Multi-Hazard Threat and Risk Imprints a Spatial form SWAT Analysis

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Abstract

Zayandeh Rood Basin, Iran is a basin with many environmental hazard threats. In last years, analysts have concentrated on building an extent of strategic responses to raise the ability of communities and businesses to control and meliorate from natural catastrophes. The experiment from each new tension adds further to the procedure of risk management. This article inspects how they belayed for, and recuperated from, the incident. Perhaps not astonishingly, it represents their exposures and absence of readiness for dealing with a risk of this dignity. Then again, it proves the resilience of real-world managers and their confidence on an aggregate experiment to operate their own improvement. In periods in which hazard management has been under drastic press to indicate effectiveness and cost efficiency. These threats function in environmental disasters with terrible reaction such as damage of human properties, disruption to human livelihood activities and the bother imposed on economy. So, hazard management is essential for solution these repercussions. Moreover, multi hazards are associated with desertification, earthquake, and aridity, similar any other nation, Iran is imperiled by many environmental risk menaces and such menaces can peak in environmental catastrophes with massive reactions such as loss of people's lives, destruction of national assets, an outage of a man-made building, dangers overhanging mass population, etc. In this case, the integrated approach uses the Arc GIS to create individual map layers that describe the spatial distribution of a parameter describing the intensity of the hazards. In this study, the intensity of the hazards threat is classified into 5 classes based on scale. In last years, increasing population and development of settlements and life-lines over perilous zones have mostly increased the effect of natural catastrophes both in industrialized and developing countries. The classes and range values include 'very high', 'high', 'moderate', 'low' and finally 'very low'. As the study area, the Zayandeh Rood Basin (Z.R.B) was selected into 10km grids. The parameters explain the hazard threats, their areal extents and densities, were determined for each grid. So, each layer map of a particular hazard and risk layer shows the spatial distribution of that particular hazard threat. In this research, each layer of the hazard threat and risk map was integrated using the Arc GIS integration analysis based on parameters. More importantly, the SWAT analysis shows the spatial distribution based on parameters of hazards and risk parameters in a grid cell, as well as showing the basin as the table whole that could result in efforts made to alleviate many hazards in the future. This approach in hazard management assessment would significantly contribute to any efforts associated to develop early warning systems incorporating hard and soft measures in a high- and very high-intensity hazard threat areas. This article evaluates some of the items relevant to the performance of diverse GIS conveniences with respect to terrain-related risks dominant in Isfahan, with specific reference to landslides.

Keywords

Multi-Hazard, Risk imprints, SWAT Analysis, Environmental Management.

I. INTRODUCTION

Integrated Assessment (IA) is an interdisciplinary process comprised of combining, interpreting and communicating knowledge, in such a way that all the causes and effects in a problem can be evaluated from a synoptic perspective with two characteristics: (i) it needs to incorporate an added value compared to single disciplinary assessment; and (ii) it needs to provide decision makers with useful information .Jeroen (2002). Rotmans, J., et al, (1997).

Environmental risks at a location in space and time is not the function of a single threat parameter but is determined by many parameters. Some threat parameters exhibit less risk while others higher risks, but a cumulative value of all threat parameters provide a more exact state of risk for a particular location in space and time. The challenge here is to determine what constitute the pertinent threat parameters of a location. This study identifies 4 main environments threat parameters that could exact risks in a particular location. The threat parameters are, (1) earthquake potential, (2) desertification and (3) Aridity. Each of these threat parameters constitutes an individual layer of hazard threat and when combined through an integration process a composite hazards threat for a particular location is determined by integrating the composite hazard threat and inherent risks in that location. This defines the integration and multi- layer analysis of risks of the study.

Risk can be defined as a function of hazard probability and vulnerability, the latter resulting from a combination of exposure and ability to cope [15]. In addition, mapping, as well as assessment, of hazard vulnerability has frequently been overlooked in favor of hazard modeling studies Freire S. & Aubrecht C, (2012).

As Ayala. Alca´ntara Ayala, Irasema Alca´ntara,(2002)puts, natural hazard threats, vulnerability, and prevention of natural disasters are frequent phenomena in developing countries. Julie et al. Julie Wilk et al, (2013) explained integrated vulnerability assessment by GIS calculating. Vishwa et al. and Freire and Aubrecht Freire S. & Aubrecht C, (2012) applied seismic and vulnerability in Himalaya by a weighted average method. In addition, Merrett and Chen applied GIS and RS in natural disasters hazard assessment.

Fadly U, and Keisuke M applied SWAT (Strength, Weaknesses, Opportunity and Threat) uses analysis in GIS for reducing tsunami disaster by using costal vegetation plans. This model is used to identify the organization's internal strength and weaknesses with respect to the threat and opportunities of the external environment.

Internal and external factors: The strength and weakness are internal factors:

- Strengths are the attributes of the organization that are helpful to achieve the aims.

- Weaknesses are attributes of the organization that are harmful to achieve the aims. External factors: The opportunities and threat presented as external factors:

- Opportunities are the external factors which are helpful to achieve propose.

- Threats are the external factors which are harmful to achieve propose.

	SWOT ANALYSIS	
	Helpful	**Harmful**
Internal Origin	Strength	Weakness
External Origin	Opportunity	Threat

FIGURE1. SHOWS THE ILLUSTRATIVE DIAGRAM OF SWOT ANALYSIS

II. STUDY REGION

The Zayandeh Rood Basin is located in the central part of Iran, with geographical coordinates between 50º 24' to 53º 24' north longitudes and 31º 11' to 33º 42' north latitude. The basin approximately covers an area of 42,000 km2. Figure 2 shows the position of this basin on the map. There is more than one hazard in Z.R.B which is tectonic activities such as the earthquake, desertification and drought. On the other hand, human activities such as using land include land use, population, and strategic situation especially in the largest city of the basin, Isfahan.

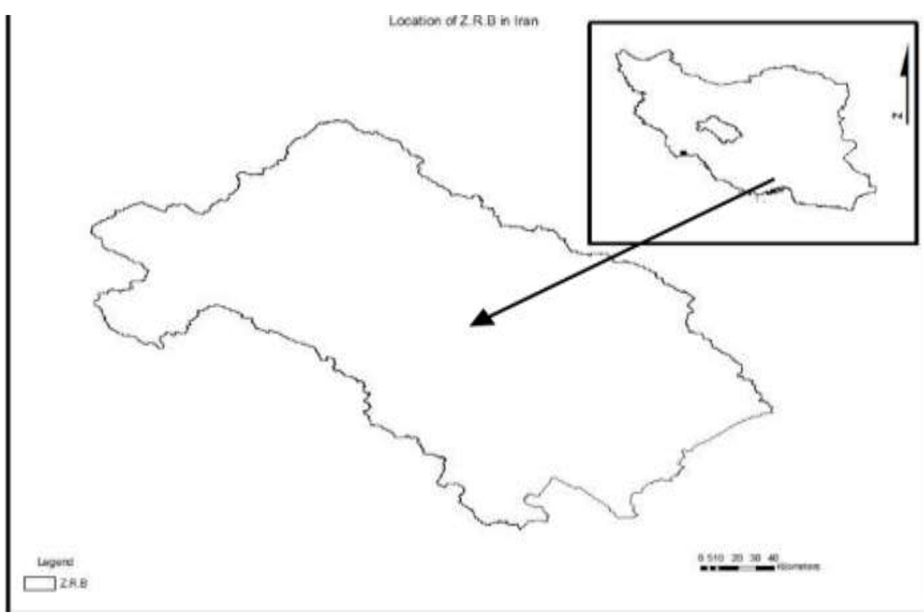


FIGURE 2. LOCATION OF Z.R.B IN IRAN

In this study, risk hazard map will be provided for Z.R.B in Iran by using Arc map 10.1 Classification and composite methods were used to derive a composite hazard map of classified hazards map (Earthquake, desertification, Aridity) and human activities.

Geomorphological processes caused geomorphological hazards in Z.R.B, including tectonic activities, such as convergence of the Arabian and Eurasia plate locations. Fault types were the main cause of earthquake in Z.R.B. Desertification hazard parameters of climate parameters, land use, geographical location and geomorphological landform were recognized as the causes of desertification in this area Maryam M. B. and Khairulmaini, O.S (2016).

The maximum precipitation of the basin occurs during winter in January and February, while the minimum is during summer in July and August. The average annual precipitation is 105.84 mm, the average annual temperature is 14.9ºC and the average evaporation is 2219.3 mm. The wind erosion in the area shows the orientation of powerful winds blowing from west to southeast and an average wind speed is 3.5 m/s [6]. The most important factors in the drought in the study area are geographical location, no normative exploitation of the surface mineral of gypsum, non-normative exploitation of land, reduced entrance runoff from upstream regions, a sharp drop in the groundwater level, winds and storms laden with chalk, dust and suspended particles, low precipitation and high evaporation.

III. MATERIALS AND METHODS

The methodological framework which is appropriate for an integrated hazard assessment consists of 3 major steps such as multi- hazards parameters, composite risk map and SWOT analysis, as illustrated in Figure 3. In the present research, 3 component hazards, namely earthquake, desertification, aridity have been formulated. The hazard components' parameters depend on the characteristic of each hazard component.

The following flowchart shows parameters of earthquake, desertification, aridity hazards and classified human activities in the study area. The flowchart also shows the combination of hazards as composite classification hazard and density human activities maps for getting the final map as risk map Figure 3.

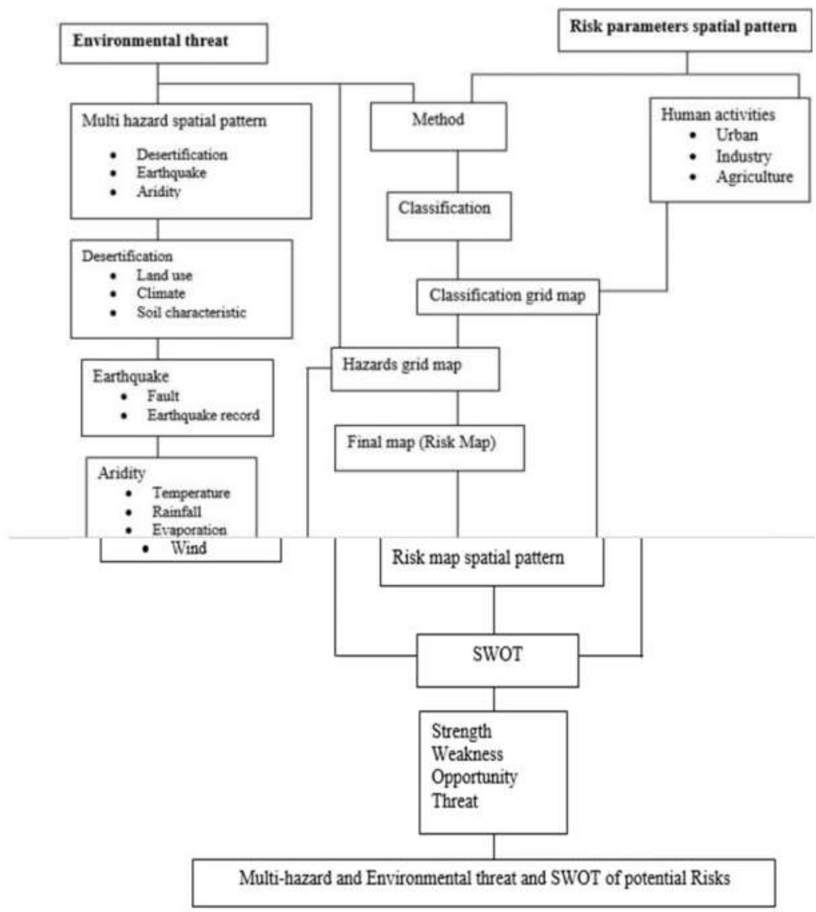


FIGURE 3. MULTI-HAZARD ENVIRONMENT THREAT ASSESSMENT PROCESS

IV. MULTI- HAZARDS PARAMETERS

In this paper of study investigate each parameter of hazards. The dataset for each hazard is included factors of the hazards. Classification of each factor was based on scoring and in GIS environment.

Investigation of parameters classified desertification hazard map

The following section will explain the parameters 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 soil characteristics such 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. Tables 3 show the classes of soil characteristics in this study. The soil information was collected by using the reviews of the studies of Natural Resources Organization of Iran] Marani Barzani, M.O S Khairulmaini, (2013).

Climate quality: Climatic factors such as wind, evaporation, precipitation and temperature are important factors for the development of deserts in arid and semi-arid areas. A climate quality map was classified on the annual precipitation and potential for evaporation by climatologic organizations] Maryam M. B., Khairulmaini, O.S (2014

Land use: One of the direct effects of factors responsible for desertification and land degradation is land use. Land use is a function of human activities. In Z.R.B, since the climate and topography are different, land use differs. In this study, land use classification was reclassified based on the purpose of study Maryam M. B. and Khairulmaini, O.S (2016

Parameters were classified based on the preview 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 as well as the classified parameters used for weighing were evaluated in a polygon attribute table and displayed as classification hazard maps (Figure 6).

Investigation of parameters classified earthquake hazard map.

Classification earthquake hazard map has been provided by carrying out earthquake parameters which are fault line, earthquake point, magnitude, depth and boundary of tectonic plate in GIS environment. Classified earthquake hazard map (Figure 7) shows five level of the hazard in Z.R.B. Based on calculating the earth quake parameters, highest class of hazard are located on South, North-west and East part of the basin.

This step focuses on classification of parameters based on the range of attributes, scoring of the parameters, the sum of the scores and analysis interpolation. The ranges of parameters have been shown in table (1). Classifying the magnitude comprises five classes with a range of (2. 6 - 4. 6). The range of scores for the magnitude is 0-25 and the depth with five classes (6 -51) and the range of depths is 25-0. The classified faults are based on types of fault in the area. Classification of the fault line map with respect to three types of fault are fault thrust, major and minor and the range of fault types is 1-3 .Classification parameters were calculated based on scoring the parameters for attributes and the sum of the scores, Marani Barzani, M.O S Khairulmaini, (2013).

Investigation of parameters classified Aridity hazard map some parameters are common between components. For example, Aridity component parameters are climate quality that they are common in desertification component also. Multi-Hazard Systems and Risk Map.

In order to measure each parameter in 10 (Km2) grids map would recognize parameters unit the parameters were measured for each grid (Km2) and subsequently the map was classified into 5 classes of ‘very high’, ‘high’, ‘moderate’, ‘low’ and ‘very low’. This method has been implemented to all the parameters of hazards and human activities, too.

Classified earthquake, desertification, aridity hazard maps, and classified human activities maps are the datasets for integrated hazards map and risk assessment. These datasets consist of a series of scoring and summing factors of the hazards and human activities parameters. These classification hazards maps were provided by scoring and weighted sum estimation. The following Figure 4 shows part of grid maps and formulate that use for classification hazards parameters in the grid map. The following part will explain the calculation of a GIS-based integrated assessment framework for the case of the present study.

In this study, sum of the factors represents level classification. Use was made of Grid map as a base map for the scoring. The scores were obtained 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 apolygon-attribute table and displayed as classification hazard maps (Figure 4).

The GIS-based integration assessment framework was used for the measurement of how places were influenced by hazards. This framework is based on a number of various parameters expressing physical hazards (i.e. exposure). These are combined into a common index on exposure with an index for risk map.

Figure 4 shows the GIS-based a part of Integrated Assessment Framework for the Z.R.B hazards ('very high', 'high', 'moderate', 'low', and 'very low'). Earthquake hazard 1: MS, Fault, and seismic depth; Desertification 2: Land use, climate quality, Soil characteristic; Aridity 3: Climate Parameters (Temperature, Rainfall, Evaporation, and wind). In order to measure hazard parameters, grid map (km2) is considered as a base map for measuring each parameter by Fn (xi+xi+xi…):

Hazard parameters $=\frac{f_n(x_i+x_i+x_i+x_i}{A}$

Where x is scoring of each parameters' classes and A is area of each grid

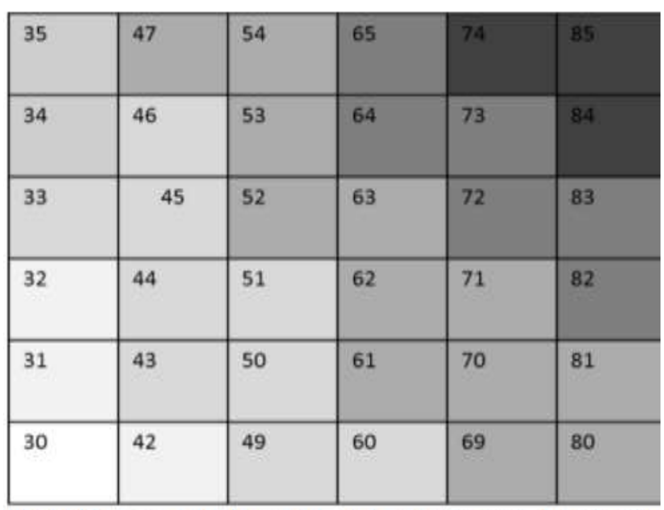


FIGURE 4. THE GRID BASED INTEGRATED HAZARDS ASSESSMENT FRAMEWORK.

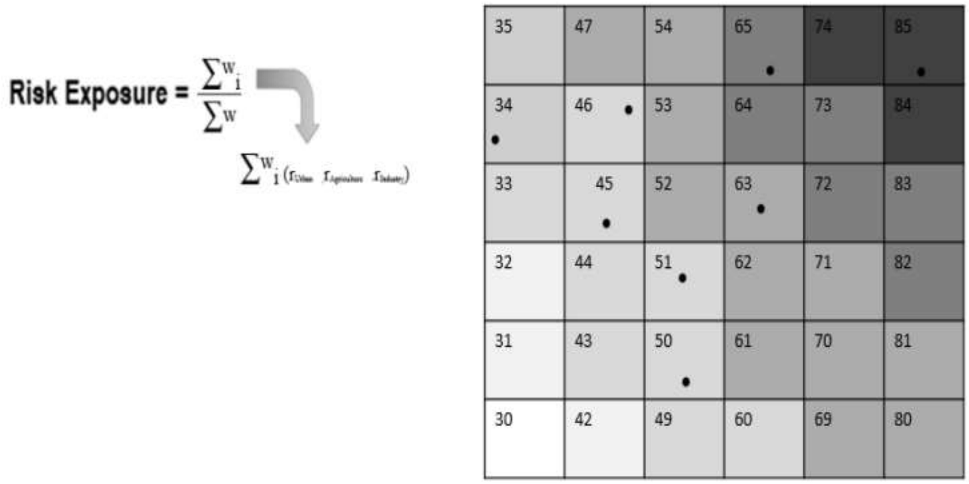


FIGURE 5. THE GIS-BASED INTEGRATED RISK ASSESSMENT FRAMEWORK

V. INTERPRETATION AND DISCUSSION

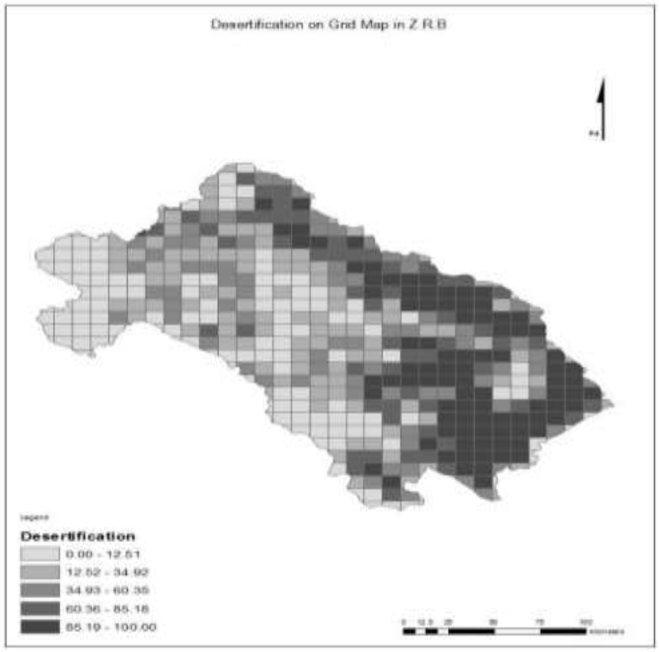
Multi-hazard Spatial Pattern Desertification: Almost half of the area is made up of desertification 47.321% of 42000 km2.The area is a high arid area. Desertification accrues in this part of the area and the hazard is distributed among all the regions of Z.R.B. The area is inhabited by one eight of the Z.R.B population. It is here where soil is especially fragile, vegetation is spared and climate is unpleasant and where desertification occurs. So desertification imposes damages on the half of the total land area of Z.R.B.

Direction of desertification has widened from eastern part of Z.R.B toward the center (Isfahan city) and the north.

The directions of desertification in Z.R.B were assigned to factors such as Soil, land use, and climate.

The desertification database of this study showed soil characteristic, climate quality, and land use in Z.R.B. Figure 6 show that desertification is increased with the decrease of vegetation in low slope area. Based on the classification desertification map, desertification intensity class is critical for the whole Z.R.B (Figure 6).

Results of desertification spatial direction show that most desertification was clustered around the center (Isfahan city).

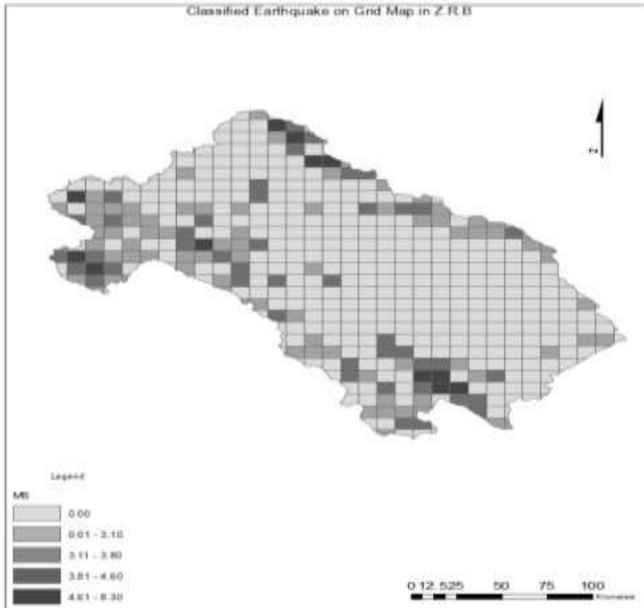


THE CLASSIFIED MAP SHOWS FIGURE 6. FIVE CLASSES OF DESERTIFICATION HAZARD WHERE THE LARGE PART OF THE AREA ARE LOCATED ON EAST PART OF THE BASIN

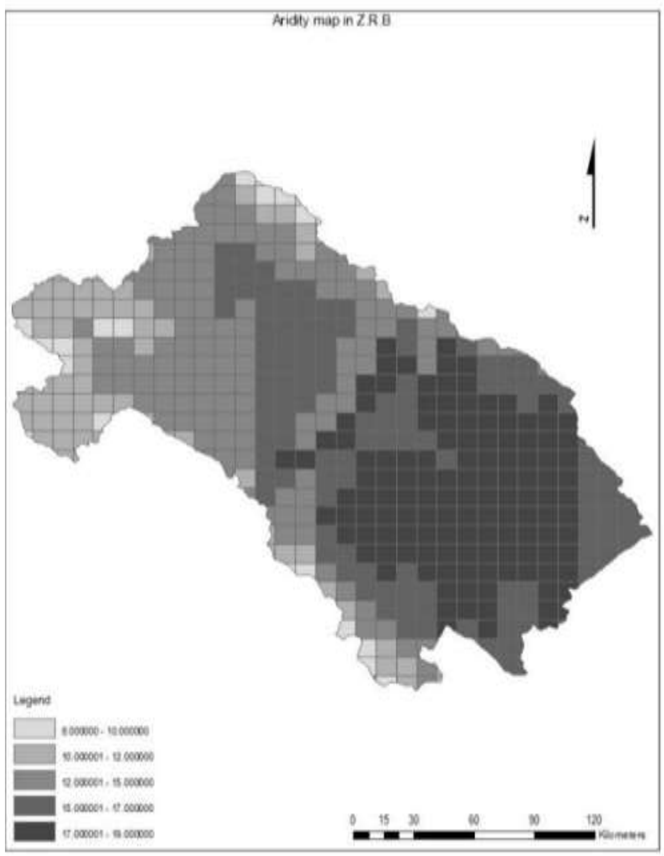
Earthquake: The reason of distribution of earthquake is that occur near tectonic plate boundary and fault. There is the tectonic plate in the Northwest to South-west of Z.R.B and the North-east to South –East (Figure 7).

Results of earthquake show proven active faults are located on Z.R.B including around the edge of boundary Zagros plate. Distribution of earthquake is down the east of Z.R.B, in southern of Z.R.B and up the east of Z.R.B.

A major earthquake is in North –West and South West of Z.R.B. Table 3 shows 1612.28km2 and 3.874% in grid map are covered by fault area. The result of earthquake spatial pattern intensity shows that most earthquake is random.



THE CLASSIFIED MAP SHOWS FIGURE 7. FIVE CLASSES OF EARTHQUAKE HAZARD WHERE THE LARGE PART OF THE AREA ARE LOCATED ON EAST PART OF THE BASIN



THE CLASSIFIED MAP SHOWS FIGURE 8. FIVE CLASSES OF ARIDITY HAZARD MAP WHERE THE LARGE PART OF THE AREA ARE LOCATED ON NORTH AND EAST PART OF THE BASIN

Aridity: The aridity maps prepared using the classified models show that there are instances of arid, semi-arid, dry and sub-humid zones in the area under the present study. A greater part of the area of Z.R.B. is covered by the semi-arid class, except for some parts in the north-western end, which belong to the humid class. The central, eastern and north of Z.R.B. is covered by the semiarid and arid classes with high temperature, evaporation, the wind and low rainfall. The total annual evaporation in this region is also higher than or equal to the annual rainfall (Figure 8).

The mean annual evapotranspiration in this region is four times higher than the mean annual rainfall. It can be seen that the climate of 25.14% to 32.5% of Z.R.B. has been identified by different aridity index models as being near hyper-arid, from 55.59% to 80.44%, it is demarcated as the acridest, 7.82% of the area is semi-arid 9.34% of the area is sub-humid and less than 1.55% of the area as humid. Maryam M. B. and Khairulmaini, O.S (2017

Risk Parameters Spatial Pattern

Human activities: In this research, human activities refer to urban, industrial and Agriculture for risk map. There are special strategic situations in the study area. The majority of parameters concentrate on Center, West, South and West-North of the area (Figure 9). In Z.R.B, the majority of the population resides in the Center of the basin. The high and very high population's classes reside in the city of Isfahan. The highest centers of agricultural land are located in the center of Z.R.B. There are a lot of plain lands in the city of Isfahan.

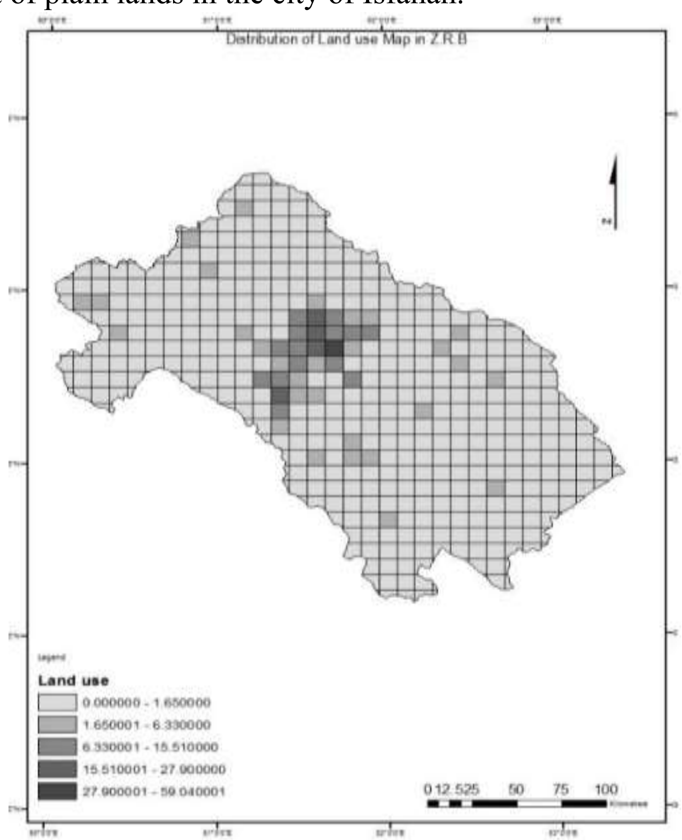


FIGURE 9. CLASSIFIED HUMAN ACTIVITIES MAP IN Z.R.B

Risk Density: Risk map which is the combination of classified hazards map and classified human activities. In order to make risk map, the integrated assessment hazards of layers are important.

Figure 10 shows grid analysis based on weighted average. Each factor has measured in each grid based on the unit. Then each factor classified in five classes and according to significant of the factors weighted average and reclassified. After this any hazard map classified and each grid was compared between the two hazards and human activities map.

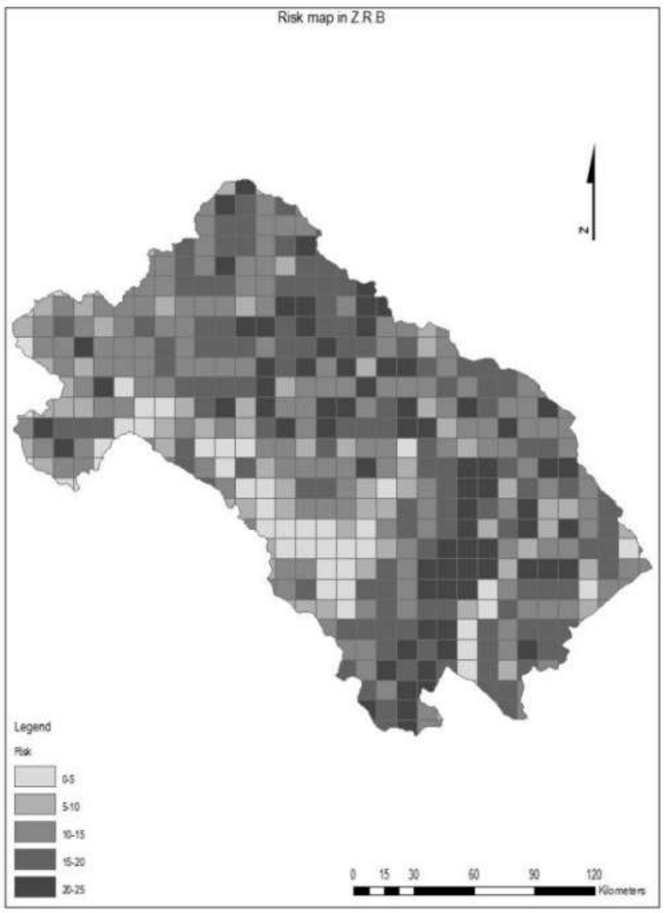


FIGURE 10. CLASSIFIED RISK MAP IN Z.R.B

Results showed multi-hazards, land use, risk clusters and percentage area for each class. High classes of risk area are 9198.93 km2 that is 21.9642 of the whole basin area. The maturity of risk is located in the north, west and east of Z.R.B. High classes of risk area are around human activities in the basin area (Table 1).

Class	Desertification	D%	Earthquake	E%	AI%	R	R%
1	571.97	1.376	101.1	0.242	7.36	3820.48	9.12215
2	2323.04	5.583	527.13	1.266	32.85	5603.38	13.3791
3	3603.75	8.661	642.42	1.543	7.82	13760.98	32.857
4	4166.46	10.013	341.63	0.821	9.34	9497.54	22.6772
5	9024.41	21.689			1.55	9198.93	21.9642
Total	19689.63	47.321	1612.28	3.874	58.92	41881.31	

TABLE 1. DISTRIBUTION OF HAZARD CLASSES AREA AND PERCENTAGE IN Z.R.B

According to frequency and intensity of the desertification and aridity occurring in the area, a qualitative hazard assessment was carried out which enabled mapping of areas that might be affected by events of different classes Elements at risk from future human activities in North and East of the area were identified. Five levels of risk (i.e. very low, low, moderate, high and very high) were detected and mapped. The areas at high risk were determined by aridity of lands with high hazards and high vulnerability conditions (resident and transport infrastructures). Areas of lower risk were identified on the basis of a lower occurrence probability and lower vulnerability linked only to eastern parts of Z.R.B (Table 2).

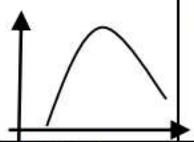
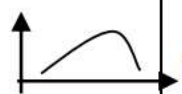
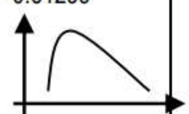
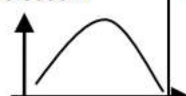
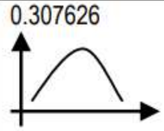
Hazards	Distribution	Direction	Intensity	Density
Desertification	1.176831 	North-East South-East	High intensity in East	High (21.689%)
Earthquake	1.888214 	North-West to South-West North-East	North-West to South-West	1.543(Low)
Aridity	-0.61299 	North East	North and East	32.85(High)
Surface morphology	0.559821 	North-West To South	North-South	42.82(High)
Risk	0.307626 	North East	North-West East	22.6772(High)

TABLE 2. DISTRIBUTION OF HAZARD CLASSES AREA AND PERCENTAGE IN Z.R.B

SWAT analysis relate to multi-hazard in Z.R.B

Parameters	Means of Verification	Strength	Weakness	Opportunities	Threats
Physical parameters	Climate quality				*
	Soil quality		*		
	Fault line		*		
	Slope		*		
	Land use	*			
Social Factors	Population	*	*		
	Industrial		*		
Housing	urban		*		
Response	Transportation	*			
	Medical facilities	*			
	Disaster management plan		*		

TABLE 3. SWAT ANALYSIS FOR RISK ASSESSMENT IN Z.R.B

The inferences of the SWAT analysis (Table 3) are as under:

A high population density, high residential density, moderate industrial, moderate agriculture is impacted for the risk in the event. Disaster management planning is an ongoing process for the threat events in the area. There is needed to make use of the strengths for converting the threats, weakness and opportunities in to improve strengths.

VI. CONCLUSION

An integrated multidisciplinary approach to assessing desertification, earthquake, aridity hazards applied in this research, including geomorphological, geo-structural and meteoroidal showed the hazards and risk have significantly increased in last decades. Since 30 years ago, growing population and human activities, desertification hazard also occurred while during the time earthquake event without any damages for human activities in Z.R.B. Furthermore, aridity hazard has gradually increased both in terms of frequency and magnitude. There is enhancing regard global about the ineffectiveness of prevalent drought management practices that are mostly depended on risk management. These functions are reflexive and, thus, only act the signs (effects) of drought rather than the underlying causes for the vulnerabilities related with effects. Via the assumption of public drought diplomacy that are focused on risk decrement and accompany by drought mitigation or preparation projects at different levels of government, the coping inclusion of nations to operate droughts can be amended. This article considers the underlying implications of drought, the principles and objectives of national drought diplomacy and a drought planning procedure that has been impressive in the procurement of drought mitigation projects. The perils related with these variations are actual but extremely unknown. Perils are outward in agriculture, fisheries and many other parts that organize the subsistence of rural populations in enlarging countries. This evolution seems to be due to a recent meteoroidal trend consisting of changes within distribution of yearly precipitation and high temperatures in the area. However, the yearly average rainfall decreased during the last decade.

Due to the increase of hazards and concerning the growth of human activities including buildings, industries, strategic planning in the area, the risk conditions were analyzed in order to achieve a risk zonation and to propose strategies for mitigating against them by management planning. The high-risk area is characterized by a high level of the hazards and this is due to the possible development of desertification, aridity and, the last but not the least, vulnerability. This is important for countries like Iran which are exposed to many threats acting on dame locality. This knowledge provides a basis for sound development planning that's focus on existing hazards at a locality in space. This work is intended to policy maker, planner disaster manager, environmental conservation group, private citizen that use available mitigation tools and technique to decrease the vulnerability of hazards. By following the multi hazards assessment a government can create an effective policy for mitigating the impact of natural hazards.

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