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RELATION OF SLOPE AND VEGETATION COVER WITH THE PROBABILITY OF LANDSLIDE OCCURRENCE NEAR FOREST ROADS

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Abstract

Many natural disturbances accrue in Iran because of its geographical condition. Mostly the recovery of this damage is impossible or requires a lot of time and cost. The general purpose of this research is to find out the relationship between slope of the terrain and the vegetation cover from one side and the mass movement of land from the other and to finally illustrate applicable data in the field of forest road construction. In this research, 39 cluster samples at a distance of 700 m along the 28 km of road were taken by systematic random method. In each cluster, the first sample was taken 50 m upward from the road; the second sample was taken 50 m downward from the road and the third sample was taken 10 m off the road. The number of landslides in each area and its relationship with road construction was analyzed in dependence of the terrain slope and the percentage of vegetation cover. Results showed that a road construction could be an effective factor for increasing mass movements. Moreover, excavated slope causes an increase of mass movement, too. Results of the research also indicated that there was an inverse relationship between an increased percentage of vegetation cover and the frequency of landslide occurrence.

Key words: cluster samples, forest, mass movement, road construction.

Introduction

Because of special geographical, topological and climate properties of Iran, natural disturbances are accruing in this country frequently. Landslide is one of these damages which are defined as general and deep movement of layers of soil on bedrock. Every year, this phenomenon cause's environmental damages and sometimes the recovery of this disruption is impossible or takes a lot of time and costs (Khosrozadeh 1999). Slope stability in a region is the most sensitive and important issue in construction and route selection, especially for mountainous roads. Ignoring this issue could cause irrecoverable damages to projects. Mass movement is a natural disturbance which has been occurring because of ignoring road construction standards (Alexander 1995). In order to prevent increasing damage costs, detecting and classifying effective factors which cause landslides in forests is necessary (Pyles and Froehlich 1997). Zezere et al. (1999) reported that the most important effective factors for landslide occurrences could be geological and petrology structure, land use, ancient landslides and human activities. Krogstad (2001) made a general evaluation plan about the probability of landslide occurrences in planning forest roads in the forests of northern America and achieved a regression model through comparing landslide areas to controlled areas and then illustrated several models about the probability level of landslide occurrences using effective factors. Borga (2005) investigated the effects of forest roads on shallow landslide in four regions of north Italy. He showed how the road could be effective on landslide occurrence in sensitive areas. Results of this model indicated quantitatively the rate of road effects on shallow landslides in forests. Pascual (2001) investigated reasons and effects of landslides in Nepal. He divided the effective factors in 2 classes: manmade and natural factors. Rollerson et al. (2004) prepared a guide map regarding areas that are sensitive to landslides in Canada. He found out that most of the landslides took place on clear cuts and on road construction areas. The general purpose of our research is to find out the relationship between the terrain slope and vegetation cover from one side and the mass movements of lands and finally to illustrate applicable data in the field of forest road construction to optimize timber logging.

Materials and Methods

The study area (1450 ha) is located in watershed number 7 in northern Iran (Fig. 1). This region is between 37°28′ to 37°32′ N and 48°59′ to 49°59′ E. Most of the study area has a small slope. Minimum altitude is about 100 m and the maximum is 1200 m.

Because of human activities over the last decades many disturbances accrued in that area. One sign of destruction is the reduction in percentage of vegetation canopy cover. In this research after studying the base maps, 39 cluster and 117 samples with a distance of 700 m along the 28 km road was taken via systematic randomize method (In each cluster 3 samples were taken). In a chosen area, one

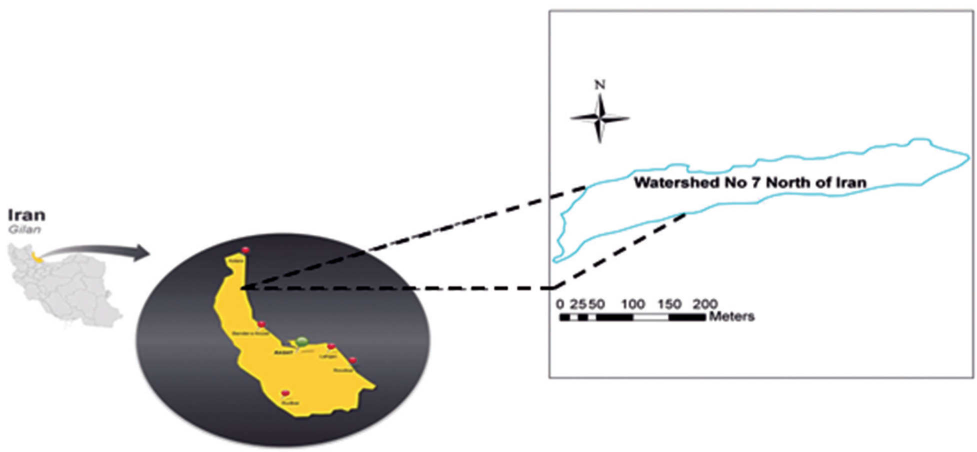

Fig 1. The study area.

sample was taken 50 m upward from the road; a second sample was taken 50 m downward from the road and a third sample was taken 10 m off the road axis. Figure 2 illustrates the location of the samples.

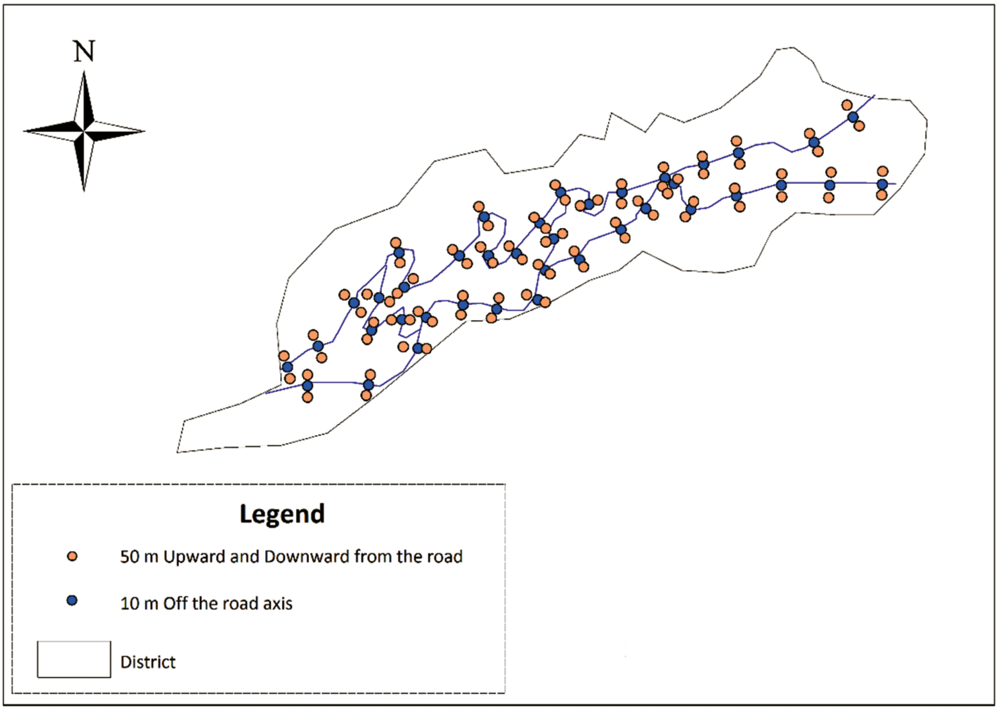

Fig. 2. Sampling locations.

Samples 50 m upward and downward from the road were considered as control plots which had the same terrain slope, slope direction and vegetation cover as the10 m samples had. No construction project took place in this area. Random systematic sampling method in shape of cluster is shown in Figure 3.

Results

Approximately 80 % of the area has a grade of less than 60 %, and 20 % of the area has a grade of 60 % to 100 %. Samples 50 m upward from the road had 4 landslides and 2 landfalls but within this 10 m off the road axis, 16 landslides and 12 landfalls were recorded which occurred along the28 km of the constructed road. Just one landslide occurred downward from the road. Thus, it can be concluded that the number of movements increase, the closer you get to the road. To summarize, results of the total mass movement along the studied road network are shown in Table 1.

The frequency of mass movements along the 28 km of constructed road indicates that most mass movements have occurred within a short distances from the road (10 m off the road). This indi-

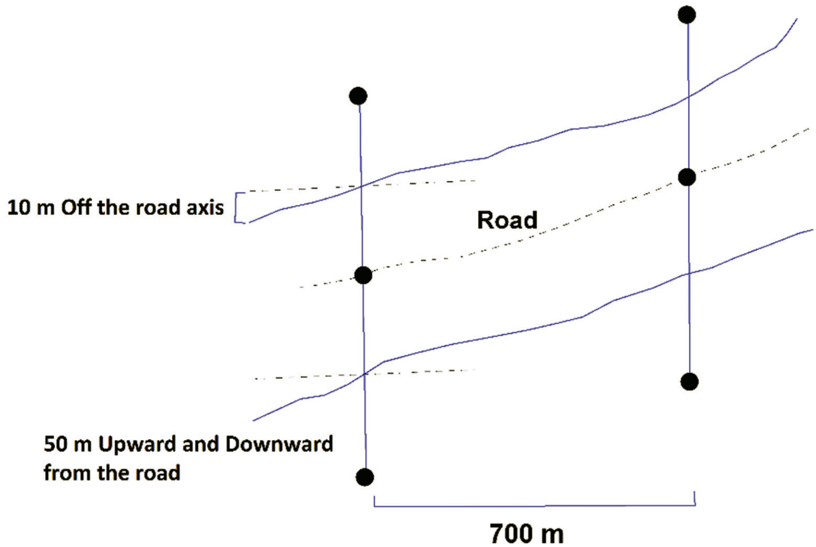

Fig. 3. View the location of clusters.

cates that road construction has an effect on landslides. In order to make results clearer, information is shown in percentage in Table 2.

Table 1. Total mass movement in the studied road network.

Sample	Number of landfall	Number of landslide
50 m upward from the road	2	4
50 m downward from the road	-	2
10 m off the road axis	12	16
Total	14	22

Table 2. Share of mass movement in sampling location.

Sample	Share of landfall, %	Share of landslide, %
50 m upward from the road	14.5	18.5
50 m downward from the road	0	9
10 m off the road axis	85.5	72.5

Landslide at the distance of 50 m downward from the road was 9 % but it was 72.5 % 10 meters off the road axis. No landfall had occurred downward the road. These results show that road construction in forests significantly increases the probability of landslides. In order to complete results, the effect of terrain grade on landslide occurrence in the study area was investigated too. The frequency of landslide and landfall and its relationship to grade classes is illustrated in Table 3.

Table 3. Frequency of landslide and landfall in different slopes.

Division of grade, %	Share of landfall, %	Number of landfall	Share of landslide, %	Number of landslide
0–30	0	0	0	0
30–60	0	0	20	4
60–80	33.3	4	20	4
80–100	66.6	10	60	14
Total	100	14	100	22

These values and percentages show that there was a significant positive relationship between the slope grade and the frequency of landslide. The landslide frequency increases an increasing terrain grade. In the next step, in each of the 117 samples the percentage of vegetation cover was measured and then classified into 5 classes to show the effect of vegetation cover on land movements. The frequency and percentage of the occurred landslides and landfalls and its relationship to classes of vegetation cover in study area is illustrated in Table 4.

Table 4. Frequency and percentage of landslide and landfall occurrences in different vegetation classes.

Class of vegetative cover, %	Share of landfall, %	Number of landfall	Share of landslide, %	Number of landslide
0–20	71.42	10	27.27	6
20–40	28.57	4	27.27	6
40–60	0	0	9.09	2
60–80	0	0	27.27	6
80–100	0	0	9.09	2
Total	100	14	100	22

According to Table 4, we concluded that there is an inverse relationship between the frequency of landslides and landfalls regarding the percentage of vegetation cover. Moreover, the rate of landslides and landfalls increase while the vegetation cover is decreasing.

Discussion

In this research, the areas which were located along the studied road were investigated through sampling method. Results indicate that mass movement along roads was higher than the rate of natural areas which were far from road construction operations. This finding was similar to Sarikhani and Gorji (2003) and Ahmadi and Esmaeli (2003) findings. In this research it was proved that the mass movement within 10 m of the road was 4 times more than that 50 m upward the road and 8 times more than 50 m downward the road. The landfall movement within 10 m of the road was 6 times more than the 50 m upward the road. Investigations about effective factors on landslide were conducted by Gerayi (2006) who demonstrated that the percentage of landslide at a distance less than 200 m far from roads was higher in comparison to further distances. Roads could be considered as an effective factor on land movements. The slope parameter could be another effective factor which leads to instability and mass movement (Keefer 2000, Wang and Xu 2001). Slope is the most important effective factor on Pathogenesis processes on a regional scale (McDaniel et al. 1992). Steep slopes cause an increase in soil erosion because of more shallow movement (Hall 1983). Slope destructions during road construction and operations without considering standards are a reason of landslide occurrences. This result was similar to Swift (1985) findings. Usually material removal from the upward to the downward in sensitive lands can intensify danger. Vegetation cover has been also recognized as an effective factor in slope stability (Komac and Gerald 2006). Rollerson et al. (2001) proved that most landslides usually occurred in road construction areas and forest clear cuttings. Vegetation cover removal causes an increase in water infiltration and consequently increases landslides. Other investigations shows that the frequency of landslide occurrences increases when a road is constructed, the forest ecosystem is changed and vegetation cover is removed (Pachauri 1992).

Conclusion

Results of this study indicate that forest road construction has significant effect on an increase in landslide occurrences and increases it several times. Thus, the relationship among them is proved. According to the collected data from this research and in comparison to other studies the hypothesis that road construction in mountainous forests causes landslide occurrences in shape of mass movement and landfall is proved. Besides, the terrain slope factor causes an increase in the frequency of landslides which indicates that slope affects the occurrence of mass movements. Moreover, results showed that there was an inverse relationship between the increasing percentage of vegetation cover and the frequency of the occurred landslides.

This paper mainly discussed the number of landslides along forest roads in relation to slope, vegetative cover and the relative distance from road. Many environmental factors are involved with landslides but their weight of influence is quite different. This paper only focused on slope and vegetative cover condition. However road construction seems the main human activities that will cause shallow landslide for area like Iran which has no or little rainfall triggered landslide. So doing such studies about other effective factors and their relation to earth mass movement in Iran is necessary.

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