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Application of Numerical Taxonomy Analysis in Sustainable Development Planning of Combating Desertification

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Abstract

Due to increasing importance of desertification challenges and its consequences the necessity of sustainable development achievement in arid and semi-arid regions is essential in order to avoid limited sources wasting, increase the efficiency of controlling, reclamation and restoration projects of natural areas. Based on the literature review, it has been recognized that combating desertification projects in Iran were yet inconsequential and incomprehensive. It is essential to achieve sustainable and comprehensive development in combating desertification issue. In relation to the mentioned case, investigation and ranking of current status of development indices of combating desertification process in different areas, is crucial which will determine the level of, budgeting and manpower polices. Therefore, numerical taxonomy model was recognized as a suitable tool for determination of ranking and classification of combating desertification indices. The study model is used for investigating and ranking of existing situation of combating desertification in the urban areas of Yazd province during the period of 2002-2007. The model evaluates development and extension of combating desertification indices in the urban areas using analytical structure and the final results are shown as the assessment Maps. The results show that Yazd, Taft, Mehriz and Khatam urban areas with expansion score of 0.89 from total combating desertification indices have unsuitable situation while Bafgh, Sadough and Tabas with expansion score of 0.44, 0.45 and 0.49, respectively had better situation. Moreover, it is recognized that budgeting and future development planning of the urban areas from combating desertification on the basis of the obtained results and raking of this research.

Keywords: Combating Desertification Indices; Numerical Taxonomy Model; Sustainable Development; Yazd Province

1. Introduction

Desertification is generally understood to refer to land degradation in arid, semi- arid and dry semi-humid climatic zones (Thomas, 1997). It involves five principal processes: vegetation degradation, water erosion, wind erosion, salinization and water logging, and soil crusting and compaction (Dregne, 1999). Nowadays human activities and impacts on natural resources, especially in arid, semi arid and humid regions was changed the meaning of desert and caused new terms such as "desertification and combating desertification". It means that desert is not limited to arid and semi arid regions, perhaps it is related to human activities and interaction with natural environment. During second–half of past century desert and desertification processes have changed from a natural event to man-made phenomena which have been accelerated by human activities. Meanwhile, this accelerating rate is a serious challenge for human societies. (Veron et al, 2006 and Yang et al., 2005).

Because of location of 16 provinces in desert conditions with 57.5 million hectares in Iran

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(FRWMO[1], 2005), the adoption of suitable policies in conformity with sustainable projects have been done for desertification and for this purpose since many years ago, in the frame work of fixation of flowing sand in Hamidieh, Albrarveh and Albaji of Khozestan province (Kochpideh and Keykhosravi, 2007) have been managed and done in different provinces of Iran, for example the improvement project of degraded rangelands (Institute of planning and agricultural economics research, 2001), green belt project (FRWMO, 2003), integrated desert management (FRWMO, 2005), wind erosion control and stabilization of moving sand Project (FRWMO, 2002), and finally national activity of combat desertification and decrease of drought effects (FRWMO, 2004). In spite of done activities and projects, about 100 million hectares of Iran's area has affected with desertification phenomenon, because of human activities especially (FRWMO, 2005), and despite accomplishment of the project and planning, while having a relative success, the project could not achieve to comprehensive recognition of desertification process, land degradation and its related damage. Therefore achievement to integrated recognition control and management of desert areas is essential and necessary for sustainable development of arid and semi-arid areas (UNEP & FAO, 1999). One of the important factors of sustainable development of combating desertification planning is recognition and determination of development level of combating desertification indices. In this research combating desertification development means investments amounts, activities and performance of combating desertification process in the urban areas of Yazd province. Since balanced combating desertification in all areas in order to achieve to sustainable development is considerable, therefore recognition of current situation of combating desertification helps desert areas mangers for better understanding and decision making and recommends them for using the limited facilities and resources for control of desertification process in less developed and deprived areas. Therefore, in order to obtain sustainable development and quantitative evaluation of combating desertification process, some indices are proposed which are the chief topics of combating desertification, such as planting, seedling, irrigation, etc in the areas. These indices are important in evaluation of combating desertification performance. In the scope of management of desert issue and in order of investigate the current condition of combating desertification indices and improvement of the indices in direction of sustainable development planning in national and international scale comprehensive and systematic researches have not been performed yet, and allocation of resources and facilities have been managed only on the basis of personal basis decision. Therefore the objective of this research is to study the assessment of development score of the urban areas from the viewpoint of combating desertification indices that has been studied in Yazd province. The results of this study could be used in sustainable development of combating desertification projects and can be used in different areas of Iran.

It should be noted that application of taxonomy model in desertification issues has no previous history and for the first time it has been used in Khezrabad region, Yazd province (Sadeghi Ravesh et al., 2009).

2. Materials and Methods

2.1. Study area

Yazd province is located in the central part of Iran plateau and interior part of Kavir Namak with an area of 128463 km2. Geographic location of the study area is 29° 36' to 35° 06' Northern latitude and 52° 48' to 58°10' Eastern longitude. (Fig.1). The climate of the areas is arid and cold according to Emberge climatic classification. The mean annual precipitation of the area is 60-80 mm with high annual variation.

The desert areas have involved about 46.7% of Yazd province, and the areas include different desert geomorphologic faces. Therefore, the province was considered as the typical province for evaluation of current condition of desertification indices.

2.2. Methodology

Ten urban areas of Yazd province have been assessed based on combating desertification development indices using numerical taxonomy technique according to performance of the National Center of Combating Desertification of Jihad- Agriculture Organization of Yazd province. Fig 2 shows the steps of numerical taxonomy analysis which is used in this study. (Azar and Rajabzade, 2003; Bergamp, 1995).

1- Forest, Range and Watershed Management Organization (FRWMO)

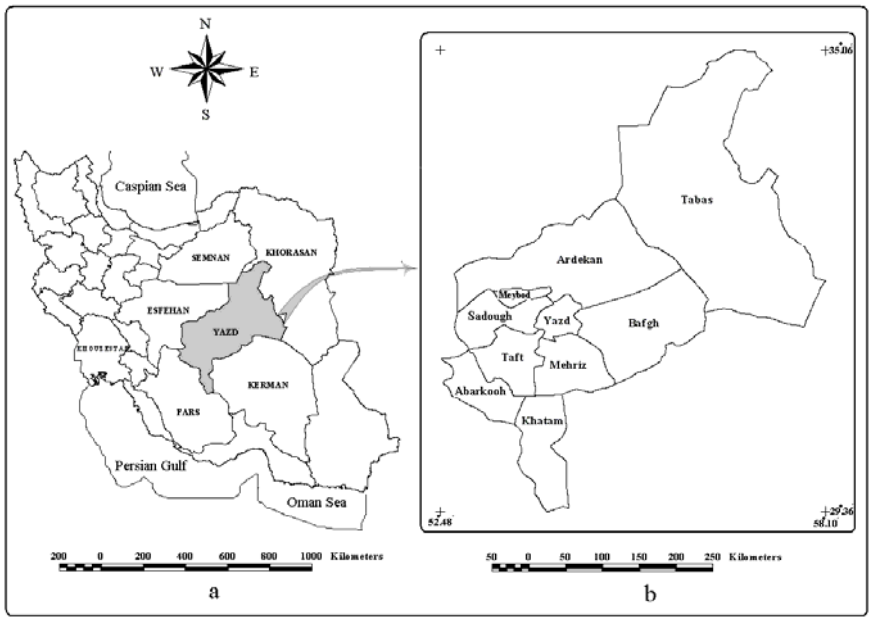

Fig. 1. Location map of the study area; a) Iran's map; b) Yazd's map

2.2.1. Determination of the options and evaluation indices

In this study, the options are the urban areas (units studied), and evaluation indexs are main desertification activities in urban areas which imply amount of investments, activities and operations about desertification in urban and province level.

2.2.2. Development data matrix

After determination of urban areas and evaluation indices, data indicate desertification activities selected at each urban level; and data matrix was formed based on Taxonomy model framework.

2.2.3. Normalization of the data matrix from equation 1

Where:

$$Z_{ij} = \frac{X_{ij} - \overline{X_i}}{S_i} \quad (1)$$

Z_{ij} = normalized value of the numbers

X_{ij} = numerical value of data

$\overline{Xi}$ = mean of data

S_i = standard deviation of data

2.2.4. Recognition of heterogeneous options

At this stage, reassessment of indices values about each urban area was done, in order to prevent unrealistic results.

2.2.4.1 Calculation and determination of cumulative distances among the options in a symmetric matrix from equation 2

$$D_{ab} = \sqrt{\sum_{j=1}^{m} \left(Z_{aj} - Z_{bj}\right)^2} \quad (2)$$

Where:

D_{ab} = cumulative distances among the options

Z_{aj} = normalized of the number related to "a" row and each column in matrix.

Z_{bj} = normalized of the number related to "b" row and each column in matrix

2.2.4.2. Determination of shortest distance between each row of the symmetrical matrix

In determining this parameter, the shortest distance was considered expect the distance of each city from itself which is equal to zero.

2.2.4.3. Determination of upper and low limits of the shortest distance from equation 3

$$\pm O_{dr} = \overline{dr} \pm 2\delta dr$$

Where:

$\pm O_{dr}$ = upper and low limits of the shortest distance

$\overline{dr}$ = the mean of the shortest distance

δdr = standard deviation of the shortest distance

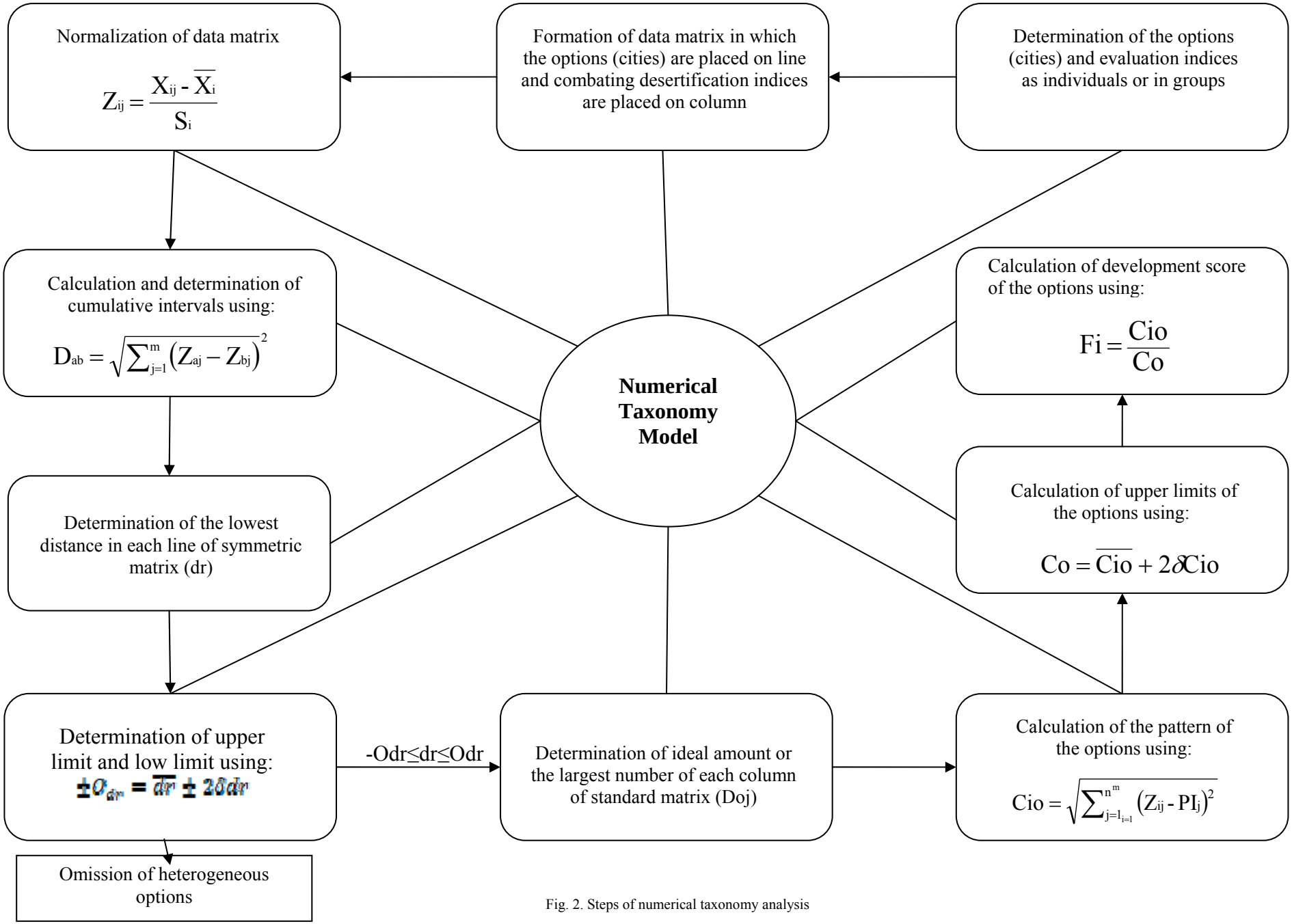

Fig. 2. Steps of numerical taxonomy analysis

2.2.5. Determination of ideal amount of standard matrix

In this step at the end of standard matrix the highest value of each column is obtained as Positive Ideal Index (PI). In combating desertification issues, development is an incremental function of the studied variables. Therefore, the highest value in each column of normalized matrix is the positive ideal value while the decreasing function of the variable of development assigns the highest negative value of standardized matrix as Negative Ideal value (NI) which is the desired score (Sadeghi Ravesh., 2008).

2.2.6. Calculation of the pattern of the options development from equation 4

$$\mathrm{Cio} = \sqrt{\sum_{j=1_{i=1}}^{n\,m} \left(Z_{ij} - PI_j\right)^2} \qquad (4)$$

Where

Cio =the pattern of the options development

Z_{ij} = normalized of the number related to each row and column in matrix.

PI_j = positive ideal number related to each column in matrix.

2.2.7. Calculation of upper limit of the options development (CO) from equation 5

$$\mathrm{Co} = \overline{\mathrm{Cio}} + 2\delta\mathrm{Cio} \qquad (5)$$

Where:

Co = upper limit of the options development

$\overline{Cio}$ = the mean of the pattern of the options development

δCio = standard deviation of the pattern of the options development

2.2.8. Calculation of development score of the options (Fi) from equation 6

$$\mathrm{Fi} = \frac{\mathrm{Cio}}{\mathrm{Co}} \qquad (6)$$

Where:

Fi = development score of the options

Cio = the pattern of the options development

Co = upper limit of the options development

2.2.9. Provision of development map of the options

In order to ease and accuracy in data analysis and to achieve results, development maps of options in terms of desertification activities were provided. For this purpose, development map for each city in relation to each index was provided using calculated development degrees of each index and GIS software.

3. Results

The taxonomy model used and assessed in the urban areas of Yazd province as the following steps:

3.1. Determination of the evaluation options (urban areas) and indices (de de-desertification indices)

In the first step in order to assess combating desertification performance, 10 urban areas of Yazd province (Abarrkooh, Ardakan, Bafgh, Taft, Khatam, Sadough, Tabas, Mehriz, Meybod and Yazd) have been selected and investigated from de desertification indices such as: the area of planted lands, the area of irrigated lands, the area of restricted lands, wells and pools, and the area of prepared or performed as combating desertification projects.

3.2. Development of the data matrix

In this stage, data indicate desertification activities were presented in data matrix format according to research literature (Jihad-Agriculture Organization of Yazd province, 2006) (Table1).

3.3. Normalization of the data matrix

After formation of data matrix and in order to equalize data scale and for preparation of unscaled data, the data has been normalized using equation 1, and normal matrix of combating
desertification indices has been formed (Table 2).

3.4. Recognition of heterogeneous urban areas

3.4.1. Calculation and determination of cumulative distances among the urban areas in a symmetric Matrix

In this step, heterogeneous urban areas have been recognized, and if there are urban areas that have more or less distance from the other urban areas the indices values of these urban areas will be reviewed, in order to get correct and logical results. For this purpose, by using Equation 2, the distance of each urban area from the other urban areas was calculated.

Table 1. Matrix of combating desertification indices for the urban areas of Yazd province for the period of 2002- 2006

Combating desertification Indices / Options (Urban area)	Planted area (ha)	Irrigation and protection (ha)	Enclosure and conservation of vegetation cover (ha)	well construction and water storage pools	Preparation of combating desertification projects (ha)
Abarkooh	1164	4683	63724	3	0
Ardakan	430	1596	29492	3	108000
Bafgh	470	4450	50670	4	92000
Taft	0	0	0	0	0
Khatam	290	2519	15676	1	15636
Sadough	840	5125	156340	3	16700
Tabas	2235	6995	198884	1	0
Mehriz	0	0	0	0	0
Meybod	2240	6725	49548	1	0
Yazd	0	0	0	0	0
$\overline{X}$	766.9	3209.3	56433.4	1.6	23233.6
S	817.43	2581.95	65075.7	1.43	39055.57

Table 2. Normal matrix of combating desertification indices for the urban areas of Yazd province during 2002- 2006

Combating desertification Indices / Options (Urban areas)	Planted area	Irrigation and protection	Enclosure and conservation of vegetation cover	well construction and water storage pools	Preparation of combating desertification projects
Abarkooh	0.49	0.57	0.11	0.98	-0.59
Ardekan	-0.41	-0.62	-0.41	0.98	**2.17**
Bafgh	-0.36	0.48	-0.09	**1.68**	1.76
Taft	-0.94	-1.24	-0.87	-1.012	-0.59
Khatam	-0.58	-0.27	-0.63	-0.42	-0.19
Sadough	0.09	0.74	1.53	0.98	-0.17
Tabas	1.79	1.47	2.19	-0.42	-0.59
Mehriz	-0.94	-1.24	-0.87	-1.12	-0.59
Meybod	**1.8**	1.36	-0.11	-0.42	-0.59
Yazd	-0.94	-1.24	-0.87	-1.12	-0.59
PI	1.8	1.47	2.19	1.68	2.17

All the cumulative distances were calculated and a two dimension matrix that is called "matrix of cumulative distances between the urban areas" is formed (Table 3). Prime diameter of this matrix represents the distance of each unit from itself which is equal to zero.

3.4.2. Determination of shortest distance between each row of the symmetrical matrix

Shortest distance between each row of the matrix (except the distance of each unit from itself and matrix diameter) is defined as shortest distance (dr) (Table 3).

Table 3. Matrix of cumulative distances among the urban areas of Yazd province

Options (Urban area)	Abarkooh	Ardakan	Bafgh	Taft	Khatam	Sadoogh	Tabas	Mehriz	Meybod	Yazd	Shortest distance (dr)
Abarkooh	0	3.18	2.6	3.27	2.13	1.54	2.97	3.27	2.08	3.27	1.54
Ardekan	3.18	0	1.40	3.59	2.78	3.37	5.06	3.59	4.24	3.59	1.40
Bafgh	2.60	1.40	0	4.15	3.02	2.64	4.55	4.15	3.92	4.15	1.40
Taft	3.27	3.59	4.15	0	1.33	3.91	4.96	0	3.92	0	0
Khatam	2.13	2.78	3.02	1.33	0	2.84	4.09	1.33	2.96	1.33	1.33
Sadoogh	1.54	3.37	2.64	3.91	2.84	0	2.45	3.91	2.85	3.91	1.54
Tabas	2.97	5.06	4.55	4.96	4.09	2.45	0	4.96	2.30	4.96	2.30
Mehriz	3.27	3.59	4.15	0	1.33	3.91	4.96	0	3.92	0	0
Meybod	2.08	4.24	3.92	3.92	2.96	2.85	2.30	3.92	0	3.92	2.08
Yazd	3.27	3.59	4.15	0	1.33	3.91	4.96	0	3.92	0	0

3.4.3. Determination of upper and low limits of the shortest distance and conclusion

Mean and standard deviation of the shortest distance have been calculated and the upper and low limits of the distance have been determined using equation 3. The amounts of the shortest distances from the lines of the matrix of cumulative distance ore between –O = 0.4288 to +O= 2.8288 (Table 3). Therefore it has been recognized that all urban areas are in homogeneous limit and it is not essential to review the scores of indices in relation to the urban areas.

3.5. Determination of ideal amount of standard matrix

In this stage, the largest number was selected as the matrix standard or in other words, the positive idea index was determined in each column (Table2).

3.6. Calculation of the pattern of the urban areas development (Cio)

After the confidence of the homogeneity of the urban areas and with due attention to standard matrix and positive ideal Index (Table 2), by using equation 4, standard deviation of the normalized data has been calculated in accordance with the indices of the urban areas from positive ideal number (PI) of the same index (Table 4), the small distance of each index from PI, represents development of that index in the city and vice versa.

3.7. Calculation of upper limit of the urban areas development (CO)

In order to determine development scores of the urban areas, ranking and preparation of the map of development indices, upper limit of the urban areas has been calculated in all cases using equation 5.

3.8. Calaulation of development score of the urban areas (Fi)

Finally, development score of the urban areas (Fi) has been calculated from equation 6 (Table 5).

In accordance with the method, development degrees of the options are between zero and one ($O \le FI \le 1$). If the amount is close to zero (0) which shows the better condition of the option from the derived development indices and vice versa.

Table 4. The pattern matrix of development of the urban areas according to the indices and all indices separately

Combating desertification Indices / Options (Urban area)	Planted area	Irrigation and protection	Enclosure and conservation of vegetation cover	well construction and water storage pools	Preparation of combating desertification projects	Cio[1]
Abarkooh	1.31	0.90	2.01	0.70	2.76	3.87
Ardekan	2.21	2.09	2.60	0.70	0	4.06
Bafgh	2.16	0.99	2.10	0	0.41	3.20
Taft	2.74	2.71	3.06	2.80	2.76	6.30
Khatam	2.38	1.74	2.82	2.10	2.36	5.16
Sadough	1.70	0.73	0.66	0.70	2.34	3.14
Tabas	0.005	0	0	2.10	2.76	3.47
Mehriz	2.74	2.71	3.06	2.80	2.76	6.30
Meybod	0	0.10	2.30	2.10	2.76	4.16
Yazd	2.74	2.71	3.06	2.80	2.76	6.30
$\overline{\text{Cio}}$	1.80	1.47	2.17	1.68	2.17	4.79
δCio	0.999	0.897	0.728	0.847	0.726	1.156

1- The pattern of the urban areas development

Table 5. Matrix of development degree of the urban areas according to the combating desertification indices and all indices separately

Combating desertification Indices / Option (Urban area)	Planted area	Irrigation and protection	Enclosure and Conservation of vegetation cover	well construction and water storage pools	Preparation of combating desertification projects	Total
Abarkooh	0.34	0.27	0.55	0.21	0.76	0.55
Ardekan	0.58	0.64	0.72	0.21	0	0.57
Bafgh	0.57	0.30	0.58	0	0.11	0.45
Taft	0.72	0.83	0.84	0.83	0.76	0.89
Khatam	0.63	0.53	0.78	0.62	0.65	0.73
Sadough	0.45	0.22	0.18	0.21	0.64	0.44
Tabas	0.0013	0	0	0.62	0.76	0.49
Mehriz	0.72	0.83	0.84	0.83	0.76	0.89
Meybod	0	0.03	0.63	0.62	0.76	0.59
Yazd	0.72	0.83	0.84	0.83	0.76	0.89
Co	3.798	3.264	3.626	3.374	3.622	7.074

3.9. Provision of development map of the urban areas on the basis of combating desertification indices

In order to ease and accuracy in data analysis and to achieve results, in framwork urban area development matrix (Table 5), and using Arcview$_{3.2a}$, development maps of urban area was provided based on various indices and total indices For this purpose, at first topography map of the study area (1:50000 scale) was scanned and then the boundaries of the province and the

urban areas (Table 5) were selected using Photoshop software and the boundaries were separated and they have been saved as Tiff format. Then by using R2V software the map raster format of the map was converted to the vector format and the vector map of the selected limits was inputted to Arcview, in order to provide the ranking of the urban areas based on the development indices. (Lillesand and Kiefer, 2000)

On the basis of taxonomy model and in order to access the development of combating desertification project in Yazd province, important results have been obtained. They have been presented below and effective projects and better planning can be offered according to taxonomy analyses:

3.9.1. Ranking of deprivation and development on the basis of taxonomy analyses

3.9.1.1. Determination of development degree on the basis of the area of planted lands index

In accordance with the area of planted lands index, Meybod and Tabas have the best conditions with development degrees of 0 and 0.0013 respectively. Abarkooh and Sadough have place in third and forth degree with development degrees of 0.21 and 0.45, respectively.

Ardakan, Bafgh and Khatam have unsuitable conditions with development degrees of 0.57, 0.58 and 0.63 respectively. Yazd, Taft and Mehriz have the worst with development degrees of 0.37 (Fig 3).

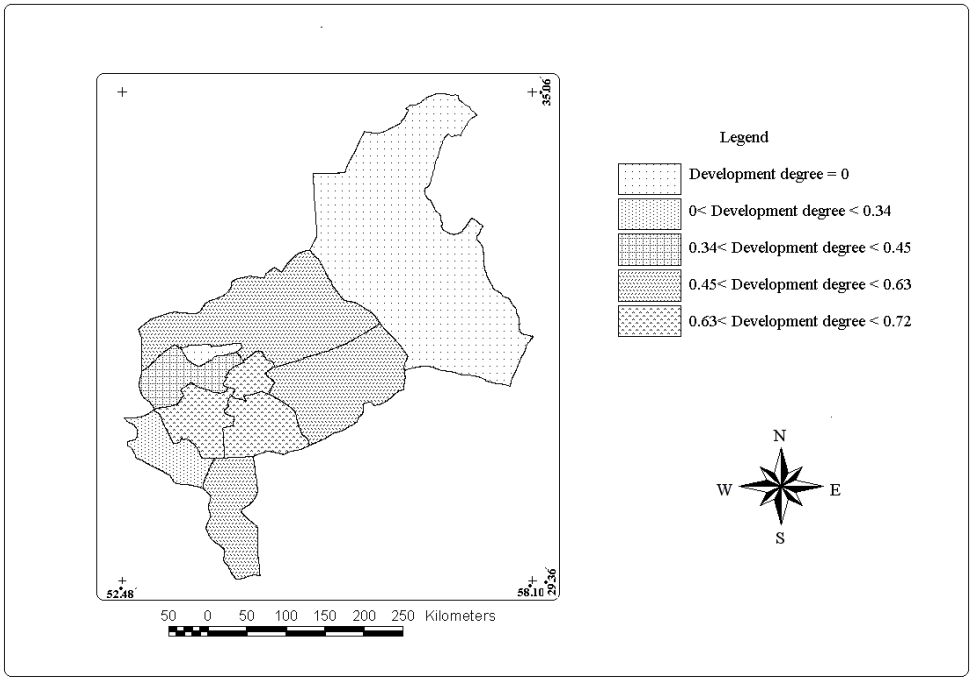

Fig. 3. Ranking of the urban areas of Yazd province on the basis of the planted lands area index

3.9.1.2. Determination of development degrees on the basis of the area of irrigated and protected lands

Tabas, Meybod and Sadough have the best condition with development degrees of 0, 0.03 and 0.22, respectively in accordance with the area of irrigated and protected lands. Abarkooh and Bafgh have unsuitable condition with development degrees of 0.53 and 0.64, respectively. While Yazd, Taft and Mehriz have the worst conditions with development degrees of 0.83 (Fig 4).

3.9.1.3. Determination of development degrees on the basis of area of restricted lands

Tabas and Sadough have the best condition with development degrees of 0 and 0.18 respectively according to the area of enclosure lands. Abarkooh, Bafgh and Meybod have been assessed in next degrees with development degrees of 0.55, 0.58 and 0.63 respectively. Ardekan and Khatam have unsuitable conditions with development degrees of 0.72 and 0.78 respectively. Taft, Yazd and Mehriz have the worst condition with development degrees of 0.84 (Fig 5).

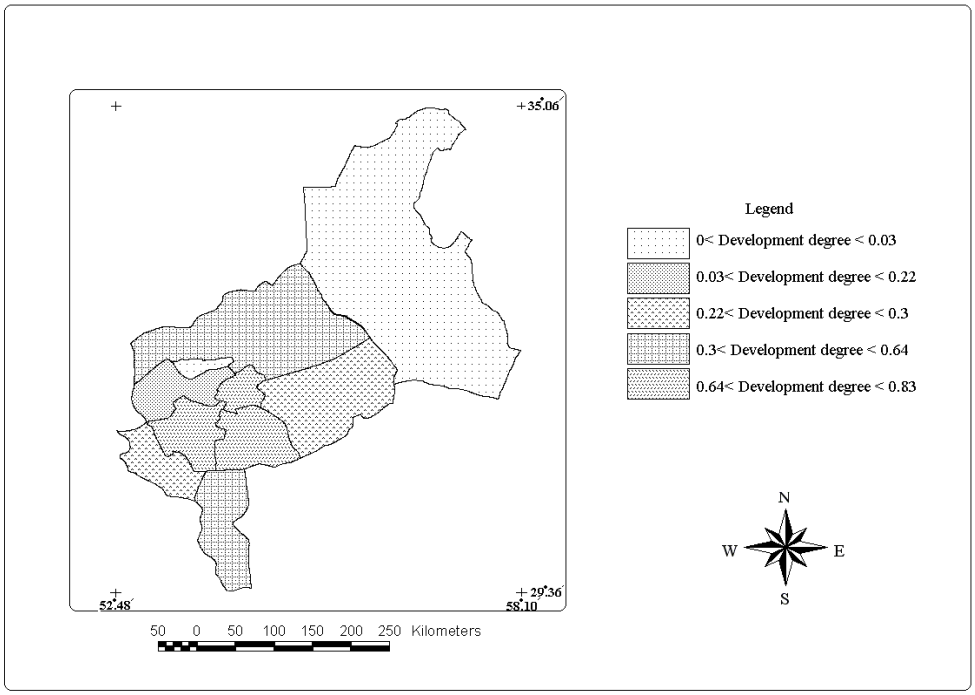

Fig. 4. Ranking of the urban areas of Yazd province on the basis of the area of irrigated and protected lands index

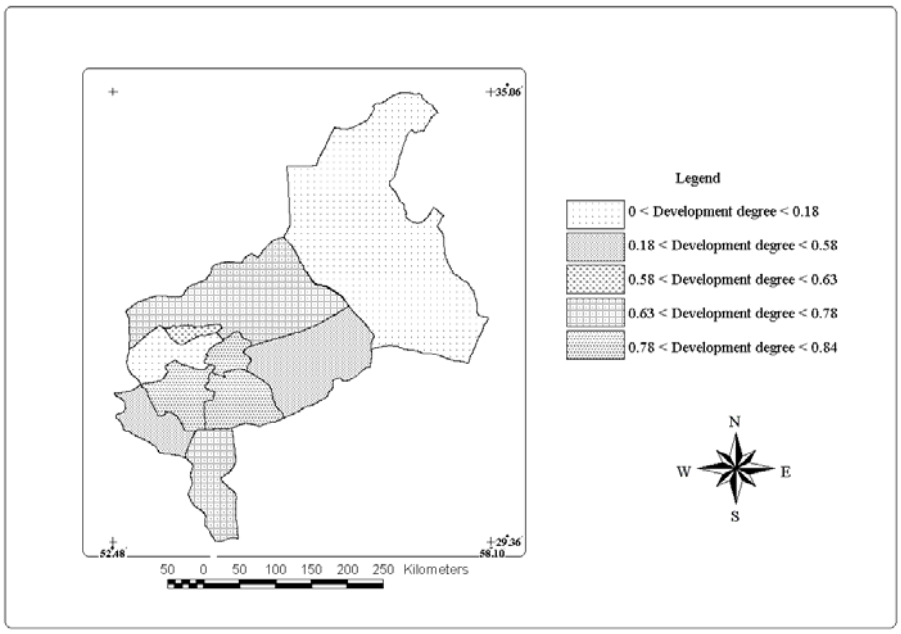

Fig. 5. Ranking of the urban areas of Yazd province on the basis of enclosure lands index

3.9.1.4. Determination of development degrees on the basis of dug and equipped wells, index

In accordance with the numbers of dug and equipped wells index and taxonomy analysis the following results have been obtained.
Bafgh with development degrees of 0 and Ardekan, Sadough and Abarkooh urban areas have suitable conditions with development degrees of 0.21. Tabas, Khatam and Meybod have unsuitable conditions with the degrees of 0.62 communally. Taft, Yazd and Mehriz have the worst condition with development degrees of 0.83 (Fig. 6).

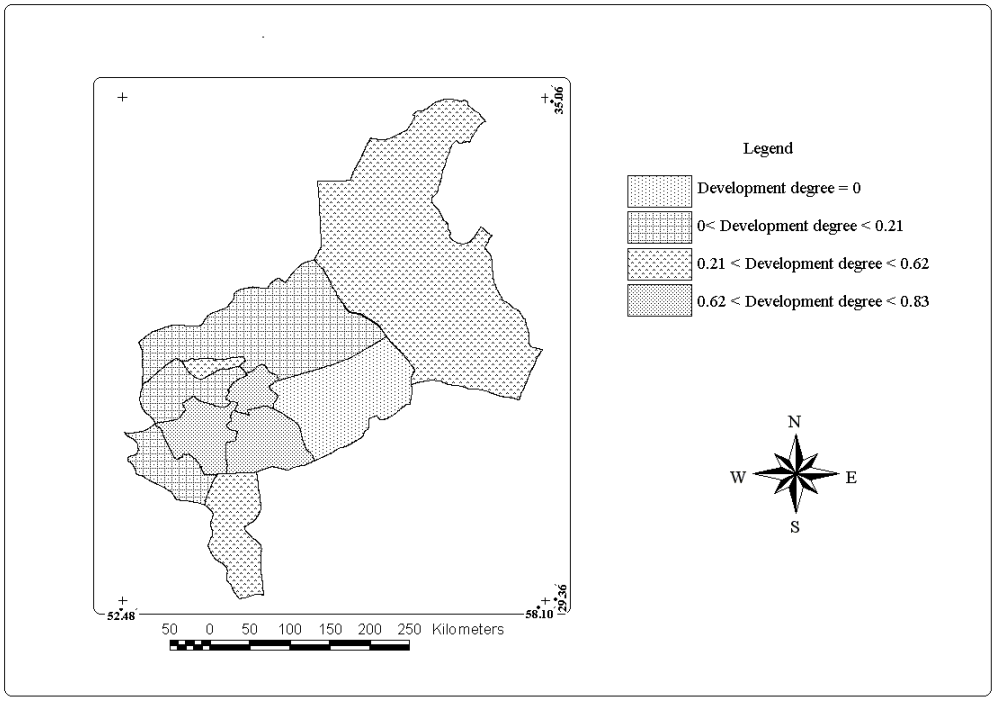

Fig. 6. Ranking of the urban areas of Yazd province on the basis of constructed and equipped wells index

3.9.1.5. Determination of development degree according to proposed or performed combating desertification projects index

According to proposed combating desertification projects index and taxonomy analysis, these results have been obtained: Ardakan and Bafgh have the most suitable condition with development degrees of 0 and 0.11, respectively. Sadough and Khatam have been assessed in next degrees with development degrees of 0.64 and 0.65 respectively. The other urban areas of the province have unsuitable conditions with the degree of 0.76 (Fig. 7).

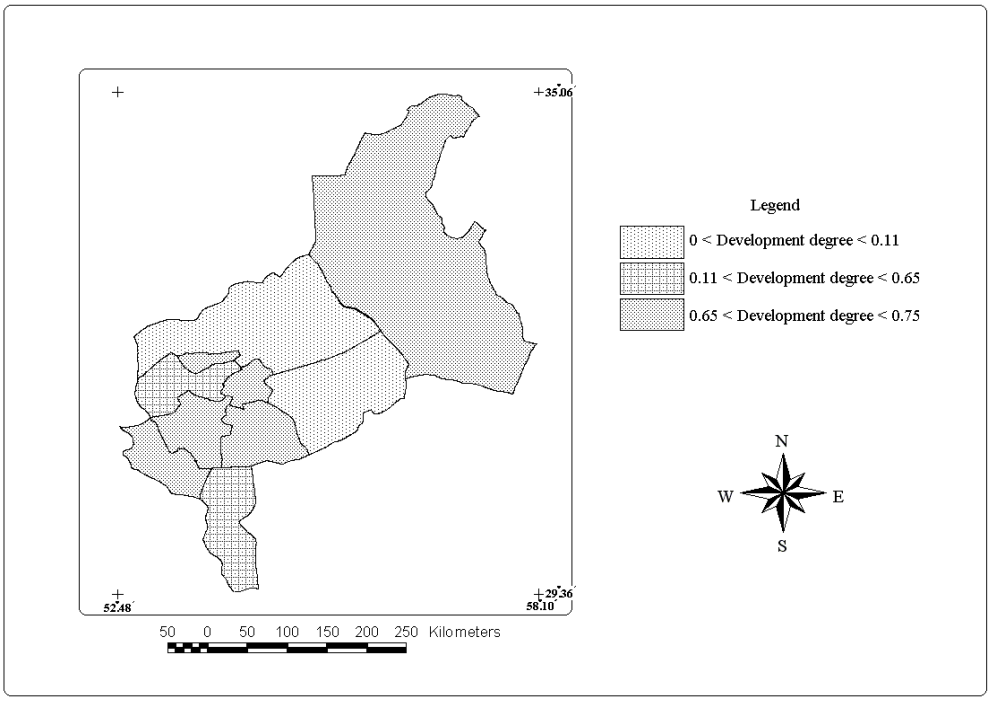

Fig. 7. Ranking of the urban areas of Yazd province on the basis of proposed or performed combating desertification projects index

3.9.1.6. Determination of development degree on the basis of all combating desertification indices

In accordance with all combating desertification indices and taxonomy analysis it has been concluded that Sadough, Bafgh and Tabas have the best situation with development degrees of 0.44, 0.45 and 0.49, respectively. Abarkooh,Ardakan and Meybod have been placed in the next ranks of combating desertification performance development. Khatam has unsuitable condition with the degree of 0.73. Yazd, Taft and Mehriz are the most deprived urban areas from all combating desertification indices viewpoint (Fig. 8).

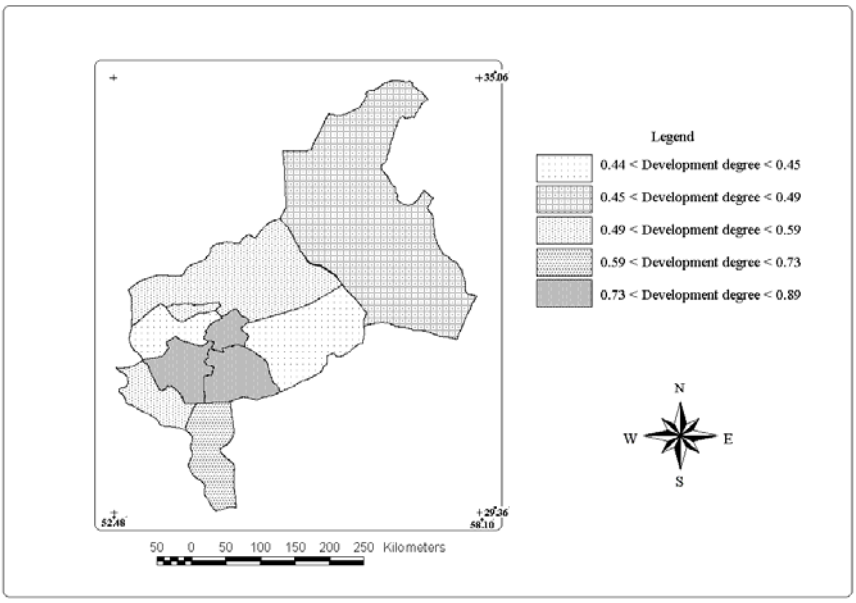

Fig. 8. Ranking of the urban areas of Yazd province on the basis of all combating desertification indices

In order to assess combating desertification status comprehensively as well as to separate from evaluation of development degree of combating desertification indices, the area of desert lands and the area of desert lands of each city and the province and the risk of desertification occurrence have been considered and the obtained results are shown in Figs 9, 10 and Table 6.

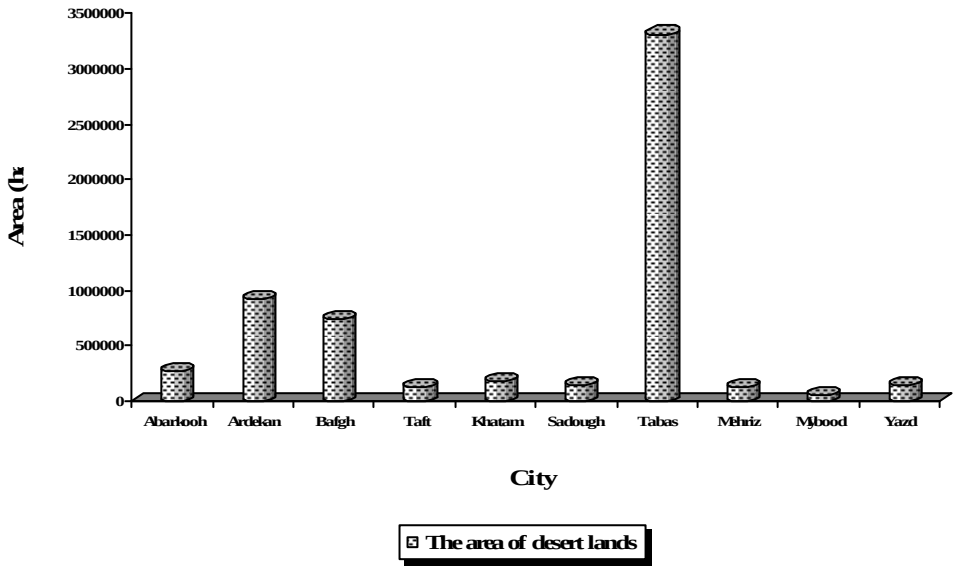

Fig. 9. The area of desert lands of Yazd province (Reference: Jihad- Agriculture Organization of Yazd province, 2006.)

Fig. 10. The comparative graph of desert lands area to the city and province area (Reference : Forest, Range and Watershed Management Organization & Tak-sabz company, 2002.)

Table 6. Potential resources affected by desertification process

Urban areas	Farm lands (ha)	Planted forest (ha)	Rangeland (ha)	Roads length (km)	Workshop number n>10	Number of habitable and urban centers	Population density (n/km^2)	Village density (n/10km^2)
Abarkooh	28460	2500	215000	181	2	2	7.9	0.83
Ardekan	22182	51517	815000	481	30	2	2.6	0.24
Bafgh	18933	79750	873000	337	1	2	3.2	0.39
Taft	49375	40898	420000	267	6	2	8.9	2.48
Khatam	38295	61335	500000	164	0	2	3.7	069
Sadough	9664	988	460000	66	10	3	5	0.55
Tabas	17595	168000	1673400	1013	4	2	1.16	0.12
Mehriz	29062	20572	455000	179	11	1	6.78	0.69
Meybod	10406	800	80000	30	35	1	50.7	1.06
Yazd	12820	0	60000	88	254	4	184.7	0.75

Reference:Management and planning organization. 2004; and Jihad- Agriculture organization of Yazd province, 2005

4. Discussion and Conclusion

The study of research references showed that there is no record in applying organizing methods such as taxonomy analysis for assessing development and zoning desertification at the national and international level. So, comparing the results of this study With similar studies is not possible.

The results of analysis show that Yazd, Taft and Mehriz have the most unsuitable and instable conditions with development degrees of 0.89. Although the area of deserted lands in Taft and Mehriz (about 120000-124000 ha) and their proportion to whole area of the mentioned urban areas (20.74% and 18.38% respectively) are small and negligible that it is justified limitations of performed combating desertification project. Because of existence of considerable and potential resources affected by desertification such as farmlands, industrial centers, populated areas, the effects of desertification development is considerable. Although Yazd has negligible desert lands area (145000 ha) the area of desert lands to the area of the city is high (58.6%). In addition, the city is political center of the province and there are many potential resources such as industrial and population centers in the boundaries of the city that have been affected by desertification.

Khatam has unsuitable and instable conditions with development degree of 0.73 and with respect to the city has the largest farming lands (about 380000 ha) it can be affected by desertification. Ardakan has not suitable condition with development degree of 0.57 and with respect to the area of desert land of the city (920000 ha) and its proportion to whole lands of the city (39.89%) is high.

According to the conducted analysis, Sadough, Bafgh and Tabas have suitable development in combating desertification indices. With respect to the large area of desert lands in the mentioned urban areas (139000, 736000, 3311000 ha, respectively) and their proportion to the area of the city and the province are high (24.73, 1.08, 48.91, 5.73, 60.3 and 25.78) and affected potential resources are

also considerable (Figs 9, 10 and Table 6), therefore desertification indices condition has been assessed positively in the urban areas.
In accordance with the results, it is essential to consider potential resources affected by combating desertification and desert lands in planning and future investments in order to achieve sustainable development in arid and semi- arid areas.

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