Assessment of combating desertification strategies using the linear assignment method

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Abstract

Nowadays desertification, as a global problem, affects many countries in the world especially developing countries like Iran. With respect to increasing importance of desertification and its complexity the necessity of attention to the optimal combating desertification alternatives is essential. Selecting appropriate strategies according to all effective criteria in combating desertification process can be so useful in rehabilitating degraded lands and avoid degradation in vulnerable fields. This study provides systematic and optimal strategies of combating desertification by group decision-making model. To this end, the preferences of indexes were obtained through using Delphi model; in the framework of Multi Attribute Decision Making (MADM). Then, priorities of strategies were evaluated by using linear assignment (LA) method. According to the results, the strategies to prevent improper change of land use (A18), development and reclamation of plant cover (A23), and control overcharging of groundwater resources (A31) respectively were identified as the most important strategies for combating desertification in this study area. Therefore, it is suggested that the aforementioned ranking results be considered in projects which control and reduce the effects of desertification and rehabilitate degraded lands.

Keywords: desertification, Multi Attribute Decision Making, Linear Assignment model, pair wise comparisons.

1Introduction

Desertification is a significant global ecological and environmental problem. That is one type of land degradation in which a relatively dry land region becomes increasingly arid, typically losing its bodies of water, vegetation and wildlife. It is caused by a variety of factors such as climatic changes and human interferences. According to United Nations Conference on Desertification (UNCOD), desertification process threatens more than 785 million people living in the arid regions. Of this number, 60 to 100 million people are affected by this phenomenon directly due to the loss of land fertility and other desertification processes (Meshkat, 1998). There are 100 million hectares in Iran faced desertification especially wind erosion, water erosion and physicochemical destruction (Forest, Rangeland and Watershed Institute, 2005).

combating desertification includes activities that are part of the integrated development of land in arid, semi-arid and dry sub-humid areas for sustainable development which are aimed at:(i) prevention and/or reduction of land degradation, (ii) rehabilitation of partly degraded land and (iii) reclamation of desertified land (Law Office of Environment and Parliamentary Affairs, 2004). By taking this framework into account, this study tries to present a systematic method for providing effective solutions among the several solutions based on different desertification criterion. Therefore, in order to achieve this goal decision-making models and linear assignment (LA) method were used to rank desertification alternatives.

Managing desert ecosystems consist of various managements in order to control desertification phenomenon and minimize economic, social and environmental loss. Making decision in management of desert areas becomes a complex process due to existence of various indexes and various criterions for decision in such areas. There are several methods in managing desert regions, and each has different preferences for environmental, social, political, economic and organizational issues. Among these different methods Multi Attribute Decision Making (MADM) can provide best answers in comparison with the others. The purpose of this study, by considering limitation of inputs, is assessing desertification strategies to achieve the optimal strategies in the framework of sustainable management of desert area. To achieve this goal Linear Assignment (LA) method which is one kind of Concordance Methods was used in the framework of MADM to rank combating desertification strategies. This method has simple algorithm that can engage simultaneously a large number of quantitative and qualitative criteria in the decision process. Besides, in different intervals of time and place, it is also capable to change the input data and provide new assessment according to this change. Therefore comparative studies would be easy to do (Asgharpour, 1999).

Since LA uses descriptive data instead of principal data, and it is easy to understand it has been applied in various fields of science (Bernardo and Blin, 1977). Some of these studies include; assessment of environmental sustainability (Hosseinzadeh et al., 2011), assessing and ranking risks (Sayadi et al, 2011), monitoring sensitivity of desertification (Symeonakis et al., 2014), footprint of research in desertification management (Miao et al., 2015), characterization and interaction of driving factors in desertification (Xu and Zhang, 2014), identifying susceptible areas toward desertification (Vieira et al., 2015), evaluation of soil fertility in the succession of karst rocky desertification (Xie et al., 2014), assessing environmental sensitivity of areas toward desertification (Sobhand and Khosravi, 2015), financial assessment of companies (Mohammadi, 2011), assessment of strategies of water supply (Mianabadi and Afshar, 2008), zoning watersheds (Ramesht and Arabameri, 2012), assignment of water resource in order to minimize the energy consumption (Joung et al, 2012), programming of robots (Ji et al, 1992), programming for dispatching helicopter in emergency missions (Celi, 2007) and so on and so forth.

By studying the research literature using decision models to provide optimal strategies in desert management is limited to research of Grau et al, Sadeghiravesh et al, and Sepehr and Peroyan. In order to select the optimal strategies for providing an integrated plan to control erosion and desertification, Grau used three decision models in his research; ELECTRE, AHP and PROMETHEE (Grau et al, 2010). The results indicate the high efficiency of these models to provide optimal strategy of desertification. Because of using complex methods in each model the results were largely the same. Sadeghiravesh prioritize the strategies in Khezr Abad region by using the following models; Analytical Hierarchy Process (AHP) (Sadeghiravesh et al, 2010), Elimination et Choice Translating Reality (ELECTRE) (Sadeghiravesh et al., 2014), Weighted Sum Model (WSM)

(Sadeghiravesh and Zehtabian, 2013), BORDA (Sadesghi Ravesh, 2014), and PERMUTATION (Sadeghiravesh , 2013), Preference Ranking Organization Method For Enrichment Evaluation (PROMETHEE) (Sadeghiravesh et al, 2016). The results of these studies are same and largely similar to the results of previous research. Sepehr and Proyan zoned vulnerability of desertification in the ecosystems of Khorasan Razavi Province and evaluated these strategies to combat desertification (Sepehr and Peroyan, 2011).

All in all, determining the effective combating desertification alternatives and criteria are essential for achieving efficient combating desertification projects. Hence, this research presents linear assignment method to objectively select the optimal combating desertification alternatives based on the results of interviews with experts in Khezr Abad region in Yazd province, Iran as the case study.

2 Material and methods

2.1 Study area

The Khezr Abad region in Yazd province, central Iran, was considered for optimal determination of alternatives to combat desertification. The study area is located nearly 10 km west of Yazd. The region extends from 53°55´ to 54°20´ east in longitude and from 31°45´ to 32°15´ north in latitude and covering an area of about 78,180 ha (Fig.1). The climate of the study area is cold and arid; based on the Amberje climate classification method (Sadeghiravesh, 2008). About 12,930 ha (16%) of the region is hilly, a sand-dune area[1], which is a part of the Ashkezar Great Erg[2], located in the northern part of the study area. About 9,022 ha (12%) of the area consists of bare lands, clay plain and desert pavement[3] (Sadeghiravesh, 2008; Kazemi Nejad, 1996). About 1,995 ha (26.5%) of all the agricultural land in the region consists of degraded or abounded lands with human activities such as traditional irrigation and natural processes like wind erosion and dust. The study area shows an absolutely typical condition of desertification, so effective solutions and optimal means of combating desertification must be pursued.

1 . An isolated hill, knob, ridge, outcrop, or small mountain.
2 . An erg (also sand sea or dune sea, or sand sheet if it lacks dunes) is a broad, flat area of desert covered with wind-swept sand
3. A desert surface covered with closely packed, interlocking angular or rounded rock fragments of pebble and cobble size.

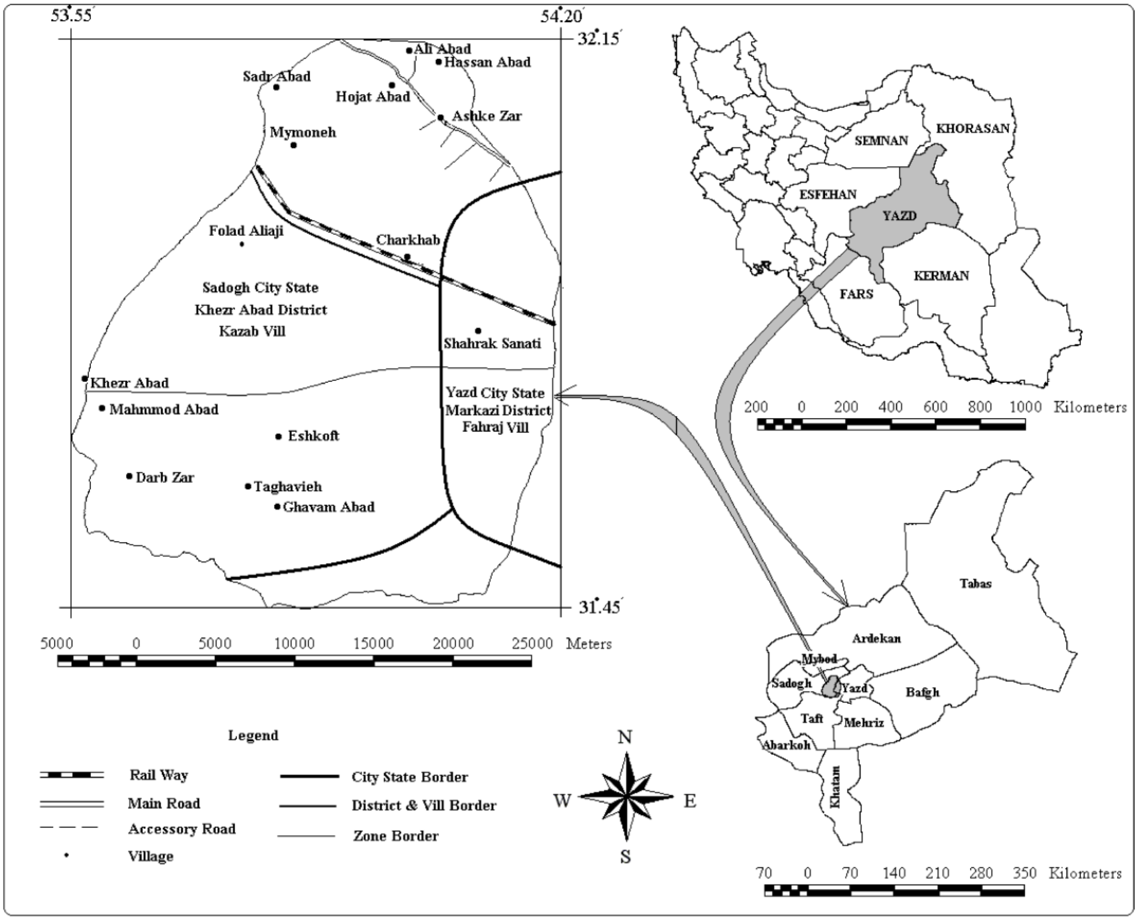

Figure1. Location of the study area

2.2 Methodology

Linear Assignment is one of the most important methods of Multi Attribute Decision Making (MADM) and subset of Concordance Methods. LA can help decision makers to choose the best option due to combining qualitative and quantitative indexes and providing appropriate weighting for each criterion. The output of this model is a collection of ranks, so it provides the required coordination in the most suitable way. In this method given choices of moot point are ranking according to their scores on each index and the final ranking of the alternatives will be characterized through linear compensation process (for every possible interaction between indexes) (Asgharpour, 1999). Based on the property simplex solution space of LA, the optimum solution is extracted in a convex space simplex and by considering all the arrangements implicitly. Moreover, the compensation property of the indexes is obtained from exchange between ranks and options (Pomerol and Romero, 2000); however, the weight vector of indexes has been obtained through expert opinion and Delphi model.

2.2.1 Selection criteria and effective strategies

Selecting criteria and alternatives can be done individually according to expert experience, resources, field studies and Delphi method. For this aim, the structured questionnaire in two parts including 16 criteria and 40 alternatives was distributed among experts familiar with the study area. The experts were asked to rate effective criteria and alternatives between 0 and 9. Finally, arithmetical mean was used to calculate the mean of obtained results, and mean values were calculated. In this case, if the mean value was less than 7 ($\bar{X}$ <7) related criterion and alternative was removed, and if the mean value was more or equal to 7 ($\bar{X}$ ≥7) related criterion and alternative was used as effective criteria (Azar and Rajabzadeh 2002; Azar and Memariani, 2003). Tables 1 and 8 show the recommended alternatives, offering criteria respectively.

Table1. The criteria and their importance mean according to the group

Code	C_1	C_2	C_3	C_4	C_5	C_6
Criteria	Expenses-benefit	Time	Participation of local communities	Beauty of landscape	Access to the technologies and scientific methods and devices	Access to the related expert
Code	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
Criteria	Proportion and adaptation to the environment (sustainability)	Traditional managemen t and local knowledge	Democratic government authority in combating-desertification projects	Oil income of government	Temporary management of projects	The problems resulted from innovation and method changes
Code	C_{13}	C_{14}	C_{15}	C_{16}		
Criteria	Indolence state administrative systems	Social and political pressures	Emergency issues related to desertification occurrence	Destruction of resources, human and social damages		

2.2.2 Calculate local priority of criteria and alternatives and establish group pairwise comparisons matrix

In order to achieve Local Priority, the structured questionnaire was designed based on literature and the nine-point Sa'aty scale; 1(least important) to 9 (most important). They were used to measure the relative importance of criteria and priority of combating desertification alternatives (Table 2).

The questionnaire was distributed among experts familiar with the study area. Using geometric mean and assumption of expert's opinion (considering all opinions have same value) pairwise comparisons matrixes were obtained according to Eq.1 and formed in a group format (Table 3).

$$\bar{a}_{ij} = \left(\pi_{k=1}^{N} a_{ij}^{\ k}\right)^{\frac{1}{N}} \quad (1)$$

In this equation aijk = component of k expert to comparison i and j. So, āij (geometric mean) for all corresponding components is obtained by Eq. 1 (Azar and Rajabzadeh, 2002; Ghodsipour, 2002).

Table2. Importance and priority degree of nine-point Satty's scale

Score	Importance Degree	Priority Degree in Pair wise 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
	1/2, 1/3,1/4, …., 1/9	Mutual Values

Table 3. Pair wise comparisons matrix

	a_{11}	a_{12}	....	a_{1n}	
A=	a_{21}	a_{22}	....	a_{2n}	A=[a_{ij}] i,j =1,2 ,…,n
	:	:	:	:	
	a_{n1}	a_{n2}	....	a_{nn}	

$a_{ij=}$ preference of i criteria to j criteria

2.2.3 Compute the priorities based on group pair wise of comparisons tables

At this stage, the data of group pairwise comparison matrixes were imported in EC software to evaluate criteria importance and alternatives priority to each criterion (Godsipour, 2002). 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 (Tables 5 and 6).

$$\bar{r}_{ij} = \frac{\bar{a}_{ij}}{\sum_{i=1} \bar{a}_{ij}} \qquad (2)$$

In this equation:

$\bar{r}_{ij}$ = normal component

ij ā = group pair wise comparison component of i to j

$\Sigma \bar{a}ij$ = total column of group pair wise comparisons

2.2.4 Formation of Normalized Decision Matrix (NDM)

The weight values of criteria importance (Wj) and alternative priorities (Pij) is considered in the form of a decision matrix based on any criteria (Table 4).

Table4. Normalized Decision Matrix

Alt	Criterion				
	C_1	C_2	C_3	-----------	C_n
	W_1	W_2	W_3	-----------	W_n
A_1	P_{11}	P_{12}	P_{13}	--------	P_{1n}
A_2	P_{21}	P_{22}	P_{23}	-----------	P_{2n}
:	:	:	:	:	:
A_m	P_{m1}	P_{m2}	P_{m3}	-----------	P_{mn}

In this matrix: m= the number of choices or alternatives, n= number of criteria, C= title of criteria, W= Weight value of related criteria, a_{ij}= weight value each alternative gains in relation to related criteria

Table5. Comparison of proposed criteria importance to access the goal

Criterion	Preference Degree
C_7	33.3
C_{16}	31.3
C_6	15.7
C_5	11
C_2	8.9

Inconsistency Ratio=0.01

Table6. Comparison of alternatives preference according to the criteria of proportion and adaptation to the environment

Alternative	Degree
A_{18}	26.6
A_{23}	22.7
A_{31}	19.2
A_{33}	15.9
A_{20}	15.5

Inconsistency Ratio=0.02

2.2.5 Ranking each option for each index

After forming the decision making matrix, attempted to rank the alternatives (Ai) for each criteria (Ci) with respect to the increasing or decreasing trends and n×m matrix framework (Table 7).

Table7. Matrix ranking of each option against each index

Criteria (C) ►	C_1	C_2	C_3	……..	C_n

Rank (A) ▼					
First	A_{11}	A_{12}	A_{13}	……..	A_{1n}
Second	A_{21}	A_{22}	A_{23}	……..	A_{2n}
Third	A_{31}	A_{32}	A_{33}	……..	A_{3n}
……..				……..	
……..				……..	
m	A_{m1}	A_{m2}	A_{m3}	……..	A_{mn}

In this matrix: m= the number of choices or alternatives, n= number of criteria, C= title of criteria, a_{ij}= each alternative in relation to related criteria

2.2.6 Forming two-dimensional matrix, Gamma (γ)

Two-dimensional gamma matrix (γ) (assignment matrix) is formed according to weight vector of the estimated criteria of group pairwise comparison. This matrix is a square matrix ($\gamma_{m.m}$) which has element i in row and element k in column. Matrix elements include the total weight of indexes which alternative i has rank k. Gamma matrix is a assignment matrix, so the optimal solution can be obtained by any kind of assignment methods such as shipping method, hungarian method, grid method and one and zero linear programming method. The most common method for solving the LA is assignment programming method (Pomerol and Romero, 2000).

2.2.7 Calculating the final rank for each alternative (A_i)

The final ranking/optimal solution of alternatives is obtained by linear programming method and through the following model:

$$\text{Maximize: } \sum_{i=1}^{m} \sum_{k=1}^{m} \gamma_{ik} . h_{ik} \qquad (3)$$

$$\text{subject to: } \sum_{k=1}^{m} h_{ik} = 1 \quad ; i = 1,2,3,\ldots,m \qquad (4)$$

$$\sum_{i=1}^{m} h_{ik} = 1 be \quad ; k = 1,2,3,\ldots,m \qquad (5)$$

$$h_{ik} \begin{cases} = 1 \\ = 0 \end{cases}$$

After solving the linear programming model a square matrix ($H_{m\times m}$) is the one that A_i is given to the final Kth rank (h_{ik}=1) ;otherwise h_{ik}=0 (Burkard and Qela, 1999; Liu, 2000)

The obvious feature of this method is a simple ranking for alternatives that caused exchanged among indexes and have no complex calculations. Also in this method there is no need for unification scale (Saaty and Vargas, 2006; Asgharpour, 1999). Meanwhile, other methods such as MADM need the both alternatives and indexes for calculating, but ranking process of LA can be done without alternative (Tajoddini, 2003).

3Result and Discussion

In the process of combating-desertification alternatives assessment in the study area the Delphi method and questionnaire were used to identify the main criteria and alternatives among 16 criteria and 40 combating-desertification alternatives and establishing hierarchical structure (Saaty, 1995) according to the group format. Tables8 and 9 show the average of alternatives priority and criteria important respectively.

The obtained results of presented questionnaire (to determine importance and priority of criteria and alternatives to establish decision hierarchical structure) show only criteria and alternatives with group mean more than 7. This considered establishing decision hierarchical chart and providing pairwise comparisons questionnaires. Figure 2 show hierarchical decision structure provided based on effective criteria and alternatives to combat desertification.

Table8. The criteria importance mean according to the group

Code	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}
Average values	5.38	7.1	5.78	5.1	7.1	7.53	8.15	5.23	5.28	5.72	2.39	2.84	2.29	5.35	6.34	7.99

Table9. The recommended alternatives to combat desertification and their priority according to the groups

Code	Alternative	values
A_1	Reducing population growth rates	5
A_2	poverty alleviation	5.68
A_3	Establishment and development of rural organizations	5.35
A_4	Increasing employment	6.7
A_5	Increasing participation of local community and supporting NGOs	6.1
A_6	Application of local forces and technology in projects (local knowledge)	6.56
A_7	Training people in utilization of new methods and use of new knowledge for optimal use of resources	6.47
A_8	Approval, promotion and implementation of laws and adaptation punishments with the crime	5.73
A_9	providing needs of local residents	5.89
A_{10}	modification of unsustainable consumption patterns, changing and improving people's livelihood patterns	5.6
A_{11}	Considering the role of women and youth in combating - desertification process	4.5
A_{12}	Organization of urban areas and prevent migration	5.23
A_{13}	Coordination between responsible agencies and organizations in combating - desertification and environmental protection	6.86

A_{14}	Raising the literacy rate	4.8
A_{15}	Development of desert ecotourism	5.32
A_{16}	multi- utilization from desert instead of mono utilization	5.27
A_{17}	Allocation combating - desertification issue to the private sector	3.79
A_{18}	Prevention of unsuitable land use changes	7.5
A_{19}	mapping land use planning and determination of desert and salt desert boundaries	6.44
A_{20}	livestock grazing control	7.34
A_{21}	Forage Production and increasing economic potential of sustainable husbandry	6.6
A_{22}	Prevention of plant cutting	6.46
A_{23}	Vegetation cover Development and reclamation	7.56
A_{24}	Protection of *Haloxylon spp*.	6.76
A_{25}	Protection of gravel surfaces (Reg)	6.45
A_{26}	prevention and reduction in heavy agricultural and industrial machineries traffics	5.57
A_{27}	Create living and non- living wind break for soil conservation	6.86
A_{28}	Improvement of soil texture	4.66
A_{29}	modification of crop rotation and follow methods	5.42
A_{30}	Modification of ploughing, fertilization, spraying methods	5.1
A_{31}	Modification of groundwater harvesting	7.24
A_{32}	Reduction in water consumption (water optimal consumption in farms)	6.6
A_{33}	Change of irrigation patterns	7.49
A_{34}	Changing traditional irrigation systems with low to modern systems with high efficiency	6.53
A_{35}	optimal Collecting and harvesting of water resources (including rivers isolating, Qanat repairing and dredging, utilization of canals and streams and desalination of salty waters)	6.64
A_{36}	Groundwater feed	6.08
A_{37}	Construction of flood broadcast networks and the use its alluviums	5.3
A_{38}	Creation of artificial precipitation to feed aquifers	3.47
A_{39}	Promotion of greenhouse cultivation	6.2
A_{40}	Introduction of new plant varieties, resistant to drought and dehydration stress by genetic engineering	6

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

In order to estimate the relative weight or priority of criteria and alternatives, pairwise comparisons questionnaire was prepared and distributed among the experts. In continuation, the group pairwise comparison matrixes of criteria importance and alternatives priority to each criterion were formed by obtaining expert opinions and combining their ideas by geometric mean. To prevent the prolongation of the word, just matrix of criteria importance (Table 10) and alternative priorities to each criteria calculated by this method are presented.

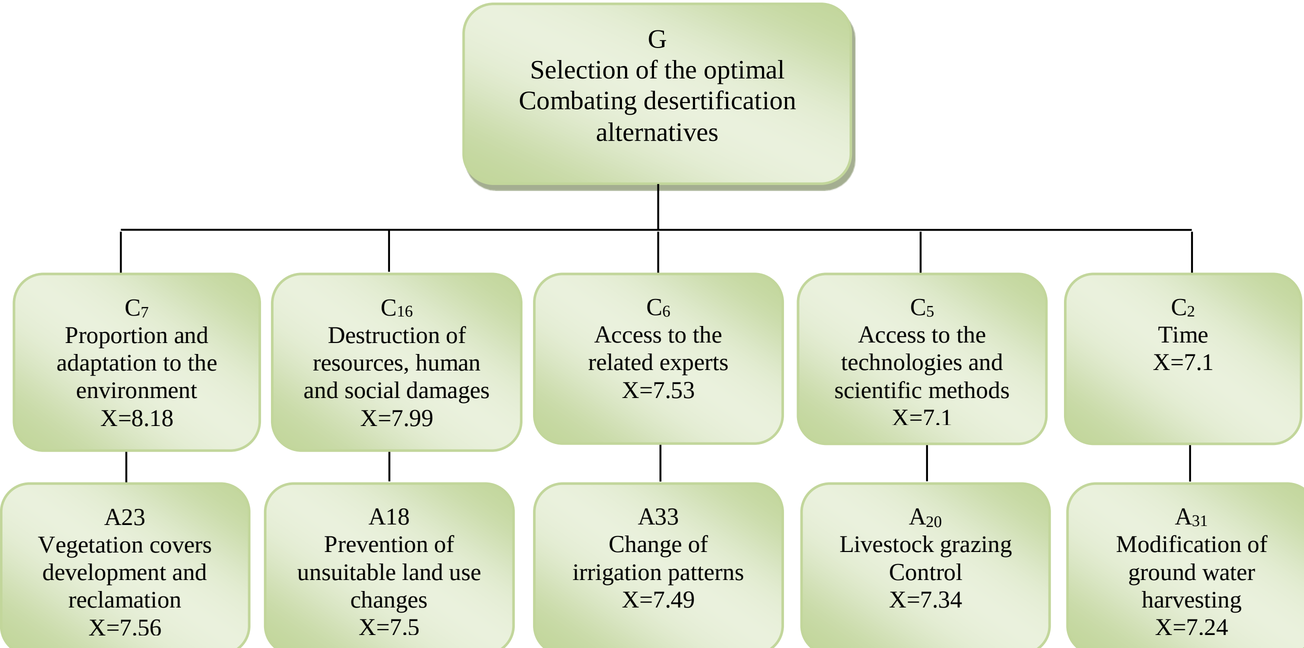

Figure2. Hierarchical decision structure to select optimal combating desertification alternatives in study area

Table10. Pairwise comparisons matrix of the criteria importance to access the goal of "offering optimal combating desertification alternatives"

Criterion	C_{16}	C_6	C_5	C_2
C_7	1.2	2.5	2.5	3.4
C_{16}		2.3	3.1	3.1
C_6			1.7	2
C_5				1.3

In continuation, matrix values of criteria importance and alternatives priorities (Table10) were entered to EC software based on each criterion importance of combating desertification criteria. Alternatives were obtained in a group format. Besides, graphs prepared based on percentage using normalization and harmonic mean (Table11).

Table11. Comparison of proposed criteria importance to access the goal

Criterion	Preference Degree
C_7	33.3
C_{16}	31.3
C_6	15.7

C_5	11	
C_2	8.9	

Inconsistency Ratio=0.01

Considering these graphs, it is observed that the alternatives are different based on each criterion. Therefore, decision making matrix of optimal combating desertification alternatives according to the group (Table 12) was formed to select final alternatives and classification of their priorities in general framework of MADM (Table 4).

Table12. Decision matrix of optimal combating desertification alternatives according to group

Criteria importance (C) ►	C2	C5	C6	C16	C7
Alternatives priority (A) ▼	0.0892	0.1095	0.1576	0.3074	0.3365
A23	0.2509	0.2387	0.2488	0.1805	0.2257
A18	0.1960	0.1635	0.1983	0.2383	0.2643
A33	0.1620	0.2565	0.2093	0.1510	0.1599
A20	0.2229	0.1762	0.1608	0.2209	0.1582
A31	0.1682	0.1633	0.1826	0.2092	0.1918

3.3 Ranking each option for each index

After forming the decision making matrix attempted to rank the alternatives (Ai) for each criteria (Ci) in a 5×5 matrix which the rows represent rank and columns represent the index (Table13). Decision matrix of combating desertification alternatives has increasing trend which means the allocate number of each alternative is more than the number of each criterion, so that alternative is more desirable among the others.

Table13. Matrix of alternative ranking

Criteria (C) ► / **Rank (A) ▼**	C_7	C_{16}	C_6	C_5	C_2
First	A_{18}	A_{18}	A_{23}	A_{33}	A_{23}
Second	A_{23}	A_{20}	A_{33}	A_{23}	A_{20}
Third	A_{31}	A_{31}	A_{18}	A_{20}	A_{18}
Forth	A_{33}	A_{23}	A_{31}	A_{18}	A_{31}
Fifth	A_{20}	A_{33}	A_{20}	A_{31}	A_{33}

3.4 Forming $\gamma_{5\times5}$ matrix according to criteria weights (W)

At this stage a 5 × 5 gamma matrix is formed, and it was estimated by sum of indexes weights which the alternative of i has rank of k. As mentioned, the weight of each index was calculated by survey of experts and based on Delphi method (Table 14).

Gamma matrix is an assignment matrix, and the optimal answer can be obtained by any of assignment methods. The most common method for solving the linear assignment method is linear programming.

Table14. The matrix of number time weight of ranking options

Rank (C) ► / **Alternative Priority (A) ▼**	First	Second	Third	Forth	Fifth
A_{23}	0.2468	0.446	0	0.3074	0
A_{18}	0.6439	0	0.2468	0.1095	0
A_{33}	0.1095	0.1576	0	0.3365	0.3966
A_{20}	0	0.3966	0.1095	0	0.4941
A_{31}	0	0	0.6439	0.2468	0.1095

3.5 Ranking alternatives

For final ranking of alternatives linear programming was used (Eq. 1 to 3), and scoring table of options or optimal matrix was formed (Table 11). Since the decision variable contains zero and one value, the output of this program is provided only based on the number 1 in Table 15. The table16 was formed according to table15.

Table15. The options scoring

$$*=H \begin{vmatrix} 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 \end{vmatrix}$$

The optimal objective function = 2.6245

→

Table16. The matrix of options optical order

$$A=*\times H \begin{vmatrix} 0 & A_{18} & 0 & 0 & 0 \\ A_{23} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & A_{31} \\ 0 & 0 & 0 & 0 & A_{33} \\ 0 & 0 & A_{33} & 0 & 0 \end{vmatrix}$$

Table17. The options ranking

$$\rightarrow \quad \begin{vmatrix} A_{18} & A_{23} & A_{31} & A_{33} & A_{20} \end{vmatrix}$$

Based on Table 17, the preference of alternatives was obtained as $A_{18} > A_{23} > A_{31} > A_{33} > A_{20}$. After evaluating all alternatives the A_{18} considered as the best one among the others.

4 Discussions

In this study a new method was presented to rank combating desertification alternatives priority. The results of final prioritization of alternatives by using LA method was similar to the results of the following methods; AHP (Sadeghiravesh et al, 2010), TOPSIS (Ivani1 and Sofi, 2014), ELECTER (Sadeghiravesh et al., 2014) and WSM (Sadeghiravesh and Zehtabian, 2013). This means alternatives A_{18}, A_{23} and A_{31} were ranked respectively first to third. It should be mentioned that LA method has limitation of ignoring decision-makers fuzzy judgment as well as aforementioned methods. Besides, some criteria have qualitative or unknown structure that cannot be accurately measured. In such case, fuzzy numbers can be used in order to achieve evaluation matrix, and prioritization method can be developed using fuzzy method. Another disadvantage of LA method is regarding the amount of data and considering only the data ranks. Therefore, large amounts of data are lost and achieving high accuracy results would not be possible (Mohammadi, 2011). Consequently, it is better to do not use rating models as ELECTER and LA when accurate amounts of data are available. Following results were obtained using pairwise comparisons questionnaires, mean of expert's opinion, group pairwise comparisons matrix of importance, and priority of criteria and alternative. According to decision matrix's table of optimal combating desertification alternatives (Table 12), criteria of proportion and adaptation to environment (C_7) and time (C_2) have the highest and lowest importance respectively. Criterion proportion and adaptation to the environment (C_7) with the importance degree of 33.6% and destruction of resources, human and social damages (C_{16}) with 30.7% were placed in first and second order, respectively. This indicates that experts are more concern about environmental issues, and challenges rose in environmental degradation. Also, these tables represent alternatives priority to each criterion. As is taken from the table, selected alternatives will be different according to each criterion. Therefore, selecting final alternatives and rank their priority combinations were conducted on decision matrix by LA model; besides, alternatives priorities were formed base on set of criteria. According to the results of final alternatives' prioritization and by considering all the alternatives, execution of prevention of unsuitable land use changes (A_{18}), vegetation cover development and reclamation (A_{23}), and modification of ground water harvesting (A_{31}), the desertification process can be stopped, and the degraded lands can be rehabilitate. Therefore, it can be expressed in the study area that land use changes are mainly caused by increasing population, unemployment, growth of industry and increasing in urbanization's desires. As an illustration, land use changes are largely happened in recent years because of pressure of drought and industrial growth which lead to conversion of pastures into farms and gardens. As a consequent result, enormous amounts of deep and semi-deep motorized wells have installed in the study area. Rangelands consist of 6 to 15 percent of case area which is strongly influenced by human activities in terms of cutting brush and livestock overgrazing, so that 40 to 50 percent of plant cover are destroyed. Irrigation in agricultural lands is mostly flooding with outdoor pools and outdoor streams with large pores in bed; therefore, more than 50% of water's consumption is wasted and the efficiency of irrigation and transmission is estimated less than 40 percent.

5 Conclusions

The obtained results of presented questionnaire (to determine importance and priority of criteria and alternatives to establish decision hierarchical structure) show only criteria and alternatives with group mean more than 7. This considered establishing decision hierarchical chart and providing pairwise comparisons questionnaires.

Desertification is the persistent degradation of dry land ecosystems which is caused mainly by climatic changes and human interferences. More than 85% of Iran is consist of arid, semi-arid and hyper-arid regions with 34 million ha of desert zones. Therefore, the major part of the country is susceptible to desertification. Although, the government has performed many projects to combat desertification in recent years it seems that they are not adequate due to the country's extensive arid regions. The problem needs more attention and effective national cooperation as well as international one over the long time.

In this research the LA method was used to give optimum alternatives in combating desertification. In accordance with the results, prevention of unsuitable land use changes was estimated as the most important strategy in the study area. Besides, other alternatives such as vegetation cover development and reclamation, balancing charging of groundwater resources respectively were placed in subsequent priorities. Hence, in the framework of macro strategies executive offers are recommended in following:

- Taking serious spatial planning and estimating ecological potential at national, regional and local levels and adapting the applications to the land potential.
- Avoiding land use changes in poor range lands with low fertility.
- Avoid the development of industries in sensitive and fragile regions.
- In terms of development and reclamation of vegetation it is better to use endemic and resistant species and pressurized irrigation systems.
- Prevent degradation of *Haloxylon* habitats and take especial attention to their rehabilitation.
- Balance the number of livestock and pasture's capacity.
- Try to reduce the number of goats in poor pastures because of their high potential in degrading rangelands.
- Avoid grazing off-season in desert rangelands (early and late grazing) due to degradation of poor vegetation.
- According to protect rangelands and support ranchers, forages should be cultivated more or be imported from another countries; in other words, when government supports ranchers in providing forages they may stop cutting brush or overgraze their livestock in rangelands during winter or nights.

The results of this research can be used in future investments aiming to obtain a sustainable development, so that the marginal ecosystems and investments in arid and semi-arid region will be protected. On the other hand, it will help the managers of desert lands to perform restricted facilities in susceptible areas to get better and suitable results and avoid investments wasting Finally, it is recommended that all combating desertification's projects in the study area be done based on all aforementioned alternatives. In this case, less investment would be wasted and the efficiency of such rehabilitation projects may increase. The results of this study will allow desert managers to apply limited investment and facilities in efficient ways which are assigned to control the process of desertification. Hence, we can achieve better results and avoid wasting the national investments.

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