Carpathian Journal of Earth and Environmental Sciences, August 2012, Vol. 7, No. 3, p. 51 - 60

USING ANALYTIC HIERARCHY PROCESS METHOD AND ORDERING TECHNIQUE TO ASSESS DE-DESERTIFICATION ALTERNATIVES. CASE STUDY: KHEZRABAD, YAZD, IRAN

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Abstract: Till now, there is no any method to consider different criteria and alternatives and present the optimal alternatives based on systematic and group perspective in de-desertification projects. Usually, the proposed alternatives according to experts are non-systematic and non-comprehensive. There is no record on application of systematic models in de-desertification field including: Multiple Attribute Decision Making (MADM). This paper tries to present the application of analytic hierarchy process method and to order preference by similarity to ideal solution and providing optimal de-desertification alternatives. In this study, experts' opinions on priority of criteria and alternatives were assessed using AHP model, Delphi technique, pirewise comparison and Expert Choice software. Finally, alternatives priorities were obtained with formation of decision matrix and TOPSIS model. That model was tested in the Khezrabad region to evaluate the determination of optimal alternatives. Results indicate that the prevention of unsuitable land use changes, vegetation cover development and reclamation, and change of ground water harvesting with the relative convergence of 0.766, 0.576 and 0.403 are the most important desertification alternatives.

Keywords: AHP, Delphi, MADM, TOPSIS Method, Pirewise Comparison.

1. INTRODUCTION

Desertification refers to land degradation phenomenon in arid, semi-arid and dry sub-humid areas resulting from various factors including anthropogenic activities. Due to critical importance of desertification issue and its complex driving factors, the need for optimal alternatives to prevent desertification, or reclamation and reconstruction of destroyed areas is essential. So, in addition to investment in controlling, reclamation and reconstruction of natural resources project should be raised.

Recent studies that offered alternatives to solve desertification problem have been non-comprehensive. On the other hand, there is no any record of using systematic models. The only work of systematic techniques and presentation of optimal de-desertification alternatives refers to the use of analytic hierarchy process (AHP) (Sadeghi Ravesh, 2008; Sadeghi Ravesh et al., 2011). Therefore, methods that offer optimal desertification management alternatives based on logical principles and reasonable theories are required. Therefore, in order to achieve this goal, based on decision making models, this paper tries to present use of analytic hierarchy process (AHP) method and technique to order preferences by similarity to ideal solution (TOPSIS), a kind of compensated-compromised multiple criteria decision making method.

Because the judgment about desertification alternatives is inaccurate, the optimal de-desertification alternatives are considered as uncertain and probable issues. The AHP method was used to determine criteria weights based on each criterion, and the TOPSIS technique was deployed for ranking alternatives based on set of criteria.

Recently, theoretical and practical research has been done on both models, such as: assessment of training quality (Noori et al., 2007), weapon selection (Dagdeviren et al., 2009), evaluation of hazardous waste transportation firms (Gumas, 2009) and transshipment site selection (Onut & Selin, 2008). In all aforementioned studies, the hierarchical structure was firstly designed. Then criteria were weighted using AHP method and finally offered choices ranked by using TOPSIS technique.

Briefly, the advantages of these methods are: 1. Interference of quantitative and qualitative criteria of decision making process; 2. Simplicity of application; 3. Consideration of many criteria in decision making process; 4. Ability to change input information and to evaluate system responsibility based on this change; 5. In these methods ranking consider the logical similarity to the ideal response. In this respect, the selected alternatives have the shortest distance from the best ideal response and the farthest distance from the worst response; 6. If some criteria could be negative and others positive, TOPSIS method that is a combination of the best accessible values of all criteria offers ideal alternative; 7. This method considers the distance from the best and the worst alternatives based on convergence to optimal alternative simultaneously; 8. Results present quantitative distances of final alternatives weight in ranking. (Malekzadeh, 1999 & Srdjerici, 2004).

2. MATERIAL AND METHODDS

2.1. The study area

Khezr Abad region covering 78,180 ha is located in the western part of Yazd Province, Central Iran within the 31º 45´ to 32º 15´ northern latitudes and 53º 55´ to 54º 20´ eastern longitudes. The climate of this region is cold and arid based on Amberje climate classification. 12,930 ha stretching in the northern part of the study area are sandy hills as a part of the Ashkzar great erg. Other 9.022 ha consist of bare land and infrastructures such as clay plain and rocky masses. Also, 1,955 ha of all agriculture land of the region represent degraded land resulting from human activities and natural processes. That spot shows typical desertification conditions in the study area and thus the need to find out effective and optimum de-desertification solutions and alternatives (Fig. 1).

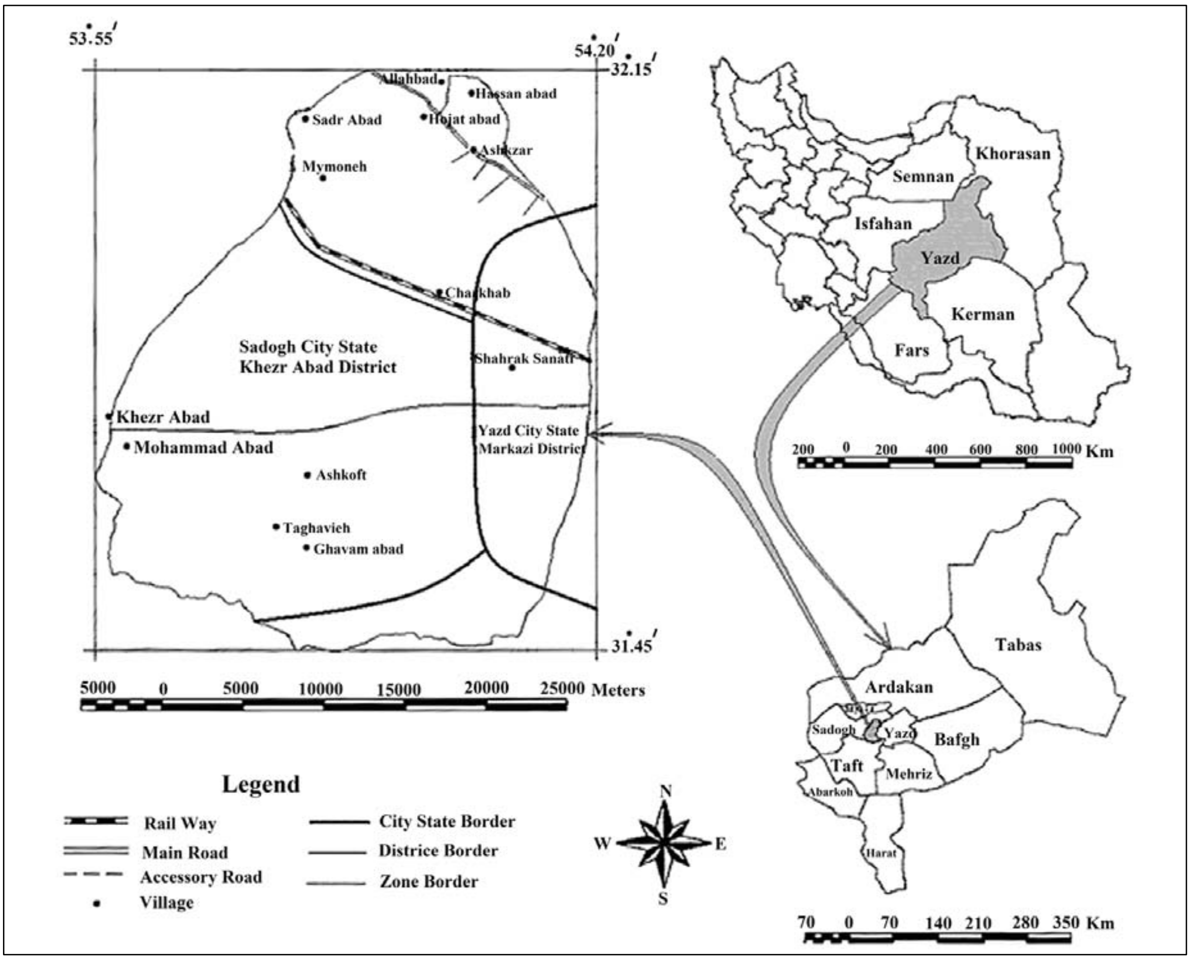


Figure 1. Location map of study area

2.2. Methodology

2.2.1. Determine the importance and priority of criteria and alternatives, and establish decision making matrix using AHP method

AHP model was introduced by Thomas L. Saaty in 1970. It is one of the most comprehensive multiple attribute decision models. This method formulates the issues in framework of hierarchical structure, as well as considers different quantitative and qualitative criteria in the issue. AHP method interfere different choices in decision and it is able to do sensitivity analysis on criteria and sub-criteria. Also, it is flexible in proportion with changes of effective desertification factors in the future. Moreover, it was established according to pirewise comparison that facilitates judgments and calculations, and uses systematical group participate to select alternatives. In addition, it shows the amount of decision compatibility and incompatibility and has strong theoretical basis that has been established based on certainly principles. (Asghar Pour, 1992; Ghodsi Pour, 2002; Sadegh Ravesh 2010).

The specific steps involved in the development and analysis of this model are as follows:

2.2.1.1. Select criteria and alternatives and establish decision hierarchical structure

Due to complexity of desertification process, resulting from various factors, different criteria and alternatives are stated by experts in every area. The number of elements at any level should be 7±2 (Saaty, 1980) to establish a hierarchical structure in order to reduce comparisons incompatibility. Therefore, the Delphi method was used to identify important and preferred criteria and alternatives regarding to group, and to establish hierarchical structure (Saaty, 1995). For this aim, a structured questionnaire was designed based on literature and the nine-point Satty's scale (Table 1), from 1(least important) to 9 (most important). The questionnaire was distributed among experts familiar with the study area. Then, arithmetical mean was used to calculate the mean of obtained results, and the primary statistical community was asked to apply their final changes based on deviations of their primary values from average. Finally, mean values were calculated. In this case, if the mean value was less than 7 ($\overline{X}$ <7), related criterion and alternative was removed, and if the mean value was more or equal to 7 ($\overline{X}$≥7) related criterion and alternative was used to design hierarchical decision structure in three levels: purpose, criteria and alternatives, respectively (Tables 4, 5, 6 & Fig. 2) (Azar & Rajabzadeh, 2002; Sung, 2001).

Table 1. Importance and priority degree of nine-point Satty's scale

Score	Importance Degree	Priority Degree in Pirewise Comparison
1	Non-importance	Equal
2	Very low	Equal-Moderately
3	Low	Moderately
4	Relatively low	Moderately - Strongly
5	Medium	Strongly
6	Relatively high	Strongly-Very strongly
7	High	Very strongly
8	Very high	Very strongly-Extremely
9	Excellent	Extremely

2.2.1.2. Calculate local priority of criteria and alternatives and establish group pirewise comparisons matrix

To achieve the local priority, a second questionnaire entitled "pirewise comparisons questionnaire" was designed using Delphi method. Experts were asked to conduct pirewise comparison on the obtained results within tte first questionnaire regarding the nine-point Saaty's scale (Table 1) based on the importance of goal and priority of each criteria, respectively. Thus, pairwise comparisons matrix of each expert about criteria importance and alternatives priority was formed (Table 2) (Ghodsi Pour, 2002).

Table 2. Matrix of pirewise comparisons

		C_1	C_2	…	C_n
$A=[a_{ij}]=$	C_1	1	a_{12}	…	a_{1n}
	C_2	$1/a_{12}$	1	…	a_{2n}
	⋮	⋮	⋮	…	⋮
	C_n	$1/a_{1n}$	$1/a_{2n}$	…	1

a_{ij}= preference of i criteria to j criteria (i, j= 1, 2 … n)
C_i= the criteria title of row matrix (C_i= C_1, C_2… C_n)
C_j= the criteria title of column matrix (C_j= C_1, C_2… Cn)

Then, using geometric mean and assumption of uniform expert's opinion, pirewise comparisons of each expert were composed according to Eq. 1, and pirewise comparisons were formed with respect to group.

$$\overline{a}_{ij} = \left(\pi_{K=1}^{N} a_{ij}{}^{k}\right)^{1/N} \quad (1)$$

Where a_{ij}^k is component of k expert to comparison i and j. So, āij (geometric mean) for all corresponding components is obtained by Eq. 1 (Azar & Rajabzadeh, 2002; Ghodsi Pour, 1998).

After formation of group-paired comparison matrix, the matrix was distributed between the statistical communities to exert their final opinions. They were asked to apply their final changes on the weights regarding to their deviations to average. Then, using geometric mean (Eq. 1), final matrices of group pirewise comparisons were obtained (Fig. 3, 4).

2.2.1.3. Compute the priorities based on group pirewise of comparisons tables

At this stage, the numbers of group pirewise comparisons matrix (values of criteria importance and alternatives priority to each criterion) were imported in EC software (Godsipour, 1381). After normalization by using Eq. 2, importance and priorities percent were showed as bar graphs using harmonic mean method or average of each level of normalized matrix (Fig. 3 and 4).

$$M.....1, 2, i= {}_{ij}/\sum \bar{a}_{ij} = \bar{a}\,\bar{r}_{ij} \qquad (2)$$

Where $\bar{r}_{ij}$ is normal component, $ij\ \bar{a}$ is group pirewise comparison component of i to j and $\Sigma\bar{a}ij$ is total column of group pirewise comparisons.

2.2.1.4. Formation of Decision Matrix (DM)

The weights of criteria importance and alternatives priority obtained from percentage of criteria importance and alternatives priority charts have been entered according to decision matrix (Table 3).

Table 3. Decision Matrix in AHP

Alt	Criterion				
	C_N W_N	....	C_3 W_3	C_2 W_2	C_1 W_1
A_1	a_{1N}	....	a_{13}	a_{12}	a_{11}
A_2	a_{2N}	....	a_{23}	a_{22}	a_{21}
A_3	a_{3N}	....	a_{33}	a_{32}	a_{31}
:	:	....	:	:	:
A_M	a_{MN}	....	a_{M3}	a_{M2}	a_{M1}

In this matrix *M* is the number of choices or alternatives, *N* is number of criteria, *C* title of criteria, *W* is weight value of related criteria, and a_{ij} is weight value each alternative gains associated to related criteria

2.2.2. Determine final weight of alternatives using TOPSIS model

This model was presented by Hwagng and Yoon in 1985. According to this method m alternatives are evaluated by n criteria and any issue can be considered as a geometric system including m points in a space of n dimensions. In addition, the selected choice should have the minimum distance to the positive ideal alternative and maximum distance to the negative ideal alternative (Tavary et al., 2008; Azar & Rajabzadeh, 2002; Pakdyn Amiri et al., 2008).

By calculating the alternatives priority according to each criterion using AHP method and formation of decision matrix (Table 3), it is observed that the priorities are different based on various criteria. Therefore, TOPSIS method was used to gain main alternatives regarding to all criteria and ranking of final priority. Integration process was applied on the obtained results of the previous steps as follows.

2.2.2.1. Formation of harmonic decision matrix (HDM) by means of Eq. 3

$$HDM= DM \times W_{n\times n} \quad (3)$$

Where DM is decision matrix and $W_{n\times n}$ is diagonal matrix of criteria weight. In this matrix each component of (H_{ij}) is obtained by Eq. 4

$$H_{ij} = a_{ij} \times w_j \quad (4)$$

Where H_{ij} is harmonic weight value each alternative gains in relation to related criteria, a_{ij} is weight value each alternative gain in relation to related criteria and w_j is weight value of related criteria

2.2.2.2. Determination of numerical values of the positive ideal alternatives (A_i^+) and negative ideal alternatives (A_i^-)

In harmonic decision matrix, each alternative which allocate itself the highest numerical values in relation to each criteria is considered as the best de-desertification alternative and is expressed as a positive ideal alternative (Ai+). Therefore, the maximum numerical value of alternatives in relation to each criterion is stated in a set entitled value number of positive ideal alternatives according to Eq. 5.

$$A^{+} = \left\{ \left(\max_{i} H_{ij} \middle| j\in j=1 \right), \left(\max_{i} H_{ij} \middle| j\in j=2 \right) \middle| i=1,2,...n \right\} \quad (5)$$

Also, the minimum numerical value of alternatives in relation with any criteria is stated in a set entitled value number of negative ideal alternatives (A_i^-) according to Eq. 6.

$$A^{-} = \left\{ \left(\min_{i} H_{ij} \middle| j\in j=1 \right), \left(\min_{i} H_{ij} \middle| j\in j=2 \right) \middle| i=1,2,...m \right\} \quad (6)$$

2.2.2.3. Calculating the distance (d) of every choice of harmonic decision matrix based on soft

Euclid in relation to positive and negative ideal alternatives by Eq. 7 and 8

$$d_i^+ = \sqrt{\sum_{j=1}^{n}\left(H_{ij} - A_j^+\right)^2}, (i = 1,2,....,m) \quad (7)$$

$$d_i^- = \sqrt{\sum_{j=1}^{n}\left(H_{ij} - A_j^-\right)^2}, (i = 1,2,....,m) \quad (8)$$

However, the distance of alternatives from positive ideal alternatives values be less, that choice can has more effective role in desertification process and vice versa.

2.2.2.4. Calculate the relative convergence of alternatives to ideal alternative and rank alternatives based on obtained deviations

$$C_i = \frac{d_i^-}{\left(d_i^- + d_i^+\right)}, (1,2,..., n) \quad (9)$$

If $A_i = A_i^+$, then $C_i = 1$, $d_i^+ = 0$, and if $A_i = A_i^-$, then $C_i = 0$, $d_i^- = 0$. Therefore, each alternative more convergence to the ideal alternative has its convergence value (Ci) closer to 1.

Finally, for showing results better, relative convergence percentages of alternatives are calculated by mean Eq. 10.

$$\%C_i = \frac{C_i}{\left(\sum_{i=1}^{n} C_i\right)} \quad (10)$$

3. RESULTS AND DISCUSSION

3.1. Selection of important criteria and preferred alternative according to group and design hierarchical decision structure

In assessing the desertification alternatives in study area, firstly the Delphi method and questionnaire were used to identify the important-preferred criteria and alternatives among 16 criteria and forty-offered de-desertification alternatives according to group (Tables no. 4, 5 and 6). Then, they were taken to establish hierarchical decision making graphs (Fig. 2) and design a pirewise comparisons questionnaire.

3.2. Calculate relative weight of criteria and alternatives and format group decision matrix (DM)

After selecting important-preferred criteria and alternatives according to group, the Delphi method of group pirewise comparisons matrices was used to determine relative weight of criteria and alternatives for achieving the goal of "offering optimal de-desertification alternatives". Here, only group pirewise comparisons matrices of criteria based on goal of "offering optimal de-desertification alternatives" (Fig. 3) and group pirewise comparisons matrix of alternatives priority according to criteria of "proportion and adaptation to the environment " are expressed (Fig. 4). The matrices of alternatives priority to other criteria were designed like figure 4.

Further, matrix values of criteria importance and alternatives priorities entered EC software based on each criterion. Both the importance and priority of de-desertification criteria and the alternatives were obtained according to group as bar graphs based on percentage using normalization and harmonic mean (Fig. 3, 4).

These graphs show us that the alternatives are different based on each criterion. Therefore, decision making matrix of optimal de-desertification alternatives according to the group (Table 7) was formed to select final alternatives and ranking of their priorities, in general framework of decision matrix in AHP (Table 2). Finally, based on the TOPSIS model, optimal alternatives were determined as following stages.

Table 7. Decision matrix of optimal de-desertification alternatives according to group

Criteria importance (C) ► Alternatives priority (A) ▼	C_2 0.089	C_5 0.109	C_6 0.157	C_{16} 0.307	C_7 0.336
A_{23}	0.250	0.238	0.248	0.180	0.225
A_{18}	0.196	0.163	0.198	0.238	0.264
A_{33}	0.162	0.256	0.209	0.151	0.160
A_{20}	0.222	0.176	0.160	0.221	0.158
A_{31}	0.168	0.163	0.182	0.209	0.192

Table 8. Harmonic decision matrix of optimal de-desertification alternatives according to group

Criteria importance (C) ► Alternatives priority (A)▼	C2	C5	C6	C16	C7
A23	0.022	0.026	0.039	0.055	0.075
A18	0.017	0.017	0.031	0.073	0.088
A33	0.014	0.028	0.032	0.046	0.053
A20	0.019	0.019	0.025	0.067	0.053
A31	0.015	0.017	0.028	0.064	0.064

3.3. Design harmonic decision matrix of optimal de-desertification alternatives

After formation of desertification decision matrix each component was harmonized by means of Eq. 4 and harmonic decision matrix was formed (Table 8).

3.4. Determination of value numbers of the positive ideal alternatives (A_i^+) and negative ideal alternatives (A_i^-)

After formation of harmonic decision matrix by Eq. 5, 6, value numbers of positive and negative ideal alternatives were determined, and relevant sets were formed. Set of positive ideal alternatives

$A_i^+ = \{0.0889, 0.0732, 0.0392, 0.0280, 0.0223\}$

Set of negative ideal alternatives

$A_i^- = \{0.0532, 0.0464, 0.0253, 0.0178, 0.0145\}$

3.5. Compute the distance (d) based on soft Euclid in relation to positive and negative ideal alternatives

At this stage, Excel software was used and each alternative distance of harmonic decision matrix was obtained in relation to positive and negative ideal alternatives based on Eq. 7, 8. Distance in relation to positive ideal alternatives:

$d_i^+ = \{d_{23}^+ = 0.0221, d_{18}^+ = 0.0138, d_{33}^+ = 0.0537, d_{20}^+ = 0.0397, d_{31}^+ = 0.0307\}$

Distance in relation to negative ideal alternative:

$d_i^- = \{d_{23}^- = 0.0301, d_{18}^- = 0.0451, d_{33}^- = 0.0127, d_{20}^- = 0.0221, d_{31}^- = 0.0207\}$

Table 4. The offering alternatives for de-desertification

Modification, creation and development of economical–social infrastructure in marginal areas

- A_1– Reducing population growth rates
- A_2– Poverty alleviation
- A_3– Establishment and development of rural organizations
- A_4– Increasing employment
- A_5– Increasing participation of local community and supporting NGOs
- A_6– Application of local forces and technology in projects (local knowledge)
- A_7– Training people in utilization of new methods and use of new knowledge for optimal use of resources
- A_8– Approval, promotion and implementation of laws and adaptation punishment with crime
- A_9– Providing needs of local residents
- A_{10}– Modification of unsustainable consumption patterns, changing and improving people's livelihood patterns
- A_{11}– Considering the role of women and youth in desertification
- A_{12}– Organization of urban areas and prevent migration
- A_{13}– Coordination between responsible agencies and organizations in desertification and environmental protection
- A_{14}– Raising the literacy rate
- A_{15}– Development of desert ecotourism
- A_{16}– Multi-utilization from desert instead of monoutilization
- A_{17}– Allocation desertification issues to the private sector
- A_{18}– Prevention of unsuitable land use changes
- A_{19}– Mapping land use planning and determination of desert and salt desert boundaries

Vegetation cover Conservation

- A_{20}– Livestock grazing Control
- A_{21}– Forage production and increasing economic potential of sustainable husbandry
- A_{22}– Prevention of plant cutting
- A_{23}– Vegetation cover development and reclamation
- A_{24}– Protection of *Haloxylon spp.*

Soil Conservation

- A_{25}– Protection of gravel surfaces (Reg)
- A_{26}– Prevention and reduction of heavy agricultural and industrial machineries traffics
- A_{27}– Create living and non living wind breaks for soil conservation
- A_{28}– Improvement of soil texture

Development of sustainable agriculture

- A_{29}– Modification of crop rotation and fallow methods
- A_{30}– Modification of plowing, fertilization, spraying methods

Development and sustainable management of water resources

- A_{31}– Change of ground water harvesting
- A_{32}– Reduction of water consumption (water optimal consumption in farms)
- A_{33}– Change of irrigation patterns
- A_{34}– Changing traditional irrigation systems with low efficiency to modern systems with high efficiency
- A_{35}– Optimal collecting and harvesting of water resources (including rivers isolating, Qanat repairing and dredging, use of canals and streams, desalination of salty waters etc.)
- A_{36}– Groundwater fed
- A_{37}– Construction of flood broadcast networks and use of its alluvia
- A_{38}– Creation of artificial precipitation to fed aquifers
- A_{39}– Promotion of greenhouse cultivation
- A_{40}– Introduction of new plant varieties, resistant to drought and dehydration stress by genetic engineering

Table 5. The offering criteria and their importance mean according to group

Code	C_1	C_2	C_3	C_4	$\mathbf{C_5}$	$\mathbf{C_6}$
Criteria	Expenses / Benefits	Time	Participation of local communities	Beauty of landscape	***Access to the technologies and scientific methods and devices***	***Access to the related experts***
Average values	5.38	7.1	5.78	5.1	***7.1***	***7.53***
Code	$\mathbf{C_7}$	C_8	C_9	C_{10}	C_{11}	C_{12}
Criteria	***Proportion and adaptation to the environment (sustainability)***	Traditional management and local knowledge	Government authority in desertification projects	Oil incomes of government	Temporary management of the projects	The problems resulted from innovation and method changes
Average values	***8.15***	5.23	5.28	5.72	2.39	2.84
Code	C_{13}	C_{14}	C_{15}	$\mathbf{C_{16}}$		
Criteria	Indolence State Administrative Systems	Political and social pressures	Emergency issues related to desertification occurrence	***Destruction of resources, human and social damages***		
Average values	2.29	5.35	6.34	**7.99**		

Table 6. The average of alternative priority according to group

Alternative	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
Average values	5	5.68	5.35	6.7	6.1	6.56	6.47	5.73	5.89	5.6
Alternative	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	A_{18}	A_{19}	A_{20}
Average values	4.5	5.23	6.86	4.8	5.32	5.27	3.79	**7.5**	6.44	**7.34**
Alternative	A_{21}	A_{22}	A_{23}	A_{24}	A_{25}	A_{26}	A_{27}	A_{28}	A_{29}	A_{30}
Average values	6.6	6.46	**7.56**	6.76	6.45	5.57	6.86	4.66	5.42	5.1
Alternative	A_{31}	A_{32}	A_{33}	A_{34}	A_{35}	A_{36}	A_{37}	A_{38}	A_{39}	A_{40}
Average values	**7.24**	6.6	**7.49**	6.53	6.64	6.08	5.3	3.47	6.2	6

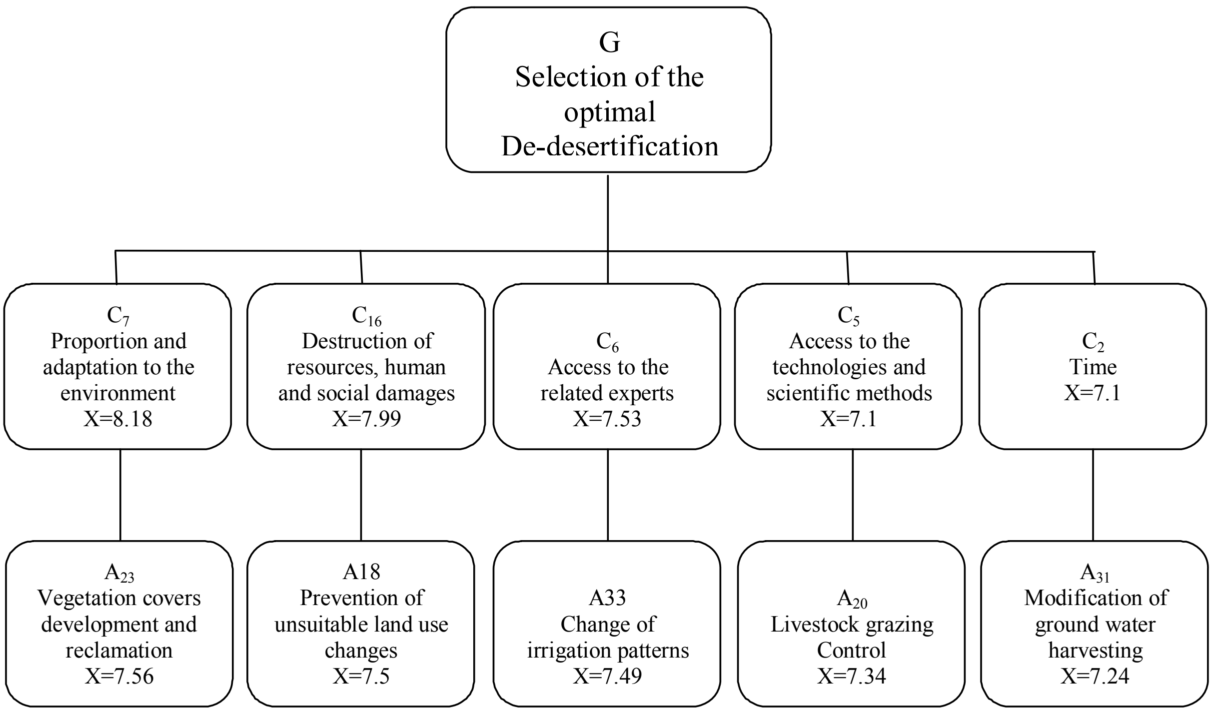


Figure 2. Hierarchical decision structure to select optimal de-desertification alternatives in Kezr Abad region

PRESENTATION OF THE BEST ALTERNATIVE TO DESERTIFICATION

Node: 0

Compare the relative IMPORTANCE with respect to: GOAL

	DESTRUCT	EXPERT	TECHNOLO	TIME
PROPORT	1.2	2.5	2.5	3.4
DESTRUCT		2.3	3.1	3.1
EXPERT			1.7	2.0
TECHNOLO				1.3

Row element is __ times more than column element unless enclosed in ()

Abbreviation	Definition
Goal	PRESENTATION OF THE BEST ALTERNATIVE TO DESERTIFICATION
PROPORT	proportion and compatibility with environment
DESTRUCT	resources destruction and environmental and human punishment
EXPERT	expert human resources
TECHNOLO	scientific implement and getetable technology
TIME	the project length of time and season

Inconsistency Ratio =0.01

Figure 3. Matrix-Chart of the criteria importance to access the goal of "offering optimal de-desertification alternatives in Kherz Abad region"

PRESENTATION OF THE BEST ALTERNATIVE TO DESERTIFICATION

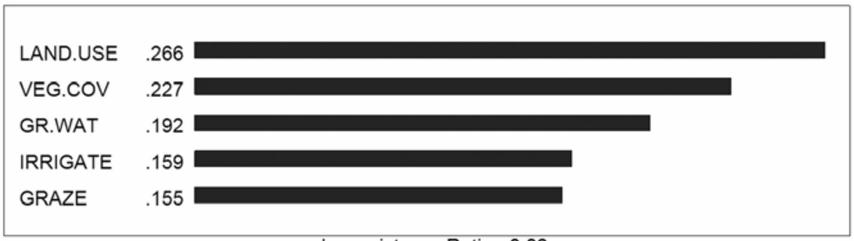
Node: 20000

Compare the relative PREFERENCE with respect to: PROPORT < GOAL

	VEG.COV	GR.WAT	IRRIGATE	GRAZE
LAND.USE	(1.1)	1.3	2.4	1.6
VEG.COV		(1.1)	1.6	1.3
GR.WAT			(1.1)	1.2
IRRIGATE				1.2

Row element is __ times more than column element unless enclosed in ()

Abbreviation	Definition
Goal	PRESENTATION OF THE BEST ALTERNATIVE TO DESERTIFICATION
PROPORT	proportion and compatibility with environment
LAND.USE	the prevention from land use unsuitable of reverse and conversion
VEG.COV	vegetation cover development and regeneration
GR.WAT	abjusment in use of under ground water resources
IRRIGATE	irrigation pattern change
GRAZE	livestock grazing control



Inconsistency Ratio =0.02

Figure 4. Matrix-Chart of alternatives priority according to the criteria of "proportion and adaptation to the environment "(C_7)

3.6. Compute the relative convergence of alternatives to ideal alternative and final alternatives ranking

Finally, relative convergence of alternatives to ideal de-desertification alternatives was obtained by means of Eq. 9. Final f alternatives priority was determined regarding to this principle that each alternative be closer to ideal alternative, its convergence value (C_i) would be closer to 1 and vice versa, and priority percentage was obtained.

Alternative Priority:

$C_i = \{C_{23} = 0.576, C_{18} = 0.0766, C_{33} = 0.191, C_{20} = 0.358, C_{31} = 0.403\}$

Alternative Priority Percent:

$\%C_i = \{\%C_{23} = 25.13, \%C_{18} = 33.39, \%C_{33} = 8.38, \% C_{20} = 15.59, \% C_{31} = 17.56\}$

4. CONCLUSION

The obtained results of presented questionnaire to determine importance and priority of criteria and alternatives to establish decision hierarchical structure show that among studied criteria and alternatives, only 5 criteria and alternatives have group mean more than 7 that considered to establish decision hierarchical chart and provide pirewise comparisons questionnaires (Tables 4, 5 and 6).

Further, following results were obtained using pirewise comparisons questionnaires, mean of experts' opinion, group pirewise comparisons matrix of importance and priority of criteria and alternative. According to figure 3, criteria of proportion and adaptation to environment (C7) and time (C2) have the highest and lowest importance, respectively. Criterion of proportion and adaptation to the environment (C7) with the importance degree of 33.3% and destruction of resources, human and social damages (C_{16}) with 31.1% were placed in first and second order, respectively. This indicates that experts are more concern about environmental issues and challenges raised in environmental degradation. Also, these tables represent alternatives priority to each criterion (Fig. 4). As is taken from these tables, selected alternatives will be different according to each criterion. Therefore, to select final alternatives and rank their priority, combination was conducted on decision matrix by TOPSIS model, and alternatives priorities were formed base on set of criteria.

In accordance with the results of final prioritized alternatives it can be concluded that with execution of vegetation cover development and reclamation (A_{23}), prevention of unsuitable land use changes (A_{18}), and modification of ground water harvesting (A_{31}), desertification phenomenon will be stopped up to 76% in Khezr Abad region. In such conditions the de-desertification projects should be focused on these alternatives to get better and suitable results, avoid investment wasting and increase control, reclamation and reconstruction project efficiency.

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Received at: 10.10.2011
Revised at: 21. 01. 2012
Accepted for publication at: 30. 03. 2012
Published online at: 04. 04. 2012