УДК 624.1311.554.3

Reza Talaei
Baku State University, Azerbaijan

DETERMINATION AND ASSESSMENT OF LANDSLIDE HAZARD INDEX IN THE HASHTJIN AREA (NORTHWESTERN REGION OF IRAN)

Реза Талаеи
Бакинский государственный университет, Азербайджан

ОПРЕДЕЛЕНИЕ И ОЦЕНКА ИНДЕКСА ОПАСНОСТИ ОПОЛЗНЯ В ОБЛАСТИ ХАШДЖИН (С.-З. ИРАНА)

Abstract. We present a technique for hazard index assessment that is used to prepare the landslide prediction map of the Hashtjin area (northwestern region of Iran) at a 1:50000 scale. The proposed technique makes it possible to determine the degree of landslide hazard and assess the landslide risks. It is established that landslides occur most often on slopes composed of alternating waterproof and water-bearing rocks. The displacement of large masses of soils or rocks on a slope is most often caused by wetting the soils by rain water. As the soils are filled with water and become heavy and more mobile, they slide over the slopes. Although the action of gravity is the primary driving force for a landslide to occur, there are other contributing factors affecting the original slope stability, namely, an increase in the steepness of the slope due to washing away the soil; the weakening of strength of rocks due to weathering, precipitations and groundwater; the influence of seismic shocks; construction and economic activity. The volume of landslide damage depends on the reason which gave rise to the landslide; in some cases it can affect large areas. Landslide hazard analysis makes it possible to establish the location of potential inclined slopes and to estimate the volume of the landslide, its frequency and distance traveled. To assess the landslide hazards, necessary data are processed by a GIS. A GIS offers a superior method for landslide analysis as it allows one to generate landslide maps and maps of likely occurrences of future landslides.

Key words: landslide, landslide hazard index, hazard assessment, GIS, Iran.

Аннотация. В работе представлена процедура оценки индекса опасности, которая была использована для составления карты опасности оползня в области Хашджин (С.-З. Ирана) в масштабе 1: 50000. Установлено, что наиболее часто оползни возникают на склонах, сложенных чередующимися водоупорными и водоносными породами. Смещение крупных масс земли или породы по склону вызывается в большинстве случаев смачиванием дождевой водой грунта. Объем ущерба от оползня зависит от причины его породившей, в некоторых случаях его последствия могут распространиться на большие территории. Анализ опасностей от оползня позволила установить местоположение потенциальных наклонных склонов и оценить объем оползня, частоту и расстояния перемещения. Для оценки опасности в ГИС были введены необходимые данные.

Ключевые слова: оползень, индекс опасности оползня, оценка опасности, ГИС, Иран.

Landslide hazard maps are an essential tool for assessing landslide risk and contributing to public safety worldwide [4]. To determine landslide hazard in Hashtjin area (NW-Iran), an assessment is needed of landslide intensity (or magnitude [6]), its frequency and likely runout distance [2]. Numerous efforts have been devoted in the last four decades to develop landslide hazard maps [9].The goal

of this paper is to present a simple procedure for assessing landslide hazard index and consequent mapping of Hashtjin area.

Materials and methods

The methodology involves the following steps:

1- Compilation of a multitemporal landslide inventory map, description and classification of landslides was mainly based on the system of Varnes [10].

2- Entery of landslide location data and slope process interpretation into a GIS

3- Determination of landslide intensity and runout distance. The landslide intensity (I_L) has been defined as a function of the landslide volume (v_L) and of the landslide expected velocity (s_L), that is, $I_L = f(v_L, s_L)$. Frequency of landslides in Hashtjin area has been classified as three classes. High frequency corresponds to recurrence intervals of less than 40 years, moderate frequency between 40 to 300 years, and low frequency when landslide events may occur with recurrence periods higher than 300 years [3]. The following equation can be used to describe the relationship between landslide volume and runout length [7]:

$$L_{max} = 15.6\ V^{0.39} \qquad (1)$$

where Lmax is runout distance and V is the volume of the landslide.

4- Definition and assessment of landslide hazard index

Results

Hashtjin area, which occupies an area of 1645.84 km2, is located in the northwest of Iran. Landslides are classified according to the types of movements (Fig. 1).

The mapped landslides cover an area of 156.75 km^2, which is 9.52% of the study area (Table 1).

Landslide intensity

The results of table 2 have been showed in expected landslide intensity map on the base of landslide magnitude classification. For the evaluation of danger in the landslide zones, the intensity of events is also introduced in a two-entry matrix.

To this end, a simple ranking of intensity, expressed by the velocity of the process, was adopted, as shown in Table 3. Large landslide, the creep cases excepted, are considered of having, at least, moderate hazard because intensity is always high [1].

Hazard index

Following the aforementioned procedure, assessment of intensity (or magnitude) and frequency for all landslide types has been carried out at each landslides and landslide zones. From each landslide source the downslope affected area has been estimated. According to Corominas et al. (2003) [1], as a result all cells have been classified according to the hazard matrix (Table 4).

At the final, the hazard index is represented in the map, which is shown in Figure 2. This map shows the hazard at the Hashtjin area for different types of failures.

Discussion

The proposed method ascertains landslide hazard in the areas of evolution of the existing landslides, and for the various types of failures. Landslide hazard classes have been estimated by combining the value of landslide frequency and intensity, in four classes, based on the estimated landslide volume and the expected landslide velocity. The index expresses landslide hazard, keeping distinct the tow components of the hazard. It is worth noticing that values of the landslide hazard index do not provide an absolute rank of hazard level. The proposed method complies with the existing and widely accepted definitions of landslide hazard [5, 6 and 10] and can be used to convert of landslide susceptibility map to hazard map [8].

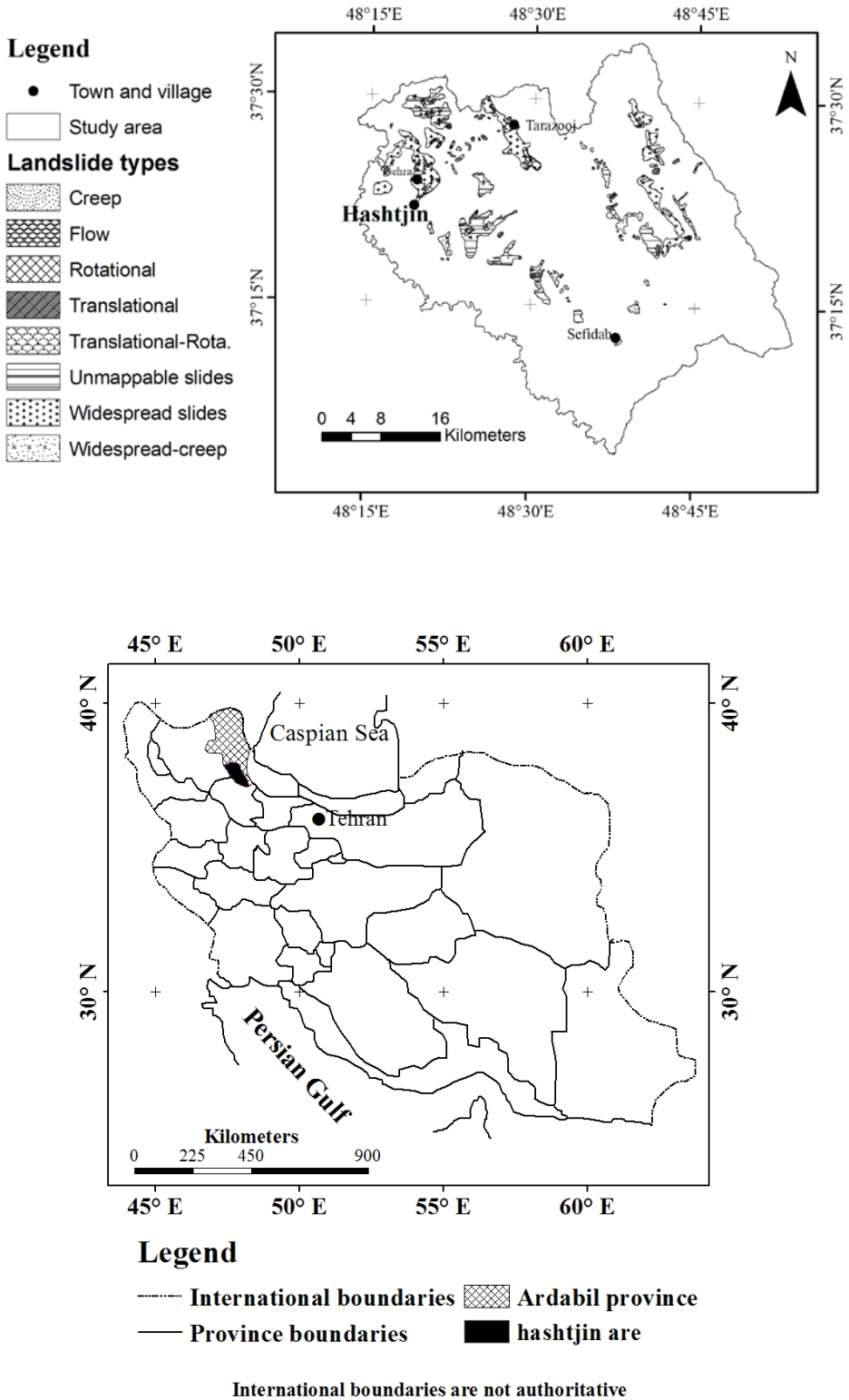

Fig 1. The position of the region of study and landslides map

Tab. 1

Frequency distribution and area of landslides with reference to their types

Type			Frequency	Percent	Cumulative Percent	Area (km^2)
Landslide	Flow		19	10.9	14.9	2.23
	Sliding	Rotational	19	10.9	25.7	3.64
		Translational	74	42.3	68.0	9.27
		Translational- Rotational	25	14.3	82.3	5.75
Landslide zone	Creep		7	4.0	4.0	4.04
	Unmappable slides		12	6.9	89.1	54.79
	Widespread slides		16	9.1	98.3	71.12
	Widespread-creep		3	1.7	100.0	5.88
Total			175	100.0	-	156.75

Tab. 2

Single landslides intensity, in four classes, based on the estimated landslide volume and the expected landslide velocity

Estimated volume (m^3)	Description	Expected landslide velocity			
		Very rapid to rapid-moving flow	Rapid translational or translational-rotational slides	Slow translational or translational-rotational slides	Slow rotational slides
>5000 <50000	Small		Slight (1)		
> 50000 <250000	Medium	Medium (2)	Medium (2)	Slight (1)	Slight (1)
>250000 <1000000	Medium-large	High (3)	High (3)	Medium (2)	Medium (2)
>1000000 <5000000	Very large	Very high (4)	High (3)	High (3)	Medium (2)
>5000000	Extremely large	Very high (4)	Very high (4)	Very high(4)	High (3)

Tab. 3

Ranking of the intensity of landslide zones

Type of mass movement zones	Expected landslide velocity			
	Very slow	Slow	Rapid	Very rapid
Unmappable zones		Medium (2)	High (3)	Very high (4)
Widespread zones		Medium (2)	High (3)	Very high (4)
Creep zones	Slight (1)	Slight (1)		
Widespread and Creep zones		Medium (2)		

Tab. 4

Index of hazard based on frequency and intensity of the landslide events

Intensity	Frequency (return period –years)		
	Low >300	Moderate 300-40	High <40
Very high (4)	Medium	High	High
High (3)	Low	Medium	Medium
Medium (2)	Very low	Low	Low
Slight (1)	Very low	Very low	Very low

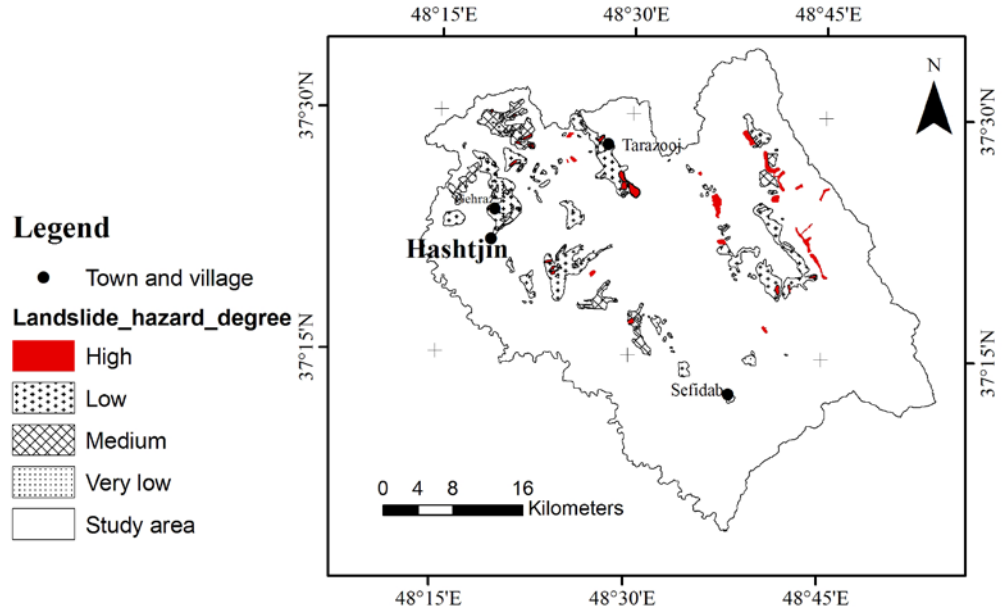

Fig. 2. Maps of the index of landslide hazard zones, for old and recent sliding, flow and landslide zones (High H.= 17.14 (km^2); Medium H.= 40.54 (km^2); Low H.=94.40 (km^2) and Very low H. = 4.66 (km^2))

REFERENCES:

1. Corominas, J., R. Copons, J., Manuel, A. Vilaplana, J. Altimir and J., Amigó. 2003. Integrated Landslide Susceptibility Analysis and Hazard Assessment in the Principality of Andorra, Natural Hazards, 30: 421-435.
2. David N. P., Gareth J. H. and Andrew H. 2005. Towards the Development of a Landslide Risk Assessment for Rural Roads in Nepal, In: In: Glade, T, M., Anderson, M. J., Crozier (eds)) Landslide hazard and risk. John Wiley & Sons Ltd, England, 597-619 pp.
3. Fell, R., J., Corominas, C., Bonnard, L., Cascini, E., Leroi, W. Z., Savage . 2008. Guidelines for landslide susceptibility, hazard and risk zoning for land use planning, Engineering Geology, 102, (3-4): 85-98.
4. Glade T., Anderson M.G., Crozier M.J. (Eds.), 2005. Landslide Hazard and Risk. Wiley, New York. 824 p.
5. Guzzetti F., Cardinali M., Reichenbach P. and Carrara A., 1999a, Comparing landslide maps:a case study in the upper Tiber River Basin, central Italy, Environmental Management, 25(3), 247–363.
6. Guzzetti F., Carrara A., Cardinali M. and Reichenbach P., 1999b, Landslide hazard evaluation: an aid to a sustainable development, Geomorphology, 31, 181–216.
7. Legros F., 2002, The mobility of long-runout landslides, Engineering Geology, 63, 301–331.
8. Reichenbach, P., M., Galli, M., Cardinali, F., Guzzetti, F., Ardizzone. 2005. Geomorphological Mapping to Assess Landslide Risk: Concepts, Methods and

Applications in the Umbria Region of Central Italy. In: Glade, T, M., Anderson, M. J., Crozier (eds)) Landslide hazard and risk. John Wiley & Sons Ltd, England, 429-468 pp.
9. Sharma, M and R. Kumar. 2008. GIS-based landslide hazard zonation: a case study from the Parwanoo area, Lesser and Outer Himalaya, H.P., India. Bull. Eng. Geol. Environ., 67: 129-137.
10. Varnes D.J. and IAEG Commission on Landslides and other Mass Movements, 1984, Landslide Hazard Zonation: A Review of Principles and Practice (Paris: UNESCO Press), 63 pp.