93%	100.00%	75%
Return on investment	42%	40%	50%
Land rate	100000.00	70000.00	50000.00
Facility available	7	5	3
Transportation	5	3	1

Table 3 Alternative to criteria rating

	C1	C2	C3	C4	C4
A1	(5,7,9)	(7,9,10)	(3,5,7)	(5,7,9)	(3,5,7)
A2	(3,5,7)	(7,9,10)	(1,3,5)	(5,7,9)	(1,3,5)
A2	(1,3,5)	(3,5,7)	(0,1,3)	(3,5,7)	(7,9,10)

Table 4 Pair-wise comparison matrix

	C1	C2	C3	C4	C5
C1	(1,1,1)	(0.2,0.33,1)	(0.142,0.2,0.33)	(0.11,0.142,0.2)	(0.2,0.33,1)
C2	(1,3,5)	(1,1,1)	(1,3,5)	(3,5,7)	(5,7,9)
C3	(3,5,7)	(0.2,0.33,1)	(1,1,1)	(1,3,5)	(1,3,5)
C4	(5,7,9)	(0.142,0.2,0.33)	(0.2,0.33,1)	(1,1,1)	(1,1,3)
C5	(1,3,5)	(0.11,0.142,0.2)	(0.2,0.33,1)	(0.33,1,1)	(1,1,1)

Calculation steps for obtaining weights of each alternatives w.r.t individual criteria are shown. Alternatives were rated according to the fuzzy scale shown in table 1.

For criterion C1(Facility Available):

Pair-wise comparison matrix of alternatives w.r.t. criteria C1.

Table 5 Pairwise comparison matrix of alternative w.r.t criteria C1

	VESU	PAL	UNN
VESU	(1,1,1)	(3,5,7)	(5,7,9)
PAL	(0.142,0.2,0.33)	(1,1,1)	(3,5,7)
UNN	(0.11,0.142,0.2)	(0.142,0.2,0.33)	(1,1,1)

Geometric mean in row wise pattern (l_i,m_i,n_i)

Geometric mean for all the alternatives were obtained as follows.

$$\tilde{r}_i = (\tilde{\alpha}_{i1} * \dots * \tilde{\alpha}_{ij} * \dots * \tilde{\alpha}_{in})^{1/n}$$

Lower bound $l_i = (1 * 3 * 5)^{1/3}$

Middle bound $m_i = (0.142857 * 1 * 3)^{1/3}$

Upper bounds $u_i = ((1 * 7 * 9)^{1/3})$

Fuzzy weights for each criterion

$$\tilde{w}_i = \tilde{r}_i * (\tilde{r}_1 + \dots + \tilde{r}_i + \dots + \tilde{r}_n)^{-1}$$

Table 6 Relative fuzzy weight

	RELATIVE FUZZY WEIGHTS
A1	(0.431844, 0.71471, 1.146215)
A2	(0.132019, 0.218494, 0.382072)
A3	(0.044006, 0.066796, 0.116803)

Defuzzified weights and normalized weights

To convert the triangular fuzzy number into single crisp value defuzzication is used. Prioritization of alternatives is done on the basis of normalized weights obtained.

DFV_i (Defuzzified value) = (lwi +mw_i+uw_i)/3

Normalization of weight = DFV_i/∑DFV_i

Table 7 Final weight matrix w.r.t C1

Defuzzified values	Normalized value
0.764256118	0.70482535
0.244195102	0.225205784
0.07586863	0.069968866

Similar procedure for obtaining GM and Relative fuzzy weight were used for all the criteria. Only pairwise comparison matrix and final defuzzified and normalized weights are shown further for other criteria.

For criteria C2 (Land Rate)

Pair-wise comparison matrix of alternatives w.r.t. criteria C2.

Table 8 Pair-wise comparison matrix for alternative w.r.t. C2

	VESU	PAL	UNN
VESU	(1,1,1)	(3,5,7)	(5,7,9)
PAL	(0.142,0.2,0.33)	(1,1,1)	(3,5,7)
UNN	(0.11,0.142,0.2)	(0.142,0.2,0.33)	(1,1,1)

De-fuzzification is carried out to convert triangular fuzzy number into single crisp value for further normalization. De-fuzzified values and normalized values for land rate criteria are shown below in the form of table

Table 9 final weight matrix w.r.t. C2

	DEFUZIFIED VALUES	NORMALIZED VALUE
A1	0.764256118	0.70482535
A2	0.244195102	0.225205784
A3	0.07586863	0.069968866

For criterion 3(Transportation)

Accessibility to region is one of the major reasons for development. Better the transportation facility available better is the growth rate and higher is the development.

Table 10 pairwise comparison matrix for alternative w.r.t. C3

	VESU	PAL	UNN
VESU	(1,1,1)	(1,3,5)	(5,7,9)
PAL	(0.2,0.33,1)	(1,1,1)	(3,5,7)
UNN	(0.11,0.142,0.2)	(0.142,0.2,0.33)	(1,1,1)

De-fuzzified weights are further normalized weights. Ranking is done on the basis of normalized weights for transportation facility.

Table 11 Final weight matrix w.r.t C3

	DEFUZZIFIED VALUES	NORMALIZED VALUE
A1	0.736114	0.618208
A2	0.368183	0.30921
A3	0.086424	0.072581

For criterion C4 (Growth Rate)

It is the most important parameter in real estate investment. Fallow land area and the built-up areas calculated for each alternative by using Arc-GIS is further used to find growth rate. Pair-wise comparison matrix of alternatives w.r.t. criteria C4.

Table 12 Pairwise comparison matrix of alternative w.r.t. C4

	VESU	PAL	UNN
VESU	(1,1,1)	(0.11,0.142,0.2)	(3,5,7)
PAL	(5,7,9)	(1,1,1)	(7,9,9)
UNN	(0.142,0.2,0.333)	(0.11,0.11,0.142)	(1,1,1)

De-fuzzified weights obtained from the Buckley’s method for criteria growth rate are further normalized to find out the priority of the alternatives

Table 13 Final weight matrix w.r.t. C4

	DEFUZZIFIED VALUES	NORMALIZED VALUE
A1	0.185691	0.179381
A2	0.788262	0.761476
A3	0.061224	0.059143

For criterion 5(Return on investment)

Investments in real estate are generally done by foreseeing future scope of return. High rate of return on investment is one of the main reasons for investing in real estate. Pair-wise comparison matrix of alternatives w.r.t. criteria C5.

Table 14 Pairwise comparison matrix of alternative w.r.t. C5

	VESU	PAL	UNN
VESU	(1,1,1)	(3,5,7)	(0.111,0.142,0.2)
PAL	(0.142,0.2,0.333)	(1,1,1)	(0.111,0.111,0.142)
UNN	5	(7,9,9)	(1,1,1)

Evaluation of Pair-wise comparison matrix for criteria

Table 15 Pairwise comparison matrix for Criteria

	C1	C2	C3	C4	C5
C1	(1,1,1)	(0.2,0.33,1)	(0.142,0.2,0.33)	(0.11,0.142,0.2)	(0.2,0.33,1)
C2	(1,3,5)	(1,1,1)	(1,3,5)	(3,5,7)	(5,7,9)
C3	(3,5,7)	(0.2,0.33,1)	(1,1,1)	(1,3,5)	(1,3,5)
C4	(5,7,9)	(0.142,0.2,0.33)	(0.2,0.33,1)	(1,1,1)	(1,1,3)
C5	(1,3,5)	(0.11,0.142,0.2)	(0.2,0.33,1)	(0.33,1,1)	(1,1,1)

De-fuzzified weights and the normalized weights obtained from the pair-wise criteria matrix are used to find the ranking of criteria.

Table 16 Final weight matrix for Criteria

	DEFUZZIFIED VALUE	NORMALIZED WEIGHTS
C1	0.080526	0.054257
C2	0.647407	0.436212
C3	0.392703	0.264597
C4	0.218236	0.147044
C5	0.145284	0.09789

Fuzzy TOPSIS:

1. In fuzzy TOPSIS pair-wise comparison matrix cannot be used instead, alternative and criteria comparison matrix was used for evaluation of distance from positive and negative ideal solution on basis of which degree of satisfaction and gaps were determined which were further used to rate the matrix.

Table 17 Alternance to Criteria Rating Matrix

	C1	C2	C3	C4	C4
A1	(5,7,9)	(7,9,10)	(3,5,7)	(5,7,9)	(3,5,7)
A2	(3,5,7)	(7,9,10)	(1,3,5)	(5,7,9)	(1,3,5)
A2	(1,3,5)	(3,5,7)	(0,1,3)	(3,5,7)	(7,9,10)

2. Max upper bound value in the above matrix =10
3. Weights used in fuzzy TOPSIS are from Buckley’s relative weights of pair-wise criteria matrix.

Table 18 Relative fuzzy Weight matrix

Criteria	RELATIVE FUZZY WEIGHTS			
C1	(0.024613,0.05211,0.1648)	0.05211	0.164856	
C2	(0.184689,0.5219,1.235)	0.521965	1.235567	
C3	(0.097038,	0.28392	0.797151	
C4	0.072812	0.142005	0.439892	
C5	0.040286	0.112158	0.283407	

4. Weighted fuzzy normalized decision matrix is obtained using the formula

$$[\tilde{V}] = [\tilde{v}_{ij}]_{n \times n}$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} * \tilde{w}_j$$

$$\tilde{r}_{ij} = \left(\frac{l_{ij}}{u_j^+}, \frac{m_{ij}}{u_j^+}, \frac{u_{ij}}{u_j^+} \right)$$

For C1 –C1 value of pair-wise comparison matrix
Lower Bounds =(5*0.024613)/10

Similarly, all other values of the weighted normalized decision matrix are calculated.

5. Now distance from ideal point is calculated for both positive and negative distances

Table 19 TOPSIS distance matrix

d+(from ideal)	d-(from negative)
0.328640469	1.542274296
0.479720865	1.388897996
0.789184668	1.066693165

6. Now closeness coefficient values are calculated. The smaller the value of positive closeness coefficient i.e. smaller is gap from positive ideal point and vice- versa for negative closeness coefficient.

Table 20 Closeness coefficient matrix

cc+(gaps)	cc-(satisfaction)
0.175658	0.824342
0.256725	0.743275
0.425235	0.574765

Cc+ is calculation as follows:

$$cc_{+1} = 0.3286 / (0.328640469 + 1.542274296)$$

III. Results And Discussion

The results obtained by following the methodology are shown and discussed in detail.

III.1 GIS RESULTS:

The digitized map obtained by means of GIS for all the three areas are shown below. The below images shows the digitized map for the year 2014-2015. Similarly the digitized map were formed for the year 2004-2005.

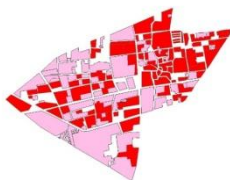
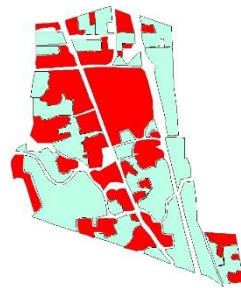


Figure 7 pal Polygon map **Figure 8** unn Polygon Map



Red color shows the built-up area and green, pink and blue area shows the fallow land available. The area result obtained by means of GIS is as shown in table below for all the study area taken.

Site	Total area	Built-up area	Fallow land
Vesu	5.778	1.993	2.08
Pal	2.08	0.58	0.99
Unn	2.91	1.079	1.329

III.2 Fuzzy AHP:

The criteria weights and weights of alternatives w.r.t to individual criteria using Fuzzy AHP are shown in table

	Criteria weight	VESU	PAL	UNN
C1	0.054257	0.704825	0.225206	0.069969
C2	0.436212	0.704825	0.225206	0.069969
C3	0.264597	0.618208	0.30921	0.072581
C4	0.147044	0.179381	0.761476	0.059143
C5	0.09789	0.179852	0.059222	0.760926

Overall weight for each alternative were obtained by simple weighted sum and the alternatives were ranked based on overall weight

Vesu	Pal	Unn
0.553254	0.31004	0.136706
1	2	3

III.4 Fuzzy TOPSIS:

Also the Results obtained by means of Fuzzy TOPSIS are tabulated below. The ranking given were on the basis of degree of satisfaction value obtained.

Site	Degree of satisfaction	Rank
Vesu	0.824342	1
Pal	0.743275	2
Unn	0.574765	3

The result obtained on the basis of study describes the best site for investment as vesu in both the cases (Fuzzy AHP and Fuzzy TOPSIS). This result obtained can be supported as it can be seen observed from the parameters data that most of the parameters are in favor of the first area. Such as public transport facilities available is best in vesu while pal and Unn falls below it. Similarly in case of return on investment and growth rate vesu surpasses the other two alternatives. The only issue was found to be higher investment amount in vesu due to its higher growth rate.

IV. Conclusion

The paper describes the incorporation of GIS based MCDM approach for real estate investment. GIS based MCDM is said as input obtained from GIS were further used in MCDM to evaluate the alternatives in basis of parameters. The GIS provides data from the visual factors while the MCDM techniques provide solution based on objective approach. The further more detailed analysis can be carried out by selection of different evaluation parameters which are more location based. The GIS can further be used to extract more location based data and can be used as input for different MCDM techniques which will help reach the goal. The paper describes an alternative for real estate investment approach. The result obtained can be verified with real world situation.

Acknowledgement

This research is the product of many people who helped us throughout the study. We are grateful to PhD scholar Harish Puppala for their guidance throughout the project.

References

- [1]. Heng Li Ling Yu Eddie W. L. Cheng, (2005), "A GIS-based site selection system for real estate projects", *Construction Innovation*, Vol. 5 Issue 4 pp. 231 – 241 <http://dx.doi.org/10.1108/14714170510815276>
- [2]. Wade Fransson, David Nelson, (2000), "Management information systems for corporate real estate", *Journal of Corporate Real Estate*, Vol. 2 Iss 2 pp. 154-169 <http://dx.doi.org/10.1108/14630010010811284>
- [3]. Claire Anumba, A.R.J. Dainty, S.G. Ison, Amanda Sergeant, (2005), "The application of GIS to construction labour market planning", *Construction Innovation*, Vol. 5 Issue 4 pp. 219-230
- [4]. Elli Pagourtzi, Konstantinos Nikolopoulos, Vassilios Assimakopoulos, (2006), "Architecture for a real estate analysis information system using GIS techniques integrated with fuzzy theory", *Journal of Property Investment & Finance*, Vol. 24 Issue 1 pp. 68-78 <http://dx.doi.org/10.1108/14635780610642971>
- [5]. Wade Fransson, David Nelson, (2000), "Management information systems for corporate real estate", *Journal of Corporate Real Estate*, Vol. 2 Issue 2 pp. 154-169 <http://dx.doi.org/10.1108/14630010010811284>
- [6]. KandyaAnurag, KolliNarendrareddy, Manju Mohan, Pathan S K., PandeySucheta (2011), "Dynamics of Urbanization and its Impact on Land-Use/Land-Cover: A Case Study of Megacity Delhi" Available: <http://www.scirp.org/journal/PaperInformation.aspx?PaperID=8286>
- [7]. Ni-Bin Chang, G. Parvathinathan, Jeff B. Breeden, Combining GIS with fuzzy multicriteria decision-making for landfill siting in a fast-growing urban region, *Journal of Environmental Management* 87 (2008) 139–153
- [8]. PETER J. WYATT (1997), "The development of a GIS-based property information system for real estate valuation", *International Journal of Geographical Information Science*, 11:5, 435-450, DOI: 10.1080/136588197242248 Available:<http://dx.doi.org/10.1080/136588197242248>