Selected Paper from 14th Iranian Hydraulics Conference

Journal of Hydrosciences and Environment

ISSN: 2345-5608

Landslide zoning in Shirin-dare Dam Water Supply Pipeline , North Khorasan

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A R T I C L E I N F O

Article history:

Received: 30 February 2023
Accepted: 31 March 2023

Keywords:

Landslide

Zoning

Shirin-dare Dam Water Supply Pipeline

mass movements

Northern Khorasan

A B S T R A C T

Landslide term is used for all mass movements on slopes, including falling, overturns and flow debris. Using the potential landslide hazard zonation, areas with high potential of landslide hazard can be detected and so prevent the landslide occurrence with providing appropriate solutions. In this study, the landslide hazard zonation along the water transmission lines of the Shirin-dare Dam Water Supply Pipeline has been done. Studied area is located at the western part of the Northern Khorasan (Bojnord). Study procedure is included of the general geology of the studied area, recognition the most important effective parameters on the landslide phenomena (such as slope, lithology, faults and streams) and also, mapping them as a layer on the basic maps. Then, each layer was validated based on the importance of the effective factors using the maps weighting method in ArcGIS software. Finally, the studied area was zoned based on the landslide potential using the overlapping of the various layers. Final zonation map shows that the North, Northwestern and Median parts of the studied area have highest landslide potential. These areas are included of Marl and red Marl and to some extend loss deposits with slopes between 14 to more of 50 degrees. Seemingly, faults (due to low occurrence) and streams (due to drought) have lower effect on the landslide potential. However, the degree of the slope and type of lithology are the most important parameters on the landslide potential, respectively.

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1. Introduction

Some parts of Iran with mountainous topography, high Tectonic and seismic activity, various climatic and geological conditions, have suitable background for creation of the landslide. Therefore, this Features and conditions despite all benefits, As well are created some hazards. According to an initial estimation about 500 billion financial damages from landslides is endured, per each year, whereas this is the irreversible loss of natural resources are not taken into accounts (Nasiri, 2004). Data recorded by the Ministry of Agriculture show that until 2000 mass movement and landslide in the Iran, has been caused of the deaths of 162 people, destroyed 176 homes, financial losses of 1,866 billion rials, the destruction of 676 hectares of forest and destroyed 170 kilometers of roads and linear structures (Salehpour, 2001). In damming construction field, landslide phenomena, considering the conditions and its properties, reduce the useful life of the dam or even failure of the dam with filling of the reservoir, or structural damaging. South Khorasan province, due to specific lithology characteristic, tectonical situation and climatic condition, numerous landslides occur every year that sometimes is associated with the great human and financial losses. The city of Bojnord and Shirvan are regions that almost every year, landslides in different dimensions are Some parts of Iran with mountainous topography, high Tectonic and seismic activity, various climatic and geological conditions, have suitable background for creation of the landslide. Therefore, this Features and conditions despite all benefits, As well are created some hazards. According to an initial estimation about 500 billion financial damages from landslides is endured, per each year, whereas this is the irreversible loss of natural resources are not taken into accounts (Nasiri, 2004). Data recorded by the Ministry of Agriculture show that until 2000 mass movement and landslide in the Iran, has been caused of the deaths of 162 people, destroyed 176 homes, financial losses of 1,866 billion rials, the destruction of 676 hectares of forest and destroyed 170 kilometers of roads and linear structures (Salehpour, 2001). In damming construction field, landslide phenomena, considering the conditions and its properties, reduce the useful life of the dam or even failure of the dam with filling of the reservoir, or structural damaging. South Khorasan province, due to specific lithology characteristic, tectonical situation and climatic condition, numerous landslides occur every year that sometimes is associated with the great human and financial losses. The city of Bojnord and Shirvan are regions that almost every year, landslides in different dimensions are happened. The incidence of these events can be seen in the large mountainous and rural areas with the different damages on agricultural lands, residential homes, roads and the associated human and financial losses (see Ghafouri and Ashouri, 1997). An area in the Khorasan province, in order to piping for water supplying to the adjacent villages (fig. 1), several studies have been done which one of them was the evaluation of landslide risk in the area that studied in this paper. Firstly, in this study, the effective factors on the landslide occurrence are evaluated in general. Then, these factors are evaluated in the studied area. Finally, based on the prepared landslide hazard zoning map, the high and low risk areas are detected and explained.

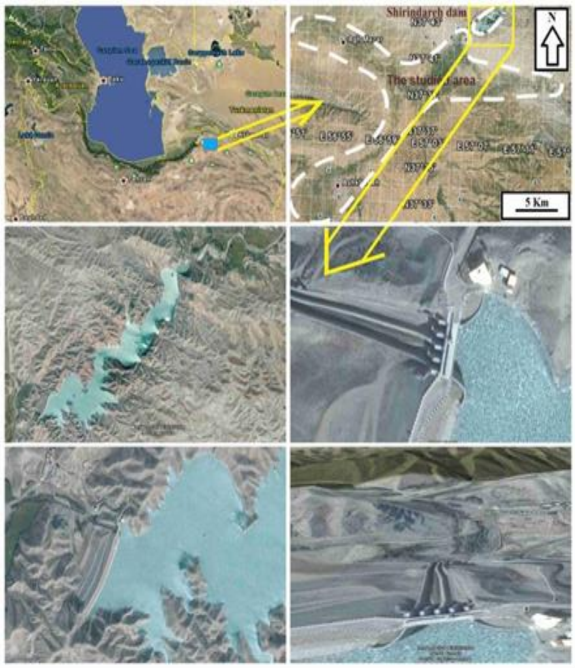

Fig.1. Satellite images of the area at different scales and also the Shirindareh dam to be the source of the water (images are from Google Earth).

Fig.2. some examples of landslides in the study area**.**

1.2. Geological setting

The studied villages in the area are located in the Maneh-Salaghan and Bojnurd cities of the Northern Khorasan province (37°33’N to 37°43’N and 57°15’E to 56°51’E). Figures.1 show location of the North Khorasan province in the Iran. According to geological features (sedimentary and tectonic) Iran is divided into several zones. In the Sedimentary-tectonic zone of Iranian plate, North Khorasan province is located in the Kope-dagh zone (fig. 1, Aghanabati, 2004). In the ongoing part, some characteristic of this zone has been expressed.

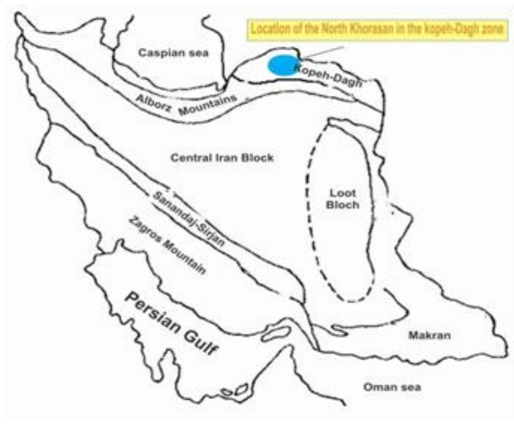

Fig. 3. tectonic zones map of Iran and location of North Khorasan (modified from Aghanabati, 2004)

Kope Dagh mountain ranges are located in the northern part of Khorasan (Iran) and Turkmenistan. This sedimentary basin occupies an extensive area in the North of Iran. Geologically point of view, it lies in northern margin of central Iran unit, Alborz unit and the southern edge of Touran plate in central Asia. This zone forms the northern end of Iranian part of the Alpine-Himalayan orogeny (Ramazani Oomali et al., 2008). In this basin thick Tertiary-Mesozoic sediments (8,000 m in Iran, 17,000 m in Turkmenistan) have been accumulated in a narrow sedimentary trough and have been intensely affected by the young alpine Neogene-Quaterner phases and were folded. Northern section of Kope Dagh ends to a basement related fault zone which delineates Touran plate boundary with Kope Dagh (Ramazani Oomali et al., 2008).

2. Materials and Methods

2.1. Landslide and factors affecting

Many different definitions by various authors and researchers to slope instability and landslides proposed that have different concept but close together (e.g. Sharpe, 1936; Terzhagi, 1950, Micheal, 1991, Gee, 1992, Cruden and Varnes 1996). The term "landslide" describes a wide variety of processes that result in the downward and outward movement of slope-forming materials including rock, soil, artificial fill, or a combination of these (Sharpe, 1936; Terzhagi, 1950). The hazard of the landslide on zoning maps show spatial distribution order of its dangerous (Van Westen, 1993). The development of these zonations schemes need to a knowledge of active processes in the analyzed region and controlling factors of the landslide (Cruden and Varnes 1996). The most important abject of hazard (landslide) zonation map is prediction of places with high and low risk. The procedure of these studies (as this study) is including the detection of effective factors on landslide (which numbers and types of them differ according to elements such as geology and climate), then zonation maps are prepared according to each factors. These maps are known as information layers. At the end, each of layers is evaluated and final landslide hazard zonation map is drowned. Rating (ordering) of an information layer and or its importance is also related to the landslide phenomenon which is considered in this study as some other studies (such as Yalcin, 2008, Van westen, 1993, Lan et al., 2004, Ahmadi et al., 2003, Farrokhnia et al., 2011, Soleymannejad 2013). Following, firstly, the most important factors on the landslide is evaluated and then these factors are investigated in the studied area.

2.2. Drainage network and Water Supplies

Drainage network is known as one of the most important agent for landslide, in many studies (e.g. Hutchinson, 1988). Drainage network, vegetation and slope considered as three main factors in Mahata River landslides in Japan (Aniya, 1985). In this study, one of the information layers which have been evaluated is Drainage network. Slope saturation by water is also a primary cause of more landslides. Although landslides are primarily associated with mountainous regions, they can also occur in areas of generally low relief. In low-relief areas, landslides occur as cut-and fill failures (roadway and building excavations), river bluff failures, lateral spreading landslides, collapse of mine-waste piles (especially coal), and a wide variety of slope failures associated with quarries and open-pit mines. Studies show that rainfall (more the 211 mm) is caused landslides in the Himalaya (Connors et al., 1987). According to new research in the United States the main cause of landslides in the present and ancient is heavy rainfall (Freer et al., 2002).

2.3. Tectonic activates

Effect of tectonic activities, as one of the most important agent on the landslide occurrence in the some studies have been evaluated (e.g. Stefouli, 1996; Yamaguchi et al., 2003). Fault, fracture and joint are resulted from tectonic activities. Translational slides commonly are controlled structurally by surfaces of weakness such as faults, joints, bedding planes, and contacts between bedrock and overlying deposits. Mentioned features induced by tectonic activity with created weak surface which facilitate landslide. Joint and fracture in the region are not frequency and obvious. But in this study, information layer of fault is provided and evaluated.

2.4. Lithology

Lithology is considered as one trigger of mass movement, so that one of the most important and effective factor in the zoning methods (see Cruden and Varnes, 1996). Lithology in most methods of zoning is considered as a layer to create slope instability. Soil physical parameters such as weight, volume, porosity and density depend on type of lithology which have effective role in slope stability. Clay, shale, mudstone, porous volcanic materials, laminated deposits have suitable background for landslide phenomena. For example, Swelling of clay minerals have effective role for trigger of this occurrence.

2.5. slope gradient and slope direction

Slope gradient is one of the primary requirements to the landslide. Landslides occur when gravitational and other types of shear stresses within a slope exceed the shear strength (resistance to shearing) (Antonini et al., 2002). However, the role of slope gradient with morphological characteristics such as plants and streams has impressive effects (Aniya, 1985). Also, the effect of slope direction is important due to sun exposure time and evaporation of the domain. In the northern hemisphere the amount of sunlight hitting the surfaces with a southern slope is greater; therefore decrease the amount of water may decline instability. Instead, on the northern slope directions due to increased evaporation and less water will cause instability in the slopes.

2.6. Roads and passage ways

In mass movements such as landslides, roads and passage ways are one of the factors affecting. In the roads and passage ways, soil was being compacted. So, surface water cannot move easily in the subsurface soil. Therefore upper layers of soil with more weight and water supplies can be easily slides (see also Cruden and Varnes, 1996).

2.7. Validation to factors

As mentioned above, in this study such as some studies in Iran (e.g. Farrokhnia et al., 2011, Soleymannejad 2013) the validation is carried out. Slope gradient and lithology type are the most important factors, respectively. Due to very low rain and drought, streams and drainage have low importance.

3. Result and discussion

3.1. Landslide zoning in Shirin-dare Dam Water Supply Pipeline

3.1.1. Lithology

As previously stated, attention to the lithology as one of the most important triggers in hillside motions is very necessary. Lithology role in the slope movements such as rockfall influenced by rock hardness and the weathering of rocks and cracks. The lithology reflects the characteristics of engineering geology and rock mechanics as well as the region. The adhesion properties and internal friction angle of the engineering properties of lithology are a lot of impact. For use of lithology as a layer, the lithology of area based on geological maps (geological maps with a scale of 1/250000) was extracted and examined in the field observations and finally the lithology map was Digitized, and converted to the information layer (Fig. 4) . Here into the classification and ranking of this factor is conducted by different researchers in different ways. But what is good for the climate of Iran seems more practical is the Haeri and Samii method (1995), Farrokhnia et al., (2011) and Soleymannejad, (2013). So, rock units in the study area based on mentioned investigations are classified and validated which modified based on field observations and properties of the area that included in final zoning map.

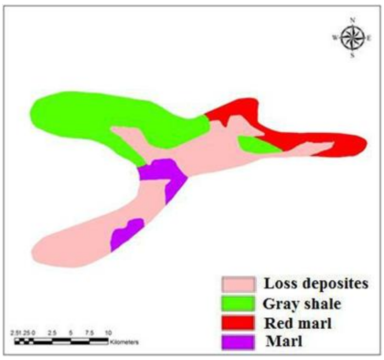

Fig. 4. validated distribution map of lithology units in the region

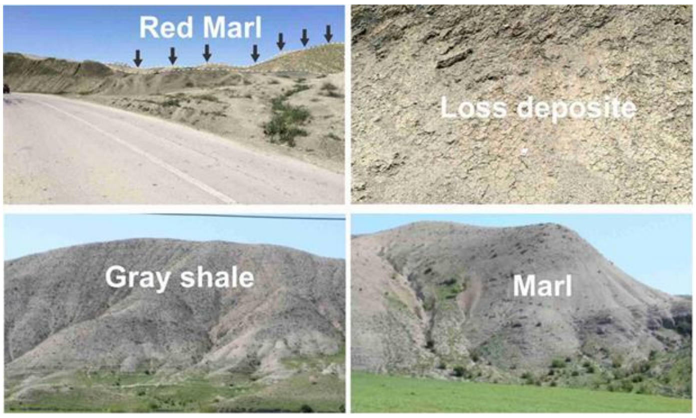

Fig. 5. .field image of lithology unite in the studied area

3.1.2. Streams

Most of the mass movement occurred after a heavy rainfall. This shows the importance drainage system in creation of landslide because they act as a flow path surface. Water flowing is a factor in improving preparedness of slope instability. In fig. 6 the main waterways of the region are drawn.

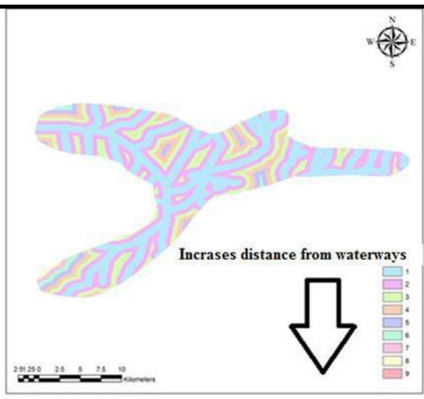

Fig. 6. validated main waterways map area

Fig. 7. Examples of the main streams in the study area

3.1.3. the amount and direction of slope

As mentioned in the affecting parameters causing instabilities section, the slope effect as one of the most effective factor in creation of instabilities is quite obvious. The slope layer (fig. 8) is prepared based on data from various maps of area (mainly topography and isopach maps) and also field observations. Here the slope is classified into five categories. Topographic map is used to prepare Tin and also for high precision of tin, several points on the same lines in height were used and then tin converted to slope.

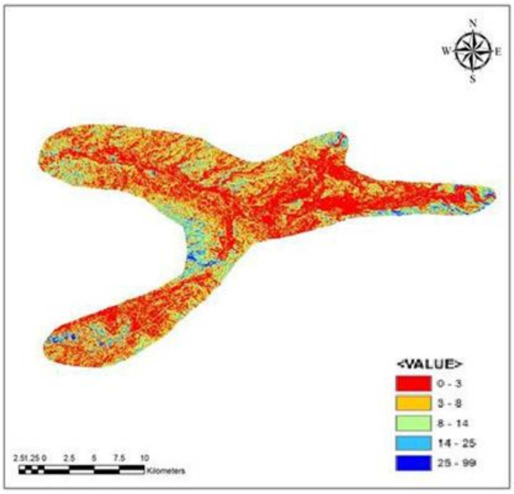

Fig. 8. validated gradient map of the study area

Also in this study, after extraction of the slopes direction from Elevation Model the slopes were divided into 9 groups (fig. 9).

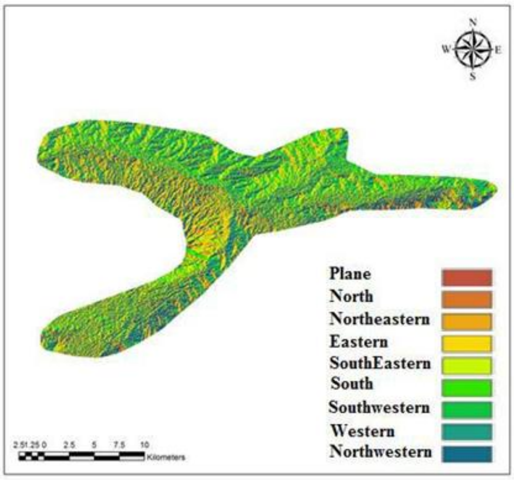

Fig. 9. validated distribution map of slope direction in the study area

3.1.4. Faults

Faults are areas to release energy of earth and the release of energy can be seasoned and triggers landslide. Faults were extracted from geological maps and were validated with data on existing GIS databases and field observations have also been (Fig. 10). Also in this study Joint study partly confined (Fig. 11). It seems that in the studied region joints are more accumulates in place of fault and in other sectors are widespread. For this reason, the distribution of joint is not used as a layer.

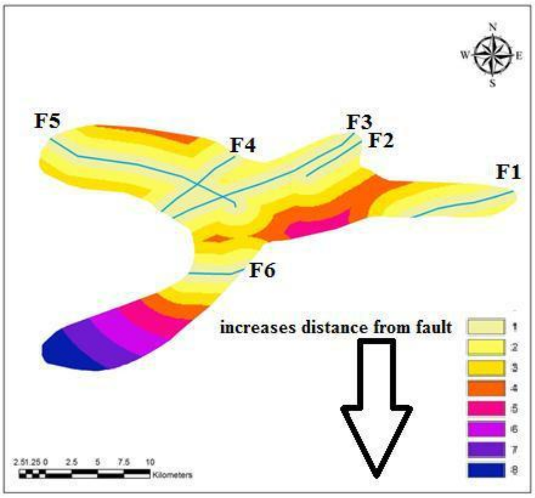

Fig. 10. validated fault map of the study area

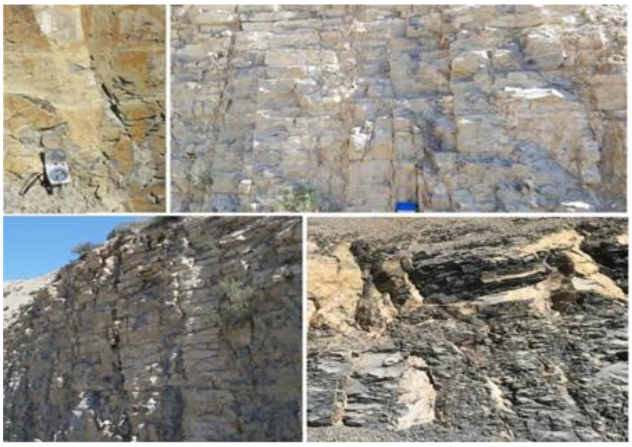

Fig. 11. Examples of joints near the some faults

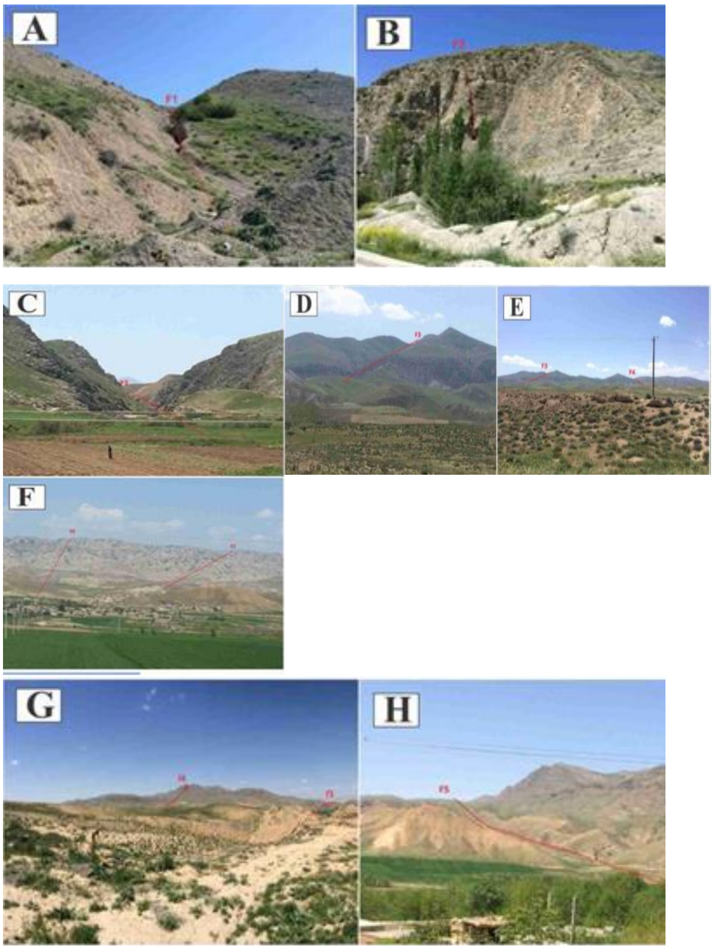

Fig. 12. A: F1 fault view toward north-east. B: F2 fault view toward north-east. C: F3 fault view toward south-west. D:F3 fault view toward south-west. E: F3 and F4 fault view toward south-west. F: F3 and F4 fault view toward north-east. G: F3 and F4 fault view toward north-west. H: F5 fault view toward north-east

3.1.5. Roads

As above mentioned, in mass movements such as landslides one of the affecting (but with low importance) factors are the road. Because during established the road gets rammed earth and underground water can easily move in the subsurface soil and increase the weight of the soil above the road, thus causing irritation of soil and creation of landslides.

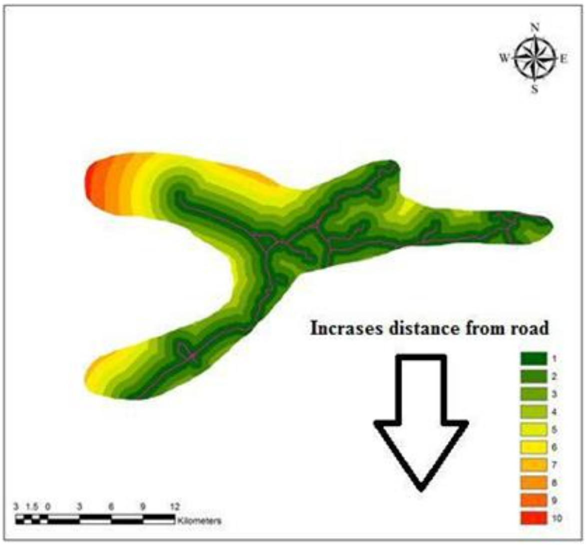

Fig. 13. Road map of the study area

3.1.6. the final map of landslide hazard zonation

For the preparation of landslide hazard zonation in the region, the validation was carried out. The appointment to validation of the previous articles (e.g. Ahmadi et al., 2003, Farrokhnia et al., 2011, Soleymannejad 2013) and previous work done in the near area were used and Classical fuzzy logic methods were used for validation. In the final stage based on the importance of effective factor, each layer has to be validated individually . The minimum value of zero and a maximum of 10 are given to each layer (fig. 14).

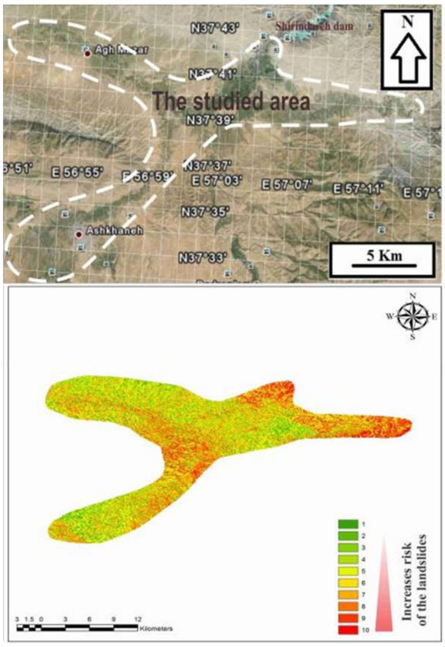

Fig. 14. the final map of landslide hazard zonation (down) as well as satellite map (top)

3.1.7. Interpretation of the final map of landslide hazard zonation in the studied area

The first glimpse to landslide hazard zonation map, the lack of focus and lack of continuity are obvious and areas with different degrees of risk scattered throughout the map. However, to some extent, we can see certain patterns in the region .As can be seen in the map, the most high-risk areas are concentrated the North, North East and the center of map. These areas have marl and red marl lithology. The dip in this section is from 14 to more than 50 degrees. Western and Southern parts are second dangerous. This section, however, has lower slope, but these deposits (gray shale and Loss) have more instability .

4. Conclusion

This study examines the risk of landslides in the area in the province of North Khorasan, after the most important parameters affecting the landslide were identified in the study area, base maps were created. These maps were used as substrate for susceptibility map, validating, and at the end of the final map of the study area were drawn landslide. Two factor fault (due to low occurrence) and channel (due to drought) have less effect on risk for landslides. However, the amount (gradient) of slope is most important, and lithology has the second important in the landslide hazard. The final map of landslide hazard zonation study area represents a lack of focus and continuity in different directions of the high-risk is high. So that areas with different degrees of risk somewhat scattered throughout the map. Most high-risk areas focused in the North, North East and the center area. In these areas marl and red marl are expanded. The dip in this section is 14 to 50 degrees. Western and Southern parts are second hazardous areas.

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