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Landslide Hazard Zonation Of Khotebesara Watershed In North Of Iran

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Abstract:
Landslides are significant natural geologic hazard around the world. Landslides cause extensive losses to livelihoods and property and claim many lives. Landslide Hazard Zonation (LHZ) simply means the division and preferably subdivision of a land surface into various zones according to the degrees of actual / potential hazard caused by landslides and related phenomena. In this research LHZ were studied in the Khotbesara watershed in the north of Iran. The ground slope, land use and rock types were used for identification of LHZ. The results showed that 7.3 percent of area is under low LHZ, 3.1 percent is under moderate LHZ, 1.9 percent is under high LHZ and 1.4 percent is under very high LHZ. The main purpose of preparing the Landslide Hazard Zonation maps is to utilize them in future planning in this region.

Key words: *Landslide, ground slope, land use, watershed, KhotebeSara*

1.Introduction

Landslides are among the major natural hazards in the world. A landslide is a common natural hazard that results in loss of human lives and causes widespread damage to property and infrastructure [1]. Landslides cause extensive losses to livelihoods and property and claim many lives. Landslide hazard (LH) defines the physical attributes of a potentially damaging landslide in terms of mechanism, volume and frequency [2]. Identification of regions having potential for landslide occurrence is one of the basic measures in natural resources management which decreases damages causes by these phenomena [1]. Hazard map for certain areas is made in order to reduce the landslide vulnerability and risk [3]. They are very significant for urban planning and land use in general. Hazard map must provide information about the possibility and the type of landslide appearance, about the instability and the dimension of the affected area. This objective is possible via different ways such as landslides hazard zonation for determining the hazardous areas and providing recipes and regulations for appropriate uses of these areas or for keep away from them [1]. Landslide Hazard Zonation (LHZ) simply means the division and preferably subdivision of a land surface into various zones according to the degrees of actual potential hazard caused by landslides and related phenomena [4]. Ideally, hazard can be assessed by answering questions: what, where, how strong" and „how often. Investigating landslide hazard and risk includes the geotechnical and engineering assessments, geomorphological and geographic analysis, polytical and economic perspective, as well as the commercial and social circumstances [1 & 6]. As a final goal, the investigation and studying of landslides is to find ways to reduce their damages. Landslides are significant natural geologic hazard around the world [1]. Mountainous terrains are characterized by steep slopes, fractured and folded and high relative relief weathered rocks [1 & 6]. Landslides appearance is consequence of complex conditions and loading which act in the slope and appear when the shear stresses exceed the value of the shear strength of the soil material. In the broad sense hazard is defined as process and situation, action and reaction which can cause damage, loss, or other unfavorable effects. Landslides in mountainous terrain often occur during or after heavy rainfall, resulting in the loss of life and damage to the natural and /or built environment [6]. Landslides constitute one of the major damaging natural hazards in mountainous regions [1 & 2]. Landslides are one of the critical geological processes, which cause not only enormous damage to civil engineering structures i.e. roads, railways, bridges, dams, bio-engineering structures, and houses but also lead to loss of life [1, 3, 5]. Hence, there is a need for landslide hazard zonation for identification of potential landslide areas. The scope of this study was to generate landslide hazard zonation maps that can be utilized to identify the potential landslide hazard in the mountainous area.

2.Material And Methods

2.1.Descriptive Of Study Area

The study area is located in the north of Iran in Guilan province (Fig1). The study area is a watershed of Khotbesara located between 48º 41′ 24″ to 48º 55′ 14″ longitude and 37º 55′ 12″ to 38º 3′ 49″ latitude, which is covered 58.8 km^2 (Fig1). The average slope of watershed is 38.6 percent. The slope aspect is north eastern and north western. The Khotbesara watershed is located north side of Alborz mountain region. The altitude ranges is -13 to 2224 meters from sea level. The sum of rivers length in this watershed is 156 km. The mean annual precipitation according to the last 10 years statistical period is 1013 mm which mostly falls at autumn and winter. The climate is very wet on the base of Demorton climate clasification. The most area of this watershed is covered by broad-leaved forest.

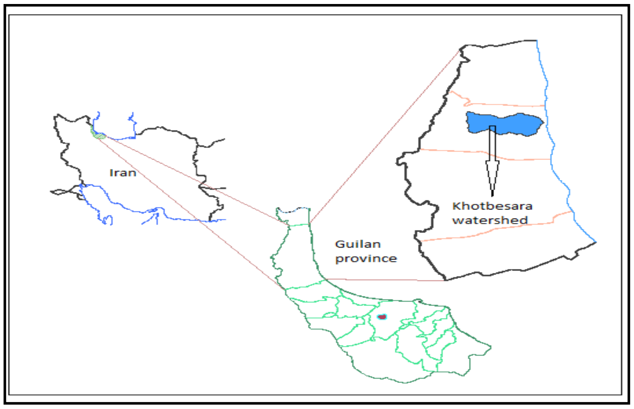


Figure 1: Location Map Of The Study Area

2.2.Method

In this study characteristics of three main factors (Vegetation covers (VC), ground slope (GS) and rock types (RT)) were used for assessing land slide hazard zonation in the study area [1 & 7]. On the base of vegetation cover map (land use), the area and percentage of vegetation cover were recorded in four classes: High (dense forest), medium (open forest), light (pasture) and agriculture). On the base of ground slope map, the area and percentage of ground slope were recorded in five classes: < 20%, 21-40%, 41-60%, 61-80% and >81%. On the base of rock types map, the area and percentage of rock types were recorded in four classes: Sandstone, Shale-Siltstone, Siltstone-Shale and Crumpled Shale. The factors and classes were weighted on a scale from 1 to 10 (). On the base of overlap of maps and sum of weighted classes (SWC), study area was divided in five landslide hazard zones: Very low (<5), low (6-8), moderate (9-10), high (11-12) and very high (>13).

Parameter	Category	Weight
vegetation covers	High	1
	Medium	2
	Light	4
	None	6
Ground Slope (%)	< 20	2
	21-40	3
	41-60	4
	61-80	8
	81-100	6
rock types	Sandstone	4
	Shale-Siltstone	8
	Siltstone-Shale	9
	Crumpled Shale	10

Table 1: Ratings For Parameters On A Scale Of 1-10

3.Results And Discussion

Vegetation cover is one of the important factors in preparing landslide hazard zonation maps (). The vegetation covers and land use areas in the study area are shown in figure 2. The statistical of different land use cover are shown in table 2. About 84.3 percent (49.6 km^2) of watershed area is covered by dense forest (Canopy cover more than 70%). About 4.3 percent (2.5 km^2) of watershed area is covered by open forest (Canopy cover less than 70%). The pasture area is 1.8 km^2 (3.1%) and about 8.3 percent of watershed area (4.9 km^2) is covered by agriculture zone. The most agriculture zone is located in lowland of watershed (Figure 2).

vegetation covers	Dense forest	Open forest	Pasture	Agriculture	Total
Area (km^2)	49.6	2.5	1.8	4.9	58.8
Percentage	84.3	4.3	3.1	8.3	100

Table 2: The Vegetation Covers (Land Use) In Khotbesara Watershed

The position of different ground slopes in watershed is shown in figure 3. The statistical of area and percentage of different ground slopes are shown in table 3. About 51.2 percent (30.1 km^2) of watershed area is covered by less than 20 of percent ground slopes and about 16.1 percent (9.5 km^2) is covered by 21 to 40 percent of slopes. The areas of ground slopes of 41 to 60, 61 to 80 and upper 81 percent were covered 7.4, 6.3 and 5.5 km^2 (Table 3).

Ground Slope (%)	< 20	21-40	41-60	61-80	>81	Total
Area (km^2)	30.1	9.5	7.4	6.3	5.5	58.8
Percentage	51.2	16.1	12.6	10.7	9.4	100

Table 3: The Ground Slope (%) Conditions In Khotbesara Watershed

The position of different rock types are shown in figure 4 and their statistics of area and percentages are shown in table 4. The most watershed area (43.2% or 25.4 km^2) is covered by sandstone and only 4.9 percent (2.9 km^2) is covered by crumpled shale (Table 4).

Rock Types	Sandstone	Shale-Siltstone	Siltstone-Shale	Crumpled Shale	Total
Area (km^2)	25.4	16.1	14.4	2.9	58.8
Percentage	43.2	27.4	24.5	4.9	100

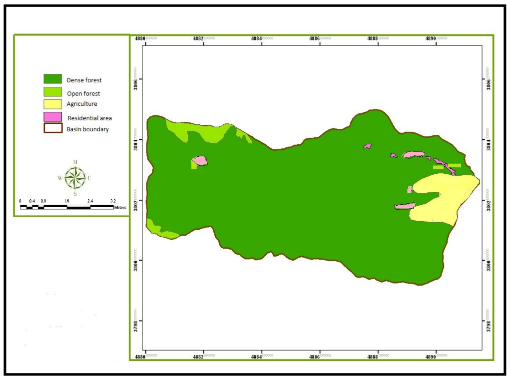
Table 4: The Rock Type Statics In Khotbesara Watershed

Combining all the controlling parameters by giving different weightage value for all the themes, the final LHZ map is prepared and categorized into Very High, High, Moderate, Low and Very Low hazard zones. The landslide hazard zonation map is shown in figure 5. The main purpose of preparing the Landslide Hazard Zonation maps is to utilize them in future planning in this region. The statistical of landslide hazard is shown in table 5. About 86.3 percent (50.8 km^2) of watershed area is covered by very low landslide hazard zoon. This zone includes areas where the combination of various controlling parameters is generally unlikely to adversely influence the slope stability. Vegetation is relatively dense, the ground slopes are generally low, about 20 percent or below. About 1.4 percent (0.8 km^2) of watershed area is covered by very high landslide hazard zoon. Geologically, this zone is highly unstable and is at a constant threat from landslides, especially during and after an intense spell of rain. Since the very high hazard zone is considered highly susceptible to landslides, it is recommended that no human induced activity be undertaken in this zone. Such areas have to be entirely avoided for settlement or other developmental purposes and preferably left out for regeneration of natural vegetation for attainment of natural stability in due course of time [1, 9 & 10].

LHZ Code	Hazard class	Area (km^2)	Percentage
1	Very low	50.8	86.3
2	Low	4.3	7.3
3	Moderate	1.8	3.1
4	High	1.1	1.9
5	Very High	0.8	1.4
Total	-	58.8	100

Table 5: Landslide Hazard Zonation (LHZ) Statistics In The Study Area

Natural factors, including bedrock geology, topography, and vegetation, influence landslide occurrence. Many anthropogenic factors, such as logging and road construction, also affect slope stability [14]. Landslides appearance is a geomorphological process associated with soil configuration and structure, hydrogeological parameters, climate and vegetation conditions in which they appear. Hazard assessment requires understanding of spatial and time variation of the threatening process. The ability of hazard and risk prediction is limited, because we can hardly say when and with which consequences (risks) something is going to happen, which makes the assessments generally determined as the probability or the possibility of a certain event [15]. Hazard represents the likelihood of landslide occurrence at locations with specific local conditions at specific time.



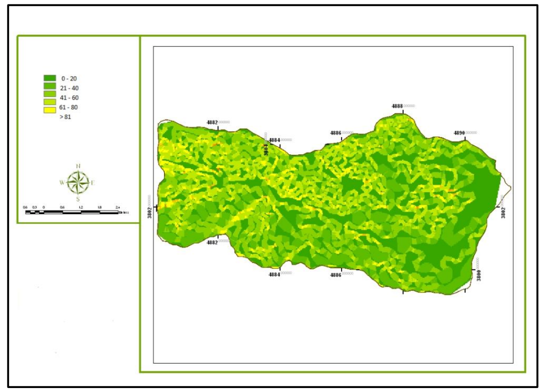


Figure 2: The Land Use Coverage Map In The Study Area & Figure 3: The Ground Slope Map In The Study Area

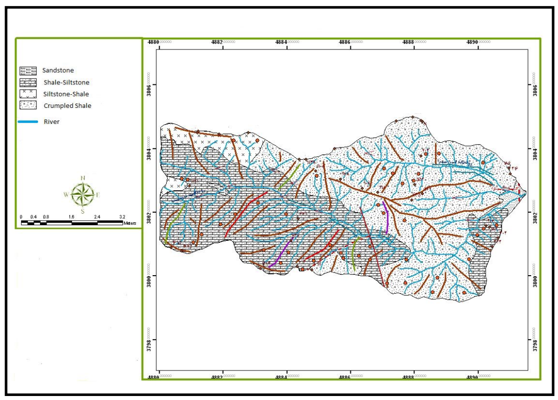


Figure 4: The Rock Type In The Study Area

Investigating landslide hazard and risk includes the geotechnical and engineering assessments, geomorphological and geographic analysis, political and economic perspective, as well as the commercial and social circumstances [1].

The maps identify the safe areas, and the areas which can be utilized with corrective measures. Therefore, by querying this spatial database with the budgetary allocations, and the user requirements the planners and developers can select the sites which are ideal for their intended purpose. Similarly, these maps can be overlaid with a map of Land Use to identify the plantations which are threatened by potential landslides, and the plantations which need to be well managed to maintain the stability of the slopes. Most importantly, an overlay of the Landslide Hazard Zonation map, and the Human Settlements and Infrastructure map can be used to identify the endangered human settlements for taking early actions to assure the safety of them. Risk is represented with the degree of accomplished hazard on specific location during a specific period of time, or the cost of accomplished consequences [16]. In many cases the vulnerability indicates on losses in larger degree than hazard. Vulnerability expresses the resulted consequences of natural force impact [8, 17 & 18].

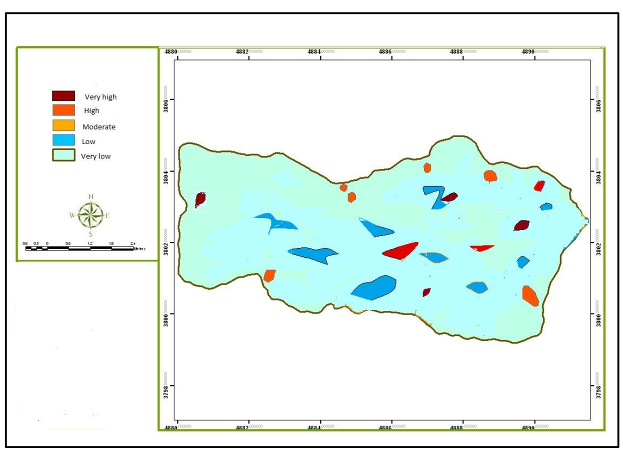


Figure 5: The Landslide Hazard Zonation Map In The Study Area

4.Conclusion

In this study landslide zonation map with five classes of hazard was prepared based on the relative effect of the vegetation cover (land use), ground slope and rock types in the Khotbesara watershed. Interpretation of future landslide occurrence needs an understanding of conditions and processes controlling landslides in the study area. A landslide hazard zonation map indicates relatively potential zones such as low, medium, medium high, high and very high for landslide occurrence.

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