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THE MCDM APPLICATION IN URBAN PLANNING PROJECTS: THE CDS PROJECT OF DISTRICT 22 OF TEHRAN MUNICIPALITY

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Abstract
This paper presents the MCDM as a potential method for using in urban planning projects. The CDS project of 22th district of Tehran is used as a case. This project has six visions that each of them has several strategies. These strategies must be prioritized for being useful for next steps of project. For this, criteria are extracted from visions, then a hierarchical structure is constructed for weighting them. Because visions have abundant strategies, ranking by AHP is difficult and vague for experts. So TOPSIS is constructed for priority of strategies and the weights of criteria that computed by AHP are used in TOPSIS. The AHP implementation steps is simplified by using the `Expert Choice' and Microsoft Office Excel is used for TOPSIS. This paper presents group decision-making using the AHP and TOPSIS as a hybrid model. The results indicate when the performance ratings are vague and imprecise, the MCDM methods are preferred solutions. It is hoped that this will encourage the application of the MCDM by urban planning experts.
Keywords: Multi Criteria Decision Making (MCDM), Technique for Order Preference by Similarity Ideal Solution (TOPSIS), Analytic Hierarchy Process (AHP), City development strategy (CDS), District 22 of Tehran.

1. INTRODUCTION

City development strategy (CDS) is one of the urban planning projects that provided in 1998 for first time in the world and has been provided for over 140 cities to now. The CDS is a process devised and owned by local stakeholders to formulate a holistic vision for city. The process involves analysis of the city's prospects for economic and social development and redress of poverty, identification of priorities for investment and development assistance, and implementation of this vision through partnership based actions (World Bank 2000). The CDS preparing process has five main steps that includes preparation, analysis, strategy formulation, implementation monitoring and evaluation and finally consulting(World Bank 2000) that outputs of this process are used for development of city as a guideline. The most important outputs of CDS are visions, strategies and their priorities. It may that one vision has abundant strategies and they must be prioritised. For ranking of strategies, the experts team regarded to some difficulties such as abundance of strategies and lack of confident method for ranking that this caused experts to be confused.

Multiple criteria decision making (MCDM) approach is used in ranking (Shyur 2006). MCDM approaches are major parts of decision theory and analysis. They seek to take explicit account of more than one criterion in supporting the decision process (Belton1990). The aim of MCDM methods is to help decision makers learn about the problems they face, to learn about their own and other parties' personal value systems, to learn about organizational values and objectives, and through exploring these in the context of the problem to guide them in identifying a preferred course of action (Belton 1990;French 1988; Russell 1990; Von Winterfeldt 1986; Watson 1987; Zeleny 1990).

The Analytic Hierarchy Process (AHP) and the Technique for Order Preference by Similarity Ideal Solution (TOPSIS) are two MCDM methods that can be used for ranking. AHP (Saaty 1980, 2008) is a key multi-criteria decision making methodology which succeeded in gaining widely acceptance of both academia and the practitioners (Cakir 2008). In the last 20 years, AHP has been used in almost all the applications related to multiple criteria decision-making (Vargas 1990; Vaidya 2006). This model uses pair wise comparison to allocate weights to the elements of each level, measuring their relative importance by using Saaty's 1 to 9 scales, and finally calculates global weights for assessment at the bottom level. Moreover, AHP is not practically usable if the number of alternatives and criteria is large since the repetitive assessments may cause fatigue in decision makers (Briand 1998).

Another popular method for solving MCDM problems is the Technique for Order Performance by Similarity to Ideal Solution(TOPSIS) which was first developed by Hwang and Yoon(Hwang & Yoon 1981). The TOPSIS bases upon the concept that the optimal alternative should have the shortest

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distance from the positive idea solution (PIS) and the farthest distance from the negative idea solution (NIS). (Wang & Elhag 2005; Shyur 2006). This method has been widely used in the literature (Abo-sinna & Amer 2005 ; Agrawal, Kohli & Gupta1991 ; Chen & Tzeng, 2004).

Because strategies ranking coincides to these models as a multiple criteria problem, using them can be the best way for solving this problem.

This paper tried to examine AHP and TOPSIS simultaneously for ranking of the strategies and the strategies of vision 1 of district 22 of Tehran CDS plan as a sample have been used. The results show that using MCDM methods is very useful tools in urban planning specially in CDS plans, because these plans are interdisciplinary which are affected by many factors such as economic, social, environmental factors.

2. CITY PROFILE

The District 22 of Tehran is about 10000 hectares where located in northwestern of the Tehran City (Capital of Iran). This district has special geographical features and laid on hillside of Alborz Mountain (Figure 1). This district figured out of city before Tehran old comprehensive plan (Farmanfarmaeian et al 1970) has been approved. In 30 years past, this district had been identified as a new town and had been designed by Farmanfarmaeian and colleagues(Armanshahr 2009).

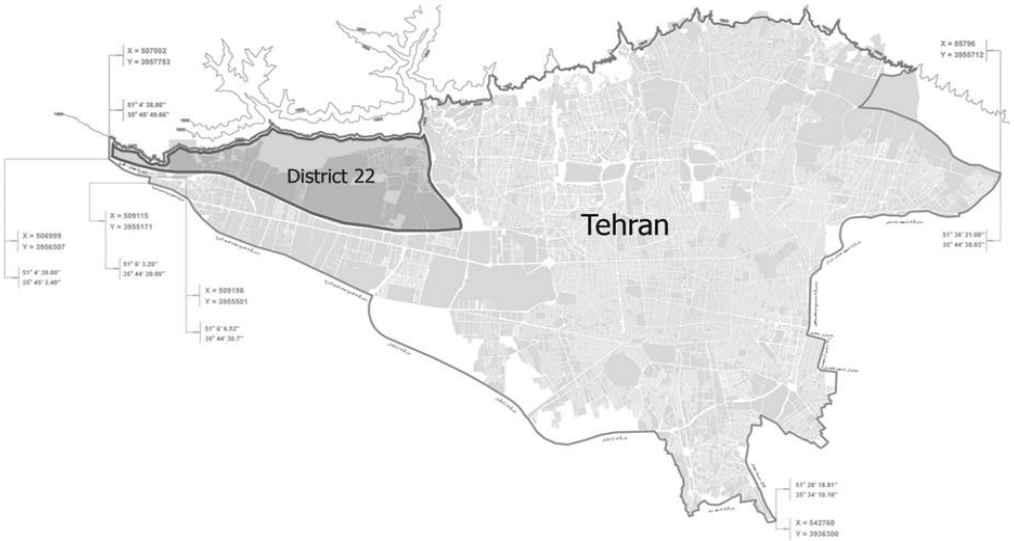

FIGURE 1 - DISTRICT 22 OF TEHRAN LOCATION
(Boomsaangaan 2006)

2.1. Historical Development

At first, the main land uses in this district were agriculture lands, military lands and green spaces but after approving the first comprehensive plan of Tehran, these lands designed as a new town and its name became Kan New Town (Armanshahr 2009). Within the war years (1981 - 1989) between Iran and Iraq, approximately 25 percent of these lands used for military garrisons construction. After the war years and when Tehran regarded to some problems such as rapid growth in population, it has been concluded that these lands can be used for solving these problems and offering a new pattern of urbanization. So, These lands joined to the city boundaries as a new district of Tehran. In 1994, the comprehensive plan was prepared for this district. Consequently, in 1999, Armanshahr consulting engineers prepared the detailed plan of this district (Armanshahr 2009).

2.2. Demographic information

The district 22 formed as a potential for improvement of Tehran rapid growth population, especially central old building of Tehran. When the detail plan of district has been approved, the habitation rate has been increased. The population increased from 37520 to 128278 persons from 1986 to 2011 that the growth rate of this 30 years period is 4.2 %. This population growth was higher than other districts growth rate in Tehran. Table 1 shows the population and growth rate in 20 years period.

TABLE 1 - THE POPULATION AND GROWTH RATE IN DISTRICT 22 OF TEHRAN IN 1986 - 2006

Year	Population	Growth rate (%)
1986	37520	-
1996	56020	4.09
2006	107820	6.76
2011	128278	1.75

(Statistical Center Of IRAN 1986,1996,2006,2011)

Also, for this district of Tehran several future populations have been estimated for 2020 (Vision year). One estimate has been done by the old detailed plan(Armanshahr 1999) that estimated the population of district 22 will be 675000 persons. Another has been done by new detailed plan(Sharestan 2007) with 350000 persons and finally, the last estimation has been done by the Urban Design Commission of District 22 in 2011 with the population of 381288 persons. These estimations show this district can play key role in improving some standards in Tehran by removing population problems and preparing facilities and public services. Tehran municipality knows the importance of this role and tries to use effectively from this potential.

2.3. Contemporary Conditions and Problems in District 22 of Tehran

The most important problems in this district is illegal constructions and mass building that implemented mostly by military organizations that cause lack of public service land uses. Another problem is possession problems. Because, many lands were agricultural land and their boundaries are indistinct, consequently, it is difficult adaptation of these land with city plans. These are the most important problems in this district. Also, some problems relate to urban management that they are general in developing countries management system. These problems cause many of executive plans do not implement correctly and on time. These problems are:

- not being unity vision on planning and management,
- confine the role of people in planning,
- not being trust between people and urban management,
- lack of urban specialist in municipality,
- abundant changes in key responsibilities in municipality,
- lack of urban facilities and public services,
- not being accuracy in plans and their policies(Armanshahr 2011).

2.4. CDS plan

Because of district 22 key role in solving Tehran problems above said, the Tehran municipality decided to prepare CDS plan for this district. The CDS plan of District 22 has been started in 2011 by Armanshahr Consulting Engineers. This plan has seven main goal in transportation, public health, employment, green spaces, landscape quality, urban spaces and public services. This plan determined 2025 as vision year and represented 6 visions for the district. These visions are Livable, Social Convergence, Islamic-Iranian, Creative and Innovator, Activity and Unanimous, Superior Governance(Armanshahr 2011).

3. PROPOSED MODEL

The ranking procedure of this study consists of several steps as shown in Fig. 2. The first step is to identify and extract the multiple criteria that are considered in the decision making process for the urban experts as decision makers to make strategies ranking. Criteria extraction has been done by experts and four criterion have been identified for vision1. Then a relationship between criteria that shows the

degree of interdependence relationship is determined by group expert discussion in general. After constructing the relationship of a criteria network structure, the criteria weights can be calculated by applying AHP. Continuously, in next step, strategies are converted to quantitative scale by Licert scale for ranking in TOPSIS. Criteria weights have been used in TOPSIS and finally, the strategies ranking are done by TOPSIS.

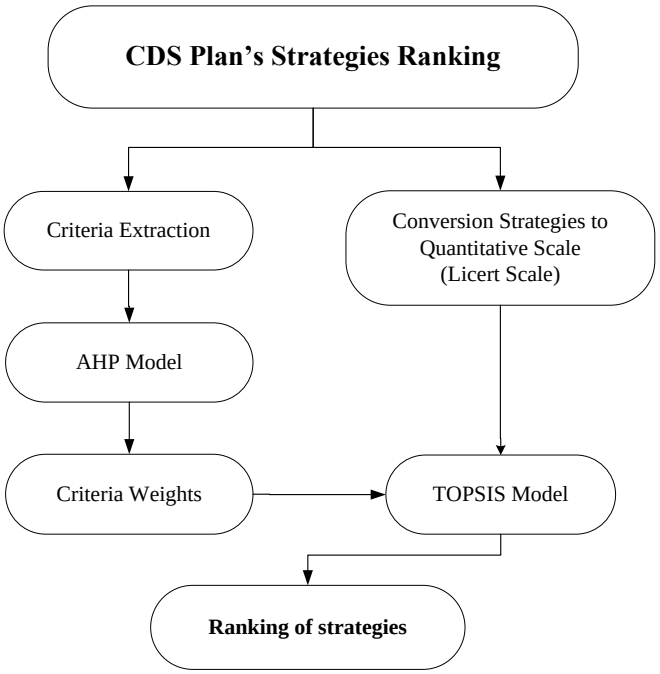

FIGURE 2 - PROPOSED CONCEPTUAL MODEL OF STRATEGIES RANKING.

3.1 Criteria Extraction

In order to develop an AHP model, a thorough literature review and informal discussions with the officials of the municipality, academics and experts working in the field of CDS plans and AHP were carried out. For vision1 that is "The District 22 of TEHRAN is Livable" , four criteria have been extracted that these are "Suitable Services for a convenient and comfortable life for all citizen", "Healthy environment", "Fluent transportation", "Safety and Security".

TABLE 2 - DESCRIPTION OF SELECTION CRITERIA (VISION 1: LIVABLE)

Row	Criteria	Description	Abbreviation
1	Suitable Services for a Convenient and Comfortable Life for all Citizen	Supplying suitable accessibility to public services for all of citizens in district	SC
2	Healthy Environment	Decision making and action according to environment protection	HE
3	Fluent Transportation	Ease of transportation and easy access to public transportation for all citizens in district	FT
4	Safety and Security	Supplying security and safety	SS

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3.2 AHP model construction

The AHP is a method proposed by Saaty (Saaty 1980, 2008). The top level of hierarchy is the main goal of the decision problem. The following lower levels are the tangible and/or intangible criteria and sub criteria that contribute to the goal.

The bottom level is formed by the alternatives to evaluate in term of the criteria. In this paper, because strategies as alternatives are abundant only criteria have been evaluated by AHP. This method also calculates a consistency ratio (CR) to verify the coherence of the judgments, which must be about 0.1 or less to be accepted. Mathematical foundations of AHP can be found in Saaty (1994,1996).

The AHP model in this paper consists of three levels. The first level is decision problem that is criteria weighting as model goal. The second level is the criteria relationship between together. This level is divided into four components: Services for all Citizen, Healthy Environment, Fluent Transportation and Safety and Security. This structure is very simple and used for criteria weighting(Figure 3).

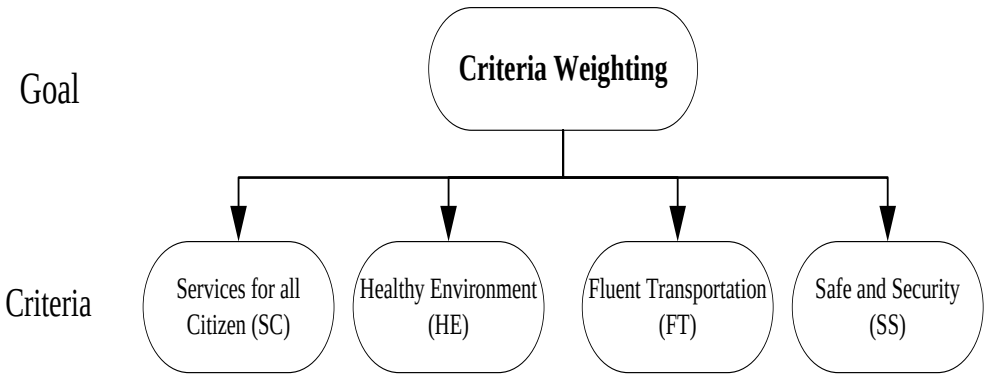

FIGURE 3 - AHP MODEL

A pair wise comparison is a numerical representation of the relationship between two elements that discerns which element is more important, according to a higher criterion. Saaty (1980, 1994) proposed a scale of 1–9, where 1 represents equal importance; that is, the two elements contribute equally to the objective, while 9 represents extreme importance that is favors one element (row component) over another (column component).

If the element has a weaker impact than its comparison element, the score range varies from 1, indicating indifference, to 1/9, an over whelming dominance by a column element over the row element. For reverse comparison of the elements, the corresponding reciprocal value is assigned, so that the matrix aij.aji = 1.

TABLE 3 - SAATY'S 1-9 SCALE FOR AHP PREFERENCE

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one over another
5	Strong importance	Experience and judgment strongly favour one over another
7	Very strong importance	Activity is strongly favoured and its dominance is demonstrated in practice
9	Absolute importance	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Intermediate values	Used to represent compromise between the priorities listed above
Reciprocal of above non-zero numbers	If activity i has one of the above non-zero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	

(Saaty 1996)

In the presented model there are about 1 pair wise matrix. In order to perform the pair wise comparisons, six face to face interviews were held with the experts in urban planning by making use a comprehensive questionnaire. As a result of these interviews and judgments, weights of the main criteria and subcriteria were determined using Expert Choice software (Version 9.48s25). After carrying out all the comparisons and determining the weights, consistency ratio of all the pair wise comparisons matrix and those of the judgments were calculated. The consistency measure is very useful for identifying possible errors in judgments. If the inconsistency ratios of all the pair wise comparisons matrix are less than 0.1, all comparisons matrix are consistent and judgments are reliable. In this study, the inconsistency ratio (CR) of the comparisons matrix was less than 0.1 and so the judgment was accepted as reliable.

TABLE 4 - *PAIR WISE COMPARISONS OF CRITERIA AND THEIR WEIGHTS*

Criteria	SC	HE	FT	SS	weights
SC	1	0.143	0.2	0.5	0.122
HE	7	1	0.333	0.5	0.137
FT	5	3	1	1	0.422
SS	2	2	1	1	0.319

CR=0.03

3.3. Conversion Strategies to Quantitative Scale (Licert Scale)

For strategies ranking, we have needed to convert strategies to quantitative measurements. For this, Licert scale has been used. for example, one of the strategies is S12: "following global standard in designing the transportation system". In this step, the experts delineate this strategy how much support four criteria and score them from 5 to 1 that 5 is highest and 1 is lowest. Table 5 shows the strategies with their scores in Licert scale.

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TABLE 5 - STRATEGIES WITH THEIR SCORES AS DECISION MATRIX (NIJ)

Vision 1 : Livable		SC	HE	FT	SS
S_1	Doing actions and measurements within CDS plan	5	3	3	3
S_2	Set sustainability as a main pillar in measurement and actions for supplying infrastructure, facilities and environment protection	3	5	4	4
S_3	Using suitable design guideline within district environment	1	4	1	3
S_4	Attention to facilities development mid profitable actions	5	1	4	3
S_5	Preventing environmental crisis and providing stake holders participation	2	4	3	5
S_6	Platting for doing actions very well according to stake holders and citizens	5	3	1	3
S_7	Continuum protection of district periphery	2	5	1	3
S_8	Create balance between residents and afloat population	5	4	3	4
S_9	Interaction with landlords of big lands for using them in facilities	3	1	1	1
S_{10}	Providing ease for investment in public facilities and Quality of Life	2	1	2	3
S_{11}	Providing ease for investment in clean industries	1	3	1	1
S_{12}	Following global standard in designing the transportation system	1	2	5	3
S_{13}	Using global standards for reducing green house gases	1	4	2	1
S_{14}	Interaction with citizens, NGOs and etc for reducing environmental pollutions	1	3	2	1
S_{15}	Providing ease in neighborhoods social interaction	1	1	1	5
S_{16}	Attention to restriction in issuance of settlement actions permission	5	3	2	1
S_{17}	Attention to restriction in issuance of economical actions permission	1	3	2	1
S_{18}	Preserve present status in civil and facility actions	2	3	1	1
S_{19}	Selling municipality property to provide charges for supplying facilities	5	1	2	1

3.4. TOPSIS Model and Results

TOPSIS is a multiple criteria method to identify solutions from a finite set of alternatives. In this paper, each of strategies as an alternative is ranked by the priority criteria. All of TOPSIS model calculation have been done by Excel software (Version 2007). The procedure can be expressed in a series of steps:

(1) Calculate the normalized decision matrix. The normalized value nij is calculated as (Eq.1):

Equation 1, The normalization equation

$$n_{ij} = x_{ij} / \sqrt{\sum_{j=1}^{m} x^2_{ij}}, \; j = 1, \ldots, m; \; i = 1, \ldots, n.$$

Table 6 shows the normalized decision matrix.

TABLE 6 - NORMALIZED DECISION MATRIX

	SC	HE	FT	SS
S_1	0.69337525	0.41602515	0.416025147	0.416025147
S_2	0.36927447	0.61545745	0.492365964	0.492365964
S_3	0.19245009	0.76980036	0.19245009	0.577350269
S_4	0.70014004	0.14002801	0.560112034	0.420084025
S_5	0.27216553	0.54433105	0.40824829	0.680413817
S_6	0.75377836	0.45226702	0.150755672	0.452267017
S_7	0.32025631	0.80064077	0.160128154	0.480384461
S_8	0.61545745	0.49236596	0.369274473	0.492365964
S_9	0.8660254	0.28867513	0.288675135	0.288675135
S_{10}	0.47140452	0.23570226	0.471404521	0.707106781
S_{11}	0.28867513	0.8660254	0.288675135	0.288675135
S_{12}	0.16012815	0.32025631	0.800640769	0.480384461
S_{13}	0.21320072	0.85280287	0.426401433	0.213200716
S_{14}	0.25819889	0.77459667	0.516397779	0.25819889
S_{15}	0.18898224	0.18898224	0.188982237	0.944911183
S_{16}	0.80064077	0.48038446	0.320256308	0.160128154
S_{17}	0.25819889	0.77459667	0.516397779	0.25819889
S_{18}	0.51639778	0.77459667	0.25819889	0.25819889
S_{19}	0.89802651	0.1796053	0.359210604	0.179605302

(2) Calculate the weighted normalized decision matrix. The weighted normalized value vij is calculated as (Eq. 2):

Equation 2, The weighted normalized equation

$$v_{ij} = w_i n_{ij}, \; j = 1, \ldots, m; \; i = 1, \ldots, n.$$

where wi is the weight of the ith attribute or criterion, and $\sum_{i=1}^{n} w_i = 1.$

Table 7 shows the weighted normalized decision matrix.

(3) Determine the positive ideal and negative ideal solution (Eq. 3).

Equation 3, The positive ideal and negative ideal solution

$$A^+ = \{v_1^+, \ldots, v_n^+\} = \left\{\left(\max_j v_{ij} \mid i \in I\right), \left(\min_j v_{ij} \mid i \in J\right)\right\},$$

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$$A^- = \{v_1^-, ..., v_n^-\} = \left\{ \left(\min_j v_{ij} \mid i \in I \right), \left(\max_j v_{ij} \mid i \in J \right) \right\},$$

where I is associated with benefit criteria, and J is associated with cost criteria. evaluation criteria can be classified into two types: benefit and cost. Benefit criterion means that a larger value is more valuable whilst cost criteria are just the reverse. For this study, all of four criteria are benefit criteria. Table 8 shows the positive ideal and negative ideal solution.

TABLE 7 - WEIGHED NORMALIZED DECISION MATRIX (WI*NIJ)

	SC	HE	FT	SS
Wi	W_1= 0.122	W_2= 0.137	W_3= 0.422	W_4= 0.319
S_1	0.08459178	0.056995445	0.175562612	0.132712022
S_2	0.045051486	0.084317671	0.207778437	0.157064742
S_3	0.023478911	0.105462649	0.081213938	0.184174736
S_4	0.085417085	0.019183837	0.236367278	0.134006804
S_5	0.033204194	0.074573354	0.172280779	0.217052008
S_6	0.09196096	0.061960581	0.063618894	0.144273178
S_7	0.03907127	0.109687785	0.067574081	0.153242643
S_8	0.075085809	0.067454137	0.155833828	0.157064742
S_9	0.105655099	0.039548493	0.121820907	0.092087368
S_{10}	0.057511352	0.03229121	0.198932708	0.225567063
S_{11}	0.035218366	0.11864548	0.121820907	0.092087368
S_{12}	0.019535635	0.043875114	0.337870405	0.153242643
S_{13}	0.026010487	0.116833993	0.179941405	0.068011029
S_{14}	0.031500265	0.106119744	0.217919863	0.082365446
S_{15}	0.023055833	0.025890566	0.079750504	0.301426667
S_{16}	0.097678174	0.065812671	0.135148162	0.051080881
S_{17}	0.031500265	0.106119744	0.217919863	0.082365446
S_{18}	0.063000529	0.106119744	0.108959931	0.082365446
S_{19}	0.109559234	0.024605926	0.151586875	0.057294091

TABLE 8 - THE POSITIVE AND NEGATIVE IDEAL SOLUTION

	SC	HE	FT	SS
A^+	0.109559234	0.11864548	0.337870405	0.301426667
A^-	0.019535635	0.019183837	0.063618894	0.051080881

(4) Calculate the separation measures, using the n-dimensional Euclidean distance. The separation of alternatives from the positive ideal solution is given as (Eq.4 & 5):

Equation 4, The separation measure from the positive ideal solution

$$d_j^+ = \{\sum_{i=1}^{n} (v_{ij} - v_i^+)^2\}^{1/2}, j = 1, ..., m$$

.

Similarly, the separation from the negative ideal solution is given as:

Equation 5, The separation measure from the negative ideal solution

$$d_j^- = \{\sum_{i=1}^{n} (v_{ij} - v_i^-)^2\}^{1/2}, j = 1,\ldots,m$$

Table 9 shows the separation of each alternative from the positive and negative ideal solution.

TABLE 9 - SEPARATION OF EACH ALTERNATIVE FROM THE POSITIVE AND NEGATIVE IDEAL SOLUTION

	+	-
d_1	0.243377385	0.157661216
d_2	0.207614868	0.192114621
d_3	0.295303516	0.159634403
d_4	0.220924777	0.202630399
d_5	0.205697476	0.206418624
d_6	0.321611547	0.125539165
d_7	0.316334318	0.137932138
d_8	0.240388542	0.158593873
d_9	0.311081827	0.113579433
d_{10}	0.187681659	0.224430868
d_{11}	0.309882062	0.123318988
d_{12}	0.188820976	0.293701508
d_{13}	0.293952554	0.152954349
d_{14}	0.261965738	0.180245714
d_{15}	0.28759728	0.250979309
d_{16}	0.326652393	0.115745154
d_{17}	0.261965738	0.180245714
d_{18}	0.320487801	0.111721003
d_{19}	0.321163052	0.126137295

TABLE 10 - THE CLOSENESS INDEX AND STRATEGIES RANKING

	Closeness	Rank
S_1	0.393132271	10
S_2	0.48061158	4
S_3	0.350892718	11
S_4	0.478403784	5
S_5	0.500874932	3
S_6	0.280753583	16
S_7	0.303637075	13
S_8	0.397495897	9
S_9	0.267458899	17
S_{10}	0.544586376	2
S_{11}	0.284669181	14
S_{12}	0.608679425	1
S_{13}	0.342251033	12
S_{14}	0.407600737	7
S_{15}	0.466004862	6
S_{16}	0.261631547	18
S_{17}	0.407600737	8
S_{18}	0.258488495	19
S_{19}	0.281996864	15

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(5) Calculate the relative closeness to the ideal solution. The relative closeness of the alternative Aj with respect to A+ is defined as (Eq. 6):

Equation 6, The closeness to the ideal solution

$$R_j = d_j^- / (d_j^+ + d_j^-), j = 1,...,m$$

Since $d_j^- \geq 0$ and $d_j^+ \geq 0$, then, clearly, $R_j \in [0,1]$.

Table 10 shows the closeness index and strategies ranking according to it.

4. CONCLUSIONS

In many cases that the experts regard to complex and ambiguous problems, having a tool to simplify them is a necessity. In urban planning, the entity of the problems is complex because, these problems are affected by many factors such as social, economic, cultural and technical factors. The CDS is a urban plan that is prepared in two past decades. The main feature of these plans is working on visions and their strategies and ranking them using participation. Urban planners need a model to ranking strategies without confusion and vague.

The MCDM methods provide a tool for solving multi criteria problems. These models allow group decision-making and completely coincide with interdisciplinary fields especially urban planning. Using them have many strength points and can be useful for urban plans especially the CDS. In this paper, the TOPSIS and AHP models had been examined in the district 22 CDS plan for strategies ranking.

The result shows using them helped the experts and caused to removing ambiguous in ranking process. Other advantage of these models that used by experts, is implementation on computer.

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