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Decision Support System for House Hunting: A Case Study in Chittagong

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ABSTRACT:* House hunting is one of the most significant tricks for several families in Bangladesh and worldwide, which also involves difficult decisions to make. It requires a large number of criteria to be simultaneously measured and evaluated. As house hunting attributes are expressed in both quantitative and qualitative terms, decision-makers have to base their judgments on both quantitative data and practical subjective assessments. Many of these criteria are related to one another in a complex way and therefore, they very often conflict in so far as improvement in one often results in decline of another. House hunting problem exist uncertainties or incompleteness data. Consequently, it is necessary to address the suitable house by using appropriate methodology; otherwise, the decision to select a house to live in will become unsuitable. Therefore, this paper establishes the application of decision support system based on a method named Analytical Hierarchical Process. This system is capable of addressing the process of hunting for a suitable house taking into account the multi-criterion analysis of the problem. Chittagong, which is the mega city of Bangladesh, has been considered as the case study area to demonstrate the application of the developed Decision Support System.

Keywords: Decision Support System, analytical Hierarchical Process, Multi-criterion analysis, house hunting (HH) in Chittagong.

1. INTRODUCTION

Chittagong is a beautiful city with its city center facing the port. Many families migrate to Chittagong due to the fact that it provides a nice and safe environment. It is however, House hunting is the mind-numbing activities in Bangladesh and worldwide. It is difficult to find the perfect area to live in without thorough research of the locations in the city. Selecting the `most excellent house is a composite decision process for home buyer or renter. It requires a large number of criteria to be concurrently measured and evaluated. Many of these criteria are related to one another in a complex way and therefore, they very often conflict

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insofar as improvement in one often results in decline of another. Furthermore, as house attributes are expressed in both quantitative and qualitative terms, decision-makers have to base their judgments on both quantitative data and practical subjective assessments [1,2]. It is worth mentioning house hunting scenario in Bangladesh is so bad because different real estate company use static system (Figure 1) such as normally search method to find out from database .This does not give efficient result and is a time consuming process. For this reason, the house hunters may still miss out the ideal home they dream of.

In this paper, the analytical Hierarchical Process (AHP) approach (which is capable of processing both quantitative and qualitative measures) is applied as a means of solving the house hunting (HH) crisis [3-5]. In the process of house hunting a multiple criteria decision model of a hierarchical structure is presented, in which both quantitative and qualitative information is represented in a combined manner. The HH crisis is then fully investigated using the AHP approach. Hence, this paper presents the design, development and application of Decision Support System (DSS) that will find a suitable house precisely in a short time with low cost. In Section 2 briefly described the literature review, in Section 3 demonstrated the application of AHP to find suitable house. In the next Section results and comparisons are represented. Finally, the paper is concluded in Section 5.

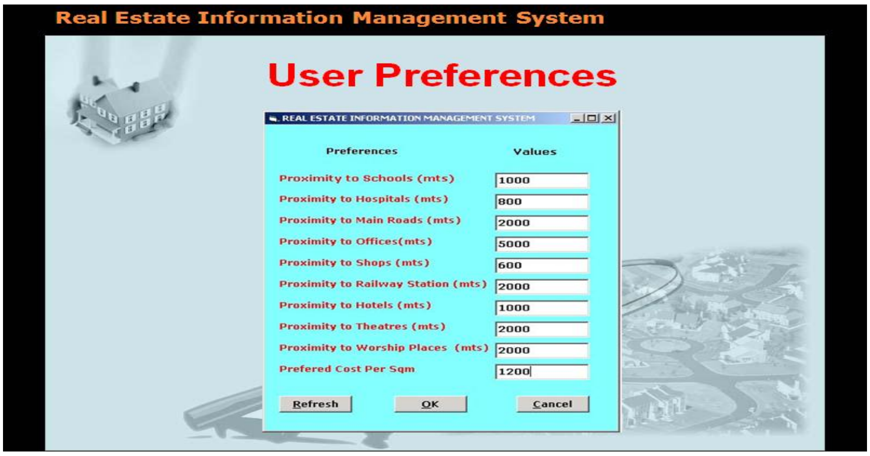

Figure 1: Scenario in Bangladesh (User Preference).

2. LITERATURE REVIEW

MCDM problems are very common in everyday life. Many methods have been proposed to solve the problem, such as Belief Rule Base decision support system, Evidential Reasoning approach, Analytic Network

Process etc. In reference 5 Evidential Reasoning method is proposed for house hunting with 16 attributes for 5 alternatives, where a belief structure is used to model an assessment as a distribution. To calculate the degree of belief 4 evaluation grades were used namely excellent, good, average and bad. The ER approach was used to obtain the combine degree of belief at the top level attribute of a hierarchy based on its bottom level attribute. Then utility function was used to determine the ranking of different alternatives [5].

The Analytic Hierarchy Process (AHP) is a mathematical technique for multi criteria decision making (MCDM) originally proposed by Saaty [3]. It enables people to make decisions involving many kinds of concerns including planning, setting priorities, selecting the best among a number of alternatives, and allocating resources. It is a popular and widely used method for multi-criteria decision making. It allows the use of qualitative, as well as quantitative criteria in evaluation develops a hierarchy of decision criteria and defines the alternative courses of actions [6-8]. AHP algorithm is basically composed of three steps: first one is structuring a decision problem and selection of criteria then priority setting of all the criteria by pair wise comparison (weighting), second one is pair wise comparison of options on each criterion (scoring) and final is both qualitative and quantitative information can be compared by using informed judgments to derive weights and priorities [1,2].

3. AHP TO DESIGN DECISION SUPPORT SYSTEM FOR HOUSE HUNTING

House hunting problem (HHP) is a massive problem in Bangladesh and global, because House hunting problem exists multiple criteria such as qualitative- location, attractiveness, safety, environment and quantitative attribute –proximity to hospital, main roads, education institution, shops, offices, recreation centers , police precincts etc [5]. In trying to select the `best' house task facing client is a multiple criteria decision-making (MCDM) process, in which a large number of criteria need to be evaluated. Most of these criteria are related to each other in a complex way.

Furthermore, many usually conflicts, such that a gain in one criterion enquires an exchange in another. As HHP decision criteria are a mix of both qualitative and quantitative characteristics, DMs have to base their decisions on both quantitative analysis and subjective (typically experiential) judgments. DMs may spontaneously and it easier to make subjective judgments by using linguistic variables However, this can cause problems during evaluation of alternatives, because it is difficult to aggregate process these two types of measure one quantitative and another linguistic .It is, therefore, necessary that any MCDA method be capable of aggregating these two types of measures in a coherent and reliable manner; ultimately providing a ranking of all decision alternatives [9].

I have provided the same set of criteria that are used in reference 5 for HHP and asked some of the house hunters to select the criteria which are considered by them while selecting a house. Here I found that 80% of the house hunters didn't select the criteria –nice neighborhood, proximity to shop, proximity to bus & railway station, proximity to recreation center, police precincts, property insurance and population density. Here, HHP is connected to qualitative attributes are Location, Attractiveness, Safeness, Environment and quantitative attributes are proximity to Main road, Hospital, Office, Eeducational institute and Cost per square feet. Also connected to alternatives are Khulsi, Devpahar, Jamal khan, Suganda, Chandgoan which is shown in figure 2 [5].

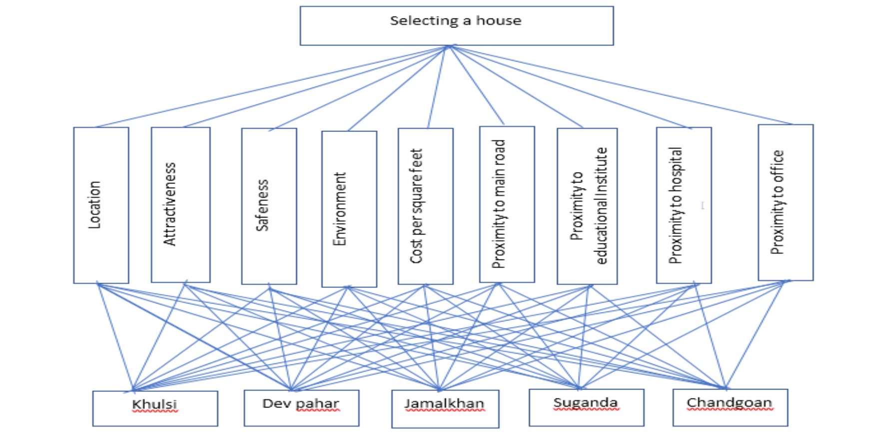

Figure 2: Alternative Courses of Action.

I can make a matrix from the 9 comparisons above shown in figure 2. Because I have 9 comparisons, thus I have 9 by 9 matrix. The diagonal elements of the matrix are always 1 and we only need to fill up the upper triangular matrix. To fill up the upper triangular matrix the following two rules are used:

1. If the judgment value is on the left side of 1, we put the actual judgment value.
2. If the judgment value is on the right side of 1, we put the reciprocal value.

To fill the lower triangular matrix, I use the reciprocal values of the upper diagonal [10]. If a_{ij} is the element of row i and column j of the matrix, then the lower diagonal is filled using eq. (1) :

$$a_{ij} = \frac{1}{a_{ji}} \qquad (1)$$

The preferences of a criterion over others are set by the users in the form of comparison matrix as shown in table 1.Each entry of the comparison matrix ranging from 1 to 9 reflects the degree of preference of a criterion over another. For instance the entry of "Prox_education institution" raw and "Prox_main roads" column which is 9, reflects the highest preference of "Prox_education institution" over "Prox_main roads".

Table 1: Pair wise comparison matrix of criteria.

Criteria	**Location**	**Attractiveness**	**Safeness**	**Environment**	**Prox_education institution**	**Prox_hospital**	**Prox_main roads**	**Prox_office**	**Cost per squ. ft**
Location	1	2	1/3`	1/4	1/5	1/6	4	1/5	1/2
Attractiveness	1/2	1	1/2	1/3	1/6	1/4	2	1/4	1/4
Safeness	3	2	1	4	5	2	3	2	2
Environment	4	3	1/4	1	4	1/3	7	1/3`	1/2
Prox_education institution	5	6	1/5	1/4	1	1/8	9	5	2
Prox_hospital	6	4	1/2	3	8	1	8	1/7	1/5
Prox_main roads	1/4	1/2	1/3	1/7	1/9	1/8	1	5	2
Prox_office	5	4	1/2	3	1/5	7	1/5	1	1/2
Cost per squ.ft	2	4	1/2	2	1/2	5	1/2	2	1

3.1 Criteria weights

In order to interpret and give relative weights to each criterion, it is necessary to normalize the previous comparison matrix of table 1. The normalization is made by dividing each table value by total column value using the eq. (2) where i and j represents the subscripts of MXN matrix

$$Z_{ij}=A_{ij}/\sum_{i=0}^{n} A_{ij} \qquad (2)$$

A=

1	2	0.33	0.25	0.2	0.17	4	0.2	0.5
0.5	1	0.5	0.33	0.17	0.25	2	.25	0.25
3	2	1	4	5	2	3	2	2
4	3	0.25	1	4	0.33	7	.33	0.5
5	6	0.2	0.25	1	0.13	9	5	2
6	4	0.5	3	8	1	8	.14	0.20
0.25	0.5	0.33	0.14	0.11	0.13	1	5	2
5	4	0.5	3	0.2	7	0.2	1	0.5
2	4	0.5	2	0.5	5	0.5	2	1

Normalized Column

0.04	0.08	0.10	0.02	0.01	0.02	0.12	0.01	0.06
0.02	0.04	0.14	0.03	0.01	0.02	0.06	0.02	0.03
0.12	0.08	0.28	0.33	0.27	0.18	0.09	0.14	0.22
0.20	0.13	0.07	0.08	0.21	0.03	0.20	0.02	0.06
0.20	0.26	0.06	0.02	0.05	0.01	0.26	0.36	0.22
0.24	0.17	0.14	0.25	0.43	0.10	0.23	0.01	0.02
0.01	0.02	0.10	0.01	0.01	0.01	0.02	0.36	0.22
0.20	0.17	0.14	0.25	0.01	0.63	0.01	0.07	0.06
0.07	0.15	0.12	0.14	0.03	0.31	0.01	0.13	0.11

w_p=(Priority Vector)

Location	0.05
Attractiveness	0.04
Safeness	0.17
Environment	0.10
Prox_edu.Ins	0.15
Prox_hospital	0.16
Prox_mainroad	0.08
Prox_office	0.14
Cost-pr-sq ft	0.12

Figure 3: Criteria weights.

Z, the normalized principal Eigen vector, since it is normalized, the sum of all elements in a column is 1. Then priority vector is calculated by calculating the average of each row of Z and the sum of all priority vector is 1. The priority vector shows relative weights among the things that I compare **[11]**. In above, Location is 5%, Attractiveness is 4%, Safeness is 17%, Environment is 10%, Prox_edu.Ins is 15%, Prox_hospital is 16%, Prox_main road is 8%, proximity to office is 14% and cost per square feet is 12%. A House buyer most preferable selection criterion is safeness, followed by remaining criteria. In this case, I know more than their ranking. In fact, the relative weight is a ratio scale that I can divide among them. For example, I can say that buyer prefers safeness 3.4 (=17/5) times more than Location and he also prefers safeness so much 2.1 (=17/8) times more than Prox_main road the whole process in shown in figure 3.

3.2 Quantitative Ranking

Distance from the main road has great importance in case of selecting location of the house which impels me to run a campaign to get the approximated distances of the locations from main road. I have collected the data from construction developers. I divide each element of the matrix with the sum of its column; I have calculated normalized relative weight n_0. The sum of each column is 1. Proximity to educational institutes as well as hospitals and offices and also cost per square feet has similar importance in case of choosing locations. Since in case of distance and cost, the lowest distance and lowest cost is best, I have calculated the distance scores by subtracting the normalized values n_0 from 1. Again I have normalized the distance scores to get the normalized value n_1. The approximated distances of those alternative locations from the road, educational institute and hospitals and also cost per square feet of those alternatives are shown in table 2,3,4,5 & 6 respectively. I have taken the normalized values of those distances using Principal Eigen vector theory.

Table 2: Proximity to Main road.

Alternatives	KM	Normalized n_0	Distance scores	normalized n_1
Khulsi	1.4	0.14	0.86	0.21
Devpahar	1.0	0.10	0.90	0.22
Jamalkhan	2.1	0.21	0.79	0.20
Suganda	2.5	0.26	0.74	0.19
Chandgoan	2.8	0.29	0.71	0.18
Summation	9.8	1.00	4.0	1.00

Table 3: Proximity to Education Institute.

Alternatives	KM	Normalized n_0	Distance scores	normalized n_1
Khulsi	2.1	0.19	0.81	0.20
Devpahar	3	0.28	0.72	0.18
Jamalkhan	2	0.19	0.81	0.20
Suganda	1.9	0.18	0.82	0.21
Chandgoan	1.7	0.16	0.84	0.21
Summation	9.8	1.00	4.0	1.00

Table 4: Proximity to Hospitals.

Alternatives	KM	Normalized n_0	Distance scores	normalized n_1
Khulsi	2.3	0.19	0.81	0.20
Devpahar	2.6	0.21	0.79	0.20
Jamalkhan	2.4	0.19	0.81	0.20
Suganda	2.0	0.16	0.84	0.21
Chandgoan	3.0	0.24	0.76	0.19
Summation	9.8	1.00	4.0	1.00

Table 5: Proximity to Office**.**

Alternatives	KM	Normalized n_0	Distance scores	normalized n_1
Khulsi	2	0.21	0.79	0.20
Devpahar	1.6	0.17	0.83	0.21
Jamalkhan	1	0.10	0.90	0.22
Suganda	2	0.21	0.79	0.20
Chandgoan	3	0.31	0.69	0.17
Summation	9.6	1.00	4.0	1.00

Table 6: Cost per square feet.

Alternatives	Thousand	Normalized n_0	Distance scores	normalized n_1
Khulsi	10	0.32	.68	0.17
Devpahar	5.5	0.17	.83	0.21
Jamalkhan	6.5	0.21	.79	0.20
Suganda	6.0	0.19	.81	0.20
Chandgoan	3.5	0.11	.89	0.22
Summation	31.5	1.00	4.0	1.00

3.3 Qualitative Ranking

Pair wise comparison, is a process of comparing alternatives in pairs to judge which entity is preferred over others or has a greater qualitative property. Table 7,8,9 and 10 show pair wise comparison matrix of alternatives based on Location, Attractiveness, Safety and Environment respectively. The pair wise comparison matrices of the alternatives per criterion are set in the similar manner as described in section 3 and the actual judgment values are set from the results of the survey (survey from construction developers) I have ran so far to understand the degree of preference of a location over another. The score of alternatives based on location is calculated from table 7 using principal Eigen vector theory and priority vector described earlier which is shown in figure 4[11].

Table 7: Pair wise Comparison Matrix of alternatives based on Location.

alternatives	**Khulsi**	**Dev pahar**	**Jamalkhan**	**Suganda**	**Chandgon**
Khulsi	1	2	3	4	5
Dev pahar	1/2	1	6	7	8
Jamalkhan	1/3	1/6	1	1/4	9
Suganda	1/4	1/7	4	1	3
Chandgon	1/5	1/8	1/9	1/3	1

A=

1	2	3	4	5
0.5	1	6	7	8
0.33	0.17	1	0.25	9
0.25	0.14	4	1	3
0.2	0.13	0.11	0.33	1
2.28	3.44	14.11	12.58	26

Column sum

Normalized Column Sums

0.43	0.58	0.21	0.32	0.19
0.21	0.29	0.43	0.56	0.31
0.14	0.05	0.07	0.02	0.5
0.11	0.04	0.28	0.08	0.12
0.08	0.04	0.01	0.03	0.04

Row Averages

(Priority vector) X=

Khulsi	0.34
Dev pahar	0.36
Jamalkhan	0.12
Suganda	0.16
Chandgoan	0.04

Figure 4: Score of alternatives based on Location.

Table 8: Pair wise Comparison Matrix of alternatives based on Attractiveness.

alternatives	Khulsi	Devpahar	Jamalkhan	Suganda	Chandgoan
Khulsi	1	8	2	6	10
Devpahar	1/8	1	1/11	1/2	8
Jamalkhan	1/2	11	1	2	3
Suganda	1/6	2	1/2	1	9
Chandgoan	1/10	1/8	1/3	1/9	1

Table 9: Pair wise Comparison Matrix of alternatives based on Safety.

alternatives	Khulsi	Devpahar	Jamalkhan	Suganda	Chandgoan
Khulsi	1	7	4	6	9
Devpahar	1/7	1	1/9	1/4	7
Jamalkhan	1/4	9	1	1/2	9
Suganda	1/6	4	2	1	5
Chandgoan	1/9	1/7	1/9	1/5	1

Table 10: Pair wise Comparison Matrix of alternatives based on Environment.

alternatives	Khulsi	Devpahar	Jamalkhan	Suganda	Chandgoan
Khulsi	1	5	4	2	9
Devpahar	1/5	1	1/2	1/3	2
Jamalkhan	1/4	2	1	1/3	4
Suganda	1/2	3	3	1	7
Chandgoan	1/9	1/2	1/4	1/7	1

Similarly I have calculated the scores of all alternatives for each of the criterion from the respective pair wise comparison matrix of alternatives based on the respective criterion denoted by C where in matrix C the process produces criteria wise

scores $\{v_{11},v_{12}\ldots\ldots v_{1n}\},\{v_{21},v_{22}\ldots\ldots v_{2n}\},\ldots\{v_{m1},v_{m2}\ldots\ldots v_{mn}\}$ for n criteria and m alternatives which is shown in table 11.

Table 11: Scores of Alternatives for All Criteria.

C =

Criteria / *Altern.*	Location	Attractiveness	Safety	Environment	Prox_edu. Ins	Prox_hospital	Prox_main road	Prox office	Cost per squ ft
Khulsi	0.25	0.46	0.50	0.61	0.20	0.20	0.21	0.20	0.17
Dev pahar	0.47	0.08	0.08	0.27	0.18	0.20	0.22	0.21	0.21
Jamal khan	0.12	0.26	0.21	0.51	0.20	0.20	0.20	0.22	0.20
Suganda	0.12	0.13	0.17	0.38	0.21	0.21	0.19	0.20	0.20
Chandgoan	0.04	0.03	0.04	0.13	0.21	0.19	0.18	0.17	0.22

3.4 Overall Assessments of Alternatives

In section 3.1 I have calculated the weights of criteria w_p from the pair wise comparison matrix of criteria and in section 3.3 I have calculated C, the matrix of the weights of the selected alternatives for each of the criterion n and alternatives m . Finally the score of those alternatives, is calculated by talking their weighted sum as denoted by eq. (3):

$$Y_i = \sum_{p=0}^{n} v_{ip} w_p \qquad (3)$$

The process is shown in Figure 5

Criteria / *Altern.*	Location	Attractiveness	Safety	Environment	Prox_edu .Ins	Prox_hospital	Prox_main road	Prox_office	Cost per squ ft
Khulsi	0.25	0.46	0.50	0.61	0.20	0.20	0.21	0.20	0.17
Dev pahar	0.47	0.08	0.08	0.27	0.18	0.20	0.22	0.21	0.21
Jamalkhan	0.12	0.26	0.21	0.51	0.20	0.20	0.20	0.22	0.20
Suganda	0.12	0.13	0.17	0.38	0.21	0.21	0.19	0.20	0.20
Chandgoan	0.04	0.03	0.04	0.13	0.21	0.19	0.18	0.17	0.22

*

0.05
0.04
0.17
0.10
0.15
0.16
0.08
0.14
0.12

=

0.30
0.20
0.24
0.21
0.15

Greatest

Figure 5: Final scores of alternatives.

The final result is simply found from the rankings of the final scores of the alternatives got from section 3.4. The scores of the alternatives with their respective ranks are shown in table 12.

Table 12: Overall assessment and Ranking of five different houses.

Alternatives	Alternative final Scores	Ranking
Khulsi	0.30	1
Dev pahar	0.20	4
Jamalkhan	0.24	2
Suganda	0.21	3
Chandgoan	0.15	5

Here Khulsi is best house because ranking is 1. Then jamal khan (2)> Suganda (3) > Dev pahar (4) > Chandgoan (5). Although in case of quantitative measurement "Khulsi" is in 2nd, 2nd, 2nd, 3rd and 5th position respectively in Proximity to main road, Proximity to education, Proximity to Hospital, Proximity to Office and Cost Per square feet, it has high score in qualitative measurements because of its attractiveness, environment and safety. Hence in overall assessment it has got the highest score. Figure 6 shows the study area in Chittagong.

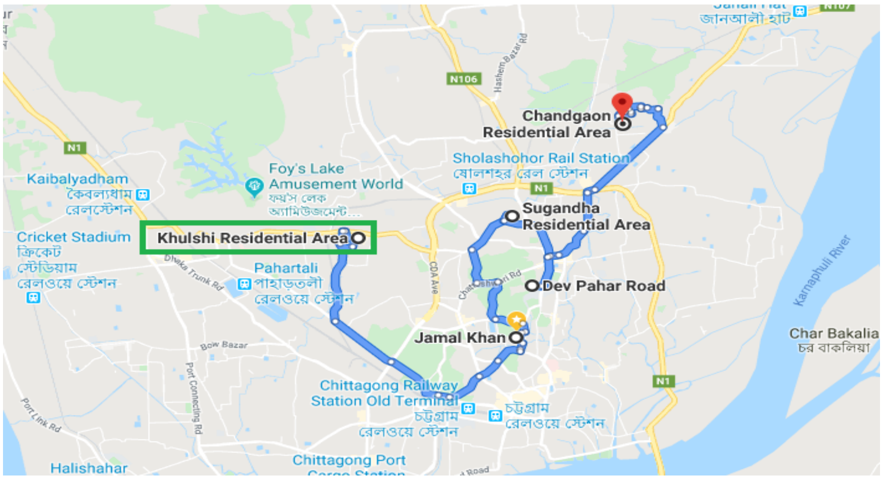

Figure 6: Study Area Chittagong District

4. COMPARISON WITH REFERENCE WORK

For comparing the result of the proposed method with the referenced work I simply took the average expected utilities of the reference work and converted those in normalized form. And table 13 shows the acquired result and expected result:

Table 13: Results of AHP and ER approach in normalized form.

Result (AHP)	Result (ER)	Normalized (ER)
0.30	0.86	0.22
0.20	0.74	0.19
0.24	0.85	0.21
0.21	0.81	0.20
0.15	0.74	0.19

The bar graph shown in figure 7 represents the results of both proposed work and the reference work that I have explained earlier in the literature review section. The results are quite similar in case of “Devpahar”, “Jamalkhan”, “Sugondha” and “Chandgaon”. Although the result for “Khulsi” of the reference work is quite low as compared to proposed work, both the methods provide highest score for ”Khulshi”. Though in AHP approach every step is dependent on previous step it is easy and simple approach with only 3 steps but ER approach is a complex approach with more than 6 steps.

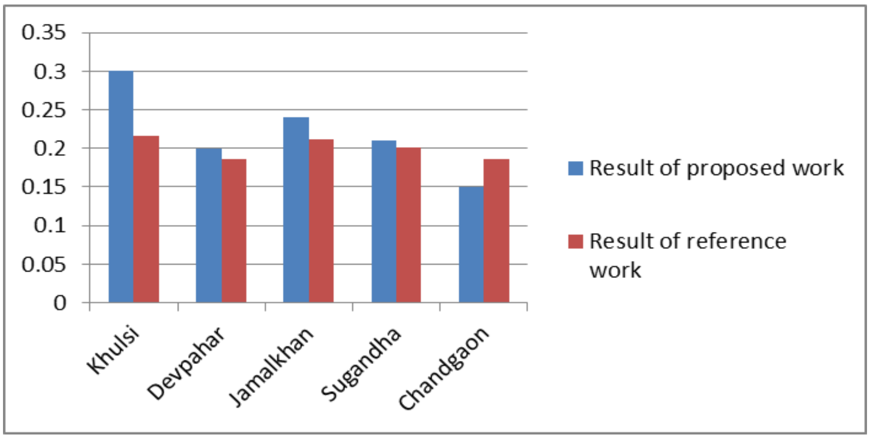

Figure 7 : Results of proposed work and reference work.

5. DISCUSSION AND CONCLUSIONS

From the results shown above, it is reasonable to say that the AHP method is a mathematically sound approach towards measuring the house performance as it employs a structure to represent an assessment as a distribution. The best alternative may change from ‘khulsi’ to any other alternatives because the preferences of a criterion over others are set by the users in table 1.Here, a user preferred safeness at first, others may prefer proximity to office or proximity to hospital etc. This approach is quite different from the other Multi Criteria Decision Making model, Finally, in a complex assessment as in the house performance appraisal which involved objective and subjective assessments of many basic attributes as shown in Table 12, it is convenient to have an approach which can tackle the uncertainties or incompleteness in the data gathered. Therefore, the AHP is seen as feasible method for performance appraisal.

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