An Integrated Desertification Hazard Assessment in Iran

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Abstract

This paper presents a classified desertification hazard on grid map of Zayandeh Rood Basin (Z.R.B) in Iran. There are potential climatic factors, the geographical location, and human activities for developing desertification. The present study is based on main factors of desertification in the study area. The classification method is based on such main parameters as the characteristic of soil, management and climate. Each parameter includes a sub-indicator with statistical data and vector map, calculating 10km² grid, are used as the data set for classifying the desertification map. The sum of score parameters was estimated by using a weighted average. In this study Arc GIS 9.3 was used to analyze the vector and grid maps. In Z.R.B, the most important factors of desertification hazard are the geographical location of the area, salinization area, elevation, slope, and human activities. Thanks to the classification hazard map, the highest class is located on salinization, of course in lowest area 1200km², highest class of classified map is level two 27475.87 km². The low-class area of the hazard map belongs to the largest part of the basin. An important factor of desertification in the area can be the geographical location of the basin located near the desert area. Using the grid layer and GIS software are beneficial for calculating area and classification hazard map, especially for large areas.

Keywords: Desertification, Classified Desertification Hazard Map, Grid map, Zayandeh Rood Basin

1. Introduction

Desertification refers to the process of land degradation which is the result of various
factors in arid, semi-arid and dry sub-humid areas. Desertification is the process that affects such ecosystems as plants, soil and human activities (Alavi panah, S.k, & Zehtabian G. R., 2001). The livelihoods of over 1.2 billion people inhabiting the dry land areas in 110 countries are currently threatened by drought and desertification (Gurung, J. D. 2010). The characteristics of climate factors, lack of the potential for vegetation in desert areas, growing human population and land use are important factors for developing desertification.

The geographical location of Iran shows that about 80% of the total area is located in an arid or semi-arid zone (Aminmansour, M. 2006). As a result of the following factors, land degradation and desertification have accelerated in Iran during the recent decades: first, the population has doubled over the last 25 years (since 1979); second, increased agricultural and pastoral products have forced people to use land extensively or convert forest and rangelands to cultivated land; third, overuse of wood and plants as fuel for household cooking and heating, and use of natural regulations tend to denude the soil and intensify the desertification (Aminmansour, M. 2006). Most of the factors affecting the desertification process in Iran are climatic such as fluctuations, drought, runoff, flood, water erosion and aridity, although mismanagement and land use alternations accelerate the desertification process and intensify the desertification.

Qualitative and quantitative factors of desertification hazard can be used to assess the desertification hazard. One of the important measurable methods for preventing the desertification hazard is to identify the sensitive areas, which is made possible by using a classification hazard map. Classified hazard maps can be used to identify critical and prone areas that are beneficial to hazard management. A variety of methods such as the following have been used by researcher for assessing desertification.

In the early 1990s FAO and UNEP dry lands in some Asian countries, the process factors were climatic quality and human activities (Ekhtesasi,M.R and Mohajeri,S.1995). Additionally, FAO and UNEP (1984) introduced a semi-quantitative method for desertification mapping based on the soil indicators and classified the desertification aspects, the potential and inherent risk as well as the rate and total risk. The desertification intensity has been subdivided on a scale of four divisions: slight to very severe. (Sepehr, A. et al. 2007).

In the ESAs project referred to as MEDALUS, four major criteria involving Soil, Vegetation, Management and Climate have been investigated using the main indicators for each major criterion. The geometric mean has been used for quality mapping. Landform and geology characteristics were excluded from the assessment.

The Greek National Committee of Combat against Desertification, Athens University (2001), produced a desertification map based on the GIS environment model developed on the overlapping layers. The desertification factors used in the method are climate, physiography, geology, soil hydrology and human effects (Greek National Committee for combating desertification, 2001). Desertification occurs only in arid, semi-arid and sub-humid areas. The hyper-arid areas are natural deserts or environmental deserts with almost 1 billion hectares in the world. These are natural deserts.

Application of remote-sensing technologies in mapping of degraded lands has shown a great promise for enhanced speed, accuracy and cost-effectiveness (Dwivedi, R. S. 1998). In the past 30 years, remote sensing has become a major technology in monitoring land desertification and reflecting desertification of and cover. A number of studies have been done using remote sensing (LANDSAT) (PAN Jing-hu, LI Tian-yu 2010; Gosh, T. K, 1992; Hansen, D. B., 1985; Graetz, R. D. et al 1988; to extract and analyze desertification by LANDSAT images.

Desertification is a phenomenon occurring in the Zayandeh Rood Basin (Z.R.B.) in Iran. There are some reasons for desert and desertification of the area such as dry land, climatic qualities such as high temperature, high wind speed, high evaporation, low rainfall, closeness to the desert (in the center of Iran), wind erosion, and human activities. The eastern part of Z.R.B. is the location for desertification area; however, desertification also occurs north and east of the area.

This paper attempts to develop a model for hazard classification map of Z.R.B. based on the situation of the study area using the pervious specific factors of desertification for the study area. The parameters include climate quality, wind and water erosion, lithology, soil parents, topography, geomorphology and Management and human activities (Fig 2).

2-Study Area Position
The Zayandeh Rood Basin is a hydrological basin in Iran. The study area is located northeast of the Z.R.B. in the central part of Iran with geographical coordinates of longitude 52° 1' to 52° 7' N and a latitude 32° 36' to 32° 40' N (Fig 1). The maximums precipitation of the basin occurs during winter in January and February and the minimum in summer in July and August. The average annual precipitation is 105.84 mm and the average annual temperature is over 14.9 Celsius. The average evaporation is 2219.3. Wind erosion in the area shows an orientation of powerful winds blowing from west to southeast and an average wind speed of 3.5m/s (Khodagholi, M. 2006). The most important factors in developing desertification in the study area are geographical location, non-normative exploitation of the surface mineral of gypsum mines, non-normative exploitation of lands, reduced entrance runoff from upstream regions, sharp drop in groundwater level, winds and storms laden with chalk, dust and suspended particles, low precipitation and high evaporation.
3-Materials and Methodology
3-1-Materials
The methodology was divided into five phases:
2-1-1 Parameters Selection: The desertification hazard map is based on such geographical parameters of Z.R.B. as lithology, geomorphologic faces, climatic quality, topography, soil characteristics and management.
2-1-2 Data Sources: In this study, the datasets include the data for grid, vector, and statistics.
2-1-3 Vector Data: Lithology map, land use, topography, the maps for land use and soil. The vector map was Prepared by the Natural Resources Organization and classified based on the purpose in GIS environment and the topography map of 1: 50000 in within the study area.
2-1-5 Statistical Data: Such climatic parameters as temperature and precipitation were used for the climatic quality map.

2-2 Methodology
Reclassification of the vector maps and grid was made based on the purposes of the study. For each parameter, the information for overlap and classification was provided by spatial analysis in the GIS environment.
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Fig. 2 Flowchart of mapping classification desertification map

2-2 - GIS Operation
Classification of each factor was based on scoring and mapping of the desertification hazard map in GIS environment. The following section will explain the maps for the classified vectors and raster for the classified desertification hazard map:

Soil
In desert area, soil loss plays an important role in increasing the desertification rate.
Soil temperature, soil organic matter, soil slope and soil depth play their roles in desert ecosystems. In this study, the soil dataset was used for such soil characteristics as depth, texture and parent soil. The soil information was extracted by using a vector map. The soil depth and texture were classified in the GIS environment.

**Climate Quality**
Climatic factors such as wind, evaporation, precipitation and temperature are important factors for the development of deserts in arid and semiarid areas.

**Land Use**
One direct effect of the factors responsible for desertification and land degradation is land use. Land use is a function of human activities. In the Z.R.B, since the climate and topography are different, land use differs.

**Elevation**
An important parameter for assessment and desertification is elevation. Due to the difference in height in Z.R.B, elevation should count as a parameter for the desertification hazard map.

**Erosion**
Wind erosion and water erosion are two of the measurable factors for desertification classification. Wind erosion was measured using IRFR method in three classes. In this study, parameters were classified based on the previews models. The sum of the factors serves as an indicator for level classification. Grid map were used as a base map for scoring. The scores were calculated and then using a weighted average, all the factors were calculated. The weighted average of the figures obtained from the factors within each grid section as well as the classified parameters used for weighting were evaluated in a polygon-attribute table and displayed as classification hazard maps (Fig. 4).

### 3. Discussion and Results
#### 3-2 Classification desertification hazard map analysis
Depending on the situation of the area desertification factors can be recognized. The factors can be the geographical situation, geomorphologic faces, climatic and managerial function. With regards to the Z.R.B, the most important factors are the geographical location, climatic quality, management, topography, soil characteristics and topography. To combine and calculate the method for measurable parameters, a weighted average was used in this study. Classification of each parameter such as soil dataset, climate, land use, erosion and elevation were the results of a desertification assessment (Fig.3). The study area was a hydrology basin of about 42000 km there with a variety climates, landforms, geographical locations, soil and lithology.

**Soil Characteristics of Z.R.B**
The soil parent of the study area included granite, gneiss, limestone, dolomite, shale,
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and sandstone. On the east of Z.R.B, sandstones, dolomite and lime extend non-uniformly among the sedimentary stones (lime, shale and marl). In the Z.R.B there are new sediments such as gravel produced by the draught of lakes in the basin, largely in the Northern and Eastern plains of the basin. Further, there are evaporating sediments containing salt and chalk around the Govkhooni Marsh (Water & Soil Research Organization, 1997).

In the mountainous area of the Z.R.B, 70% of the area is composed of lime stones, conglomerate and marl limes. The slope of this type varies from 25 to over 40% at different points with low deep soil of light to moderate texture. In 12-25% slope hills, there are igneous, metamorphic, chalk Marl and sandstones of light to moderate texture and low slope. 2-8% of the total basin is side slopes with deep to half deep gravel of light to moderate texture. The Low and high chalk and marl are in the slope 5-8% gradient with a heavy deep texture. In the 1% slope gradient, deep soil of average to heavy texture contain high salinity, alkaline, chalk and salt crystals. The eastern part of the Z.R.B is too deep of heavy and too heavy texture whose surface contains mining materials (Fig. 3).

Elevation
The highest part of the basin is located in the west and southwestern regions. The lowest part is located east of the basin. As can be seen, about 60% of the basin is lower than 2000 meters and 33% is between 2000 to 2500 meters and only 7.2% is higher than 2500 meters (Fig. 4). The average height of the basin weight is about 1957 meters (khodagholi, M, 2006) such that the lowest part of the basin, namely the eastern part, is about 800 meters (the high and highest class of desertification area).

Climate Quality of the Z.R.B
In the Z.R.B, the main effective component is the height of the area which reduces the air temperature and pressure as well as the precipitations. However, because of the rainfall originating from the massifs in the west, there are more precipitations compared to that in the eastern part of the basin with low elevations (khodagholi, M, 2006). The largest part of the basin (eastern part) has a greater temperature and evaporation, lower precipitation and higher wind speeds (Fig. 4). Moderate, high to highest rate of desertification occurs in the Z.R.B region.

Erosion in the Z.R.B
Wind erosion is an important factor for the existing desertification. The Northern and Eastern parts of the Z.R.B typically reflect the highest rate of wind erosion. The appearance of the area was covered by sandy and chalky faces due to wind erosion. Owing to high rainfall and lack of vegetation, water erosion occurs west and north of the Z.R.B (mountain area) within the Z.R.B. Types of water erosion include surface erosion, stream erosion and Gully erosion.

Land use of Z.R.B
In general, pastures and uncultivated lands are the dominant land use in the study area. The central part of the Z.R.B area is agricultural. Bayer land is located east,
north and central east of the Z.R.B. The eastern and northern parts of the basin have a greater potential for developing deserts. The third and fourth classes of desertification hazard map are located on the pasture and barren land area. Most of the forests and rain-fed areas are also located west and northwest of the Z.R.B.

**Geomorphologic Units**
Mountains and high elevations extending to the western part of the Z.R.B and playas are located on central and eastern parts of the Z.R.B. The numerous alluvial plains are located on the skirt of the mountainous area in the Z.R.B. There are associated terrace, different playas, different alluvial fan and seasonal stream alluviums in the Zayandeh Rood Basin. There are playas and plains composed of the Zayandeh Rood River sediment, alkalinity, largely of ground water and 0.5% slope, often with grass and prairie. Water body as Govkhooni Marsh, a playa is located in the eastern part of the Z.R.B. Gavkhooni playa is one of the sediment playas which serves as a tectonic seduction between the folds filled with the sediment from the surrounding mountains. Based on the sedimentological and palaeoclimatological evidences, it appears that the Gavkhuni Marsh was larger during the late Tertiary period. (Jaafarian, M. A. 1986; Toomanian, N. et. al, 2006).

**Lithology**
In the study area, granite, gneiss, schist and andesite stone massifs belong to the Precambrian period, the oldest formation. Stones of Triassic period can be divided into two parts. The lower part is composed of lime and dolomite stones, new and old alluvial and the upper part is generated from tafoni, shale and sandstone. In the eastern part of the basin, there is shale and in the western part of the basin, there is Jurassic formation. In its upper part, there are lime stones and in the lower part, there are lime and shale. In the eastern part of the study area, there are sandstones, dolomite and lime extending from the Carboniferous period. Non-conformity among the sedimentary stones (lime, shale and marl), Barmin-Apsin and different Jurassic stones and triassic shows the advancement of the cretaceous sea in the region. The faces from the cretaceous period are largely found at the basin level extending more towards the southern part. (Natural Resources Organization of Isfahan 1997)
In the Z.R.B, the pediment type is a slope plain of 153659 hectares area which is a land unit slope plains with much salinity and alkalinity, puffing surface and less than 1% slope, deep soil of average to heavy texture, with much of salinity and alkalinity of chalk and salt crystals. These land units are found in the Northern Z.R.B. In the area there are alluvial fan and slope alluvial plain type.
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![Classification hazard map of Z.R.B for assessing desertification](image)

**Fig. 3** Classification hazard map of Z.R.B for assessing desertification

**Table 1. Distribution desertification classes area and percentage**

<table>
<thead>
<tr>
<th>Class</th>
<th>Desert Area</th>
<th>Desert Area %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>571.97</td>
<td>1.376</td>
</tr>
<tr>
<td>2</td>
<td>2323.04</td>
<td>5.583</td>
</tr>
<tr>
<td>3</td>
<td>3603.75</td>
<td>8.661</td>
</tr>
<tr>
<td>4</td>
<td>4166.46</td>
<td>10.013</td>
</tr>
<tr>
<td>5</td>
<td>9024.41</td>
<td>21.689</td>
</tr>
<tr>
<td>Total</td>
<td>19689.63</td>
<td>47.321</td>
</tr>
</tbody>
</table>

Table 1 shows hazards classification and area for each class of the hazards. High classes of desertification area is 9024.41 that is 21.689% of whole basin area. The maturity of the hazard is located on North and East of Z.R.B.
The hazard classification map shows five classes of desertification in the Z.R.B (Fig.3). Classified hazard map were driven by composite of the layers which are soil, climate quality, elevation, land use and erosion in form of five classes. A very high class for desertification in the study area is 1.96% of the total study area. The location of the classes is the lowest slope gradient, elevation and hyper-arid area in the eastern part of the Z.R.B. High sensitive area is 5.96% of the total study area of 2474.21km$^2$. The moderate represents 28.63% of the total study area of 11880.05 km$^2$. Low classes included a large area of the basin. It is 41.07%of the total area of 17039.99 km$^2$. A lowest class includes 22.36% of 9277.12 km$^2$. 

3-2 Composite Layers and Classified Desertification Map
The hazard classification map shows five classes of desertification in the Z.R.B (Fig.3). Classified hazard map were driven by composite of the layers which are soil, climate quality, elevation, land use and erosion in form of five classes. A very high class for desertification in the study area is 1.96% of the total study area. The location of the classes is the lowest slope gradient, elevation and hyper-arid area in the eastern part of the Z.R.B. High sensitive area is 5.96% of the total study area of 2474.21km$^2$. The moderate represents 28.63% of the total study area of 11880.05 km$^2$. Low classes included a large area of the basin. It is 41.07% of the total area of 17039.99 km$^2$. A lowest class includes 22.36% of 9277.12 km$^2$. 

Fig.4 Classified desertification and land use map of Z.R.B
4. Conclusions
This study evaluated a classification hazard map. The methodology was developed by studying the desertification factors and grid map. The hazard classification map provides conditions for recognizing the critical centers of hazards and prevents the hazards in the basin. In the regions, the lime materials of soil increases due to weathering of the lime formation such that some layers with limited lime are made which are not suitable for the growth of plants. As a result, natural vegetation decreases and soil erosion occurs. Desertification factors such as climate, topography, land use, geographical situation are effective in the development of desertification. The development of technology has influenced the quantitative assessment of desertification using remote-sensing and GIS software as valuable techniques for a classification hazard map, especially large areas. A large part of the area is located in the arid and semi-arid areas, slopes, elevations and climates seem to be the major factors in the development of desertification.

Acknowledgment
This work was supported by the University of Malaya and the data gathered was supported by the Natural Resources Organization of Isfahan, Iran and Sepahan Andish Consulting Engineering for the Hazard Information Data, (2007).

References