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LANDSLIDE HAZARD EVALUATION AND ZONATION OF KARAJ-CHALUS ROAD (*North of Iran*)

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ABSTRACT

Mass wasting, one of the major natural disaster, have resulted into significant injury and loss to the human life and damaged Property and infrastructure throughout the world. The studied area is located in the Alborz mountains Range from Karaj to Chalus, central Alborz mountain range, Iran; where is frequently affected by several different mass wasting types and needs to be considered and immediate attention. In this study 9 causative factors, include: drainage density, aspect, slope, vegetation density, lineation density, main fault buffer, landuse, lithology and seismic activity was considered. The studies have shown that the northern part of the rout falls under very low to low risk except near the MarzanAbad city because of the KalarDasht heights. Increasing vegetation density is one of the reasons for reducing the risk in the northern part of the rout. Very high risk zones are mainly concentrated between Aderan and Nesa cities that explained by the presence of steep slopes and the effect of the faults which affected this section of rout. There are significant risk reducing by getting away from the road. In general, most of the areas on this rout are zones that have the medium to high instability.

Contribution/Originality: This study uses new estimation methodology in landslide hazard zonation in Karaj-Chalus Road and the results of this study will help to preventing slope instability by enhancing the high risk areas.

1. INTRODUCTION

Mass wasting, one of the major natural disaster, have resulted into significant injury and loss to the human life and damaged Property and infrastructure throughout the world (Parise and Jibson, 2000; Dai *et al.*, 2002; Crozier and Glade, 2005; Kanungo *et al.*, 2006; Pan *et al.*, 2008; Raghuvanshi *et al.*, 2014; Girma *et al.*, 2015).

In general, heavy rainfall, high relative relief and complex fragile Geology with increased manmade activities, such as roads on mountains have resulted in increased mass wasting activities in the highlands of Iran.

Predicting hazardous events like landslides are particularly difficult because no laboratory exists that can preliminarily measures the necessary variables, refine the techniques, and apply the results (Dattilo and Spezzano, 2003).

It is essential to identify, evaluate and delineate mass wasting hazard prone area for proper strategic planning and mitigation (Bisson *et al.*, 2014; Raghuvanshi *et al.*, 2014; Girma *et al.*, 2015). Therefore, to delineate mass wasting susceptible slopes over large areas, Landslide Hazard Zonation (LHZ) techniques can be occupied.

The Landslide Hazard Zonation (LHZ) of an area becomes important whereby the area is classified into different LHZ ranging from very low hazard zone to very high hazard zone (Arora *et al.*, 2004)

Terrain information, such as, land cover, geology, geomorphology and drainage could also be derived from it and the existing thematic information can be updated to enable the quantification of human interference on the Earth's surface. Geographic Information System (GIS), as a computer-based system for data capture, input, manipulation, transformation, visualization, combination, query, analysis, modeling and output, with its excellent spatial data processing capacity, has attracted great attention in natural disaster assessment (Carrara *et al.*, 1999)

GIS analysis helped in determining macroscopic variables such as elevation, slope gradient, slope aspect, drainage density, etc. from Digital Elevation Model (DEM). The integration of remotely sensed data into GIS can help to develop a decision support system for further monitoring and prediction of similar activity in the area (Nagarajan *et al.*, 1998; Saha *et al.*, 2002).

Mass wasting are resulted because of natural and external activating factors. The natural factors are mainly: Geological factors (lithology or soil type, structural discontinuity characteristic, shear strength of the material, groundwater condition and its effect), Geometry of the slope (slope inclination, aspect, elevation and curvature) and landuse or landcover (Anbalagan, 1992; Ayalew and Yamagishi, 2004; Wang and Niu, 2009; Raghuvanshi *et al.*, 2014).

-The external factors which generally trigger landslides are: rainfall, seismicity and human activities such as: construction activities and soil preparation for agriculture in mountainous regions (Collison *et al.*, 2000; Keefer, 2000; Parise and Jibson, 2000; Dai and Lee, 2001; Bommer and Rodrı´guez, 2002; Dahal *et al.*, 2006; Wang and Niu, 2009; Raghuvanshi *et al.*, 2014). Several L.H.Z. techniques have been developed over the past and these can be broadly classified into three categories: expert evaluation, statistical methods and deterministic approaches (Leroi, 1997; Guzzetti *et al.*, 1999; Casagli *et al.*, 2004; Fall *et al.*, 2006; Kanungo *et al.*, 2006).

The present study area is located in the Alborz mountains Range from Karaj to Chalus, central Alborz mountain range, Iran (Fig 1). The road of this area is frequently affected by mass wasting (several different mass wasting types), and because of the damages and awful traffic on this route, it needs to be considered and immediate attention.

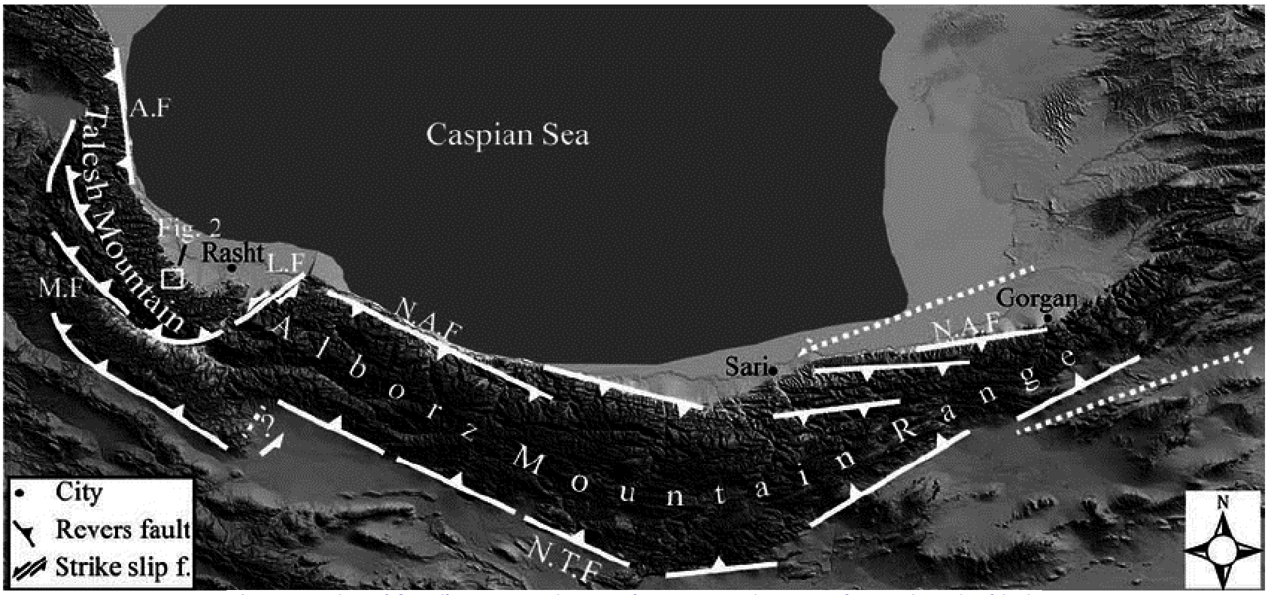

Fig-1. Location of the Alborz mountain range between Caspian Sea and central Iranian block.
Source: Digital Elevation Model from Alaska Satellite Facility website and modified by the author

2. OBJECTIVE AND GENERAL METHODOLOGY

The main objective of the present study was to prepare a L.H.Z. map of the study route. The general methodology followed include landslide inventory mapping, followed by preparation of a statistical hazard model based on various causative factors and their interrelation with past landslide. Finally L.H.Z. map was prepared based on relative influence of various causative factors.

3. THE STUDY AREA

The study area is located at the central Alborz which is known as one of the most landslide prone area in Iran (Fig 2). The length of Karaj-Chalus rout that studied in this case is about 189 kilometers, and most part of this road is a mountainous area that has the attitude of -30 to 3755 meters (Fig 3).

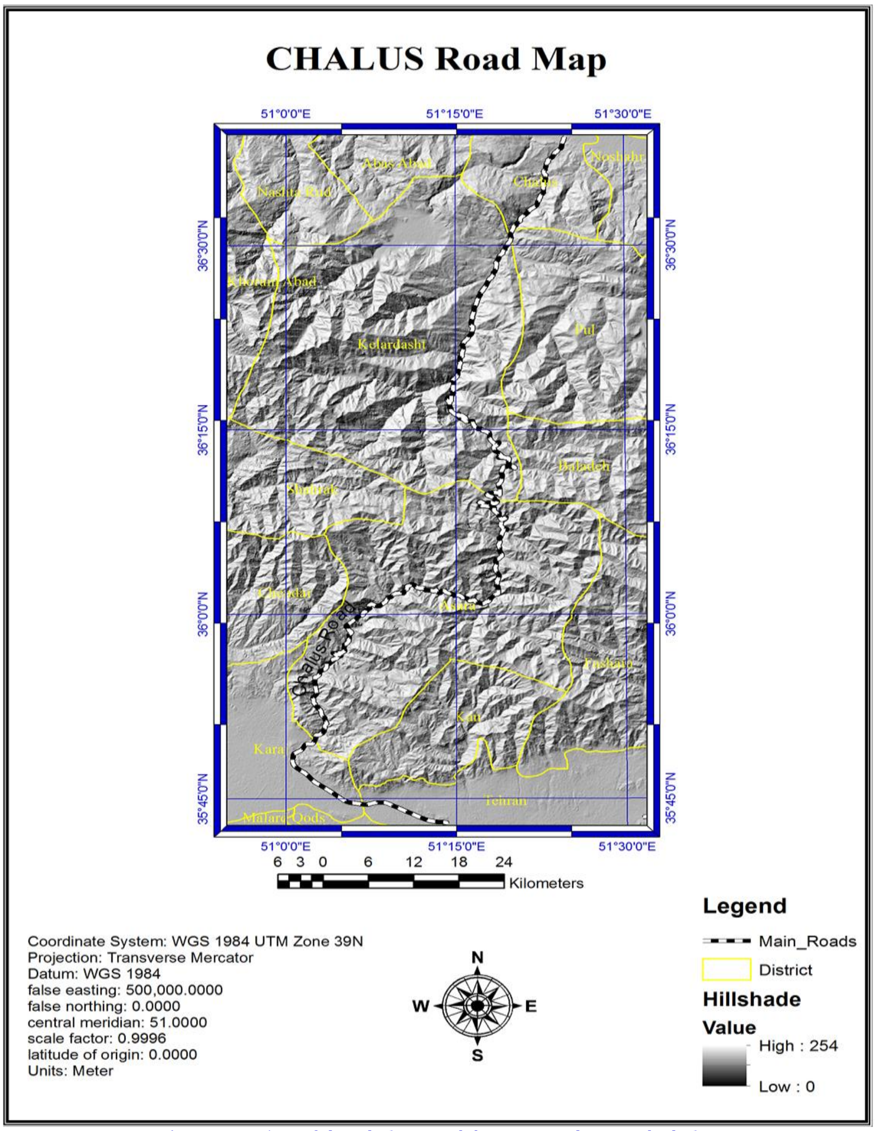

Fig-2. Location of the Chalus Road, between Tehran and Chalus.
Source: Digital Elevation Model from Alaska Satellite Facility website and prepared by the author as map

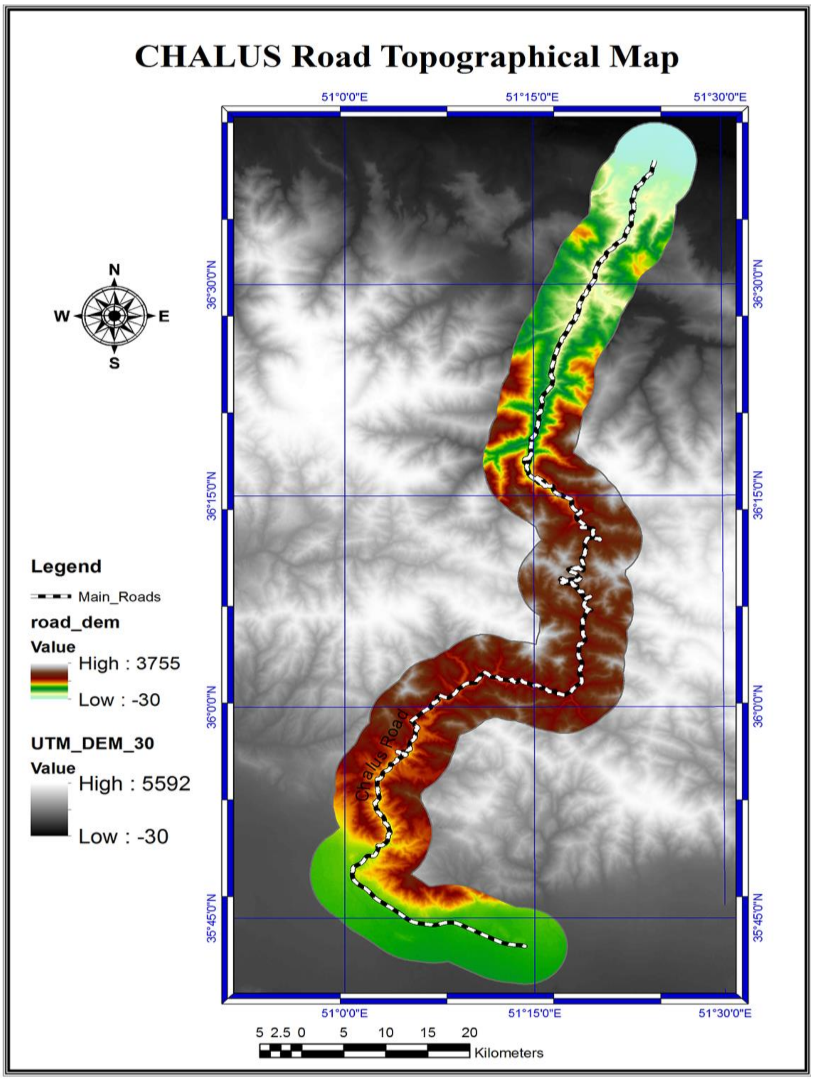

Fig-3. Topographic Map of Chalus Rout

Source: Digital Elevation Model from Alaska Satellite Facility website and prepared by the author as map

The regional geological characteristic were described by several geologist and can be found in the geological maps of the area at the scale of 1:100000 prepared by the Geological survey of Iran that known as Chalus, Marzan Abad and Tehran.

We can see the widespread variety of geological formation throughout this road, because of the long length of it (Fig 4).

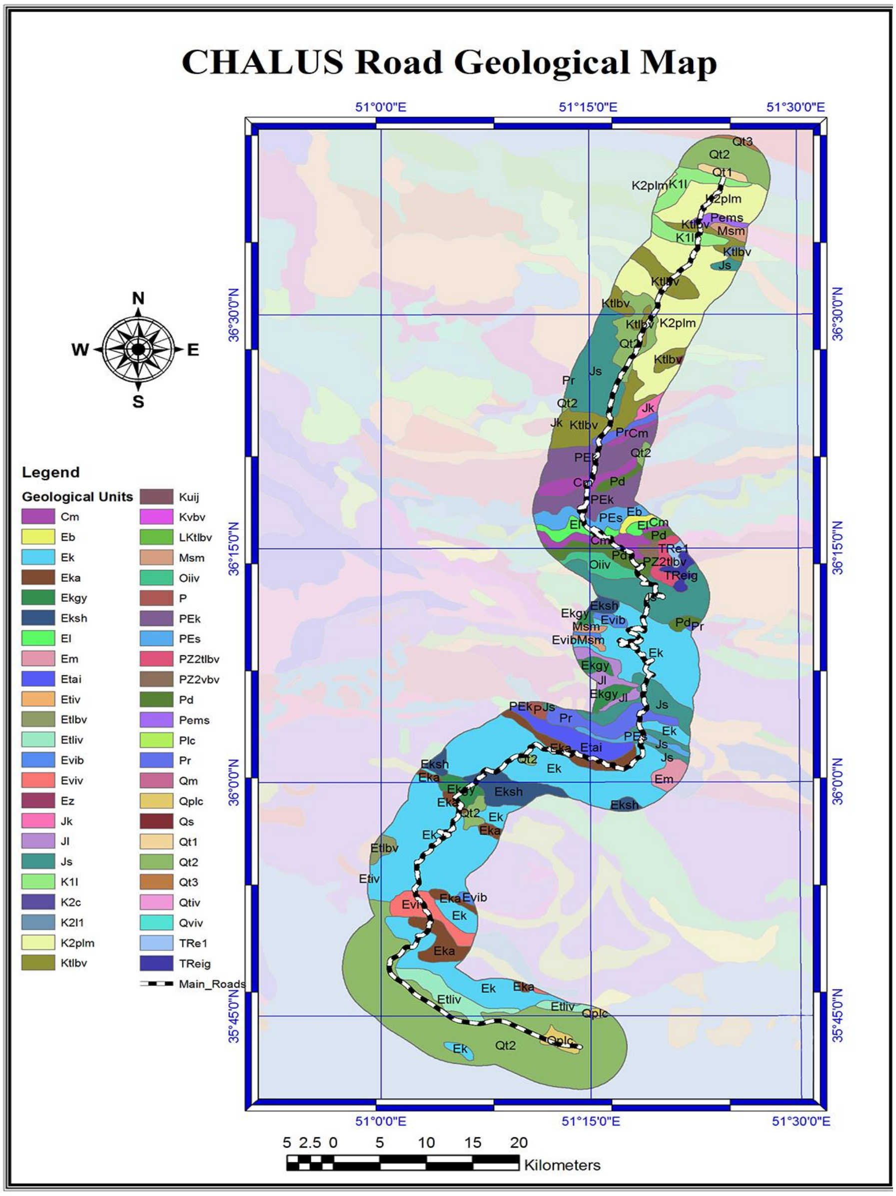

Fig-4. Geological Map of Chalus Rout

Source: Digital Elevation Model from Alaska Satellite Facility website and prepared by the author as map

4. METHODOLOGY

In this study, map combination approach was followed. This approach for landslide susceptibility donation mapping involves a number of steps:

i) Selection and mapping of the causative factors.

ii) Thematic date layer preparation with relevant categories of the factors.

iii) Assignment of weights and ratings to factors and then categories respectively.

iv) Integration of thematic data layers.

v) Preparation of landslides susceptibility zonation map showing different zones.

The prerequisite for landslide susceptibility zonation mapping is the preparation of the thematic data layers pertaining to different causative factors. These factors include: lithology, lineament, slope, aspect, landuse or landcover, drainage and etc.

Many of these factors can be obtained from the digital elevation models (DEM) (Fig 5) and the other are accessible from geological maps and satellite imagery (Fig 6 and Fig 7).

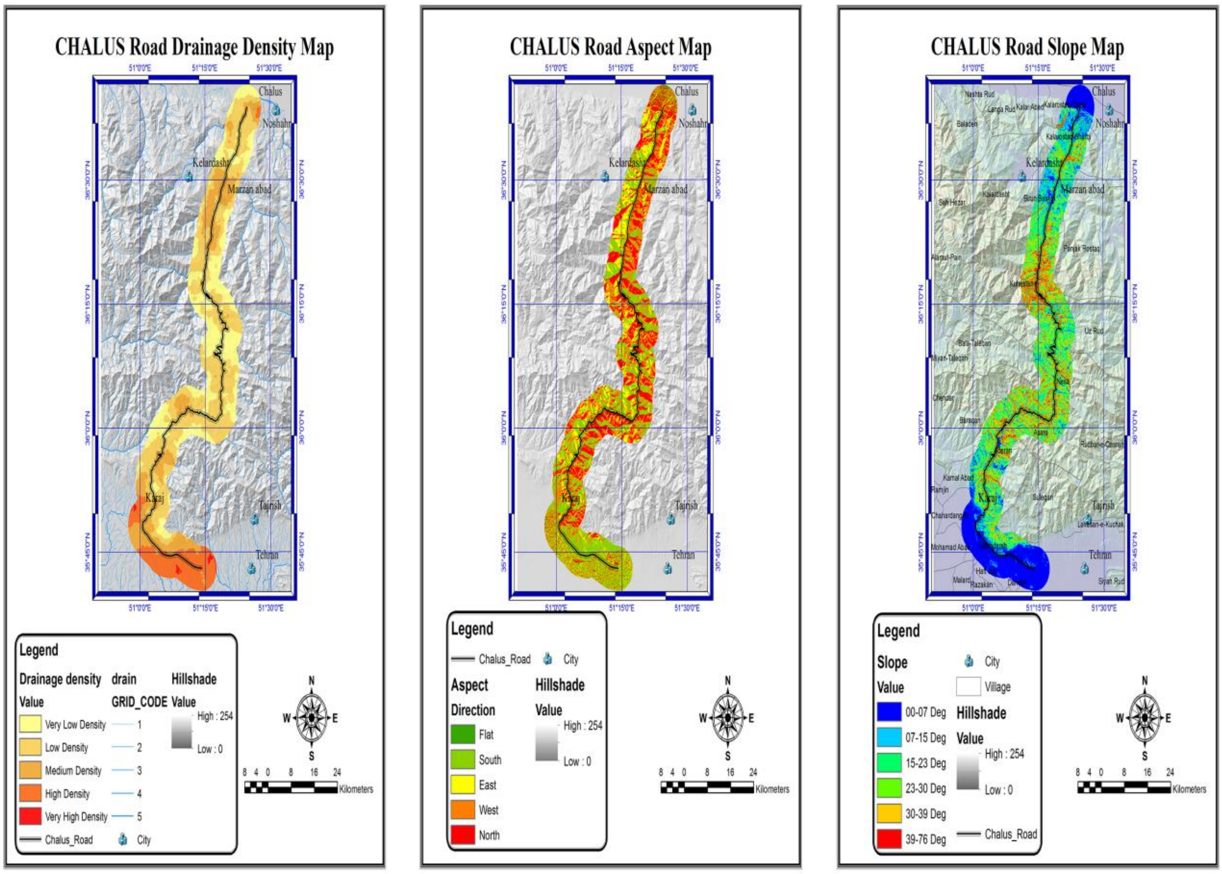

Fig-5. Drainage density, Aspect and Slope maps of Chalus road (Obtained from DEM and processed with GIS)
Source: Digital Elevation Model from Alaska Satellite Facility website and prepared by the author as map

5. LANDSLIDE HAZARD ZONATION

During the present study, 9 causative factors, drainage density, aspect, slope, vegetation density, lineation density, main fault buffer, landuse, lithology and seismic activity was considered. It was assumed that these causative factors were probably responsible for landslides in the area. By using the raster calculator in ArcGIS 10.3 the hazard map of the study area was prepared by setting a weighting assigned to causative factors equal to "1" for each of them. Further, landslide hazard zonation map of the Chalus road was prepared and classified into five classes as: Very low risk, Low risk, Medium Risk, High risk and very high risk (Fig 8).

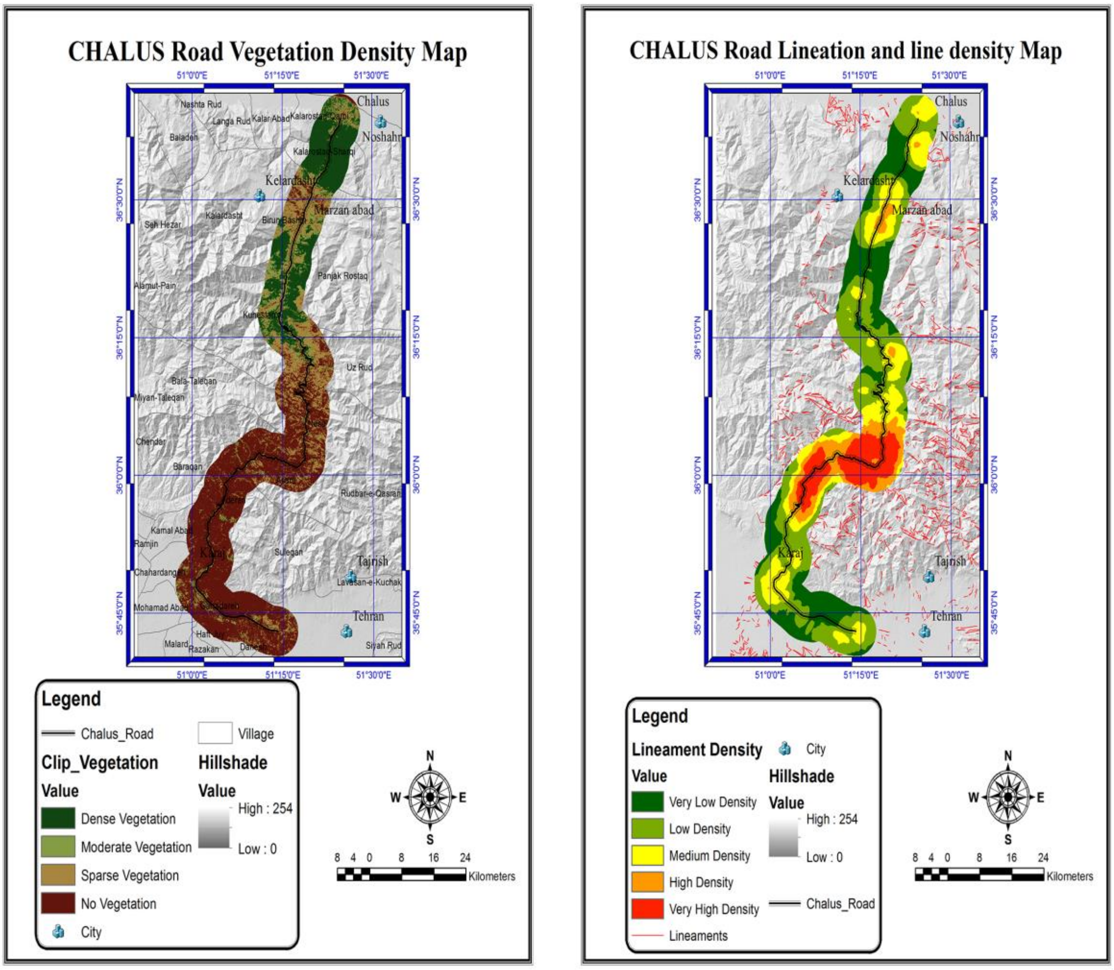

Fig-6. Vegetation Density and Lineaments and Line Density of Chalus rout (obtained from satellite imagery)

Source: Digital Elevation Model from Alaska Satellite Facility website and prepared by the author as map

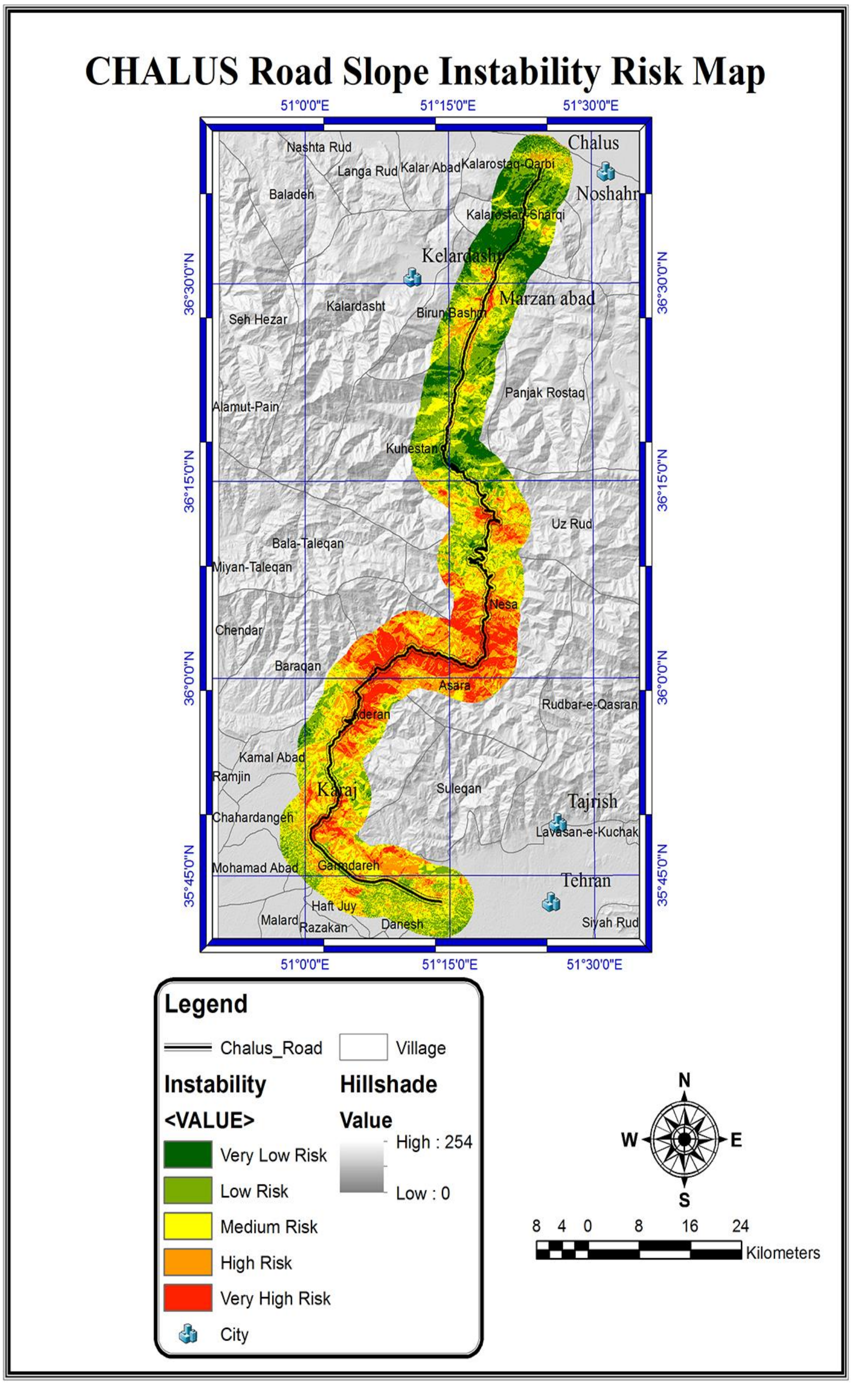

Fig-7. Landslide hazard zonation map of Chalus road.

Source: Digital Elevation Model from Alaska Satellite Facility website and prepared by the author as map

6. DISCUSSION

The landslide hazard map prepared for the present study road (fig. 8), has revealed that the northern part of the rout falls under very low to low risk except near the MarzanAbad city because of the KalarDasht heights. Increasing vegetation density is one of the reasons for reducing the risk in the northern part of the rout. Very high risk zones are mainly concentrated between Aderan and Nesa cities that explained by the presence of steep slopes and the effect of the faults which affected this section of rout. In this section and of course other sections, those hillside that facing to the west have a more chance in instability because of lack of sunlight. There is a significant risk reducing by getting away from the road, which indicates a decrease of manmade activities. In general, most of the areas on this rout are zones that have the medium to high instability. Due to the high traffic, especially on vacations, and mountainous cold weather conditions, to prevent the landslide risks, the essential measures are necessary to considered.

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