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Effect of fault network on zoning of mass movement using GIS Case Study: Science and Research Branch, Islamic Azad University

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Key words: Landslide hazard zonation, Watershed of Science and Research Branch, Islamic Azad University, slope, slope direction, GIS, lithology, pedology, fault.

Abstract

Investigation of effective factors on landslides and identifying vulnerable areas are considered as an important step in achieving sustainable management of natural resources. With regard to the location of Islamic Azad University on active fault of North Tehran, subsequent degradation of the natural environment, non-principal roads, lack of management of water flows and extensive constructions in the University, a comprehensive study is required. The importance of the study is to identify high-risk regions through which hazards could be prevented. Some of the most important factors in landslide such as slope, slope direction, rivers, roads, faults, lithology, and penology were investigated and their maps were digitized using GIS. Also, the information layer of landslide was produced through field studies, interpretation of aerial photographs and GPS. Finally, zoning map of landslide hazard was produced. According to the results, the highest landslide was related to the lithological units E1tsv. It contained green tuff in the shape of mass, and shale, deictic and andesitic lavas occurred in a slope of 50-70%, in the South and West.

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Introduction

Mass movements and landslides have been considered and defined from different aspects widely in countries like Japan, Italy, USA, Mexico, Yugoslavia and India, struggling with this issue. Mass movements classifications, classification of different regions in terms of landslide susceptibility and fixation have been performed so far in order to study mass movements and landslides.

Aghanabati (2004) investigated North Tehran fault for the first time. Paleontology studies have been done on this fault. Shahnazari *et al.,* (2008) stated that Iran's research background in landslides is new compared to other countries and most serious researches are related to the last decade.

Most of these studies have been started following the occurrence of landslides such as being buried of whole village of Fatalak (Rudbar) after the earthquake of June in 1991, destruction of Chelou village in Shahrekord after heavy rainfall in 1996, high occurrence of landslides in the Ghezel-Ozen watershed and several other cases in different parts of Iran. Ounagh (2009) investigated modeling and landslide hazard zonation in Alamout watershed. Slope, slope direction, height, rainfall and lithology of the study area as well as influence of each factor on the landslide were considered in this research. Landslide zonation in Madarsou watershed was investigated by (Bay, 2007). Mass movement hazard zonation in Oujanchay watershed was performed by (Karami, 2006). Komakpanah (1994) investigated the strategies to reduce landslide losses in the country. Abbasi *et al.,* (2002) studied the neo-tectonic stress at the southern edge of the central Alborz. Their results showed that ground motion in areas near fault and in mountainous areas caused phenomena such as landslides and rock- falls.

Therefore, the areas near seismic faults should be taken into consideration in terms of fault zone, slope, and landslide. Construction is extremely important in areas close to the fault and fault zone should be taken into account.

The aim of this study was to evaluate the impact of faults network on zoning of mass movement using GIS in Science and Research Branch, Islamic Azad University watershed.

Materials and methods

Location and characteristics of the study area

Science and Research watershed is located between latitudes 35° 46′ and 35° 48′ and longitudes 51° 20′ and 51° 18′ in the southern slopes of Central Alborz Mountains. The mentioned watershed is located between two rivers, namely Hesarak and Farahzad and its name is due to the proximity of buildings and installations of the Science and Research Branch, Islamic Azad University. It cannot be considered as an independent watershed because it has no distinct waterway, located between Hesarak and Farahzad watersheds. Waterway system is not distinct in this watershed and it has been formed by a series of wandering waterways that pours down the plain and snowy ones. From north, south, east and west, it is limited to the Farahzad and Hesarak watersheds, altitude of 1700 m, hydrological unit of Farahzad and hydrological unit of Hesarak, respectively.

Methods

Initially, documents, reports, articles and books in connection with the subject of research were collected and then regions which were prone to landslides and mass movements were determined by aerial photographs and Digital Elevation Model (DEM) of the study area and satellite images of Landsat and Aster. Also, the study area was delineated on topographic map of 1/50000 and preliminary investigations such as identifying buildings, installations and networks on topographic map, and drawing contour lines and waterway of the region were conducted. Geological map of Tehran (1:100000), formations map of the study area, map of major and minor faults, lithology map,

geomorphology map and the map of distance from roads and communication routes were also prepared.

Finally, morphometric data were analyzed using different software, such as Arc GIS, Global mapper, and Excel. Field visits were also conducted to check the accuracy of obtained results. Fig.1. shows the location of Science and Research Branch, Islamic Azad University watershed.

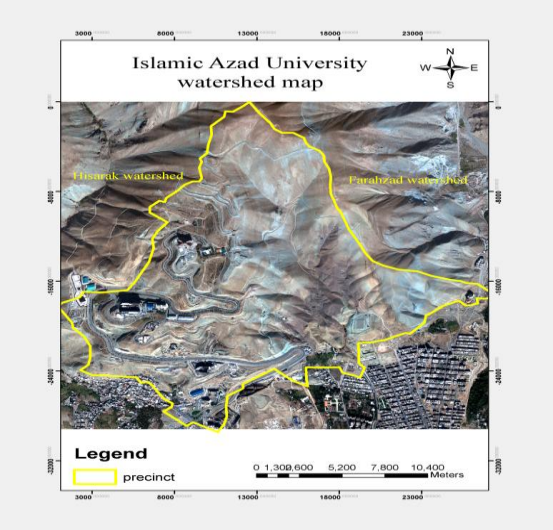

Fig. 1. Science and Research Branch, Islamic Azad University watershed.

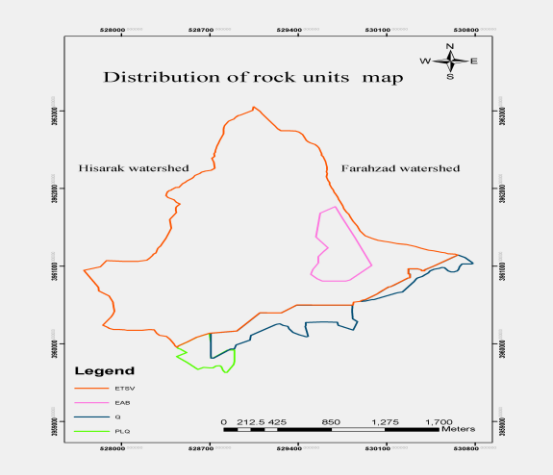

Fig. 2. Classification of rock units in Science and Research Branch, Islamic Azad University watershed.

Results

The role of different rocks in landslide of the study area was investigated using rock unit map obtained from geological map. Table 1. shows the classification of rock units and number of landslides in each rock unit.

Table 1. Distribution of rock units and number of landslides in Science and Research Branch, Islamic Azad University watershed.

number of landslides in each rock unit	rock units (%)	rock unit)M(	Symbol
2	4/10%	184430/99	E_1^{ab}
8	85/6%	3849211/966	E_1^{tsv}
3	7/88%	354224/31	Q_1^{t}
1	2/42%	108488/82	PL-Q

Slope

Slope map of the watershed was generated and classified by Digital Elevation Model in GIS. Results derived from integrating slope layer with landslides distribution map showed that there was a linear relationship between increasing slope and landslide. Table 2. shows the classification of slope, slope percentage, and number of landslides in each slope class.

Table 2. Classification of slope, slope percentage, and number of landslides in each slope class.

number of landslides in each slope class	slope percentage	classification of slope	slope class
1	4/7%	30<	1
2	8/63%	30-50	2
2	14/47%	50-70	3
6	25/06%	70-80	4
8	47/14%	80>	5

Slope direction

In the Northern Hemisphere, directions to the south and west are in exposure of sunlight for a longer time than directions to the north and east, leading to increasing the annual evapotranspiration. But in Science and Research Watershed, the dominant directions are North-East with low sunlight and more soil moisture.

Fig.3. and Fig.4. show the slope direction and fault zone maps of Science and Research Branch, Islamic Azad University Watershed, respectively.

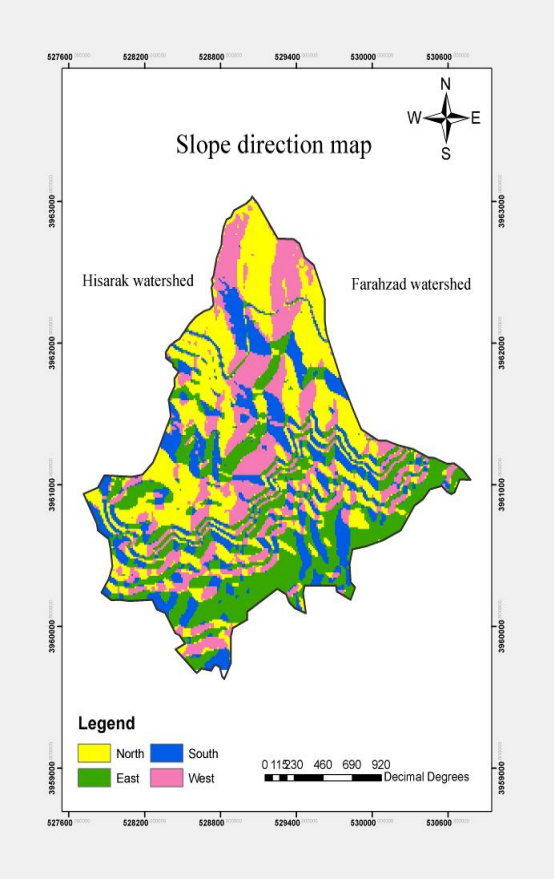

Fig. 3. Slope direction map of Science and Research Branch, Islamic Azad University Watershed.

Distance to fault

Faults are considered as aggravating factor for landslides and due to the University placement on the North Tehran Fault, this is more important. Therefore, in order to establish the relationship between landslides with fault factors, the map of fault classification was combined with the map of landslide distribution. As a result and with regard to the aim of the determination of disaster-prone areas, a fault zone of 60-2000 meter was determined. The investigations showed that all of the buildings were on the hazard line. Table 3. shows the distance from fault and the buildings at risk.

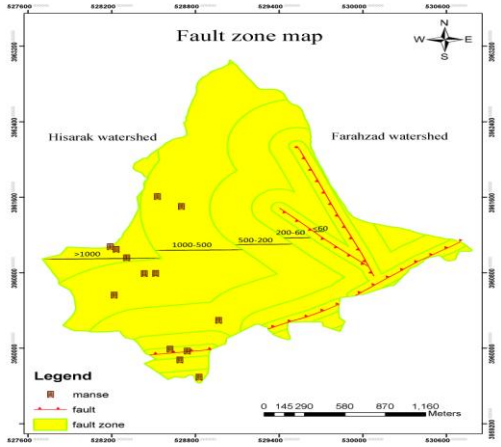

Fig. 4. Fault zone map of Science and Research Branch, Islamic Azad University Watershed.

Table 3. Distance to fault classification, buildings at risk.

buildings at risk	Distance to fault
Sciences،Library	60<
Humanities ،Bus station	60-200
Economics ،Food industries Office	200-500
Engineering ،Hotel ،Dining hall	500-1000
Physics laboratory ،Site ،ground Football	1000>

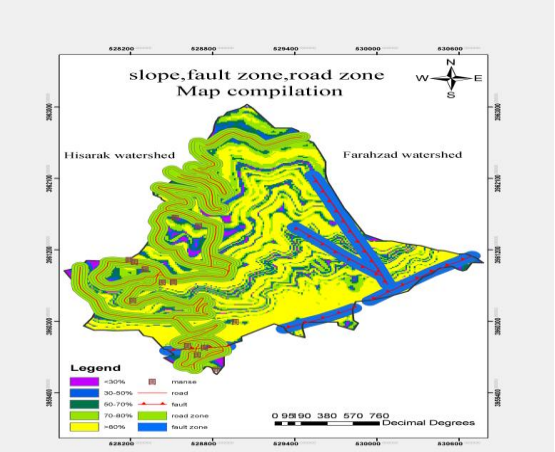

Fig. 5. Disaster-prone zone of Science and Research Branch, Islamic Azad University Watershed.

Since the study watershed is an urban area, road construction is also among the important factors of landslide as most landslides are due to the non-principal roads in the area. In order to determine disaster-prone zone of the study area, road zone map and fault zone map were combined. Results showed

that all buildings were located on fault and road disaster-prone zones. Fig.5. shows the disaster-prone zone of Science and Research Branch, Islamic Azad University Watershed.

Pedology

The type of soil texture has a great effect on the leaching phenomenon. Leaching is stronger and faster in light-textured soils such as the study area and causes landslide. Table4. Shows soil susceptibility to runoff and landslides. Land units of Science and Research Branch, Islamic Azad University Watershed are shown in Fig. 6.

Table 4. Soil units, land units and soil susceptibility to runoff .

Potential runoff	groups of soil Hydrologic	Number of Soil units	Component of land units
high	C	2	1.1.1
high	C	2	2.1.1
high	C	2	2.1.2
high	C	1	2.1.3

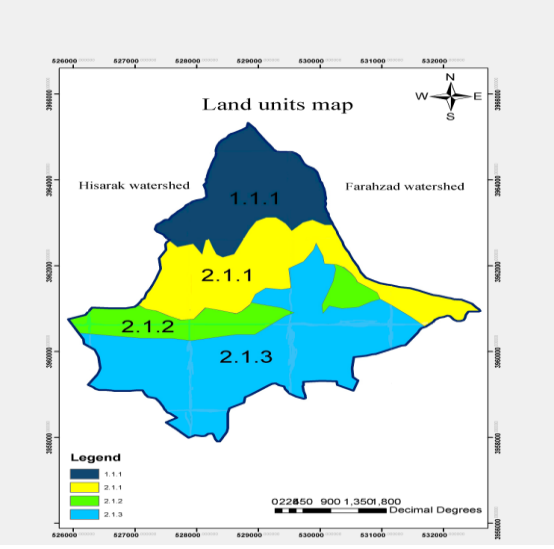

Fig. 6. land units of Science and Research Branch, Islamic Azad University Watershed.

Discussion

Since landslide is one of the major natural disasters, having a significant role in changing the shape of the Earth, therefore, study on factors affecting landslide and identification of prone areas to landslide is considered as an important step in natural resource management and achieving sustainable development. In this research, factors affecting landslide were investigated using GIS. From satellite images, topographic maps and field studies, it is concluded that in the study area factors such as faults, slope and soil have a significant influence on mass movement (landslide).

According to the results, a linear relationship was found between increased slope and landslide (Nasiri and Oroumiei, 2005). The highest risk was found for slopes of more than 80% but regarding the construction of the buildings, a slope of 70-80% was more important. In addition, increasing landslide was observed in the northern and eastern slopes and lithology showed different sensitivity.

Contrary to expectations, no landslide was observed in PL-Q unit and the dominant landslide was found in E1ab, tE1tsv unit due to the involvement of human factor through road construction and logging. The soil of the study area is mainly sandy loam- loamy sand and very light. A lot of landslides are observed due to the watershed altitude, high rainfall and sever leaching (Tehran Municipality region 5, 2003).

Results showed that total watershed area was located on fault disaster prone zone (60 m-2 Km) and also buildings were on the hazard line (20 m) (Mojarab and Zare, 2009). Results showed that assessment of fault activity was based on mechanical relationship between fault geometry and regional tectonic stress field. Most of the landslides were unnatural and due to the human impractical activities, having a higher risk (sorbi *et al.*, 2009).

In order to reduce possible risks and the destruction of buildings and roads, impractical constructions should be avoided as much as possible and seedling cultivation is recommended for the sides of the roads that are prone to landslides. In addition, buildings located within 60 meters of the fault zone should be protected against earthquake.

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