Framework the Application of MCDM for Residential Land Development Site Selection in Nashik region

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***Abstract*: We know In recent years, several factors have had an increasing influence on the current practice of selection of residential land development, that are Increased ecological and environmental awareness, Social acceptance of land development activities, Complex permitting process, Multiple plan reviews by numerous regulatory agencies. An important phase within the overall residential land development process is preliminary project planning, which a highly coordinated effort is involving a number of decisions that are made by a variety of individuals. One critical decision faced by the project owner and the development team, during the preliminary planning phase, is the initial selection of the most appropriate site for a proposed conceptual development plan.**

The scope of this paper deals with (1) formulating a model for the preliminary planning phase of residential site selection; and (2) developing an associated decision support system that can assist the decision makers during this phase of the project. The analytical hierarchy process was the decision making theory used in the site selection decision support system. Analytical hierarchy process uses a hierarchical structure comprising both quantitative and qualitative factors that are based on factual data and the knowledge and experience of the decision makers.

To understand this survey was conducted and decision support system technique was applied to study the interaction and relation of one factor over another. These factors are also prioritized to see the priority of one factor over another. The result of this study discovered that the depending upon respondent's feedback he can decide impact factors that affect selection residential building sites from project managers point view in Nashik city.

***Keywords*: Residential land development site selection, Safety impact factor selection; F-AHP (triangular scale); MCDM.**

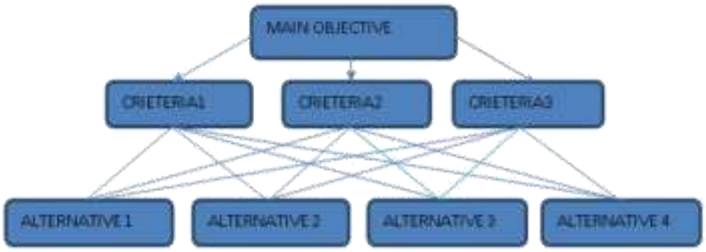
I. INTRODUCTION

The Fuzzy-Analytic Hierarchy Process method is one of the best methodologies based on triangular fuzzy analytic hierarchy process to solve the multi-decision making problems. It enables multiple decision makers on evaluation and uses F-AHP scale. By considering the number of residential projects in Nashik city, knowledge of the project manager & his behavior in site selection residential project plays a vital role in the land development site selection of construction industries. The aim of the research is implementation of land development site selection process on residential construction site with reduction in overall cost of the project. In this way, this research provides a better understanding and alertness about site selection procedures and different impact factor selection during a site selection of building construction project. The aim was to combine residential construction projects scheduling, site selection assessment activities on site and construction cost analysis to value safety costs and its distribution throughout a residential project. In this way, this research provides a better understanding of assessment and comparison of costs during a residential construction project.

A. Fuzzy Analytical Hierarchy Process (FAHP)

In this article, by using fuzzy AHP technique we propose a new method for safety impact factor selection problem. In this research paper, FAHP is used to make the decision of most suitable site selection factors in residential projects. The pair-wise comparisons are used to derive accurate ratio and scale priorities, Developed by Thomas Saaty , FAHP helps to capture both subjective and objective evaluation measures, providing a useful mechanism for checking the consistency of the evaluations thus reducing bias in decision making, [3,6]. In its simplest form, this structure comprises objectives, criteria and alternatives level. In this we given the preferences to each alternative of each main criterion and on the basis of given priority weights we decide the different site selection factors that affect land development process of residential construction

Each set of criteria would then be further divided into an appropriate level of alternative, recognizing that the more criteria included, the less important each individual criterion may become as illustrated Fig. 1.



$\widetilde{d_{nn}^{k}}$

$$\widetilde{d_{ji}} = \left[\frac{\sum_{i=1}^{k} \widetilde{d_{ji}}}{k}\right]$$

$$\tilde{A} = \begin{bmatrix} d11 & \cdots & d1n \\ \vdots & \ddots & \vdots \\ dn1 & \cdots & dnn \end{bmatrix}$$

Fig. 1: F-AHP hierarchy of objectives, criteria and alternatives

Step 1: Decision makers are required to compare each factor in the hierarchy. Decision makers use the fuzzy scale shown in Table 1 to compare factors. They use experimental data, perception, background, knowledge, etc. to make comparisons. Decision Maker compares the criteria or alternatives via linguistic terms shown in Table 1

Table 1: Linguistic terms and the corresponding triangular fuzzy numbers

Saaty scale	Definition	Fuzzy Triangular Scale
1	Equally important (Eq. Imp.)	(1, 1, 1)
3	Weakly important (W. Imp.)	(2, 3, 4)
5	Fairly important (F. Imp.)	(4, 5, 6)
7	Strongly important (S. Imp.)	(6, 7, 8)
9	Absolutely important (A. Imp.)	(9, 9, 9)
2	The intermittent values between two adjacent scales	(1, 2, 3)
4		(3, 4, 5)
6		(5, 6, 7)
8		(7, 8, 9)

According to the corresponding triangular fuzzy numbers of these linguistic terms, for example if the decision maker states "Criterion 1 is Weakly Important than Criterion 2", then it takes the fuzzy triangular scale as (2, 3, and 4). On the contrary, in the pair wise contribution matrices of the criteria, comparison of C2 to C1 will take the fuzzy triangular scale as (1/4, 1/3, 1/2).

The pair wise contribution matrices are shown in Eq.1, where dij^{k} indicates the k^{th} decision makers preference of i^{th} criterion over j^{th} criterion, via fuzzy triangular numbers. Here, "tilde" represents the triangular number demonstration and for the example case,$d^{1}12$ represents the first decision maker‟s preference of first criterion over second criterion, and equals to, $d^{1}12 = (2,3,4)$.

$$\widetilde{A^{k}} = \begin{bmatrix} \widetilde{d_{11}^{k}} & \cdots & \widetilde{d_{1n}^{k}} \\ \vdots & \ddots & \vdots \\ \widetilde{d_{n1}^{k}} & \cdots & \widetilde{d_{nn}^{k}} \end{bmatrix}$$

Step 2: If there is more than one decision maker, preferences of each decision maker ($\widetilde{d_{nn}^{k}}$) are averaged and ($\widetilde{d_{ji}}$) is calculated as in the Eq. 2.

$$\widetilde{d_{ji}} = \left[\frac{\sum_{i=1}^{k} \widetilde{d_{ji}}}{k}\right]$$

Step 3: According to averaged preferences, pair wise contribution matrices is updated as shown inEq. 3.

$$\tilde{A} = \begin{bmatrix} d11 & \cdots & d1n \\ \vdots & \ddots & \vdots \\ dn1 & \cdots & dnn \end{bmatrix}$$

Step 4: According to Buckley [48], the geometric mean of fuzzy comparison values of each criterion is calculated as shown in Eq. 4. Here, ri still represents triangular values.

$$r_i = \prod_{j=i}^{n} d_{ji}$$

Step 5: The fuzzy weights of each criterion can be found with Eq. 5, by incorporating next 3 sub steps.

Step 5a: Find the vector summation of each r_i.

Step 5b: Find the (-1) power of summation vector. Replace the fuzzy triangular number, to makeit in an increasing order.

These 7 steps are performed to find the normalized weights of both criteria and the alternatives. Then by multiplying each alternative weight with related criteria, the scores for each alternative is calculated. According to these results, the alternative with the highest score is suggested to the decision maker. In order to make the methodology clear and see its applicability, a real case study is taken in the next chapter.

1). Introduction.

The questionnaire interview was carried out among number of project manager and contractors small construction residential companies which are located in the Nashik region of Maharashtra (India). The majority of these firms are operating in Residential and G+4 projects. The interviews were carried out among top-level project managers who have an experience more than 8years and owners of the companies. Top-level managers and owners were selected for the interviews because they were assumed to have sufficient knowledge about the land development site selection process, working site conditions and various criteria. The 12 interviews took place over a 3 month period between February to May 2018 and each lasted approximately half to one hours. The questionnaire was carried through face-to-face interviews and it consisted of questionnaire format including different FAHP tables. The interviews reflects the opinion of experts from 12 firms, Results for Whole impact Factor Mean Score, and Fuzzy Analytic Hierarchy Process (F-AHP)

a) Application Fuzzy Analytic Hierarchy Process

The Fuzzy AHP methodology is applied in Decides impact factors that affect site selection on residential sites from project managers point view in Nashik city India. Therefore an example is considered for deciding the impact factors that affect land development process for residential sites among the number of alternative available in Nashik city residential building among four factors, selection attributes were identified and these are: MA- Market analysis, FA-Feasibility analysis, EF-Environmental Factor, RC-Regulatory condition And best other alternatives in residential construction.

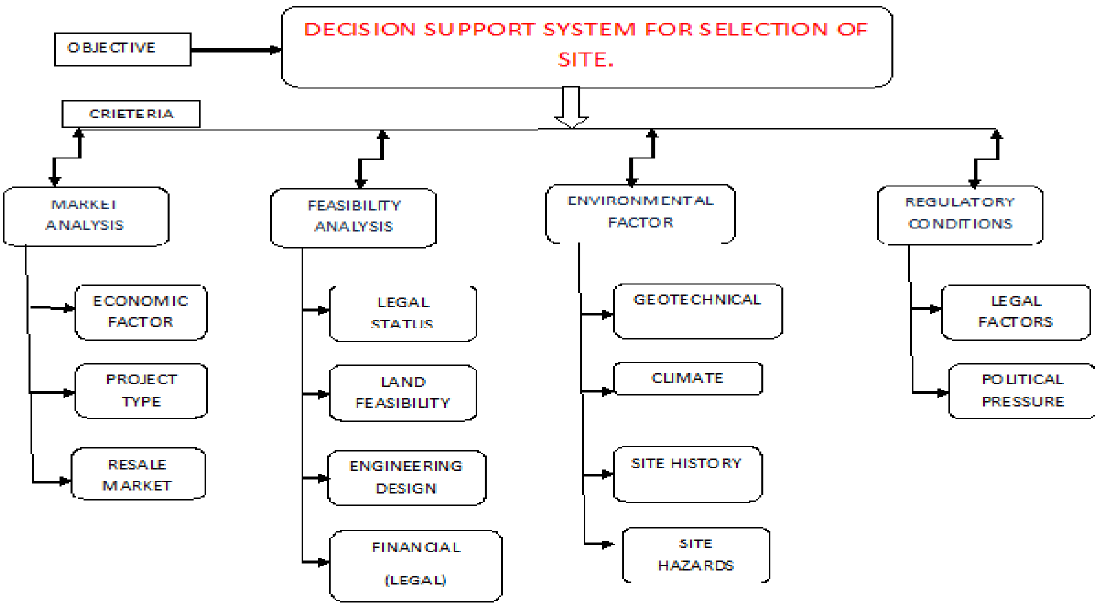


Fig. 2: The hierarchy of the criteria and the alternatives

Fig. 1. Determining Weights of Main Criteria (Level 1)

Table II: Pair Wise Comparisons of Main Criteria

A Imp	S. Imp	F. Imp	W. Imp	Criteria	Eq Imp	Criteria	W. Imp	F. Imp	S. Imp	A Imp
(9,9,9)	(6,7,8)	(4,5,6)	(2,3,4)		(1,1,1)		(2,3,4)	(4,5,6)	(6,7,8)	(9,9,9)
				MA	✓	FA				
				MA		EF			✓	
				MA	✓	RC				
				FA	✓	EF				
	✓			FA		RC				
	✓			EF		RC				

Table III: Comparison matrices for main criteria

	MA	FA	EF	RC
MA	(1,1,1)	(1,1,1)	(1/8,1/7,1/6)	(1,1,1)
FA	(1,1,1)	(1,1,1)	(1,1,1)	(6,7,8)
EF	(6,7,8)	(1,1,1)	(1,1,1)	(6,7,8)
RC	(1,1,1)	(1/8,1/7,1/6)	(1/8,1/7,1/6)	(1,1,1)

MA=$(1x1x1/8x1)^{1/4}$;$(1x1x1/7x1)^{(1/4)}$;$(1x1x1/6x1)^{(1/4}$ **= 0.5946; 0.6147; 0.6389**

FA= $(1x1x1x6)^{1/4}$; $(1x1x1x7)^{(1/4)}$; $(1x1x1x8)^{(1/4)}$ **=1.5650; 1.6265; 1.6817**

EF=$(6x1x1x6)^{1/4}$; $(7x1x1x7)^{(1/4)}$; $(8x1x1x8)^{(1/4)}$ **= 2.4494; 2.6457; 2.8284**

RC= $(1x1/8x1/8x1)^{1/4}$;$(1x1/7x1/7x1)^{1/4)}$;$(1x1/6x1/6x1)^{1/4)}$ **=0.3535; 0.3779; 0.4082**

Table .IV: Geometric means of fuzzy comparison values

Criteria	ri		
MA	0.5946	0.6147	0.6389
FA	1.5650	1.6265	1.6817
EF	2.4494	2.6457	2.8284
RC	0.3535	0.3779	0.4082
Total	4.9625	5.2648	5.5532
Reverse (power of -1)	0.2015	0.1899	0.1800
Increasing Order	0.1800	0.1899	0.2015

In the fifth step, the fuzzy weight of Quality criterion is found by the help of Eq. 5 and shown in Eq. 6. Hence the relative fuzzy weights of each criterion are given in Table 5.

Criteria	Wi		
MA	0.1070	0.1167	0.1287
FA	0.2817	0.3088	0.3388
EF	0.4408	0.5024	0.5699
RC	0.0636	0.0717	0.0822

In the sixth step, the relative non-fuzzy weight of each criterion (M_i) is calculated by taking the average of fuzzy numbers for each criterion. In the seventh step, by using non fuzzy M_i, the normalized weights of each criterion are calculated and tabulated in Table 6.

Table VI: Averaged and normalized relative weights of criteria

Criteria	M_i	N_i
MA	0.1174	0.1169
FA	0.3097	0.3084
EF	0.5043	0.5023
RC	0.0725	0.0722

ii) Determining Weights of Alternatives with respect to Criteria (Level 2)

Table VII: Pair Wise Comparisons of Market analysis Factor with Alternatives Area

A Imp	S. Imp	F. Imp	W. Imp	Criteria	Eq. Imp	Criteria	W. Imp	F. Imp	S. Imp	A. Imp
(9,9,9)	(6,7,8)	(4,5,6)	(2,3,4)		(1,1,1)		(2,3,4)	(4,5,6)	(6,7,8)	(9,9,9)
		✓		EC-F		PT				
		✓		EC-F		RM				
	✓			PT		RM				

Table VIII: Comparison matrices for main criteria with Market analysis Factor**.**

MARKET ANALYSIS	EC-F	PT	RM
EC-F	(1,1,1)	(4,5,6)	(4,5,6)
PT	(1/6,1/5,1/4)	(1,1,1)	(6,7,8)
RM	(1/6,1/5,1/4)	(1/8,1/7,1/6)	(1,1,1)

Table IX: Geometric means of fuzzy comparison values

Criteria	ri		
EC-F	2.5198	2.9240	3.3019
PT	1.0000	1.1186	1.2599
RM	0.2751	0.3057	0.3466
Total	3.7949	4.3483	4.9084
Reverse (power of -1)	0.2635	0.2299	0.2037
Increasing Order	0.2037	0.2299	0.2635

Table X: Relative fuzzy weights of each criterion.

Criteria	Wi		
EC-F	0.5132	0.6722	0.8700
PT	0.2037	0.2571	0.3319
RM	0.0560	0.0702	0.0913

Table XI: Averaged & normalized relative weights of Criteria.

Criteria	Mi	Ni
EC-F	0.6851	0.6704
PT	0.2642	0.2585
RM	0.0725	0.0709

Table XII: Pair Wise Comparisons of Feasibility analysis Factor with Alternatives Area

A. Imp (9,9,9)	S. Imp. (6,7,8)	F. Imp. (4,5,6)	W. Imp (2,3,4)	Criteria	Eq. Imp (1,1,1)	Criteria	W. Imp. (2,3,4)	F. Imp. (4,5,6)	S. Imp. (6,7,8)	A. Imp (9,9,9)
		✓		LS		LF				
				LS	✓	ED				
				LS		FIN			✓	
				LF	✓	ED				
				LF		FIN			✓	
				ED	✓	FIN				

Table XIII: Comparison matrices for main criteria with Feasibility analysis Factor

FEASIBILITY ANALYSIS	LS	LF	ED	FIN
LS	(1,1,1)	(4,5,6)	(1,1,1)	(1/8,1/7,1/6)
LF	(1/6,1/5,1/4)	(1,1,1)	(1,1,1)	(1/8,1/7,1/6)
ED	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)
FIN	(6,7,8)	(6,7,8)	(1,1,1)	(1,1,1)

Table XIV: Geometric means of fuzzy comparison values

Criteria	ri		
LS	0.8408	0.9193	1.0000
LF	0.3799	0.4111	0.4518
ED	1.0000	1.0000	1.0000
FIN	2.4494	2.6457	2.8284
Total	4.6701	4.9761	5.2802
Reverse (power of -1)	0.2141	0.2009	0.1893
Increasing Order	0.1893	0.2009	0.2141

Table XV: Relative fuzzy weights of each criterion

Criteria	Wi		
LS	0.1591	0.1846	0.2141
LF	0.0719	0.0825	0.0967
ED	0.1893	0.2009	0.2141
FIN	0.4636	0.5315	1.1304

Table XVI: Averaged & normalized relative weights Of Criteria.

Criteria	Mi	Ni
LS	0.1859	0.1576
LF	0.0837	0.0709
ED	0.2014	0.1707
FIN	0.7085	0.6006

Table XVII: Pair Wise Comparisons of Environmental Factor with Alternatives Area

A. Imp.	S. Imp.	F. Imp.	W. Imp.	Criteria	Eq. Imp.	Criteria	W. Imp.	F. Imp.	S. Imp.	A. Imp.
(9,9,9)	(6,7,8)	(4,5,6)	(2,3,4)		(1,1,1)		(2,3,4)	(4,5,6)	(6,7,8)	(9,9,9)
				GT	✓	CL				
				GT		S-HI		✓		
				CL		S-HI		✓		

Table XVIII: Comparison matrices for main criteria with environmental Factor

ENVIRONMENTAL FACTOR	GT	CL	S-HI
GT	(1,1,1)	(1,1,1)	(1/6,1/5,1/4)
CL	(1,1,1)	(1,1,1)	(1/6,1/5,1/4)
S-HI	(4,5,6)	(4,5,6)	(1,1,1)

Table XIX: Geometric means of fuzzy comparison values

Criteria	ri		
GT	0.5503	0.5848	0.6299
CL	0.5503	0.5848	0.6299
S-HI	2.5198	2.9240	3.3019
Total	3.6204	4.0936	4.5617
Reverse (power of -1)	0.2762	0.2442	0.2192
Increasing Order	0.2192	0.2442	0.2762

Table XX: Relative fuzzy weights of each criterion

Criteria	Wi		
GT	0.1206	0.1428	0.1739
CL	0.1206	0.1428	0.1739
S-HI	0.5523	0.7140	0.9119

Table XXI: Averaged & normalized relative weights of Criteria.

Criteria	Mi	Ni
GT	0.1457	0.1282
CL	0.2642	0.2325
S-HI	0.7260	0.6391

Table XXII: Pair Wise Comparisons of Regulatory condition with Alternatives Area

A Imp. (9,9,9)	S. Imp. (6,7,8)	F. Imp. (4,5,6)	W. Imp. (2,3,4)	Criteria	Eq Imp. (1,1,1)	Criteria	W. Imp. (2,3,4)	F. Imp. (4,5,6)	S. Imp. (6,7,8)	A Imp. (9,9,9)
		✓		L-FAC		P-PRE				
				L-FAC	✓	S-HAZ				
			✓	P-PRE		S-HAZ				

Table XXIII: Comparison matrices for main criteria with Regulatory condition

REGULATORY COND.	L-FAC	P-PRE	S-HAZ
L-FAC	(1,1,1)	(4,5,6)	(1,1,1)
P-PRE	(1/6,1/5,1/4)	(1,1,1)	(2,3,4)
S-HAZ	(1,1,1)	(1/4,1/3,1/2)	(1,1,1)

Table XXIV: Geometric means of fuzzy comparison values

Criteria	ri		
L-FAC	1.5874	1.7099	1.8171
P-PRE	0.6933	0.8434	1.0000
S-HAZ	0.6299	0.6933	0.7937
Total	2.9106	3.2466	3.6108
Reverse (power of -1)	0.3435	0.3080	0.2769
Increasing Order	0.2769	0.3080	0.3435

Table XXV: Relative fuzzy weights of each criterion

Criteria	Wi		
L-FAC	0.4395	0.5266	0.6241
P-PRE	0.1919	0.2597	0.3435
S-HAZ	0.1744	0.2135	0.2726

Table XXVI: Averaged & normalized relative weights of Criteria.

Criteria	M_i	N_i
L-FAC	0.5300	0.5221
P-PRE	0.2650	0.2610
S-HAZ	0.2201	0.2168

Table XXVII: Normalized non-fuzzy relative weights of each alternative for each criterion.

Criteria	MA	FA	EF	RC
EC-F	0.6704			
PT	0.2585			
RM	0.0709			
LS		0.1576		
LF		0.0709		
ED		0.1707		
FIN		0.6006		
GT			0.1282	
CL			0.2325	
S-HI			0.6391	
L-FAC				0.5221
P-PRE				0.2610
S-HAZ				0.2168

By using Table 6 and Table 27, individual scores of each alternative for each criterion are presented in Table XXVIII

Table XXVIII: Aggregated results for each alternative according to each criterion

Criteria	MA	FA	EF	RC	Priority
Weights	0.1169	0.3084	0.5023	0.0722	
EC-F	0.6704				0.07836
PT	0.2585				0.0302
RM	0.0709				0.0082
LS		0.1576			0.0486
LF		0.0709			0.0218
ED		0.1707			0.0526
FIN		0.6006			0.1852
GT			0.1282		0.0643
CL			0.2325		0.1167
S-HI			0.6391		0.3210
L-FAC				0.5221	0.0376
P-PRE				0.2610	0.0188
S-HAZ				0.2168	0.0156

II. RESULTS AND DISCUSSION

Table XXIX. Weights of Factors by Four Major Criteria

Criteria	Alternative	Weights (%)
ENVIRONMENTAL FACTOR	S-HI	32.10
FEASIBILITY ANALYSIS	FIN	18.52
ENVIRONMENTAL FACTOR	CL	11.67
MARKET ANALYSIS	EC-F	7.836
ENVIRONMENTAL FACTOR	GT	6.43
FEASIBILITY ANALYSIS	ED	5.26
FEASIBILITY ANALYSIS	LS	4.86
REGULATORY CONDITION	L-FAC	3.76
MARKET ANALYSIS	PT	3.02
FEASIBILITY ANALYSIS	LF	2.18
REGULATORY CONDITION	P-PRE	1.88
REGULATORY CONDITION	S-HAZ	1.56
MARKET ANALYSIS	RM	0.82

Depending on this result, **Alternative 10(KNOWLEDGE)** has the largest total score. Therefore, it is suggested as the very important factor among other of them to Decides safety impact factors that affect safety assessment of residential building from project managers point view in Nashik city, with respect to 4 main criteria and the fuzzy preferences of decision makers. **Alternative 7(QOP)** has the second largest total score, **Alternative 9** has the third largest total score, **Alternative 1** has the fourth largest total score **Alternative 8** has the fifth largest total score **Alternative 6** has the sixth largest total score **Alternative 4** has the seventh largest total score **Alternative 11** has the eighth largest total score **Alternative 2** has the ninth largest total score **Alternative 5** has the tenth largest total score **Alternative 12** has the eleventh largest total score. **Alternative 13** has the twelfths largest total score & **Alternative 3** has the thirteenth largest total score.

According to result we can also find how many times one alternative is preferred by customer than another alternative.

- Alternative 10 is preferred by customer 1.73times than alternative 7(32.10/18.52)
- Alternative 10 is preferred by customer 2.75 times than alternative 9(32.10/11.67)
- Alternative 10 is preferred by customer 4.09 times than alternative 1(32.10/7.836)
- Alternative 10 is preferred by customer 4.99 times than alternative 8(32.10/6.43)
- Alternative 10 is preferred by customer 6.10 times than alternative 6(32.10/5.26)
- Alternative 10 is preferred by customer 6.60 times than alternative 4(32.10/4.86)
- Alternative 10 is preferred by customer 8.53 times than alternative 11(32.10/3.76)
- Alternative 10 is preferred by customer 10.62 times than alternative 2(32.10/3.02)
- Alternative 10 is preferred by customer 14.72 times than alternative 5(32.10/2.18)
- Alternative 10 is preferred by customer 17.07 times than alternative 12(32.10/1.88)
- Alternative 10 is preferred by customer 20.57 times than alternative 13(32.10/1.56)
- Alternative 10 is preferred by customer 39.14times than alternative 3(32.10/0.82)

III. CONCLUSION

The major objectives of the present research effort included (1) the construction of a preliminary project planning model for residential land development; (2) the development of a Framework for a decision support system for the site selection process using an appropriate decision making methodology; and (3) the application of the framework to an appropriate software platform resulting in a computerized decision support system. The decision support system was then used in a residential land development site selection case study. The case Study example indicated that the proposed decision support system, using the analytical hierarchy process, could be successfully applied to the site selection process for a residential Land development project. In addition, with some slight modifications, the existing decision hierarchy and accompanying DSS could also be used for determining the preferred site development plan for a given site. The creation of the preliminary planning model and the development of the associated decision support system added considerable value and insight into the decision making process by

1. Developing a formalized structure for the decision making process
2. Requiring a systematic approach to the site selection process
3. Selecting a mathematical procedure (F-AHP) that provides a measure of consistency in judgments and preferences

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