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Assessment Reasons of Landslide (Case Study Hardang in the South West of Isfahan Province, Iran)

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ABSTRACT

Snow melt water (snowmelt) that seeps into the subsurface is a major factor contributing to the development of landslides in mountainous areas in the south of Isfahan region. An examination of historical temperature data in relation to landslide occurrences reveals an association between the landslide events and intervals of rising temperatures in the present (warm period in quaternary) that accelerate the production of snow melt water. Historical climatic data recorded at local weather stations located near the landslide sites are used to show the association and to identify a temperature threshold that may be useful for forecasting the onset of some landslides. The change temperature is defined by the number and temporal distribution of snowmelt related landslide events. In this research, we have tried to indicate the relation of glacier system and and also the effect that this phenomenon had in stimulating the instabilities, and for access to such a purpose, the old slip situated in Hardang Village, located at West South of Isfahan Province has been evaluated. In order to study this slip, at first the effect of the effective factors in creation of slip were evaluated such as litho -logy, gradient and tectonic,…, and then the limits of glacier system during the present time and icing periods of Quaternary were specified using the intermediate model of IDW in Software Arc.GIS. at Isfahan province.
The results obtained from this research indicate that:
Existence of glacial deposits and which confirm activating of the glacial system and next to the glacial within the limit of the landslide under study during the glacial epoch (Quaternary cold phase).
The place of occurring this landslide is in a location that has been in the cold phase of Quaternary within the activity limit of glacier system and at the present with warming weather and changing the climate, it has not been placed within the limit of the glacier system and so change the formative systems and it has provided the conditions for the sudden melting of the icy deposits and occurrence of the landslide.
KEYWORDS: landslide, glacier system, Hardang, climate change.

1. INTRODUCTION

Mass movements cause between one and two billion dollars in financial losses each year in the United States (Highland and Brown, 1996). The resultant need to predict landslide occurrence at landscape scales has led to the development of numerous stochastic and process-based models, with increasing emphasis on the use of GIS in the past 10 years. Stochastic statistical modeling approach have generally taken the form of multivariate statistical analyses of landscape characteristics associated with past land sliding,Jibson and Keefer (1988) Pike(1988) Carrara(1989) Carrara et al(1991) Anbalagan(1992) Maharaj (1993) DeYoung(1996) or weighted hazard ratings based on environmental attributes related to land sliding _Bernknopf et al(1988) Gupta and Joshi(1990) Hadzinakos et al(1991)Pachauri and Pant(1992) Wang and Unwin(1992) Go¨kceoglu and Aksoy(1996). The process-based landscape models have generally used some variation on the factor of safety equation _e.g., Selby(1985) coupled with geomorphic, hydrologic, geologic, an vegetation data to estimate slope, cohesion, and moisture content _Okimura and Kawatani (1986)van Asch et al (1993) Montgomery and Dietrich(1994) Miller(1995) Van Westen and Terlien, (1996) Mont-gomery et al.(2000).

Regarding the effects of changing climate and glacial on the occurrence of landslide, we can refer to the following individuals :

Oberian in parallel with the researches of Ireland Geological Organization on the landslides in south Europe and Ireland stated that the climatic changes can cause instability of the slopes and provide the conditions for occurrence of landslide (Oberian and et al., 2008).

Shumeister and colleagues, in Newzealand area have worked on the effect of glacial on occurrence of landslides. The results of these researches indicated that occurrence of great landslides on the bed stone is much more in the regions that formerly the glacial has passed them (Shumeister and et al., 2009).

Catani & colleagues, with studying on approximately 100 landslides within the cold and mild weather areas in south Italy which some parts of it is covered by snow proved that alteration in the frost and melting of

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snow and ice, simultaneous with sudden changes in temperature create penetration of water into the ground and creation of landslide (Catani & and et al., 2010).

Soldati and colleagues, with studying the existing landslides on Italy dolomites found that there is direct relation between increasing the number of active landslides with change in climate in the time period between the past glacial era and Holocene. In general, we can concluded that despite various factors that are effective in creation of landslide, some of the landslides can be mentioned as the landslides due to the change in climate (Soldati et al., 2004).

Shirani , while studying the landslides in south Isfahan proved that some areas with fairly high rainfall and much temperature difference have most correlation with occurrence of earthquakes (Shirani , 2004).

1-1-Situation of the area under study

The landslide under study has been located at a region called Hardang in 75 km south west of Isfahan. In this region various types of foothill instabilities are observed. One of the most outstanding movements is great old landslide that its vibrations severely threaten Hardang village which is close to this instability. The area of this landslide is 29.271 sqm almost equal to 2.9 acre and its environment is 867 m.

The field studies of this landslide indicate existence of glacial deposits in the area. Also existence of deep valleys in the middle parts of this landslide indicate the effect of glacial processes in creating this landslide. Existence of the tilted trees in the ending sections of this landslide indicate the present activity of this landslide

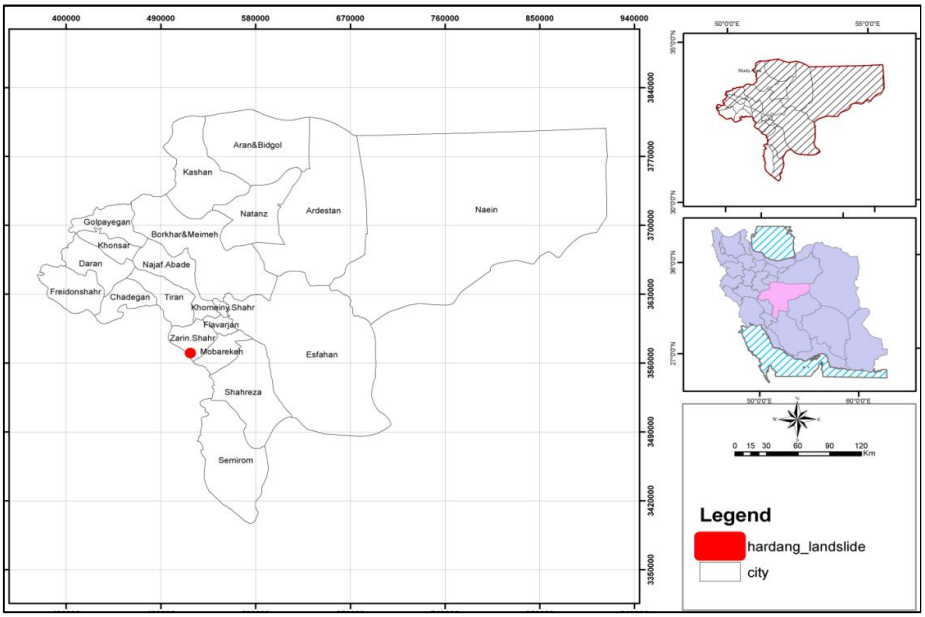

Figure (1): situation of the landslide in Hardang

2-MATERIALS AND METHODS

First of all, the authors of this paper investigated the air photographs and field studies to find the place of Hardang landslide in Isfahan on DEM of province using Software Arc GIS 9.3 (digital altitudinal model with 85m cellular size gained from the digital photos of radar). In order to determine the position of glacier system in province, the statistics of 93 climatic and synoptic stations of Isfahan and neighboring provinces investigated and analyzed. Among these stations, the stations with temperatures 5 degree or under 5 degree during 3 or 4 months called cold stations. The average of 3 cold months in cold stations were calculated for the statistical period and then the map of formative systems were prepared by IDW method and using Software Arc GIS9.3 in Isfahan. Finally, after overlapping these maps with situation of slide. After Integrating of these two maps, the conditions were prepared to analyze the place of slide occurrence and its relationship to glacier system.

3- DISCUSSION AND RESULT

The region between permanent snow line and water-ice equilibrium line consists of the regions that have been (anaglacial) within the limit of cooling ditch and at the present (cataglacial), they are situated within the

limit of the heat ditch. This limit is the border of thermodynamic reaction between the ditches that is changed alternatively and this thermodynamic reaction can be one of the factors for creating landslide.

In anaglacial, a major part of the rainfall poured in a solid form and due to the governing of cooling conditions, much amount of snow fall was stored. In this phase, the phase, the forming system has been next to fluvial glacier in the form of glacial. In cataglacial , increasing entrance of heat energy has been caused to decrease rainfall and increase evaporation and a major part of the material that has been stored in the environment in the form of snow and ice, starts to melt with the beginning of warm phase and it frees the potential energy which stores in itself during the long periods in a short time to the environment. In fact, in this stage with increasing temperature, melting the ices resulted from the solidification in Quaternary causes that the volume of the superficial flows increases very much and penetrate in the land. These kinds of the processes are regarded as **preglacia** behaviors and these changes provide the conditions for occurrence of various types from the types of mass movements. One of the most important types of the landslides that are usually observed in these areas is soli-flexion. This movement often occurs in the slopes that their constituents are clay materials or in fine deposits and non-continuous masses such as loose grain deposits of Quaternary, such that the materials in these type of slopes attract some water, lost their stability and hardness state and as a result they are changed into plastic form and the smallest pressure and force causes that they become movable. Penetration of water or superficial water tables and/ or water resulting from melting of ice in the warm phases cause that the fine deposits attract water and their weight is increased, with increasing weight and reducing friction due to the wet, instability of the materials and surfaces becomes more and they are dislocated under the effect of more gravity.

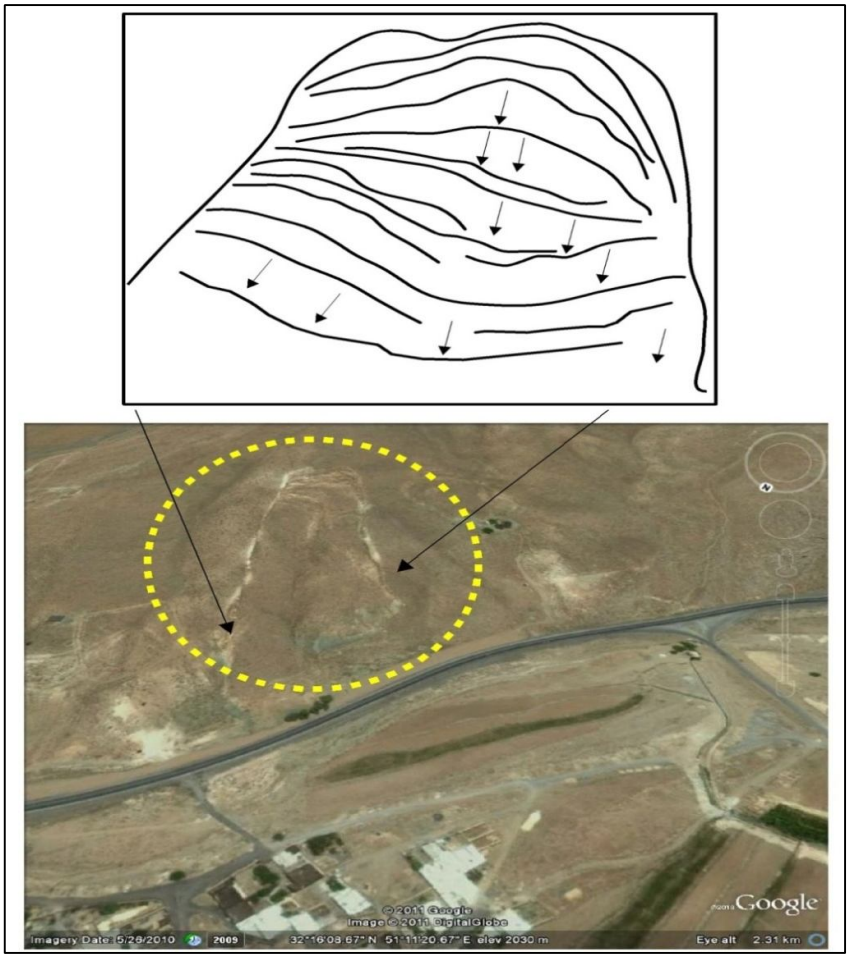

Figure (2) : landslide in Hardang

The most abundant soli-flexions are formed in the slopes with severe or partially severe slope in a very extensive level (Khayam, 1994). Fractures in the permanent icy conditions consist of movement of fine grain soils that were full of ice during the past, and this type of movement can occur in each mild slope. The main mechanism in the next to glacial system consists of the continuous event of freezing and defrosting, freezing is very weak in the dry environment whereas it is very much in wet environments. In the wet environments since

water penetrates very well in the stones or in the deposits and it is frozen in the temperature of under zero degree, while freezing the volume of water is increases and it causes to fracture the stones and/ or inflame the soil. During the melting of ice and snow also the stone pieces which had been connected by ice are separated and fall down. The comparative study that was performed in 1953 at Kark Vaj North Switzerland between air temperature and atmospheric rainfall and stone fall indicates that the most amount of stone falling occurs during the melting of snow (Rap, 1960). In this diagram, the circle is the sign for falling of agglomerates, small triangle is the sign for falling of small pieces of stone and large triangle is the sign for falling of large pieces of stone. Figure (2).

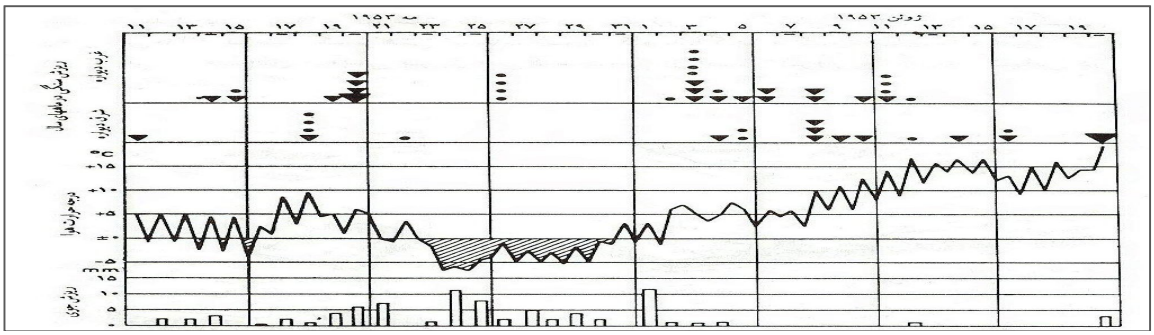

Figure (2). Comparison between temperature and atmospheric fall and stone fall (Rap, 1960).

On the other side, the water that is obtained from melting snows and deep icing of the deposits saturates soil very well and causes to create a special type of soil-flexion called jelly flexion (movement of materials in colloid form within the glacial environments). This movement occurs when saturation of soil from water is complete, because frozen soils impede from penetrating water towards down. Melting of ice and snow saturates the land surface of the area and creates soil current within the superficial soil level (Chorli, 1985).

Partially, existence of little amounts of water and ice create creep, because these materials act as a transferring environment and as a result slow creeping movement is as a result of the effects for disintegration of the materials created from the alteration of melting and freezing and materials inflation.

4-CONCLUTION

Hardang landslide is as an index for these types of landslides. In general, for justifying the occurrence of these types of landslides we can state that considering the fact that the dominating process on permanent snow line and its higher heights is freezing and the dominating process on water-ice equilibrium line and the range between this line and permanent snow line is melting, dislocations of these two borders within the areas under the effect of this process usually causes to create a regular sequence of melting and freezing .

Consecutive melting and freezing of snow and depositions and also their abundant nutrition in the cold season cause formation of special phenomena including some of the types of sloping movements. Often in the limits higher than permanent snow line these processes have less effect since persistence of snow in these areas is usually more than one year, but in the limits lower than this, permanent snow line does not exceed from one year, the changes of temperature around zero degree axis cause to melt a section of the snow layer and its penetration inside the deposits and re- freezing of penetrating waters. The rate of this process effect depends on the duration of icing period and particularly its repetition.

As a result of the said freezing and melting, stones and infrastructures are disintegrated. Therefore in the areas that the snow coverage persists at least more than one month, such a process occurs easily. In cases where the weather is warmed periodically, the superficial structures of the frozen ice are gradually changed to the masses of sliding mud and create soli-flexion in the slopes. The more the thickness size of the frozen land and repetition of cold and warm periods, the more the scope of these phenomena will occur . Another important point is this that the temperature limit between zero to 5 degrees coincides with the limit of a height between permanent snow line and water-ice equilibrium line. Thus considering temperature, the range of zero to 5 degrees is the most appropriate region for landslide occurrence.

If we generalize this temperature model to a location model, we can state that considering location, the range of a height between permanent snow line and water-ice equilibrium line also has the best conditions for occurring of landslide.

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