INTERNATIONAL JOURNAL OF STRATEGIC PROPERTY MANAGEMENT
ISSN 1648-715X print / ISSN 1648-9179 online

2012 Volume 16(2): 188–200
doi:10.3846/1648715X.2012.686459

GREENHOUSE LOCATING BASED ON ANP-COPRAS-G METHODS – AN EMPIRICAL STUDY BASED ON IRAN

Nahid REZAEINIYA [1], Sarfaraz HASHEMKHANI ZOLFANI [2] and Edmundas Kazimieras ZAVADSKAS [3] ✉

[1] *Department of Industrial Engineering, Alghadir Institute of higher education, Tabriz, Iran*
E-mail: nah.rezaeiniya@gmail.com
[2] *Department of Industrial Engineering, Shomal University, Amol city, Iran*
E-mail: sa.hashemkhani@gmail.com
[3] *Institute of Internet and Intelligent Technologies, Vilnius Gediminas Technical University, Sauletekio al. 11, LT-10223 Vilnius, Lithuania*
E-mail: edmundas.zavadskas@vgtu.lt

Received 26 October 2011; accepted 2 February 2012

ABSTRACT. The selection of a location among alternative locations is a multi criteria decision-making problem including both quantitative and qualitative criteria. In this paper, we describe the research and development of hybrid MCDM methods for greenhouse locating. Selection of the most appropriate location for investor is an important problem which requires assessment and analysis of several factors. The paper clarifies the structure of important criteria in greenhouse locating. The six factors identified were: labor, government, environment, physical condition, regional economy and raw materials. In this research, analysis network process (ANP) is applied to find the relative weights among the criteria and to emphasize the interdependent relationships, thus increasing the accuracy of our results COPRAS-G method is applied to rank for five regions in Amol city, in Iran. This article can be a guideline for investors to select the best location for greenhouses.

KEYWORDS: Greenhouse locating; Analysis network process (ANP); COPRAS-G method

1. INTRODUCTION

It is the first duty of investors to transform financial resources into investments in the right places at the right times and earn benefits. However, where to invest and how to invest is always a risky and complicated problem (Guneri et al., 2009). The construction of greenhouse is one of this investors that nowadays lack of proper management in site selection and construction of greenhouse, cause lack of productivity in this sector of agriculture. Due to population growth and increasing consumption, supply of food needs is an important problem for people and countries. In this regard, greenhouse production has been leading to increase productivity of limited resources of water and soil (Jaafarnia and Homaei, 2009). Greenhouse is a place that covered with transparent material and its temperature, light, humidity and other environmental factors can be managed (Hasandokht, 2005). The first point for the construction of greenhouses is to choose the appropriate location (Jaafarnia and Homaei, 2009). For greenhouses locating must consider several factors: heating supply, greenhouse expansion plans, access to electricity, access to specialized labor, access to fuel (Jaafarnia and Homaei, 2009), land costs, construct costs, raw materials (Hasandokht, 2005), regional economic situation, laws relating to land within the urban (Mollahoseini and Seylsepur, 2008),use of appropriate soil, labor costs, access to proper transportation (Jaafarnia and Homaei, 2009; Hasandokht, 2005), land topography, proximity to market (Jaafarnia and Homaei, 2009; Mollahoseini and Seylsepur, 2008), access to adequate water (Jaafarnia and Homaei, 2009; Hasandokht, 2005; Mollahoseini and Seylsepur, 2008), related industry status, Government (Guneri et al., 2009), and etc.

Greenhouse location should be selected according to these factors. Locating is a decision under a variety of factors and can be evaluated according to different aspects. Therefore greenhouse locating can be viewed as a multiple criteria decision making (MCDM) problem. The MCDM methods deal with the process of making decisions in the presence of multiple criteria or objectives (Önüt et al., 2008). Priority based, outranking, distance-based and mixed methods could be considered as the primary classes of the MCDM methods. In this research a hybrid MCDM model encompassing analytic network process (AHP) and the complex proportional assessment of alternatives with grey relations (COPRAS-G method) is used for greenhouse. Specifically, ANP is initially used for calculating the weight of each criterion and COPRAS-G method is used for ranking and selecting the best location.

In literature, there exist studies that used MCDM for locating problems: Guneri et al. (2009) used Fuzzy ANP approach for shipyard locating in Turkey, in that research they propose a network structure with ANP method and solved problem with Chang's method in fuzzy environment. Weber and Chapman (2011) used AHP for location intelligence. Kaya (2011) used fuzzy AHP for location selection of wastewater treatment plant. Önüt and Soner (2008) used AHP and TOPSIS approaches under fuzzy environment for transshipment site selection. Vahidnia et al. (2009) used fuzzy AHP for Hospital site selection in Iran. Kuo (2011) used ANP, Fuzzy DEMATEL and TOPSIS in international distribution center locating problem. Chou et al. (2008) used fuzzy multi-criteria decision model for international tourist hotels location selection. Önüt et al. (2010) studied shopping center site selection; they used Fuzzy TOPSIS and Fuzzy AHP in the research. In this paper, we classify greenhouse locating's criteria in six classes and use a hybrid model of MCDM methods as a guideline for investors. Radfar et al. (2011) used AHP-COPRAS-G for forest road locating. Zavadskas et al. (2004) used ELECTRE for valuation of commercial construction projects for investment purposes. Ozcan et al. (2011) used ELECTRE for multicriteria analysis of multi-criteria decision making methodologies and implementation of a warehouse location selection problem. Banias et al. (2010) used ELECTRE for optimal location of a construction and demolition waste management facility. Gundogdu (2011) used ELECTRE for selection of facility location under environmental damage priority. Brauers and Zavadskas (2008) used multi objective optimization by ratio analysis (MOORA) in location theory with a simulation for a department store. Turskis and Zavadskas (2010) used a new fuzzy additive ratio assessment method (ARAS-F) for analysis in order to select the logistic centers locations. Peldschus et al. (2010) used game theory two person zero-sum games for sustainable assessment of construction site. Mallozzi (2011) used cooperative games in facility location situation with regional fixed costs). In this study, ANP used to find weight of criteria and then COPRAS used to select the best location for greenhouses. To illustrate this research, Amol city in Iran selected as a case study.

2. METHODOLOGY

Over the past decades the complexity of economical decisions has increased rapidly, thus highlighting the importance of developing and implementing sophisticated and efficient quantitative analysis techniques for supporting and aiding economical decision-making (Zavadskas and Turskis, 2011). Multiple criteria decision making (MCDM) is an advanced field of operations research, provides decision makers and analysts a wide range of methodologies, which are overviewed and well suited to the complexity of economical decision problems (Hwang and Yoon 1981; Zopounidis and Doumpos, 2002; Figueira et al., 2005; Antucheviciene et al., 2011; Podvezko, 2011). Multiple criteria analysis (MCA) provides a framework for breaking a problem into its constituent parts. MCA provides a means to investigate a number of alternatives in light of conflicting priorities. Over the last decade scientists and researchers have developed a set of new MCDM methods (Kapliński and Tupenaite 2011; Kapliński and Tamosaitiene, 2010; Tamosaitiene et al., 2010). They modified methods and applied to solve practical and scientific problems.

2.1. Analytic Network Process

The ANP, also introduced by Saaty, is a generalization of the AHP (Saaty, 1996). Saaty (1996) suggested the use of AHP to solve the problem of independence on alternatives or criteria, and the use of ANP to solve the problem of dependence among alternatives or criteria. Many decision-making problems cannot be structured hierarchically because they involve the interaction and dependence of higher level elements on lower level elements (Saaty and Takizawa, 1986). This is a network system. However in ANP, criteria in the lower level may provide feedback to the criteria in the higher level, and the Inter dependence among the criteria in the same level is permitted (Liang and Li, 2007). Another difference between AHP and ANP in calculation process is that a new concept "supermatrix" is introduced in ANP (Liang and Li, 2007).

The recent applications of ANP method in shortly are listed below:

– Boran et al. (2008) used ANP for personnel selection.
– Dagdeviren et al. (2008) applied fuzzy ANP model to identify faulty behavior risk (FBR) in work system.
– Ayag and Ozdemir (2009) applied fuzzy ANP approach to concept selection.
– Yazgan (2010) applied fuzzy ANP for selection of dispatching rules.
– Kuo (2011) used ANP, Fuzzy DEMATEL and TOPSIS in international distribution center locating problem.

The application steps of ANP are as follows (Saaty, 1999; Saaty, 2001):

Forming the Network Structure

Firstly, criteria, sub criteria and alternatives are defined. Then, the clusters of elements are determined. Network is formed based on relationship among clusters and within elements in each cluster. There are few different relationships that have effects. Direct effect may be considered as a regular dependency in a standard hierarchy. Indirect effect dependency of which is not direct and must flow through another criteria or alternative. Another effect is the self-interaction one. Last are interdependencies among criteria which form a mutual effect.

Forming Pairwise Comparison Matrices and Obtaining Priority Vector

Pair wise comparisons are performed on the elements within the clusters as they influence each cluster and on those that it influences, with respect to that criterion. The pairwise comparisons are made with respect to a criterion or sub criterion of the control hierarchy (Saaty, 1999). Thus, importance weights of factors are determined. In pairwise comparison, decision makers compare two elements. Then, they determine the contribution of factors to the result (Saaty, 2001).

In ANP, like AHP, it is formed pairwise comparison matrices with use 1-9 scale of relative importance proposed by Saaty (Saaty, 1996). 1-9 scale of relative importance is given at Table 1.

Table 1. Scale of relative importance

Intensity of importance	Definition
1	Equal importance
3	Moderate importance
5	Essential or strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate value between adjacent scale values

Adapted from Saaty (1980) and Saaty and Vargas (2006).

The values of pairwise comparisons are allocated in comparison matrix and local priority vector is obtained from eigenvector which is calculated from this equation:

$$AW = \lambda_{enb} w \tag{1}$$

In this equation, A, W and λ_{enb} stands for the pairwise comparison matrix, eigenvector and eigenvalue, respectively.

Saaty has proposed normalization algorithm for approximate solution for w (Saaty, 1980).

The matrix which shows the comparison between factors is obtained as follows:

$$A = \left[a_{ij}\right]_{n \times n},\ i = \overline{1,n};\ j = \overline{1,n} \tag{2}$$

Significance distribution of factors as percentage is obtained as follows:

$$B_i = \left[b_{ij}\right]_{n\times 1},\ i = \overline{1,n} \tag{3}$$

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{4}$$

$$C = \left[b_{ij}\right],\ i = \overline{1,n};\ j = \overline{1,n} \tag{5}$$

$$w_i = \frac{\sum_{i=1}^{n} c_{ij}}{n} W = [w_i]_{n\times 1} \tag{6}$$

Forming Super matrix and Limit Super Matrix

The overall structure of super matrix is similar to Markov chain process (Saaty, 1996; Saaty, 2005). To obtain global priority in a system that has interdependent effects, all local priority vectors are allocated to the relevant columns of super matrix. Consequently, super matrix is a limited matrix and every part of it shows the relationship between two elements in the system. The long term relative impacts of the elements to each other are obtained by raising the super matrix power. To equalize the importance weights, power of the matrix is raised to the *2k +1*, where k is an arbitrary large number. The new matrix is called limited Super matrix (Saaty, 1996). The consistency of elements comparisons are calculated as follows:

$$D = [a_{ij}]_{n\times n} \times [w_i]_{n\times 1} = [d_i]_{n\times 1} \tag{7}$$

$$E_i = \frac{d_i}{w_i},\ i = \overline{1,n} \tag{8}$$

$$\lambda = \frac{\sum_{i=1}^{n} E_i}{n} \tag{9}$$

$$CI = \frac{\lambda - n}{n-1} \tag{10}$$

$$CR = \frac{CI}{RI} \tag{11}$$

In the equations above, *CI*, *RI* and *CR* represent consistency indicator, random indicator and consistency ratio, respectively. Consistency of pairwise matrix is checked by consistency index (CI). For accepted consistency, CI must be smaller than 0.10 (Saaty, 1980).

2.2. COPRAS-G method

In order to evaluate the overall efficiency of a project, it is necessary to identify selection criteria, to assess information, relating to these criteria, and to develop methods for evaluating the criteria to meet the participants' needs. Decision analysis is concerned with the situation in which a decision-maker has to choose among several alternatives by considering a particular set of criteria. For this reason Complex proportional assessment (COPRAS) method (Zavadskas and Kaklauskas, 1996) can be applied. This method was applied to the solution of various problems in construction and assessment of road design solutions (Zavadskas et al., 2007). The most of alternatives under development always deals with future and values of criteria cannot be expressed exactly. This multi criteria decision-making problem must be determined not with exact criteria values, but with fuzzy values or with values in some intervals. Zavadskas et al. (2008) presented the main ideas of complex proportional assessment method with grey interval numbers (COPRAS-G) method. The idea of COPRAS-G method with criterion values expressed in intervals is based on the real conditions of decision making and applications of the Grey systems theory. The COPRAS-G method uses a stepwise ranking and evaluating procedure of the alternatives in terms of significance and utility degree.

The recent developments of decision making models based on COPRAS methods are listed below:

- Ginevičius and Podvezko (2008) evaluated of banks from the perspective of their reliability for clients;
- Datta et al. (2009) solved problem of determining compromise to selection of supervisor;
- Bindu Madhuri et al. (2010) presented model for selection of alternatives based on COPRAS-G and AHP methods;
- Uzsilaityte and Martinaitis (2010) investigated and compared different alternatives for the renovation of buildings taking into account energy, economic and environmental criteria while evaluating impact of renovation measures during their life cycle;
- Chatterjee et al. (2011) presented materials selection model based on COPRAS and EVAMIX methods;
- Podvezko (2011) presented comparative analysis of MCDM methods (SAW and COPRAS).
- Medineckiene and Björk (2011) solved problem of preferences regarding renovation measures.
- Tupenaite et al. (2010) presented multiple criteria assessment of alternatives for built and human environment renovation.

The procedure of applying the COPRAS-G method consists in the following steps (Zavadskas et al., 2009):

1. Selecting the set of the most important criteria, describing the alternatives.

2. Constructing the decision-making matrix $\otimes X$:

$$\otimes X = \begin{bmatrix} [\otimes x_{11}] & \dots & \dots & [\otimes x_{1m}] \\ [\otimes x_{21}] & \dots & \dots & [\otimes x_{2m}] \\ \vdots & \dots & \ddots & \vdots \\ [\otimes x_{n1}] & \dots & \dots & [\otimes x_{nm}] \end{bmatrix} = \begin{bmatrix} [\underline{x}_{11}; \overline{x}_{11}] & [\underline{x}_{12}; \overline{x}_{12}] & \dots & [\underline{x}_{1m}; x_{1m}] \\ [\underline{x}_{21}; \overline{x}_{21}] & [\underline{x}_{22}; \overline{x}_{22}] & \dots & [\underline{x}_{2m}; \overline{x}_{2m}] \\ \vdots & \vdots & \ddots & \vdots \\ [\underline{x}_{n1}; \overline{x}_{n1}] & [\underline{x}_{n2}; \overline{x}_{n2}] & \dots & [\underline{x}_{nm}; \overline{x}_{nm}] \end{bmatrix}; j = \overline{1,n}, i = \overline{1,m} \quad (12)$$

Here $\otimes x_{ji}$ is determined by $\underline{x}_{ji}$ (the smallest value, the lower limit) and $\overline{x}_{ji}$ (the biggest value, the upper limit).

3. Determining significances of the criteria.

4. Normalizing the decision-making matrix $\otimes X$:

$$\underline{\tilde{x}} = \frac{\underline{x}_{ji}}{\frac{1}{2}\left(\sum_{j=1}^{n}\underline{x}_{ji} + \sum_{j=1}^{n}\overline{x}_{ji}\right)} = \frac{2\underline{x}_{ji}}{\left(\sum_{j=1}^{n}\underline{x}_{ji} + \sum_{j=1}^{n}\overline{x}_{ji}\right)}, \bar{\tilde{x}} = \frac{\overline{x}_{ji}}{\frac{1}{2}\left(\sum_{j=1}^{n}\underline{x}_{ji} + \sum_{j=1}^{n}\overline{x}_{ji}\right)} = \frac{2\overline{x}_{ji}}{\sum_{j=1}^{n}(\underline{x}_{ji} + \overline{x}_{ji})}; \; j = \overline{1,n}; \; i = \overline{1,m} \tag{13}$$

In formula $\underline{x}_{ji}$ (13) is the lower value of the i criterion in the alternative j of the solution; $\overline{x}_{ji}$ is the upper value of the criterion i in the alternative j of the solution; m is the number of criteria; n is the number of the alternatives, compared. Then, the decision-making matrix is normalized:

$$\otimes\tilde{X} = \begin{bmatrix} [\underline{\tilde{x}}_{11};\bar{\tilde{x}}_{11}] & [\underline{\tilde{x}}_{12};\bar{\tilde{x}}_{12}] & \dots & [\underline{\tilde{x}}_{1m};\bar{\tilde{x}}_{1m}] \\ [\underline{\tilde{x}}_{21};\bar{\tilde{x}}_{21}] & [\underline{\tilde{x}}_{22};\bar{\tilde{x}}_{22}] & \cdots & [\underline{\tilde{x}}_{2m};\bar{\tilde{x}}_{1m}] \\ \vdots & \vdots & \ddots & \vdots \\ [\underline{\tilde{x}}_{n1};\bar{\tilde{x}}_{n1}] & [\underline{\tilde{x}}_{n2};\bar{\tilde{x}}_{n2}] & \dots & [\underline{\tilde{x}}_{nm};\bar{\tilde{x}}_{nm}] \end{bmatrix} \tag{14}$$

5. Calculating the weighted normalized decision matrix $\otimes\hat{X}$. The weighted normalized values $\hat{x}_{ji}$ are calculated as follows:

$$\otimes\hat{x}_{ji} = \otimes\tilde{x}_{ji} \cdot q \text{ or } \underline{\hat{x}_{ji}} = \underline{\tilde{x}}_{ji} \cdot q_i \text{ and } \bar{\hat{x}}_{ji} = \bar{\tilde{x}}_{ji} \cdot q_i \tag{15}$$

In formula (15), q_i is the significance of the i *–th* criterion.

Then, the normalized decision-making matrix is:

$$\otimes\hat{X} = \begin{bmatrix} [\otimes\hat{x}_{11}] & [\otimes\hat{x}_{12}] & \dots & [\otimes\hat{x}_{1m}] \\ [\otimes\hat{x}_{21}] & [\otimes\hat{x}_{21}] & \cdots & [\otimes\hat{x}_{2m}] \\ \vdots & \vdots & \ddots & \vdots \\ [\otimes\hat{x}_{n1}] & [\otimes\hat{x}_{n2}] & \dots & [\otimes\hat{x}_{nm}] \end{bmatrix} = \begin{bmatrix} [\underline{\hat{x}}_{11};\bar{\hat{x}}_{11}] & [\underline{\hat{x}}_{12};\bar{\hat{x}}_{12}] & \dots & [\underline{\hat{x}}_{1m};\bar{\hat{x}}_{1m}] \\ [\underline{\hat{x}}_{21};\bar{\hat{x}}_{21}] & [\underline{\hat{x}}_{22};\bar{\hat{x}}_{22}] & \cdots & [\underline{\hat{x}}_{2m};\bar{\hat{x}}_{2m}] \\ \vdots & \vdots & \ddots & \vdots \\ [\underline{\hat{x}}_{n1};\bar{\hat{x}}_{n1}] & [\underline{\hat{x}}_{n2};\bar{\hat{x}}_{n2}] & \dots & [\underline{\hat{x}}_{nm};\bar{\hat{x}}_{nm}] \end{bmatrix} \tag{16}$$

6. Calculating the sums P_j of criterion values, whose larger values are more preferable:

$$P_j = \frac{1}{2}\sum_{i=1}^{k}(\underline{\hat{x}}_{ji} + \bar{\hat{x}}_{ji}) \tag{17}$$

7. Calculating the sums R_j of criterion values, whose smaller values are more preferable:

$$R_j = \frac{1}{2}\sum_{i=k+1}^{m}(\underline{\hat{x}}_{ji} + \bar{\hat{x}}_{ji}); \; i = \overline{k,m} \tag{18}$$

In formula (18), $(m - k)$ is the number of criteria which must be minimized.

8. Determining the minimal value of R_j as follows:

$$R_{\min} = \min_j R_j; \; j = \overline{1,n} \tag{19}$$

9. Calculating the relative significance of each alternatively Q_j the expression:

$$Q_j = P_j + \frac{\sum_{j=1}^{n} R_j}{R_j \sum_{j=1}^{n} \frac{1}{R_j}} \tag{20}$$

10. Determining the optimally criterion by K the formula:

$$K = \max_i Q_i;\; j = \overline{1,n} \tag{21}$$

11. Determining the priority order of the alternatives.

12. Calculating the utility degree of each alternative by the formula:

$$N_j = \frac{Q_j}{Q_{\max}} \times 100\% \tag{22}$$

where: Q_j and $Q_{\max}$ are the significances of the alternatives obtained from equation (20).

3. GREENHOUSE LOCATING MODEL BASED ON ANP AND COPRAS-G METHOD

3.1. Identification of necessary criteria for greenhouse locating

The aim of this study is to utilize a hybrid model of MCDM methods for greenhouse locating. Amol city is locating in north of the Iran and is one of the best places for greenhouse.

There are a lot of greenhouses in this city that they have greenhouse production and export them too. In this paper we want to select the best regions for greenhouses in Amol city. We classify criteria in six classes, as they are shown in Table 2. After the criteria were defined, we divided Amol city to five regions, these regions are: (Bala khiyaban litkooh (A_1), Paien khiyaban litkoh (A_2), Dashtesar (A_3), Daboo (A_4), Haraz peye jonubi (A_5)). These candidates were evaluated using the hybrid selection model.

Table 2. Criteria classification and the description

Criteria	Descriptions
Labor x_1	Labor costs
Government x_2	Incentive
Environment x_3	Proper soil
	Proper water
	Topography
	Proper transportation
	Access to fuel
	Access to electricity
	Proximity to market
Physical condition x_4	Land costs
	Construct costs
Regional economy x_5	Regional economic situation
	Related industry status
Raw materials x_6	Access to materials

Based on the nature of six evaluation criteria, optimization directions for each evaluation criterion is determined as follows:

$$\otimes x_{2,3,5,6}\,\overrightarrow{optimaldirection(Max)}$$

$$\otimes x_{1,4}\,\overrightarrow{optimaldirection(Min)}$$

3.2. Calculate the weights of criteria for greenhouse locating

First, criteria weights were determined by avoiding the interdependence among criteria (Dagdeviren, 2010). To this end, a pairwise comparison matrix was formed and pairwise comparisons were defined by a group of experts, on the basis of Saaty's 1-9 scale. The Information about experts is shown in Table 3.

Table 3. Background information of experts

Variable	Items	No	Variable	Items	No
1) Education background	Bachelor	3	3) Sex	Male	4
	Master	2		Female	2
	Ph.D.	1			
2) Service tenure	1–10	2	4) Age	30–40	4
	11–20	3		41–50	2
	21–30	1			

The pairwise matrix and calculated weights are shown in Table 4. The degree of consistency of the pairwise comparison matrix is measured with the use of the consistency ratio (CR) index. It is considered logically consistent if the CR is less than or equal to 0.1. The CR value for this pairwise comparison matrix is 0.090, which is acceptable. At the end of pairwise comparisons, criteria weights were calculated.

Next, the group of expert determines the interdependence between the criteria that is presented in Figure 1.

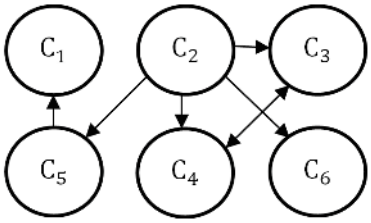

Figure 1. Dependency among criteria

The normalized eigenvectors matrix of this structure is presented in Table 5. A value of "zero" in Table 5 indicates that there is no dependence between two criteria and the numerical values show the relative impact between two criteria.

w_c calculated by using the data given in Tables 4 and 5.

$$w_c = \begin{bmatrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \end{bmatrix} = \begin{bmatrix} 0.200 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1.000 & 0.429 & 0.417 & 0.800 & 0.800 \\ 0 & 0 & 0.143 & 0.500 & 0 & 0 \\ 0 & 0 & 0.429 & 0.083 & 0 & 0 \\ 0.800 & 0 & 0 & 0 & 0.200 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.200 \end{bmatrix} \times \begin{bmatrix} 0.105 \\ 0.205 \\ 0.270 \\ 0.270 \\ 0.106 \\ 0.044 \end{bmatrix} = \begin{bmatrix} 0.021 \\ 0.553 \\ 0.174 \\ 0.138 \\ 0.105 \\ 0.009 \end{bmatrix}$$

Table 4. The pairwise comparison matrix for criteria

	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**Weights**
C_1	1	1/5	1/4	1/4	3	2	0.105
C_2	5	1	1/2	1/2	2	5	0.205
C_3	4	2	1	1	2	5	0.270
C_4	4	2	1	1	2	5	0.270
C_5	1/3	1/2	1/2	1/2	1	3	0.106
C_6	1/2	1/5	1/5	1/5	1/3	1	0.044

Table 5. Degree of relative impact for criteria

	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
C_1	0.200	0	0	0	0	0
C_2	0	1.000	0.429	0.417	0.800	0.800
C_3	0	0	0.143	0.500	0	0
C_4	0	0	0.429	0.083	0	0
C_5	0.800	0	0	0	0.200	0

According to the calculation made, C_2, C_3 and C_4 were three of the most important considering criteria.

3.3. Evaluation of regions for greenhouse locating

At this stage of the application, the group of experts evaluated each region according to each criterion and Table 6 developed. It indicates initial decision making matrix, with the criterion values described in intervals. For the weight of criteria we used w_c of ANP method. The initial decision making matrix, has been normalized first as discussed in section 2. The normalized decision making matrix is presented in Table 7. Using equations (17) to (22) for all the regions, these are furnished in Table 8.

Based on the results of Table 8, the ranking of the three persons is A_5, A_2, A_4, A_1 and A_3. Hybrid approach results indicate that A_5 is the best candidate with the highest degree and it is the best region for greenhouses in Amol city.

Table 6. Initial decision making matrix with the criterion values described in intervals

	$\otimes x_1$	$\otimes x_2$	$\otimes x_3$	$\otimes x_4$	$\otimes x_5$	$\otimes x_6$
opt	*min*	*max*	*max*	*min*	*max*	*max*
q_i	0.021	0.553	0.174	0.138	0.105	0.009
Regions	$\underline{x}_1,\overline{x}_1$	$\underline{x}_2,\overline{x}_2$	$\underline{x}_3,\overline{x}_3$	$\underline{x}_4,\overline{x}_4$	$\underline{x}_5,\overline{x}_5$	$\underline{x}_6,\overline{x}_6$
A_1	[70;80]	[55;70]	[80;90]	[60;80]	[40;60]	[55;65]
A_2	[40;60]	[70;80]	[70;75]	[70;80]	[55;65]	[65;75]
A_3	[50;55]	[70;75]	[60;70]	[80;85]	[65;75]	[70;75]
A_4	[60;70]	[65;75]	[75;80]	[65;75]	[60;70]	[70;80]
A_5	[65;75]	[75;80]	[65;75]	[60;70]	[70;75]	[70;85]

Table 7. Normalized weighted matrix $\hat{X}$

		$\otimes x_2$	$\otimes x_3$	$\otimes x_4$	$\otimes x_5$	$\otimes x_6$
opt	*min*	*max*	*max*	*min*	*max*	*max*
Regions	$\hat{\underline{x}}_1,\hat{\overline{x}}_1$	$\hat{\underline{x}}_2,\hat{\overline{x}}_2$	$\hat{\underline{x}}_3,\hat{\overline{x}}_3$	$\hat{\underline{x}}_4,\hat{\overline{x}}_4$	$\hat{\underline{x}}_5,\hat{\overline{x}}_5$	$\hat{\underline{x}}_6,\hat{\overline{x}}_6$
A_1	[0.004;0.005]	[0.085;0.108]	[0.037;0.042]	[0.022;0.030]	[0.013;0.019]	[0.001;0.002]
A_2	[0.002;0.004]	[0.108;0.123]	[0.032;0.035]	[0.026;0.030]	[0.018;0.021]	[0.001;0.002]
A_3	[0.003;0.003]	[0.108;0.116]	[0.028;0.032]	[0.030;0.032]	[0.021;0.024]	[0.001,0.002]
A_4	[0.004;0.004]	[0.100;0.116]	[0.035;0.037]	[0.024;0.028]	[0.019;0.023]	[0.001;0.002]
A_5	[0.004;0.005]	[0.116;0.123]	[0.030;0.035]	[0.022;0.026]	[0.023;0.023]	[0.002;0.002]

Table 8. Evaluation of utility degree

Regions	P_j	R_j	Q_j	N_j
A_1	0.153	0.061	0.232	86.2%
A_2	0.17	0.062	0.247	91.8%
A_3	0.161	0.068	0.231	85.8%
A_4	0.166	0.062	0.243	90.3%
A_5	0.177	0.057	0.269	100%

4. CONCLUSION

It is the first duty of investors to transform financial resources into investments in the right places at the right times and earn benefits. However, where to invest and how to invest is always a risky and complicated problem. Greenhouse locating has become one of the most important problems for investors; nevertheless, few applicable models have been addressed that concentrates on this problem. This paper presents a model for greenhouse locating in Amol city that it can be used to improve the performance of greenhouses. In this study, we proposed an effective model for greenhouse locating using both ANP and COPRAS-G methods. This application has indicated that the model can be efficiently used in locating and ranking candidates. Proposed model has significantly increased the efficiency of decision-making process in greenhouse locating. Although the application of the model proposed in this study is specific to greenhouses, it can also be used with slight modifications in decision-making process.

REFERENCES

Antucheviciene, J., Zakarevicius, A. and Zavadskas, E. K. (2011) Measuring congruence of ranking results applying particular MCDM methods, *Informatica*, 22(3), pp. 319–338.

Ayag, Z. and Ozdemir, R. G. (2009) A hybrid approach to concept selection through fuzzy analytic network process, *Computers & Industrial Engineering*, 56(1), pp. 368–379. http://dx.doi.org/10.1016/j.cie.2008.06.011

Banias, G., Achillas, C., Vlachokostas, C., Moussiopoulos, N. and Tarsenis, S. (2010) Assessing multiple criteria for the optimal location of a construction and demolition waste management facility, *Building and Environment*, 45(10), pp. 2317–2326. http://dx.doi.org/10.1016/j.buildenv.2010.04.016

Bindu Madhuri, C., Anand Chandulal, J. and Padmaja, M. (2010) Selection of best web site by applying COPRAS-G method, *International Journal of Computer Science and Information Technologies*, 1(2), pp. 138–146.

Boran, S., Goztepe, K. and Yavuz, E. (2008) A study on election of personnel based on performance measurement by using analytic network process (ANP), *International Journal of Computer Science and Network Security*, 8(4), pp. 333–338.

Brauers, W. K. M. and Zavadskas, E. K. (2008) Multi-objective optimization in local theory with a simulation for a department store, *Transformations in Business & Economic*, 7(3), pp. 163–183.

Chatterjee, P., Athawale, V. M. and Chakraborty, S. (2011) Materials selection using complex proportional assessment and evaluation of mixed data methods, *Materials & Design*, 32(2), pp. 851–860. http://dx.doi.org/10.1016/j.matdes.2010.07.010

Chou, T. Y., Hsu, C. L. and Chen, M. C. (2008) A fuzzy multi-criteria decision model for international tourist hotels location selection, *International Journal of Hospitality Management*, 27(2), pp. 293–301. http://dx.doi.org/10.1016/j.ijhm.2007.07.029

Dagdeviren, M. (2010) A hybrid multi-criteria decision-making model for personnel selection in manufacturing systems, *Journal of Intelligent Manufacturing*, 21(4), pp. 451–460. http://dx.doi.org/10.1007/s10845-008-0200-7

Dagdeviren, M., Yuksel, I. and Kurt, M. (2008) A fuzzy analytic network process (ANP) model to identify faulty behavior risk (FBR) in work system, *Safety Science*, 46(5), pp. 771–783. http://dx.doi.org/10.1016/j.ssci.2007.02.002

Datta, S., Beriha, G. S., Patnaik, B. and Mahapatra, S. S. (2009) Use of compromise ranking method for supervisor selection: a multi criteria decision making (MCDM) approach, *International Journal of Vocational and Technical Education*, 1(1), pp. 7–13.

Figueira, J., Greco, S. and Ehrgott, M. (Eds) (2005) *Multiple criteria decision analysis: state of the art surveys*. New York: Springer.

Ginevičius, R. and Podvezko, V. (2008) Multi-criteria evaluation of Lithuanian banks from the perspective of their reliability for clients, *Journal of Business Economics and Management*, 9(4), pp. 257–267. http://dx.doi.org/10.3846/1611-1699.2008.9.257-267

Gundogdu, C. E. (2011) Selection of facility location under environmental damage priority and using ELECTRE method, *Journal of Environmental Biology*, 32(2), pp. 221–226.

Guneri, A. F., Cengiz, M. and Seker, S. (2009) A fuzzy ANP approach to shipyard location selection, *Expert Systems with Applications*, 36(4), pp. 7992–7999. http://dx.doi.org/10.1016/j.eswa.2008.10.059

Hasandokht, M. (2005) *Greenhouse management (greenhouse product technologies), 1st Edition*. Marzedanesh publication, pp. 31–35. (In Persian)

Hwang, C. L. and Yoon, K. (1981) Multiple attribute decision making: a state of the art survey, *Lecture Notes in Economics and Mathematical Systems*, 186, Berlin: Springer-Verlag.

Jaafarnia, S. and Homaei, M. (2009) *Comprehensive and illustrated guide, Greenhouse cultivation of cucumbers and tomatoes, 7th Edition*. Iran green agriculture school, pp. 2–10. (In Persian)

Kaya, I. (2011) Multicriteria location selection of wastewater treatment plant by fuzzy analytic hierarchy process, *Journal of Multiple-Valued Logic and Soft Computing*, 17(4), pp. 305–320.

Kapliński, O. and Tupenaite, L. (2011) Review of the multiple criteria decision making methods, intelligent and biometric systems applied in modern construction economics, *Transformations in Business & Economics*, 10(1), pp. 166–181.

Kapliński, O. and Tamosaitiene, J. (2010) Game theory applications in construction engineering and management, *Technological and Economic Development of Economy*, 16(2), pp. 348–363. http://dx.doi.org/10.3846/tede.2010.22

Kuo, M. S. (2011) Optimal location selection for an international distribution center by using a new hybrid method, *Expert Systems with Applications*, 38(6), pp. 7208–7221. http://dx.doi.org/10.1016/j.eswa.2010.12.002

Liang, C. and Li, Q. (2007) Enterprise information system project selection with regard to BOCR, *International Journal of Project Management*, 26(8), pp. 810–820.

http://dx.doi.org/10.1016/j.ijproman.2007.11.001

Mallozzi, L. (2011) Cooperative games in facility location situations with regional fixed costs, *Optimization Letters*, 5(1), pp. 173–181. http://dx.doi.org/10.1007/s11590-010-0200-3

Medineckiene, M. and Björk, F. (2011) Owner preferences regarding renovation measures - the demonstration of using multi-criteria decision making, *Journal of Civil Engineering and Management*, 17(2), pp. 284–295.

http://dx.doi.org/10.3846/13923730.2011.582380

Mollahoseini, H. and Seylsepur, M. (2008) *Greenhouse production management, 1st Edition*. Sarva publication. (In Persian)

Önüt, S., Kara, S. and Tugba, E. (2008) A hybrid fuzzy MCDM approach to machine tool selection, *Journal of Intelligent Manufacturing*, 19(4), pp. 443–453. http://dx.doi.org/10.1007/s10845-008-0095-3

Önüt, S. and Soner, S. (2008) Transshipment site selection using the AHP and TOPSIS approaches under fuzzy environment, *Waste Management*, 28(9), pp. 1552–1559. http://dx.doi.org/10.1016/j.wasman.2007.05.019

Önüt, S., Efendigil, T. and Kara, S. S. (2010) A combined fuzzy MCDM approach for selecting shopping center site: an example from Istanbul, Turkey, *Expert Systems with Applications*, 37(3), pp. 1973–1980. http://dx.doi.org/10.1016/j.eswa.2009.06.080

Ozcan, T., Çelebi, N. and Esnaf, Ş. (2011) Comparative analysis of multi-criteria decision making methodologies and implementation of a warehouse location selection problem, *Expert Systems with Applications*, 38(8), pp. 9773–9779. http://dx.doi.org/10.1016/j.eswa.2011.02.022

Peldschus, F., Zavadskas, E. K., Turskis, Z. and Tamosaitiene, J. (2010) Sustainable assessment of construction site by applying game theory, *Inzinerine Ekonomika-Engineering Economics*, 21(3), pp. 223–237.

Podvezko, V. (2011) The comparative analysis of MCDA methods SAW and COPRAS, *Inzinerine Ekonomika-Engineering Economics*, 22(2), pp. 134–146.

Radfar, I., Hashemkhani Zolfani, S., Rezaeiniya, N. and Shadifar, M. (2011) Using AHP- COPRAS-G method for forest roads locating. In: *2nd IEEE international conference on emer-*

gency management and management sciences (ICEMMS), Beijing 2011, pp. 547–550.

Saaty, T. L. (1996) *Decision making with dependence and feedback the analytic network process*. Pittsburgh: RWS Publications.

Saaty, T. L. and Takizawa, M. (1986) Dependence and independence: from linear hierarchies to nonlinear networks, *European Journal of Operational Research*, 26(2), pp. 229–237. http://dx.doi.org/10.1016/0377-2217(86)90184-0

Saaty, T. L. (1999) Fundamentals of the analytic network process, *ISAHP*, 12-14 August, 1999, Kobe, pp. 348–379.

Saaty, T. L. (2001) *Making with dependence and feedback, 2nd Edition*. Pittsburg: RWS Publication.

Saaty, T. L. (1980) *The analytic hierarchy process*. New York: McGraw-Hill.

Saaty T. L. and Vargas L. G. (2006) *Decision making with the analytic network process*. Springer.

Saaty, T. L. (2005) *Theory and applications of the analytic network process: decision making with benefits, opportunities, costs, and risks*. Pittsburg: RWS Publications.

Tamosaitiene, J., Bartkiene, L. and Vilutiene, T. (2010) The new development trend of operational research in civil engineering and sustainable development as a result of collaboration between German–Lithuanian–Polish scientific triangle, *Journal of Business Economics and Management*, 11(2), pp. 316–340. http://dx.doi.org/10.3846/jbem.2010.16

Tupenaite, L., Zavadskas, E. K., Kaklauskas, A., Turskis, Z. and Seniut, M. (2010) Multiple criteria assessment of alternatives for built and human environment renovation, *Journal of Civil Engineering and Management*, 16(2), pp. 257–266. http://dx.doi.org/10.3846/jcem.2010.30

Turskis, Z. and Zavadskas, E. K. (2010) A new fuzzy additive ratio assessment method (ARAS–F). Case study: the analysis of fuzzy multiple criteria in order to select the logistic centers location, *Transport*, 25(4), pp. 423–432. http://dx.doi.org/10.3846/transport.2010.52

Uzsilaityte, L. and Martinaitis, V. (2010) Search for optimal solution of public building renovation in terms of life cycle, *Journal of Environment Engineering and Landscape Management*, 18(2), pp. 102–110. http://dx.doi.org/10.3846/jeelm.2010.12

Vahidnia, M. H., Alesheikh, A. A. and Alimohammadi, A. (2009) Hospital site selection using fuzzy AHP and its derivatives, *Journal of Environmental Management*, 90(10), pp. 3048–3056. http://dx.doi.org/10.1016/j.jenvman.2009.04.010

Weber, P. and Chapman, D. (2011) Location intelligence: an innovative approach to business location decision-making, *Transactions in GIS*, 15(3), pp. 309–328. http://dx.doi.org/10.1111/j.1467-9671.2011.01253.x

Yazgan, H. R. (2010) Selection of dispatching rules with fuzzy ANP approach, *The International Journal of Advanced Manufacturing Technology*, 52(5-8), pp. 651–667. http://dx.doi.org/10.1007/s00170-010-2739-7

Zavadskas, E. K. and Turskis, Z. (2011) Multiple criteria decision making (MCDM) methods in economics: an overview, *Technological and Economic Development of Economy*, 17(2), pp. 397–427. http://dx.doi.org/10.3846/20294913.2011.593291

Zavadskas, E. K. and Kaklauskas, A. (1996) Determination of an efficient contractor by using the new method of multi criteria assessment. In: Langford, D. A. and Retik, A. (eds.), *International symposium for "The organization and management of construction". Shaping theory and practice*. Vol. 2: Managing the construction project and managing risk. CIB W 65; London, Weinheim, New York, Tokyo, Melbourne, Madras. London: E and FN SPON, pp. 94–104.

Zavadskas, E. K., Kaklauskas, A., Peldschus, F. and Turskis, Z. (2007) Multi-attribute assessment of road design solutions by using the COPRAS method, *The Baltic Journal of Road and Bridge Engineering*, 2(4), pp. 195–203.

Zavadskas, E. K., Kaklauskas, A., Turskis, Z. and Tamosaitiene, J. (2008) Selection of the effective dwelling house walls by applying attributes values determined at intervals, *Journal of Civil Engineering and Management*, 14(2), pp. 85–93. http://dx.doi.org/10.3846/1392-3730.2008.14.3

Zavadskas, E. K., Kaklauskas, A., Turskis, Z. and Tamosaitiene, J. (2009) Multi-attribute decision-making model by applying grey numbers, *Informatica*, 20(2), pp. 305–320.

Zavadskas, E. K., Ustinovichius, L. and Stasiulionis, A. (2004) Multicriteria valuation of commercial construction projects for investment purposes, *Journal of Civil Engineering and Management*, 10(2), pp. 151–166. http://dx.doi.org/10.1080/13923730.2004.9636299

Zopounidis, C. and Doumpos, M. (2002) Multi-criteria decision aid in financial decision making: methodologies and literature review, *Journal of Multi-Criteria Decision Analysis*, 11(4-5), pp. 167–186. http://dx.doi.org/10.1002/mcda.333