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The Spatial Analysis and Environmental Evaluation of Natural Events in Valley-Mountainous Cities (Case Study: Sardasht City)

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Abstract. The nature, in spite of its own resistance and resistance and strength, is considered as one of the most sensitive and fragile ecosystems in the world. A large part of Iran is mountainous. Natural calamities are the dangers which always threaten these mountainous areas, and the occurrence of these dangers imposes considerable damages to human societies. Sardasht City in East Azerbaijan is one of the regions which due to specific Geological, topographical, and climatic conditions along with human factors is considered as an area susceptible to the occurrence of natural events. The objective of the present study is to conduct a spatial analysis of the conditions of the resistance of Sardasht against natural calamities (flood and earthquake). To obtain this aim, the 1100000 map of geology was used and the score of each of indices (fault, waterways, and heights) were determined and their risky areas in the scope of the city were identified. The results of this research indicate this issue that Sardasht is located at rank 1 in terms of 0-100 m distance from the fault line, at rank 2 in terms of 100-200 m distance from waterways, and rank 2 in terms of the height of 300-1500 m above sea level.

Keywords: Spatial analysis, environmental evaluation, natural events, valley-mountainous cities, Sardasht City

1. INTRODUCTION

Human beings, since their creation, have always been threatened by hostile forces of nature among which flood and earthflow are the most devastating. Natural environment are always changing and these changes naturally are shaped by human activities. Therefore, humanity have always in relation and conflict with the natural environment and from the beginning, in the life of cities, there has been a mutual correlation between human beings and the environment. In fact, the environment has acted as a determining phenomenon (Talebzadeh, 2009: 99). Nowadays, sustainability of human residences has consistently increasing in relation with natural calamities due to the concentration of population and economic activities in expansive and concentrated regions and the poor and irregular settlements of low-income residents and those of urban and rural areas (Zangiabadi and Esmaeilian, 1391: 114) in such a way that cities which were on vulnerable areas such as the bed with steep topography, proximity to the fault line, the area prone to falling rocks and floods have been greatly vulnerable. Therefore, before doing each action in physical construction and development, the natural grounds of cities and their areas around them and their effects. In different countries of the world, to control and reduce these threats and the damages resulting from them, principled planning in suing natural environment is used (Khayyam, 1992: 3). In the studied area, due to its location in mountainous and situation prone to flood and large numbers of faults, the lack of observing and maintaining required principles cause that these negligence of the nature change into threats and crises. To identify the scope and the scope of each of the factors of flood, fault, and rivers, it is necessary that appropriate measures should be considered for reducing and minimizing damages resulting from natural calamities in Sardasht City.

2. STATEMENT OF THE PROBLEM

Long ago and since the advent of urbanization, in spite of all structural changes, cities have always been faced with realities which were considered as natural dangers. No point on the earth are safe

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of unrespectable events and there have always been reports from all over the world stating the natural calamities and crises. Parallel to increasing in the human density and activities in accident-prone areas, natural disasters increase vulnerability. Investigating the effect of natural disasters on human settlements particularly cities are among the most important issues considered by urban planners, urbanists, and architects (Karim Saleh, 2006: 197). Instability of environments is different in terms of the role of different factors and in different forms. To determine vulnerable regions, analyzing the performance of natural forces and sometimes the role of humanity in the process, or intensification of this process are necessary (Rustaei, 2000: 4). Natural disasters have been and will be always present on the earth. In most of the cases, the occurrence of natural disasters such as flood, earthquakes, storms, etc. cause devastating effects on human settlements and impose large casualty on their residents. In addition, they can devastate constructions and infrastructures of these regions and impose vast economic and social side-effects on human societies and countries. Cities as places of congregation of human population are not exceptional from these natural disasters. The negligence to appropriate positioning of cities, and the lack of required planning for preventing the unbridled growth of cities have caused that cities be expanded on The main flood streams, faults or the scope of rivers (Ghanavati et al. 2009: 17). This issue per se can result in the intensification of vulnerability and increase in financial and life losses resulting from these disasters. One of the cities of Iran which is faced with this problem more than others is Sardasht City. This city, due to its mountainous situation and the existence of flood streams and its rivers on the one hand, and due to being located on a lot of faults on the other hand, suffers from a lot of vulnerability to natural disasters. Sardasht City is located in a mountainous situation, consequently, to organize and design the mountainous environment, its vulnerability as its important structural characteristics and its prone to disasters resulting from the presence of different and complicated ecosystems should be paid attention to.

Research objectives

To investigate the degree of devastation and influence of natural factors such as flood and earthflows in the city

To determine the area of natural factors of floods and earthflows in the city

Research hypothesis

There is a direct correlation between the situation of Sardasht City and damages resulting from natural disasters.

Significance of the research

The mountainous situation of Sardasht and a lot of faults crossing under this region have resulted that the city be exposed to natural disasters. These factors cause that organizations and facilities constructed in the city have little productivity. In addition, these issues has caused that residents' lives in this region be disturbed. Therefore, it is necessary to investigate comprehensively natural factors such as flood and earthflow and also their scope of performance.

The characteristics of the studied region

The border City of Sardasht with an area more than 1411 km^2 is located at the southwest of West Azerbaijan province. This township covers 3.7 of area of the province. Sardasht northerly is adjoined to Piranshahr, north westerly to Mahabad, easterly to Bukan, and southerly to Kurdistan Province and Iraq, and westerly to Iraq. This township includes 3 urban points, 2 counties, 6 rural districts, and 297 villages. Sardasth City is the center of this township and is located at 45 degrees 48 minutes longitude and 36 degrees 9 minutes latitude. Sardasht, due to

its tectonics belongs to Sanandaj-Sirjan Zone and is one of the most dynamic tectonic units in Iran, however up to now; no evidence of occurring earthflow in this region has been reported.

Table 1. Used indices.

Indices
Used variables
0-500 m height above sea level
1500-500 m height above sea level
300-1500 m height above sea level
0-100 m distance from the fault
300-100 m distance from the fault
More than 300 m distance from the fault
0-100 m distance from the waterway
100-300 m distance the waterway

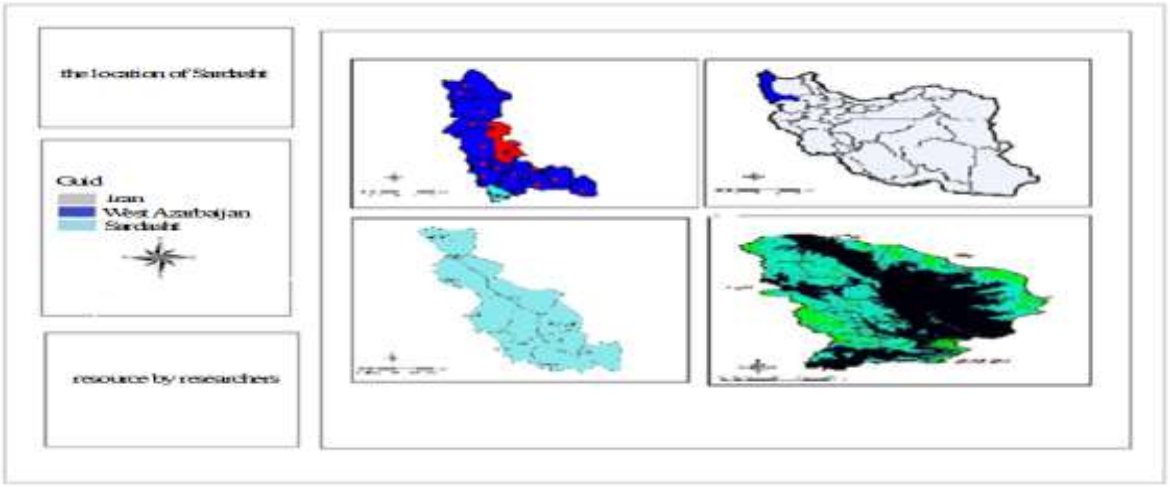

Figure 1. The location of Sardasht, resource by researchers.

Resource: researchers

Material and methods

The method of the present study is a descriptive-analytical one and the procedure of doing the present study was conducted was so that the geological map with the scale of 1,100,000 was digitalized by GIS and for each of the natural factors such as faults, heights, waterways, separate layers were prepared and scored using the AHP model. Finally, the risk-prone scope of each of the layers, regarding their scores were identified and illustrated by GIS.

Table 2. Weights of indices.

	0-500 m height above sea level	1500-500 m height above sea level	300-1500 m height above sea level	0-100 m distance from the fault	100-300 m distance from the fault	More than 300 m distance from the fault	0-100 m distance from the waterway	100-300 m distance the waterway	More than 300 m distance from the waterway
0-500 m height	1	0.2	0.142857	0.125	0.166667	0.25	0.125	0.166667	0.2
1500-500 m height	5	1	0.2	0.142857	0.25	2	.166667	0.333333	5
300-1500 m height	7	5	0.1	0.333333	4	6	1	2	6
0-100 m distance from the fault	8	7	0.3	1	4	7	1	7	7
100-300m distance from the fault	9	4	0.25	0.25	1	4	0.333333	2	5
More than 300 m distance from the fault	4	0.5	0.166667	0.142857	0.25	1	0.166667	2	2
0-100 m distance from the waterway	8	0.6	1	1	3	6	1	4	5
100-300 m distance the waterway	6	0.3	0.5	0.142857	0.5	0.5	0.25	1	3
More than 300 m distance from the waterway	5	0.2	0.166667	0.142857	0.2	0.5	0.2	0.333333	1

Resources: researchers

Natural crises and disasters in Sardasht

Nature is a place for residence in cities and urban units as well as other human activities which always imposes conditions on cities (Zangi Abadi and Esmaeilian, 2012: 114) in such a way that in the northern regions of Sardasht an earthflow with magnitude of 6 ° Mrkaly occurred in 1951 (Counselling Engineers of Development and Reconstruction, 2003). Based on recorded reports by the International Institute of Earthflow Engineering and seismology during 1984-2207, 11 earthflows with moderate magnitude occurred in this region. The latest on is related to an earthflow with magnitude 4.1 in 7/2007 and the most severe was related to 2002 with 4.8 ° Richter whose main canon was at 15 km distant from Sardasht on the active fault of Piranshahr.

Factors affecting flooding in Sardasht

Flood is an untimely disaster which can causes devastation of cities and villages and endanger the life and properties of their residents (Malekian et al. 2012: 132). The more the degree of porosity in stones, the more the amount of water penetrating in them. Accordingly, little amount of water are running on the surfaces. In mountainous regions, there is no possibility of occurrence of soil layers on skirt of mountains; consequently, the surface of skirts of mountains remain without much soil and are under direct influence of climatic conditions.

1. Climatic factors: rainfall, the amount and intensity of rainfall more effective in the occurce of streams. The more the amount of rainfall, the more filled the holes on the ground with water and the more the extra water runs on the surface. The intensity of rainfall does not allow water to penetrate in the ground and streams are created as quickly as possible in such a way that rainfall lines cross Sardasht with more than 700 mm. due to the conditions dominating this region, the annual temperature of Sardasht City is higher particularly in

low-lying areas and valleys. A large part of the city particularly in low-lying areas around Zab, there is a curved area with the same temperature 12.5° centigrade.

2. Concentration time: the maximum of time it takes that water from the farthest point of the basin passes his hydrological path and reaches the output point. Concentration time depends on The topography of the region, area, shape, main channel length, channel slope, roughness, contour, soil type, density and type of vegetation, manage and obtain the land and other factors, and other hand, the intensity of rainfall and its temporal and spatial distribution can increase concentration time (Alizadeh, 2006: 485).
3. Topographic slope: because of the direct relationship with the permeability, the surface soil moisture, topographic slope has great functions in creating severe flood in the catchment area (Yamani and Ghanaei, 2005: 49).
4. Land cover: effective factors which cause that more water penetrates in the ground and prevent runoff and flooding is vegetation cover on the ground because it causes the friction of movement of water and increases the degree of water penetration.

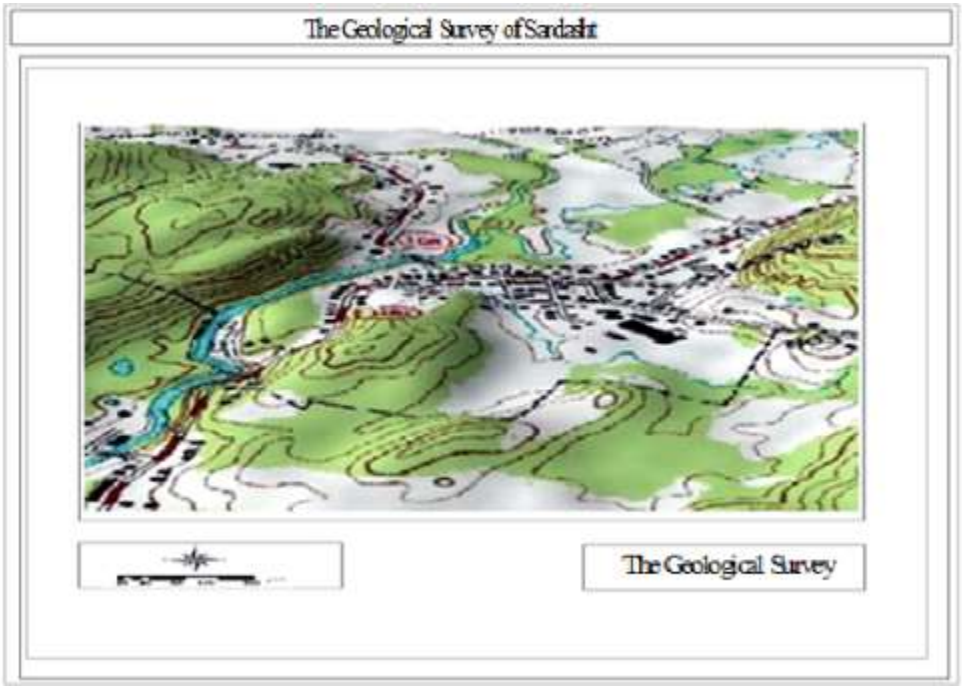

Figure 2. The topography of Sardasht City.

Sardasht City with its mode of location in the skirts of mountains and mentioned factors provide the grounds for the emergence of flood-prone areas. The least precipitation in this region causes running floods and gathering water in Sardasht's streets and hinders the everyday life of people in this city.

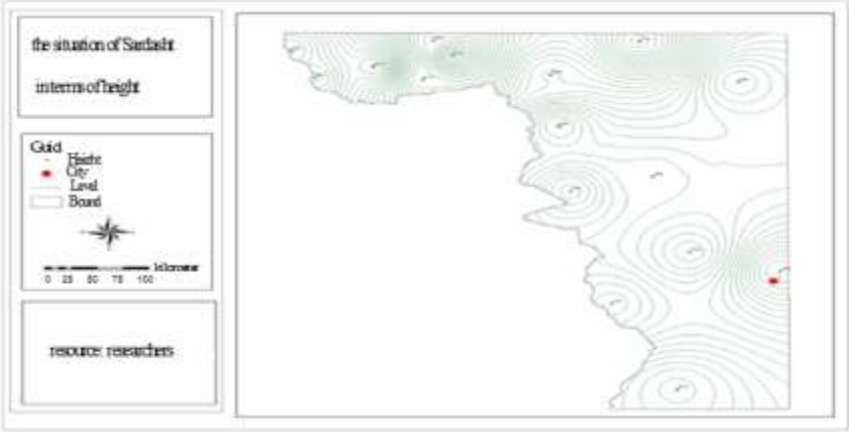

Figure 3. The situation of Sardasht in terms of height, resource: researchers.

To do so, available heights in Sardasht were divided into three classes, and rank 3 was given to 0-500 m height, rank 2 to 500-1500 m height, and rank 1 to more than 1500 m height. Sardasth with 1500 m height was located at rank 2 and between 4 height points which westerly it restricted to 1741 m height, southerly to 2215 m height, northerly to 2014 m height, and easterly it is limited to 1485 height in such a way that the whole constructed surface, 44 percent of the surface of the city are established on a ground with 1500-1546 m height, and 28 percent of it are on 1453-1500 m height. In comparison with urbanization standards, 40 to 50 percent of the city has been constructed on unfavorable heights. The slope of the lands in Sardasht at the skirt of mountains adjoined to the relatively deep valley at the east of the city, ups and downs and uneven conditions of the city have faced the city with different slopes and their direction toward the whole scope of the city in such a way that about 62 percent of the scope of the city are located at a 0-19 percent slope, and about 30.87 percent at 19-38 percent slope, and 5.52 of the whole level is located between 57-38 percent of the whole scope is located between 38-57 percent slope. The rest of the scope of the city (1.58 percent) is located at above 57 percent slope which in comparison with urbanization criteria, about 40 to 50 percent of the city are located at unfavorable environments (Fahar, 2008: 68-69).

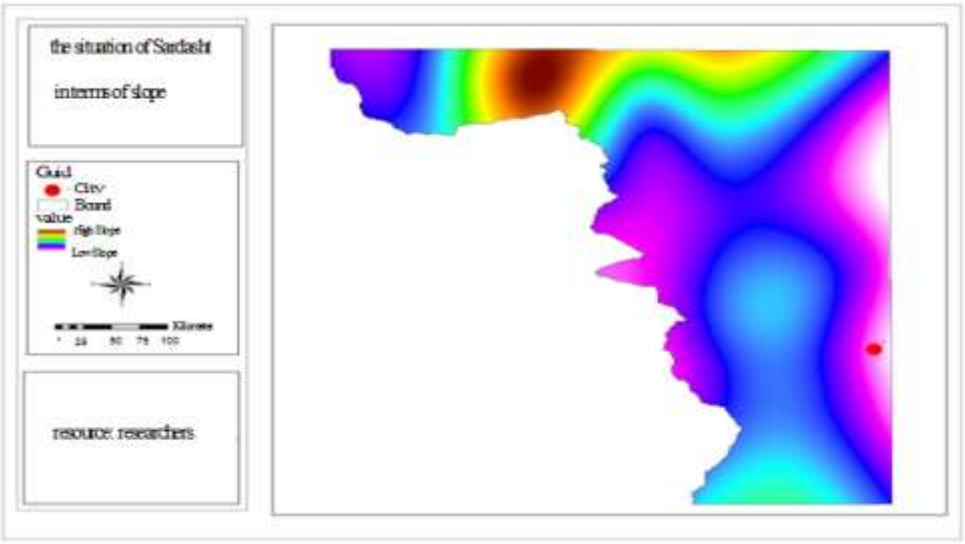

Figure 4. The situation of Sardasht in terms of slope, resource: researchers.

These characteristics has given a particular situation to Sardasht in such a way that the least amount of rainfall in heights causes flood and waterlogging in the streets and Sardasht is changed into a basin which all water are run towards it. Therefore, the running water in Sardasht is leveled in terms of the situation of the city. Safe locations in terms of running water are points are those which are located at far distances from surface water. Accordingly, rank 1 was give to 0-100 m distance from points located at the area of running water and are imposed by the most degree of vulnerability, and rank 2 is for 100-300 m distance, while rank 3 was given to the safest point in terms of running water.

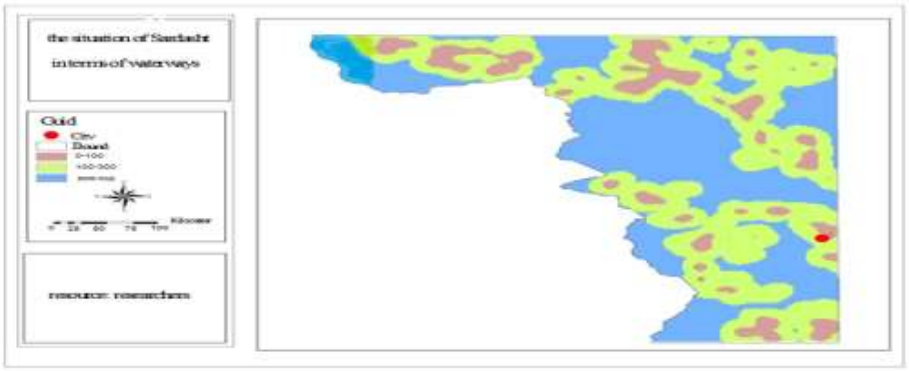

Figure 5. The situation of Sardasht in terms of waterways, resource: researchers

Sardasht is located at rank 2 in terms of running water, it means that it is located at the moderate level, but its situation and mode of location has changed conditions in such a way that the slope of the city, the amount of rainfall and its intensity as well as the devastation of vegetation in higher heights are among cases which together has changed Sardasht into a flood-prone area.

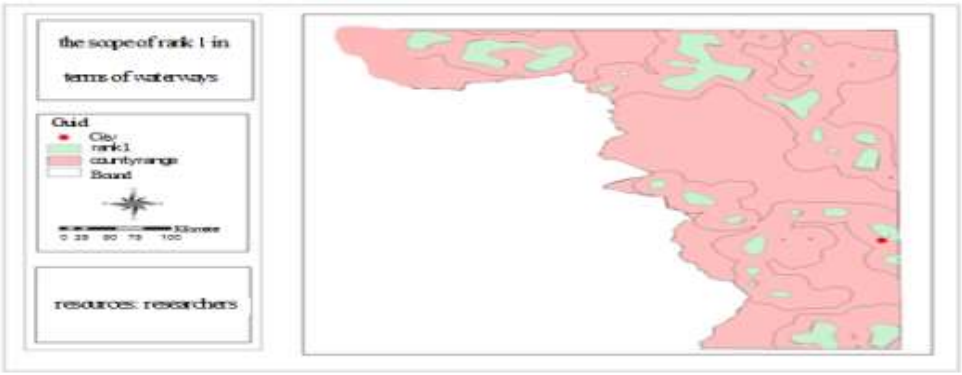

Figure 6. The scope of rank 1 in terms of waterways: resources: researchers.

Factors affecting earthflows in Sardasht

In most of mountainous valleys in Iran during recent 50 years, using natural resources particularly water has been increased. The continuous increase of consuming and consequently pressure on natural resources have provided grounds for facing serious challenges in these areas (Kadivar, 2011: 67). Natural resources have always suffered from one of the most natural threats which is mass motions which all process resulting from it causes displacement of a more or less amount of surface residues and it is located at mass realm. The domain motions are four main types of Falling, Creeping, Landslide, Gelifraction, which in Iran, this process occur more than other domain motions or at least it is reported more than others (Zomorodian, 2002: 4). In general, the young generally mountainous and domain topography, tectonic functions, climatic situation, and weak residues such as layers of clay and marl and shale, and activity of the river and dinging it

along with the role of humans and unconscious measures and their devastation in relation with the environment are some part of main reasons for earthflow. In the shielding field of Sardasht, 29 main and secondary fault are available. The most important of them are active fault of Piranshahr which crosses from the east. For the first time, Eftekhar Nejad (1973) called this fault as the Fault of Piranshahr which separates Marbles Jurassic Cretaceous (Mesozoic Geology) in the southeast from Quaternary alluvial in the northeast (Agha Nabati, 2004: 530). In addition, five secondary fault cross within the city, and seven faults at a radius of 1 km from the city have endangered the residential point. On the other hand, regarding the fact that Sardasht City has a continuous and irregular texture, in terms of vulnerability of the texture, it is located among highly vulnerable textures (Fahar, 2008: 72). To investigate the quiddity of the location of faults and determine points exposed to danger, the ranking faults and their scopes was conducted in such a way that rank 1 was given to the 0-100 m distance from the fault which is the most risky point for earthflow, rank 2 was given to the 100 -300 m distance and rank 3 was given to more than 300 m distance from the fault which is the safest point in terms of earthflow in such a way that the more the distance from the scope of the fault, the higher the coefficient of safeness.

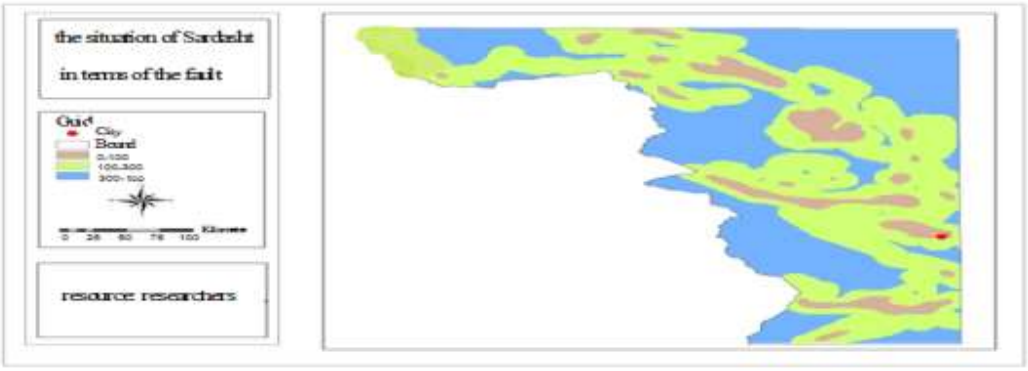

Figure 7. The situation of Sardasht in terms of the fault, resource: researchers.

In the region of Sardasht, the climate (rainfall, moisture, and temperature changes) and the weathering resulting from it, as well as high slopes covered with their deposition and instability of them and the fault of Sardasht-Piranshahr as a system and in relation with each other provide the grounds for enhancing the potential of earthflow in this region. To illustrate and determine the scope of the most effect of faults, their scope was identified and the rank with the minimum and maximum levels of risks were identified for the scope of Sardasht. The findings indicate this issue that Sardasht is located at rank 1 in terms of the scope of the fault, at rank 2 in terms of runoffs, and rank 2 in terms of heights. Referring to the findings, Sardasht is the riskiest area in terms of natural disasters.

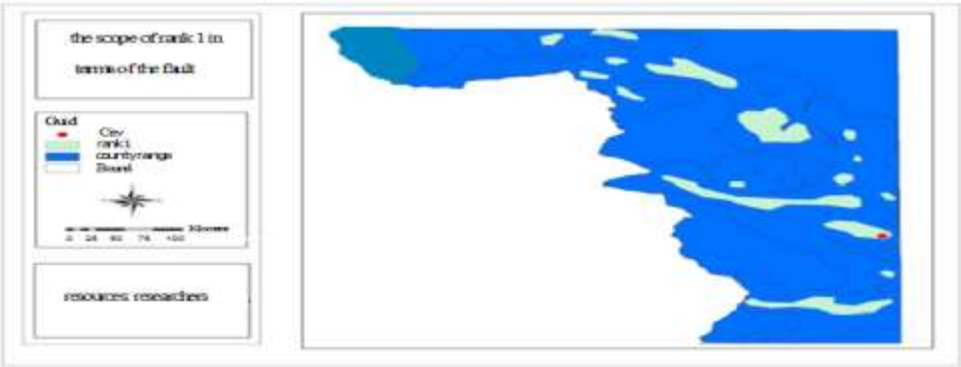

Figure 8. The scope of rank 1 in terms of the fault, resources: researchers.

5. CONCLUSION

In relation with the reasons of earthflow in Sardasht,

1. The existence of a sliding impermeable layer under the permeable layer
2. High levels of rainfall in the region
3. The existence of different lithology and porosity of different hardness
4. Mainly mountainous and steep topography and high latitude as well as high slope speed, and facilitating effective parameters
5. The role and intervention of the human factor in the destruction of forest coverage and changing them into agricultural land
6. The flow of Zab Saghir Badbi River and fast flowing water as well as running water underground and digging peripheral waterways are among factors intensifying the occurrence of natural disasters in Sardasht. With a closer view and regarding the capability which Sardasht enjoys for resisting natural disasters, each king of development and expansion of the city seems Inappropriate.

Table 3. The score of each index.

Index	Score	Rank
0-500 m height	0.159124	9
1500-500 m height	0.526792	6
300-1500 m height	0.184117	3
0-100 m distance from the fault	0.291512	1
100-300m distance from the fault	0.104747	4
More than 300 m distance from the fault	0.454461	7
0-100 m distance from the waterway	0.209865	2
100-300 m distance the waterway	0.0660815	5
More than 300 m distance from the waterway	0.0296389	8

Resource: researchers

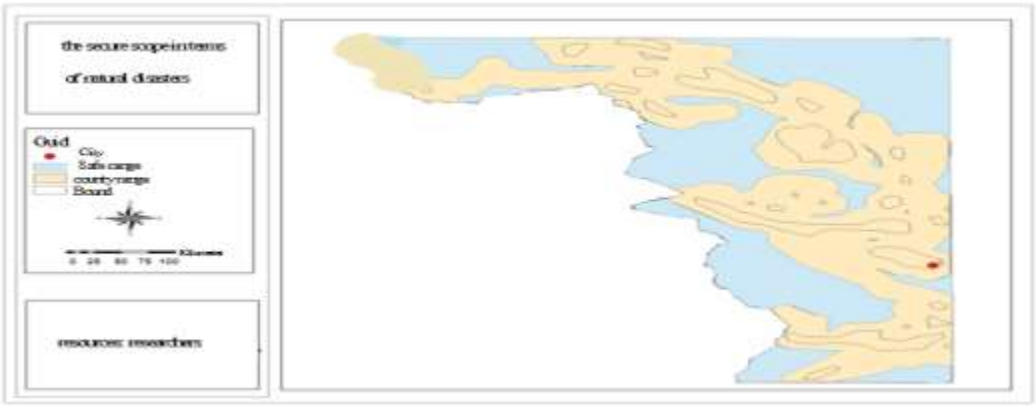

Figure 9. The secure scope in terms of natural disasters

Accordingly, to determine the safest location for development the city physically in the future, the location where is at rank 3, i.e. the safest location with the least distance from the city is the most appropriate. As observed in the conducted positioning, scopes 1 and 2 are the best regions for developing the city in the future, but scope 1 is the valley adjoined to Zab River which is not an appropriate location for development, but scope 2 enjoys all conditions for physical development of the city in the future.

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