Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 4 [1] December 2014: 117-128

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

ORIGINAL ARTICLE

Mapping Desertification using Iranian Model of Desertification Potential Assessment (IMDPA) and GIS in Golestan Province, Iran

H. Ranjbaran, H. Shurvarzy, A. Alimohammadi
Department of GIS, Faculty of Geodesy and Geomatic Engineering, K. N. Toosi University of Technology

ABSTRACT

Approximately 78 percent of Iran's area is located in arid and semi-arid regions and one third of this area is exposed to desertification. Thus, identification of desertification criteria and assessment of their intensity seems necessary. This research was carried out in the semi-arid area of Aghband in Golestan province, with an area of 3062.5 square kilometer, for drafting the desertification intensity map. To assess the desertification risk, the IMDPA model and geomorphological profiles were employed in the research in which the map of working units were prepared based on geological maps, land utilization, satellite images and field visits. The damage risk was also prepared by combining the risk severity maps, distribution, and vulnerability degree of components based on the risk formula. The obtained results showed that the region under study included 3 units, 5 types and 40 geomorphologic profiles. The results also showed that vegetation and soil criteria stood at 2.67, being in the high class (III), and 2.54, being in the medium class (II) of desertification, respectively. The quantitative value of desertification for the entire area was 2.03 (Class II). 30.03 percent of the region was located in high and very high damage class (III and IV) and 26.23 of the region required monitoring measures and management plans.

Keywords: *Desertification Risk, IMDPA Model, Geomorphology Profile, Damage, Critical Class, Golestan Province*

Received 15.08.2014 **Revised 10.09.2014** **Accepted 26.11.2014**

INTRODUCTION

Nowadays, deserts are not only limited to arid and semi-arid lands, but the terms desert and desertification is explored in human's approach toward nature. Deserts have transformed from "being" to "becoming" in recent centuries and humans have accelerated this transformation[1]. Kharin (1983) provided the following definition for desertification phenomenon:The intensification or development of desert conditions is referred to the process leading to decreased biologic production of ecosystems, and deterioration of human environmental condition in addition to decreased generation of ranges, forests and even agricultural products[2]. Considering constraints imposed by climate, especially inadequacy of rainfall and inappropriateness of seasonal and annual distribution along with extreme evaporation that causes imbalance in water level and lack of humidity, insufficient vegetation is considered as the main factor in arid and semi-arid regions as vegetation provides necessary protection for the soil and preventing fluvial erosion[3]. Lack or insufficiency of vegetation in such regions is affected by climate limitations (weather conditions) affecting natural production of water with respect to time and place, on the one hand, and edaphic and ecologic limitations that are under the influence of climate limitation, on the other hand[4]. This issue applies to other regions affected by other factors, contributing to the emergence, development and intensification of fluvial erosion, such as topographic properties, rainfall, and land utilization that pave the way for emergence, development and intensification of erosions. These factors contribute to the ecological deterioration, environmental imbalance and ultimately creation of desertification conditions. Williams (1981) maintained that development of areas affected by fluvial erosions that are accompanied by climate condition changes and physical conditions in arid and semi-arid regions that bring about many extreme limitations for natural growth and development of vegetation, is one of the important factors of desertification that can spread to nearby regions with temperate climate.

REVIEW OF LITERATURE

The first formal and broad action with regard to assessment of desertification for a better understanding of this phenomenon was taken in 1977 through preparation of the global desertification map of United Nations Convention to Combat Desertification (UNCCD Map) by FAO, UNESCO, and WMD. The abovementioned map shows desert areas as well as the surrounding areas exposed to high desertification risk such that it can show the three following types of information for each region:

A) Desertification Risk rate for each region;
B) Processes leading to desertification;
C) Human and environmental factors.

A research work was conducted in 1980 for designing the initial methods for assessment and preparation of desertification map by FAO and UNEP for the following objectives[5]:

- Developing methods for assessment and mapping desertification;
- Execution of these methods and testing them in other desert areas;
- Improving the knowledge of the personnel involved.

In the above methods, the current status and the rate of desertification risk has been taken into consideration and 8 desertification processes have been specified as below:

1. Aeolian Erosion;
2. Vegetation Degradation;
3. Salinity and Alkalinity of Soil;
4. Concentration of Poisonous Materials;
5. Fluvial Erosion;
6. Soil Structure Destruction;
7. Decrease in Organic Compounds;
8. Transformation to marshes.

The above plan was tested and assessed within four years and through field visits in various countries of the world, such as Mexico, Texas, Sudan, Syria, Pakistan, Turkmenistan, and Australia. It was then published in 1984 as the preliminary research method for assessment and desertification mapping which is recommended for use in range conditions[6].

Deregne et al. (1977) prepared the first desertification map in four weak, medium, high, and very high classes for arid lands. They made recommendations for sunshine and aridity degrees and specified that determining the initial condition for assessment of the current desertification status is one of the problems[7].

Horst et al. (1980), from Hamburg University, prepared and issued the land use and desertification maps for the Darfur region in Sudan. These maps show that desertification processes depend largely on types of land use, and land use map is considered as the essential first step toward assessment of desertification[5].

To assess the desertification risk of Baring region, Grrunblatt (1992) used five desertification indices: fluvial erosion, vegetation degradation, range manipulation, human and habitation. Desertification risk was then calculated after combination with each of these[8].

According to MEDALUS methodology, Ladisa et al. (2002) considered 6 indices for desertification risk assessment: soil, climate, vegetation, land utility, quality management, and human pressure. Each index is of its own layers. Land utility and quality management means are employed in the present study for preparation of final desertification map[9].

Using IMDPA, Raeisi (2008) assessed the desertification severity of KahirKenarak Region and concluded that soil, Aeolian erosion, climate and vegetation have the largest impact on desertification in the region[10].

To assess desertification potential in Cheshme Khan region, Rezayi Rad (2008) assessed the soil, water and irrigation, vegetation, and socio-economic context using IMDPA. Their results showed that among all studied criteria, vegetation devoted a larger area to the high class. The large impact of vegetation on desertification has been due to over-grazing, traditional methods of animal husbandry, and dependency of lives on natural resources. Unlimited water resources with respect to quality (EC and SAR) accounted for the minimal effect of water and irrigation on desertification. Among all social and economic indices, habitation type index had the greatest effect on the severity of desertification[11].

Jafarizade (2011) assessed the desertification severity in Mollasani area of Ahvaz using IMDPA. Desertification risk was assessed in the present study based on seven criteria: climate, geology, vegetation, agriculture, erosion, socio-economic issues, and civil and industrial development technologies. The results indicated that vegetation, with a value of 3.52, was in very high class, while geology and geomorphology, with a value of 1.24, were in the low and negligible classes of desertification. The quantitative value of desertification severity for the whole region was estimated at DS=1.83 which stands in the medium class[6].

Approximately 80 percent of Iran is situated in arid and semi-arid regions and one third of these regions are exposed to desertification. Assessment and mapping desertification risk and damage precedes all logical planning for desertification[12].

Many studies have been conducted in various countries to assess and map desertification in those countries and all the studies have resulted in regional models for those countries. Iranian Classification of Desertification (ICD)[1], Modified Iranian Classification of Desertification (MICD) with an emphasis on Aeolian erosion processes[13], FAO (1984) and Iranian Model of Desertification Potential Assessment (IMDPA) are among the most important methods and models proposed thus far[14].

The non-quantitative nature of recommended criteria, insensitivity of some recommended indices to minimal changes (or the broad scope of limitation class number), immeasurability of some of the assessment criteria, unequal weight of recommended indices for different processes, especially from the number perspective, are among the disadvantages of FAO-UNEP method[15]. On the one hand, domestic methods such as ICD cannot be utilized in comparative studies due to their quantitative nature assessment of desertification factors and doubling the score of environmental factors in regions without vegetation[13, 16]. Ahmadi and Nazari Samani (2005) reported that IMDPA method makes use of GIS capabilities in mixing information layers, and providing simple assessment and basic data collection and reducing diagnosis error is of greater accuracy in comparison with other methods[14].

Desertification has occurred in its active form in Aghband semi-arid region due to the special climate geomorphologic condition of the region. Therefore, assessment of the intensity of desertification criteria and their identification using IMDPA model as an assessment basis for compiling management programs for preventing and controlling desertification in the region seems necessary as a national countermeasure.

IMDPA

The severity of desertification is assessed in this method through nine criteria including soil, erosion (Aeolian and fluvial), climate, water, vegetation, agriculture, technological development, and management. As in MEDALUS method, the geometric average is used for combining the data [17].

Advantages to IMDPA

1. The capability of the model to assess desertification potential for different climates: arid, semi-arid , arid and semi-humid, and humid;
2. The possibility to prepare maps for 9 criteria and 36 main indices affecting desertification in each region and the whole country;
3. Prioritization of criteria and indices effective in desertification and possibility to plan and make decisions for the region and the country for controlling and managing them;
4. The possibility to use the obtained data in spatial and land utility planning;
5. The possibility to use GIS for calculation of index and total score and presenting desertification severity map[17].

Case Study

Coordinates and Conditions

The region under study, with an area of 2989.25 square kilometers, is located in Golestan province at the latitude of 37 08' 01'' to 37 36' 49'' and longitude of 54 23' 52'' to 55 39' 31''. The region under study is located in the north of Golestan province and includes parts of Gorganrud and Atrak drainage basins. Figure (1) shows the situation of the region under study in Iran and in Golestan province.

Figure 1 – Geographical map of the region understudy

Preparation of Geo-Morphologic Profile Map

The morphologic profiles of the region are classified into mountains and plains for the assessment of desertification risk. To this end and for the current study, topographic and geological maps with a scale of 1:250000 and aerial photos with a scale of 1:40000 were utilized. After preparation of the data, ArcGIS Desktop 10 was used for preparation of the slope map.

Selecting an appropriate model for desertification assessment (IMDPA).The Iranian IMDPA model was used in this study for desertification assessment and map preparation. Nine criteria, 35 indices, and 3 climates of arid, semi-arid, and arid/semi-humid were proposed in the IMDPA model. The nine criteria included climate, geology and geomorphology, soil, vegetation, water, erosions (fluvial and Aeolian), agriculture, socio-economy issues, industrial and civil development. A weight between 1 and 4 was assigned to each layer based on their influence on desertification, and considering other resources and documentations by other researchers as well as the conditions of the region; 1 indicated the best and 4 indicated the worst weight[6]. The numerical values of indices produced as working units in ArcGIS Desktop 10 software were then converted into subject maps.

Table 1- Classification of Desertification Classes of IMDPA Model

Class	Range	Sign
Low	0-1.5	I
Mean	1.6-2.5	II
High	2.6-3.5	III
Very High	3.6-4	IV

As observed, the map of each criterion is classified into four classes of low and negligible, medium, high, and very high.

Implementation

IMDPA Model Criteria

Climate Criterion

Climate is comprised of three indices of annual rainfall level, aridity, and continuity of aridity.

Annual rainfall level

Annual rainfall level, regardless of its distribution throughout the year, is an appropriate general index for assessing rainfall component.

Aridity index

The aridity index used in climate assessment for desertification studies can be one of De Martonne, Silianinov, Gezrotermic, Torentvit or FAO indices.

Aridity index

Aridity index is a phenomenon independent of annual rainfall. This phenomenon occurs in arid, humid and even very humid regions.

Climate criterion = (annual rainfall level * aridity index * continuity of aridity)$^{1/3}$ eq. 1

Table 2- Indices for assessment of climate criterion

Evaluation Index	Low	Mean	High	Very High
	0-1.5	1.6-2.5	2.6-3.5	3.6-4
Annual Rainfall	<280	150-280	75-150	<75
Aridity Index	<0.65	0.45-0.65	0.2-0.45	<0.2
continuity of aridity (Years)	3-4	5-6	6-7	>7

Geology criterion

To assess this criterion, the following three indices are utilized: stone sensitivity, land utility type, and slope. This criterion is calculated by the geometrical mean of abovementioned indices and as per the following formula.

Geology criterion = (stone sensitivity * slope * land utility type)1/3----------------------------eq.2

Table 3- the weight of geomorphologic and geology criteria

Evaluation Index	Low	Mean	High	Very High
	0-1.5	1.6-2.5	2.6-3.5	3.6-4
Slope	<5	5-15	15-30	>30

Vegetation criterion

Planning for de-desertification (desert greening) of arid regions with few and unpredictable rainfall can be with great complexity. However, awareness of humidity, soil temperature, and vegetation and generation capability of arid and desert regions can be effective in the management of these regions. Thus, to assess the vegetation by the proposed model, some indices were proposed (as reported in table 4). The vegetation criterion map was ultimately prepared by the geometric mean of these indices.

Vegetation Criterion=(vegetation percentage * manipulation of vegetation * renovation of vegetation)1/3 -- eq.3

Table 4- Vegetation Criterion Indices

Evaluation Index	Low	Mean	High	Very High
	0-1.5	1.6-2.5	2.5-3.5	3.6-4

Agriculture Criterion

Three main indices of agricultural utility or planting pattern, utility of products in comparison with plantation appropriateness with planting conditions and agriculture intensity (utility of inputs and machinery) were selected as the main indices effective in land degradation and as a result improving desertification.

Table 5 – Indices of Agriculture Criterion

Evaluation Index	Low	Mean	High	Very High
	0-1.5	1.6-2.5	2.5-3.5	3.6-4

Erosion Criterion

Fluvial Erosion Sub-Criterion

Three indices of type and intensity of fluvial erosion, land utility type, and density of vegetation canopy can be considered for the assessment of this sub-criterion.

Aeolian Erosion Sub-Criterion

To assess this sub-criterion, three indices of emergence of erosion profile or the intensity of Aeolian erosion, vegetation percentage and the number of the days with dust storms can be used.

Socio-economic criterion

Economy and poverty, institutional and legal factors, and communities are different socio economic indices.

Industrial and Civil Development Criterion (Technologic Desertification)

One of the criteria considered in desertification assessment is the industrial and civil development criterion or technologic desertification that is regarded as one of the important processes of desertification.

Soil Criterion

Considering the conditions of the region, indices utilized for soil criterion include EC and drainage. To assign weights to these indices, salinity map of the province and other existing maps were used.

Table 6- indices related to soil criterion for assessment of the current condition

Evaluation Index	Low	Mean	High	Very High
	0-1.5	1.6-2.5	2.6-3.5	3.6-4
EC (dS/m)	<5	5-8	9-16	>16
Drainage	Good	Mean	Low	Very Low

Ground Water

Table 7 shows the indices selected for assessment of current desertification status with regard to water resources. These indices include Electric Conductivity (EC), the level of Chlorine and SAR. Then, desertification intensity map is prepared based on the aforementioned indices. SAR stands for Sodium Absorption Ratio and is obtained through the following equation.

$$SAR = \frac{Na}{\sqrt{\frac{(ca+mg)}{2}}}$$ **eq.4**

Table 7 – Assessment Indices for Water Criterion

Evaluation Index	Low	Mean	High	Very High
	0-1.5	1.6-2.5	2.6-3.5	3.6-4
EC (µmohs/cm)	<750	750-2250	2250-5000	>5000
SAR	<18	18-26	26-32	>32
CL (mg/lit)	<250	250-500	500-1500	>1500

In the model utilized in this study, nine criteria of climate, geology and geomorphology, vegetation, agriculture, water, soil, erosion, socio-economic issues, and civil and industrial development were studied. Each criteria has several indices.

Weights were assigned to layers, in a linear and almost equal fashion, based on the influence they had on desertification considering the conditions of the region. The assigned weights ranged from 0 to 4; 0 being the best and 4 being the worst weight. 0 is assigned to pools, civil areas and such regions. A map is then prepared for each index and considering the weight assignment performed. The prepared map is then categorized after calculation of each criterion. As witnessed, the map of each criterion is categorized in one of the four classes of low and negligible, medium, high and very high as per the weights they obtained. Thus, nine maps of criteria condition were obtained. These maps can be used for qualitative study of each criterion and their effect on desertification. The final map, showing the desertification status based on the criteria climate, geology and morphology, vegetation, agriculture, water, soil, erosion, socio-economic issues, civil and industrial development (technologic), was ultimately prepared by the geometric mean of aforementioned criteria and through the following equation:

$$DM= (Q_C . Q_V . Q_S . Q_G . Q_A . Q_E . Q_W . Q_{(S-E)} . Q_T)^{1/9}$$ --eq.5

Risk Zoning by IMDPA Model

Desertification risk in the region under study

To assess the current desertification condition, each of the indices were reviewed in each working unit and weights were assigned to them. Then the desertification class was specified for each index. After determining the nominal value of each profile, the current status of desertification was determined and the respective map was prepared. The following results were obtained with regard to scoring the IMDPA method as one of the methods for assessing the desertification intensity and considering all the collected data in the region under study as well as the structure of the method and its assessment approach.

Climate Criterion

To assess the climate criterion, three indices of annual rainfall level, aridity, and continuity of aridity were used.

Annual rainfall level

With regard to this criterion, the region under study was in two classes of low and negligible (%68.96) and medium (%31.04) and considering the area of each unit, the mean of nominal values assigned to this parameter was 1.25 which is in the low and negligible class.

Aridity

With regard to this criterion, the region was situated in two classes of high with a distribution of %49.62 and very high with a distribution of %50.38. Considering the area, the numerical value is in the high class (3.11).

Continuity of Aridity

To measure this index, the 5-year moving average was employed and the whole region proved to be in the low and negligible class with a weight of 1.31.

Final results of Climate criterion

The final map of desertification intensity based on climate criterion shows that the region is in two classes of low and negligible and medium with a distribution of %48.76 and %51.24, respectively. Table 2 shows all indices affecting the climate criterion.

Geology criterion

To assess this criterion, three indices of slope, sensitivity of formation, and land utility were utilized.

The final results of geology criterion

The final map of desertification intensity drawn based on this criterion shows that the region is in three classes of low and negligible, medium and high with a distribution of 31.8, 60.7 and 7.49, respectively. Table 3 shows all indices affecting geology criterion.

Vegetation Criterion

To assess and score this criterion, three indices of manipulation of vegetation, vegetation condition and renovation of vegetation were considered. Considering this criteria, %45.21 of the region is devoted to agriculture which is considered as classless in this criterion and is scored in agriculture criterion.

Final results of vegetation criterion

The final map of desertification intensity based on this criterion shows that the region is in two classes of medium and high with a distribution of 24.17 and 30.62, respectively. With regard to this criterion, the region is in the high class.

A. Agriculture criterion

To assess this criterion, three indices of agricultural utility or planting pattern, utility of products in comparison with plantation appropriateness with planting conditions and agriculture intensity (utility of inputs and machinery) were utilized. Considering this criterion, ranges formed %54.79 of the region which is considered as classless in this criterion and is scored in vegetation criterion.

Final results of agriculture criterion

The final map of desertification intensity based on this criterion show that the region is in two classes of medium and high with a distribution of %34.8 and %2.13, respectively. With regard to this criterion, the region is in the medium class.

Socio-economic criterion

Communities, type of utilization, yield and ownership are among socio-economic indices.

Final results of Socio-economic criterion

The final map of desertification intensity based on this criterion shows that the region is in two classes of medium and high with a distribution of 91.12 and 8.88, respectively. With regard to this criterion, the region is in the medium class.

Erosion Criterion

Fluvial erosion sub-criterion

Three indices of type and intensity of fluvial erosion, land utility type, and density of vegetation canopy were used for the assessment of this sub-criterion.

Final results of fluvial erosion sub-criterion

The final map of desertification intensity based on this sub-criterion shows that the region is in three classes of low and negligible, medium and high with a distribution of %30.6, 46.95, and 22.98, respectively. With regard to this sun-criterion, the region is in the medium class.

Aeolian erosion sub-criterion

To assess this sub-criterion, three indices of emergence of erosion profile or the intensity of Aeolian erosion, vegetation percentage, and the number of days with dust storms were used.

Final results of Aeolian erosion sub-criterion

The final map of desertification intensity based on this sub-criterion show that the region is in three classes of low and negligible, medium and high with a distribution of %45.35, 45.53, and 9.12, respectively. With regard to this sun-criterion, the region is in the medium class.

Final results of erosion criterion

According to the study conducted on the region based on this criterion, the region is in three classes of low and negligible, medium and high with a distribution of %37.76, %60.51 and %1.73, respectively. The quantitative value of this criteria was 1.75 and in medium class. With regard to this criterion, the region is in the medium class.

Civil Development Technology Criterion

Three indices of conversion of agricultural lands and gardens in the suburbs to residential areas, conversion of ranges and forests to cities and industrial areas, and inappropriate planting and density of mines and roads are the three indices used for assessment of this criterion.

Final results of Civil Development Technology Criterion

Considering the following equation, it can be concluded that:The numerical value of this criterion was calculated at 2.4133. Therefore, with regard to this criterion, the region is in the medium class.

Ground water criterion

Due to the unavailability of information on the quality of ground water in Atrak region situated near the national border, interpolation method was used for scoring the part related to Atrak region. Electric Conductivity (EC), the level of Chlorine and SAR (Sodium Absorption Ratio) were used assessment of this criterion.

Final results of ground water criterion

As per the calculations performed, and with regard to this criterion, the region is in two classes of low and negligible and medium with a distribution of %32.61 and %67.39, respectively. With regard to this criterion, the region is in the medium class.

Soil criterion
To assess this criterion, two indices of drainage and electric conductivity were utilized.
Final results of soil criterion
As per the calculations performed, and with regard to this criterion, the region is in three classes of low and negligible, medium and high with distributions of %5.86, %75.07 and %19.07, respectively. With regard to this criterion, the region is in the high class. Table 8 shows the indices affecting the soil criterion.

Table 8 – the weight average of quantitative values of indices affecting soil criterion.

No.	Desertification Class	Mean Numerical Value
1	Mean	2.39
2	High	2.71
Final Results	High	2.54

Analysis of desertification criteria and indices in Aghband region
Desertification criteria
Desertification criteria of the region under study follow in order of their significance: vegetation (2.67), soil (2.54), technologic development (2.42), socio-economic issues (2.21), agriculture (2.08), climate (1.72), erosion (1.7), geology (1.65), and ground water (1.6).

Table 9 – weight average of criteria quantitative value

Desertification Class	Numerical Value	Eva. Index	No.
High	2.67	Vegetation	1
High	2.54	Soil	2
Mean	2.42	technologic development	3
Mean	2.21	socio-economic issues	4
Mean	2.08	Agriculture	5
Mean	1.72	Climate	6
Mean	1.7	Erosion	7
Mean	1.65	Geology	8
Mean	1.6	ground water	9

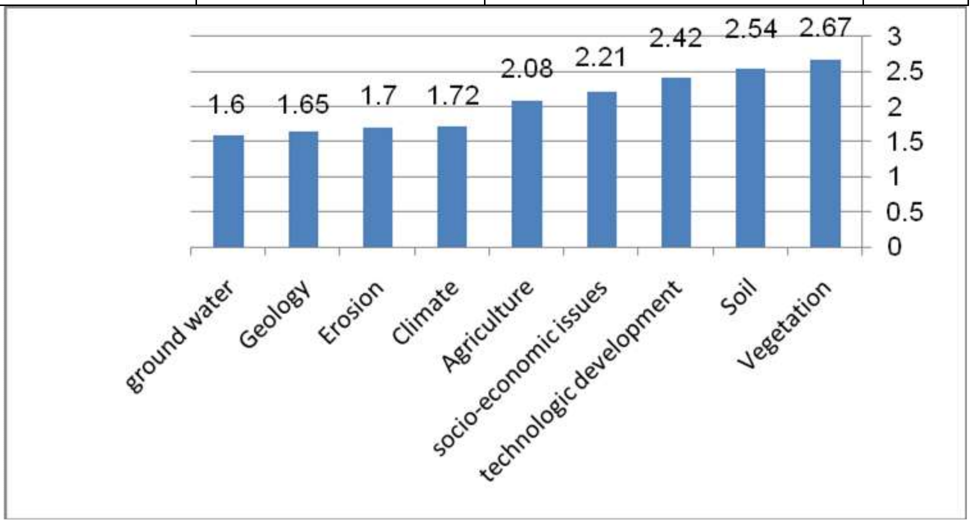

Figure 2 – analysis of weight average of desertification criteria in Aghband region

Desertification intensity
Considering the calculations performed, the quantitative value of desertification intensity of the semi-arid region of Aghband in Golestan Province stood at 1.9473281. The desertification class of the entire region was assessed as medium (II) according to the classification of IMDPA model. With regard to the distribution, %31.32, %50.88 and %17.80 of the region was located in low and negligible, medium and high classes, respectively.

Table 10- distribution of desertification risk class in Aghband region

Class	Danger Class	Weight Range	Area (ha)	Distribution Percentage
I	Low	0-1.5	95925.92	31.32
II	Mean	1.6-2.5	155811.59	50.88
III	High	2.6-3.5	54512.5	17.80
	Sum		302800	100

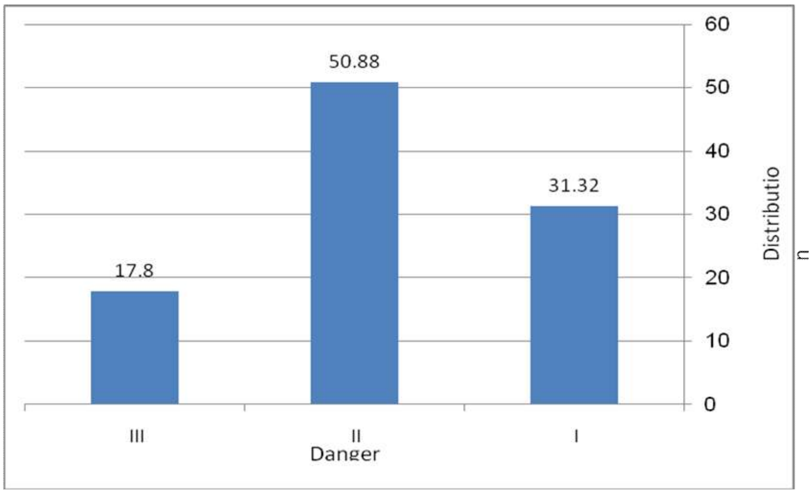

Figure 3 – Distribution comparison diagram of desertification risk class in Aghband region

The following can be concluded based on the below equation:
Assessments made in the weight average of quantitative values of IMDPA criteria showed that the vegetation criterion, of high class and with a value of 2.67, is the most effective factor in the severity of desertification in the semi-arid region of Aghaband.

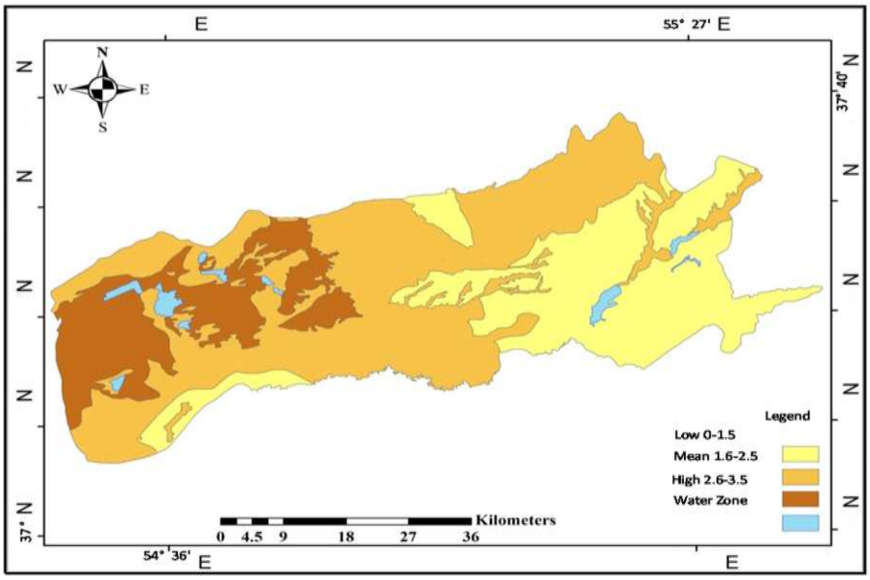

Figure 4- the final desertification map of Aghband semi-arid region according to IMDPA model

Vulnerability of elements exposed to risk

To determine the vulnerability class of elements, expert-advised coefficients were used for elements exposed to risk. The region under study lacked important industrial infrastructures and water supply channels with great sensitivity. Connecting roads, ranges, and residential areas are of greater significance in comparison with the aforementioned elements. The roads are important for transportation and connecting the villages to the nearby cities such as Gorgan, GonbadKavoos, Minoodasht, and MaravehTapeh.

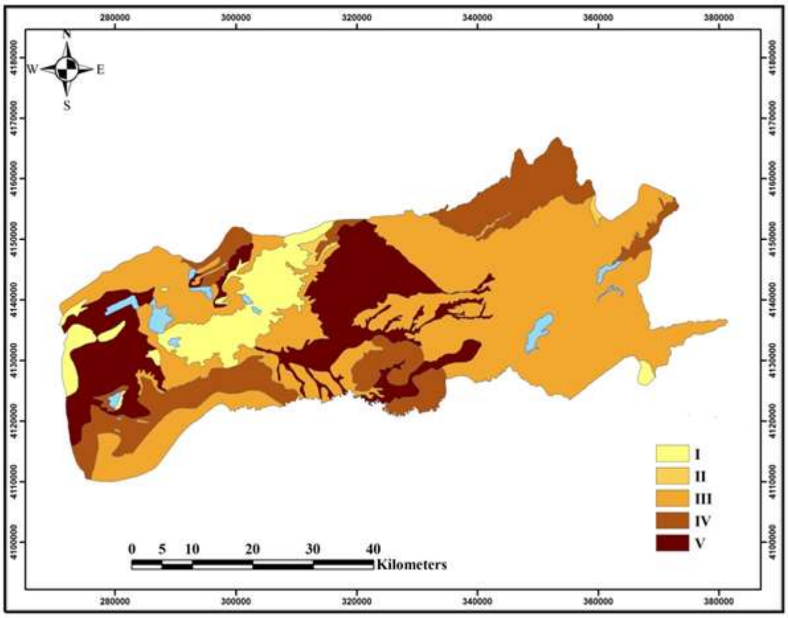

Figure 5 –vulnerability map of elements exposed to desertification risk in Aghband region

Table 11 – area distribution of vulnerability classes of elements exposed to risk in Aghband region

Area Distribution	Area (ha)	Vulnerability Range	Quality	Vulnerability Class	No.
5/28	16166/38	<7	V. Low	I	1
51/31	157147/64	15-35	Mean	III	2
18/51	56691/82	35-45	High	IV	3
24/9	76244/16	>50	V. High	V	4
100	306250		Sum		
0/01	137620/916		Chi-Square		

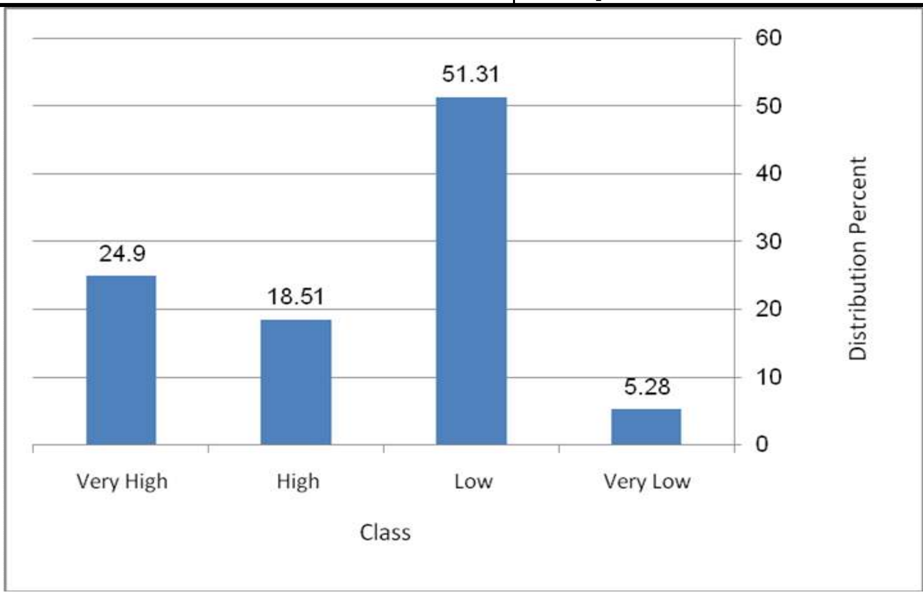

Figure 6 - distribution comparison diagram of vulnerability class areas of elements exposed to risk

Desertification Risk

The risk value is calculated by the general equation, and pixels were categorized in four classes of low, medium, high and very high based on turning points of distribution curve.

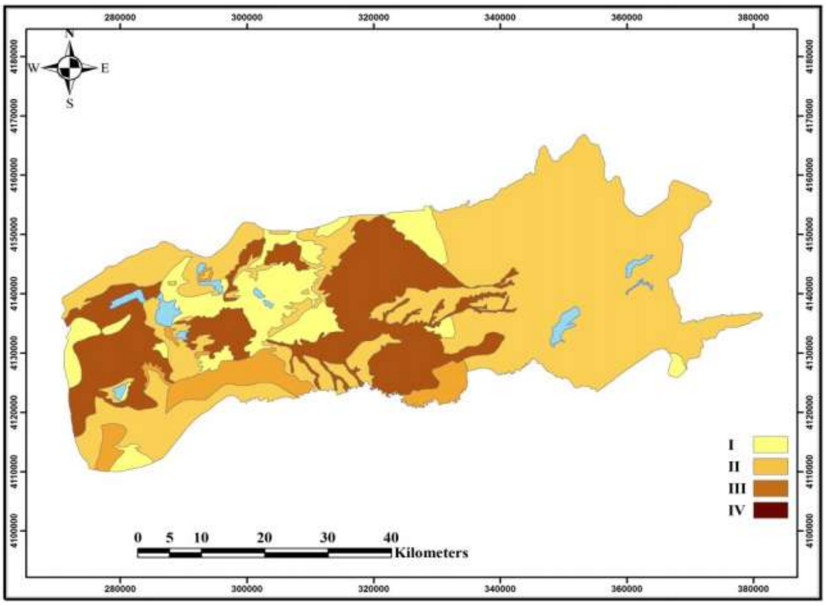

Figure 7 – desertification risk map of the region under study

CONCLUSION

Combating desertification and its destructive impacts seems to be a new and all-inclusive unavoidable challenge for the global community as occurrence of desertification phenomenon in one part of the world will bear consequences for all inhabitants of planet earth. Thus, identification of highly sensitive regions seems necessary as the first step toward avoiding the desertification impacts. To this end, the study assessed the risk and damage severity of Aghband semi-arid region in Golestan province using IMDPA model. In the model utilized in this study, nine criteria of climate, geology and geomorphology, vegetation, agriculture, water, soil, erosion, socio-economic issues, and civil and industrial development were assessed to study the desertification status of Aghband semi-arid region. Considering the assessments conducted and among all desertification criteria in the region under study, vegetation criterion was of greater influence. Vegetation has frequently been emphasized by desertification studies throughout the world. Additionally, this criterion stands at the first rank of significance and influence on desertification in Iran. Assessments made on the weight average of quantitative values of desertification indices showed that the four indices of conversion of agricultural lands to residential and industrial areas or improper planting, conversion of plantations to residential and industrial areas, renovation of vegetation and manipulation of vegetation have the greatest influence, and slope has the smallest influence, on desertification of the region. Considering the conducted studies, the effect of desertification criteria can be prioritized as below: vegetation, soil, technologic development, socio-economic issues, agriculture, climate, erosion, geology and ground water. The obtained results signify that the criteria showing humans' direct involvement with resources have the greatest impact on desertification intensity. This can be explained by irregular manipulation in ranges (in the form of overgrazing and digging out shrubs) and plantations (in the form of improper conversion of lands and irregular plantations). The quantitative value of desertification intensity (current desertification status) for the entire region was estimated at DM = 2.03 based on the nine criteria. According to IMDPA model classification, this value stands in the medium class. This might be due to the presence of marsh plain which is because of the heavy texture, and being dipped in torrents.

REFERENCES

1. S. M. M. Ekhtesasi,(1996).How to Classify Desertification in Iran," Institute of Forest Research, p. 14.
2. N. G. e. kharin,(1983). "Methodological Bases for Evaluation and Mapping of desertification," YLym, Ash khabad.
3. R. P. C. Morgan,(1986). "Soil Erosion and Conservation," D. A. Davidson. University of Strathclyde. Longman Scientific and Technical. Hong Kong.
4. B. O. Williams, (1981)."Practical experience in combating desertification," Problem and Prospects of Desertification Control in the ESCAP region, Bangkok, Thailand, p. 10.
5. G. M. a. F. N. I. Horst,(1980). "Mapping Desertification in the sudan: a Methodological Approach," Homburg Uni. Pb. Germany.
6. M. Jafarizadeh, (2011)."Assesment of Desertification using IMDPA," MSc, Natural Science, Tehran.

7. D. H. H. Deregne, H. Flohn, V.A. Kovda,(1977). "Status of desertification in the hot arid regions: estimate aridity index map: Experimental world schema of aridity and drought probability at a scale of 1:25.000.000," UNCD, Kenia.
8. J. Grrunblatt, (1992)."Pilot study for desertification assessment and mapping, Baring Kenya, World atlas of desertification," Homburg. University of Germany, p. 365.
9. G. T. Ladisa, M. and Trisorio Luzzi, G, (2002)."Characterization of Area Sensitive to Desertification in Southern Italy, Proc. Of the second int. on new Trend in water and Engineering for Safety and life," Eco-compatible solutions for Aquatic Environmental, p. 5.
10. A. Raeisi, (2008).Assessment Effective Criteria in Desertification using IMDPA model in Kahir-Konarak Region," MSc, Natural Science, Tehran.
11. N. R. Rad,(2008). "Evaluation of Desertification Potential in Cheshmeh Khan Region Using IMDPA," Msc, Natural Science, Tehran.
12. A. A. H. Ahmadi, M. Ekhtesasi, M. Jafari, A. Golkarian, (2006)."Assessment and Mapping Desertification using Modified MEDALUS in Fakhr Abad-Mahriz," Iran Natural Resource, vol. 3, p. 14.
13. A. A. H. Ahmadi, M. Ekhtesasi, M. Jafari, A. Golkarian, (2005)."Evaluation and Mapping Desertification Using ICD and MICD in Fakhr-Mahriz Abad Region," Biaban Journal, vol. 1, p. 20.
14. A. S. H. Ahmadi, (2005)."Introducing Iranian Model of Desertification Potential Assessment (IMDPA) for desertification," p. 8.
15. M. D. M. Meshkat, M. Ekhtesasi, K. Dashtakian, (2006). "Mapping of Erosion of Vegetation Type, Wind Erosion and Salty Lands in Yazd Desert," Desert Research, vol. 1, p. 7.
16. H. A. Gh. Zehtabian, M. Ekhtesasi, R. Jafari, (2002). "Determination Wind Erosion in Kashan City using Desertification Model," Natural Science, vol. 2, p. 14.
17. A. s. M. Ekhtesasi, (2011). "Methods and Models in Assessment and Mapping Desertification," Yazd University, vol. 1, p. 286.

CITATION OF THIS ARTICLE

H. Ranjbaran, H. Shurvarzy, A. Alimohammadi. Mapping Desertification using Iranian Model of Desertification Potential Assessment (IMDPA) and GIS in Golestan Province, Iran. Bull. Env. Pharmacol. Life Sci., Vol 4[1] December 2014: 117-128