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# Preparation of Landslide Hazard Zonation Map of Jharkhand Hilly Areas

Jayanti Prabha Bharti<sup>1</sup>, Waqar Khan<sup>2</sup>, Parvesh Kumar<sup>3</sup>, Dileep Kumar Gupta<sup>4</sup>

<sup>1</sup>Faculty of VGI, UPTU, <sup>2</sup>Faculty of Galgotia College of Engg, Gr. Noida,

<sup>3</sup>DTU Research Scholar, <sup>4</sup>Faculty of VGI

<sup>1</sup>bhartijayanti@gmail.com

**Abstract:** Landslide is one of the most hazardous natural phenomena which occurs due to ground movement and failure of slopes in hilly areas. Hence my research work is mainly focused on preparation of landslide hazard zonation map of Jharkhand hilly areas. This map is mainly based on the guidelines of the LHZ mapping (Ambalagan, 1992 and, BIS 14496, 1998). In this work, first I have selected a scale for mapping and determined litho logical, structural, slope morphometry, land cover, relative relief and hydrological conditions of different hilly areas of Jharkhand with the help of site exploration and survey data. On the basis of these data, landslide hazard zonation factor has been decided for different conditions. Further, all the factors has been summed up and final hazard factor is observed. By this factor, we finally draw the hazard map for different hilly areas of Jharkhand. We observe that only Giridh area lies in high hazard zone. Some areas like Ranchi, Singhbhum and Hazaribagh lie in medium hazard zone. Some areas like Garhwa, Palamu are in low hazard zone. Hence constructions should be avoided in Giridh area of Jharkhand.

**Keywords:** BIS 14496, Jharkhand hilly area, hazard map

## 1. INTRODUCTION

Landslide is one of the most hazardous natural phenomena which occurs due to ground movement and failure of slopes in hilly areas. As the whole world is covered with many hills and mountains including India, So it is a serious threat for people living around hilly areas and engineering constructions around it. Now a day's engineering constructions are increasing with very fast rate in different hilly regions of the world. Lack of proper geological and geotechnical investigation adversely affects existing geoenvironmental condition. Hence it is essential to know about landslide hazard evaluation technique so that problems related slope stability can be avoided.

Ali Yalcin and Fikri Bulut 2007; Lulseged Ayalew et.al., 2005, Carrara et.al., 1992; Mantovani et.al., 1996; Varnes 1984; Van Westen et.al. 1992, 1996; Crozier 1986 etc. attempted to review the underpinning issues, concepts,

objectives and methodology for ultimately reducing hazard and risk arising from landslides.[1,2]

In Indian contexts, many workers like Pachauri and Pant 1992; Gupta and Joshi 1990; Anbalagan 1992, Anbalagan and Singh 1996; Sharma 2008; Saha et.al., 2002; Nagarajan et.al., 1998, etc. have carried out the studies of landslides in different regions of the country and drawn landslide hazard zonation map in different hilly areas like NAINITAL, MANIPUR etc.[1,2] but there is no any hazard map of JHARKHAND HILLY AREA prepared so far.

Hence present paper is focused on preparation of landslide hazard zonation map of Jharkhand hilly areas.

## 1.1 GENERAL DESCRIPTION OF JHARKHAND

Jharkhand state is a land blessed with the natural gift of immense mineral potential. Its many areas are covered with hills.



**Fig 1. Jharkhand district map**

### A) BOKARO DISTRICT

Bokaro district lies in the eastern portion of Jharkhand state. In winter season temperature comes down to 3 to 4<sup>0</sup>C when

cold wind blows, otherwise the temperature ranges between 10 to 15°C.[3] The average rainfall is 1570 mm. geologically the area is comprised with Archean Granites and Gneisses. In northern part Gondwana rock formation occur in patches. [4] It consists of area of less than 300 meter elevations. The districts have climatic condition slightly different because of less elevation and less forest cover.

#### **B) CHHATRA DISTRICT**

Chatra district is located in the Hazaribag plateau. It has an elevation of about 450 m. Kalua hill and Lahabar hill forms the higher elevations of the district.[3] Geologically the area is comprised with Archean granites and gneisses. In southern part Gondwana rock formation occur in patches. Major rivers flowing in the district are Yamuna, Barki, Chako, Damodar and Garhi. [4] The district receives an annual rainfall of 1250 mm. and most of the rainfall occurs during the rainy season.

#### **C) DHANBAD DISTRICT**

Dhanbad district is located in the eastern portion of the state. Geologically, the area is comprised with Archean granites and gneisses. In southern part Gondwana rock formation occur in patches.[4] During winter season temperature range from 8.4 to 34 °C and during summer season temperature ranges from 13.3 to 45.5°C. During rainy season the temperature ranges from 15 to 36 °C. Average annual rainfall is 1270 mm. This district has relatively less forest cover. Forest is confined in the northern hilly area. [3]

#### **C) DUMKA DISTRICT**

Dumka district is the part of Santhal Paragana Commissioner and is located in the north eastern part of the state. The average elevation of the hill ranges between 150 to 300 meters.[3] Geologically the area has basaltic trap and sedimentary beds. Quartz and gneisses are found in some places. [4] Major rivers draining the district are Ajay, Mor, Barakar, Brahmani etc. The district receives an annual rainfall of 1500 mm. and most of the rainfall occurs during the rainy season. During winter season the temperature varies between 16 to 21 °C and during summer season it varies between 22 to 30°C.[3]

#### **D) EAST SINGHBHUM**

East Singhbhum district is situated at the extreme corner of the southeast of Jharkhand. The Dalma and Dhalbhum are main hill ranges and covered by dense forest. The relief is high in southern and north western portion of the district.[3] Geologically the area is comprised with granites, gneiss and schist. Formations of igneous, sedimentary and metamorphic rocks of Dharwarian period are found at places [4].

Major rivers in the district are Subarnarekha and Kharkai. The district receives an annual rainfall of 1500 mm. and

most of it occurs during the rainy season. Mean annual temperature is above 26 °C.[3]

#### **E) GARHWA DISTRICT**

Garhwa district is located in the north-western part of the state. Geologically the area is comprised with Archean granites and gneisses. Alluvium of recent to sub-recent age is found in the river valley. During winter season temperature ranges from 9.5 to 35 °C and during summer season the temperature ranges from 18 to 45 °C. The average rainfall is about 120cm.[3]

#### **F) GIRIDIH DISTRICT**

Giridih district is located in the northern part of the state. The lower plateau areas have relatively rough terrain having an elevation of 390 meters. In the north and North West there is a table land having an elevation of 250 meters, where steep scarp is found. Geologically the area is comprised with Archean granites and gneisses with capping of laterites at some places. The district receives average annual rainfall of 1350 mm. and most of the rainfall occurs during the rainy season. The highest temperature goes up to 40 °C but the average temperature during winter season remains at 10 °C. The hilly portions are under thick forest cover. Important trees are sal, Khair, semal.[3]

#### **G) HAZARIBAG AREA**

Geologically the area is comprised with Archean granites and gneisses with Gondwana series in the southern part of the district. The district receives annual rainfall of 1350 mm and more than 80 percent rainfall occurs during monsoon season. Annual average temperature is 23°C. In summer season the temperature in extreme cases increases to 44 °C and during winter the same come down to 2 to 3 °C.[3]

#### **H) KODERMA DISTRICT**

Kodarma district lies in the northern portion of the state. The northern scarps have steep slopes. Average elevation of the area ranges 300 to 500 meters above mean sea level. The plateau of the district has Dharwarian rocks like quartz and schist containing Pegmatite veins in which good quality mica is found. Southern part of the district comprised with Archean granites and gneisses. The average rainfall of the area is 1200 mm. and most of the rainfall takes place during rainy season. The average annual temperature remains about 25°C, but summer and winter season records much variation in temperature.[3]

#### **I) PALAMU DISTRICT**

Palamu district is located in the north-western parts of the state. Geologically the hill area is made of metamorphic rocks with sandstones, conglomerates and lava capping having thick mantle of laterite at some places. During winter season the area records 16 to 18 °C and during summer season the temperature increases up to 41 °C.[3]

**J) RANCHI DISTRICT**

Ranchi district is located in the centre of the state. Hills lying on west have elevation above 800 meters and those lying in east have elevation less than 75 metres. The district experiences pleasant climatic condition though tropic of Capricorn passes over it due to higher elevation.[3]

**K) SAHIBGANJ**

Sahibganj district is located in the north east of the state. Geologically the area has basaltic trap and sedimentary beds. Quartz and gneisses are found in some places. The district receives an annual rainfall of 1500 mm. and most of the rainfall occurs during the rainy season. During winter it becomes cool and record average temperature of 15 °C. but during summer temperature ranges from 30 to 40 °C. Plain areas have become almost devoid of vegetation but hilly area have considerable vegetative.[3]

**L) WEST SINGHBHUM**

West Singhbhum district is located in the southern portion of the state. The plain areas have the elevation about 300 meters but the hilly areas have about 300 to 500 meters.

Geologically the area is comprised with Archean granites and gneisses. Dharwarian formations occur at some places. The district receives an annual rainfall of 1420 mm. and most of the rainfall occurs during the rainy season. The winter season remains reasonably cold when minimum temperature is 3 to 4 °C and the average temperature remains at 16 °C. The area reveals variation in land use pattern. All the hilly ranges are under forest areas. [3]

**2. METHODOLOGY**

The methodology is based on the guidelines of the LHZ mapping (Ambalagan, 1992 and Bureau of Indian standard, BIS 1998). In this method, first thematic or base maps are prepared by using survey of India. Then some geological factors are calculated on the basis of different type of geological properties of existing rock with the help of IS 14496 code rating scheme. These geological factors are

**2.1 LITHOLOGY**

First we calculate lithological factor depending on different type of rocks with the help of following lithological rating scheme.

**TABLE 1: Lithological rating scheme (after ANBALGAN, 1992 and BIS 14496)**

Lithology	Types Of Rock	Rating		
Rock Type	Type 1			
	QUARTZITE AND LIME STONE	0.2		
	Granite And Gabbro	0.3		
	GNEISS	0.4		
	Type 2			
	Well Cemented Sedimentary Rock	1.0		
	Poorly Cemented Sedimentary Rock	1.3		
	Type 3			
	Slate And Phyllite	1.2		
	Schist	1.3		
	Highly Weathered Shale, Schist And Phyllite	2		
Soil Type	Ordered Well Cemented Fluvial Fill Material	0.8		
	Clayey Soil With Naturally Form Surfaces	1		
	Sandy Soil With Naturally Form Surface	1.4		
	Older Well Compacted	1.2		
	Younger Loose material	2		
Correction factor		For rock type 1		For rock type 2
	For highly weathered rock, C <sub>1</sub>	C <sub>1</sub>	4	1.5
	For moderately weathered rock, C <sub>2</sub>	C <sub>2</sub>	3	1.25
	For slightly weathered rock, C <sub>3</sub>	C <sub>3</sub>	2	1

## 2.2 STRUCTURE

Structures of the area include bedding planes, several set of joints, faults and folds etc. After calculating lithological factor, we calculate structural factor depends on bedding inclinations with the help of structural rating scheme.

**TABLE 2: Structural rating scheme (After ANBALGAN, 1992 and BIS 1998, IS 14496)**

RELATIONSHIP OF STRUCTURAL DISCONTINUITY WITH SLOPE		CATEGORY	RATING
RELATIONSHIP OF PARALLELISM B/W THE SLOPE AND DISCONTINUITY	I	$>30^0$	0.20
	II	$21-30^0$	0.25
	III	$11-20^0$	0.30
	IV	$0-10^0$	0.40
	V	$<5^0$	0.50
RELATIONSHIP OF DIP OF DISCONTINUITY AND INCLINATION OF SLOPE	I	$>10^0$	0.3
	II	$10^0 - 0^0$	0.5
	III	$0^0$	0.8
	IV	$-10^0 - 0^0$	1.0
	V	$> -10^0$	0.2
DIP OF DISCONTINUITY	I	$<15^0$	0.20
	II	$16-25^0$	0.25
	III	$26-35^0$	0.30
	IV	$36-45^0$	0.40
	V	$>45^0$	0.50
DEPTH OF SOIL COVER	I	$<5$ m	0.65
	II	6-10 m	0.85
	III	11-15 m	1.30
	IV	16-20 m	2.0
	V	$>20$ m	1.20

## 2.3 SLOPE MORPHOMETRY, RELATIVE RELIEF, LAND USE AND LAND COVER, AND HYDROGEOLOGICAL CONDITION

After calculating lithological and structural factor, we calculate slope morphometry factor, relative relief factor, land use and land cover factor and hydro geological factor with the help of IS 14496 chart.

**TABLE 3: Other geological rating scheme (After ANBALGAN, 1992 and BIS 1998, IS 14496)**

CONDITION	TYPES	DEGREE	FACTOR
SLOPE MORPHOMETRY	ESCAPEMENT CLIFF	$>45^0$	2.0
	STEEP SLOPE	$36-45^0$	1.7
	MODERATELY STEEP SLOPE	$26-35^0$	1.2
	GENTLE SLOPE	$16-25^0$	0.8
	VERY GENTLE SLOPE	$<15^0$	0.5
RELATIVE RELIEF	LOW	$<100$ m	0.3
	MEDIUM	100 – 300 m	0.6
	HIGH	$>300$ m	1
LAND USE AND LAND COVER	AGRICULTURAL/ POPULATED FLAT LAND		0.6
	THICKLY VEGETATED FOREST		0.8

CONDITION	TYPES	DEGREE	FACTOR
	AREA		
	MODERATELY VEGETATED AREA		1.2
	SPARSELY VEGETATED AREA WITH LESSER GROUND COVER		1.5
	BARREN LAND		2
HYDROGEOLOGICAL CONDITION	FLOWING		1.0
	DRIPPING		0.8
	WET		0.5
	DAMP		0.2
	DRY		0.0

After calculating all geological factors, we summed up these factors. Maximum value of all these factors are kept from following table

**TABLE 4: Maximum rating for contributory factors, BIS 14496**

CONTRIBUTORY FACTORS	RATING ( MAXIMUM)
LITHOLOGY	2
STRUCTURAL	2
SLOPE MORPHOMETRY	2
RELATIVE RELIEF	1
LANDUSE/ LAND COVER	2
HYDROGEOLOGY	1
<b>TOTAL</b>	<b>10</b>

Finally we decide hazard zone on the basis of final value with the help of following table

**TABLE 5: BIS 14496, Zone classification**

AREA OF JHARKHAND	LITHOLOGICAL FACTOR	STRUCTURAL FACTOR	SLOPE MORPHOLOGY	RELATIVE RELIEF
BOKARO	0.9 1.2	0.25	1.7	0.6
CHHATRA	0.9 1.2	0.25	1.7	1
DHANBAD	0.6 0.8	0.25	1.7	0.3
DUMKA	0.6 0.8	0.25	1.7	0.6
EAST SINGHBHUM	1.2 1.6 1.3	0.25	1.7	1
GARHWA	0.9 1.2 1.4	0.25	1.7	0.3
GIRIDIH	1.2 1.6	0.25	1.7	0.6
HAZARIBAGH	0.9 1.2	0.25	1.7	0.3

KODERMA	0.4 0.6 0.8 1.3	0.25	1.7	1
PALAMU	1.25 1.4	0.25	1.7	0.3
RANCHI	0.6 0.8 1.3	0.25	1.7	1
SAHIBGANJ	0.4 0.8 1.4	0.25	1.7	0.3
WEST SINGHBHUM	1.2 1.6	0.25	1.7	1

### 3. CALCULATIONS AND RESULTS

TABLE 6: CALCULATIONS OF TOTAL HAZARD EVALUATION FACTOR & ZONE

AREA OF JHARKHAND	LAND USE & LAND COVER	HYDROGEOLOGICAL FACTOR	THEF	ZONE
BOKARO	1.5	0	4.95 5.25	LOW HAZARD ZONE MEDIUM HAZARD
CHHATRA	0.8	0	4.65 4.95	LOW HAZARD ZONE LOW HAZARD ZONE
DHANBAD	1.2	0	4.05 4.25	LOW HAZARD ZONE LOW HAZARD ZONE
DUMKA	1.2	1	4.35 4.5	LOW HAZARD ZONE LOW HAZARD ZONE
EAST SINGHBHUM	0.8	0	4.95 5.35 5.05	LOW HAZARD ZONE MEDIUM HAZARD LOW HAZARD ZONE
GARHWA	1.2	0	4.35 4.65 4.85	LOW HAZARD ZONE LOW HAZARD ZONE LOW HAZARD ZONE
GIRIDIH	0.8	0	6.15 6.55	HIGH HAZARD ZONE HIGH HAZARD ZONE
HAZARIBAGH	1.2	0.5	4.85 5.15	LOW HAZARD ZONE MEDIUM HAZARD
KODERMA	1.2	0	4.55 4.95 4.75 5.45	LOW HAZARD ZONE LOW HAZARD ZONE LOW HAZARD ZONE MEDIUM HAZARD
PALAMU	0.6	0	4.1 4.25	LOW HAZARD ZONE LOW HAZARD ZONE
RANCHI	1.2	0	4.75 4.95 5.45	LOW HAZARD ZONE LOW HAZARD ZONE MEDIUM HAZARD
SAHIBGANJ	1.2	0.5	4.35 4.75 5.35	LOW HAZARD ZONE LOW HAZARD ZONE MEDIUM HAZARD
WEST SINGHBHUM	0.8	0.5	5.45 5.85	MEDIUM HAZARD MEDIUM HAZARD

TABLE 7: Total hazard evaluation factor

ZONE	TEHD value	Description of zone
1	< 3.5	Very low hazard zone
2	3.5-5.0	Low hazard zone
3	5.1-6	Medium hazard zone
4	6.1-7.5	High hazard zone
5	> 7.5	Very high hazard zone

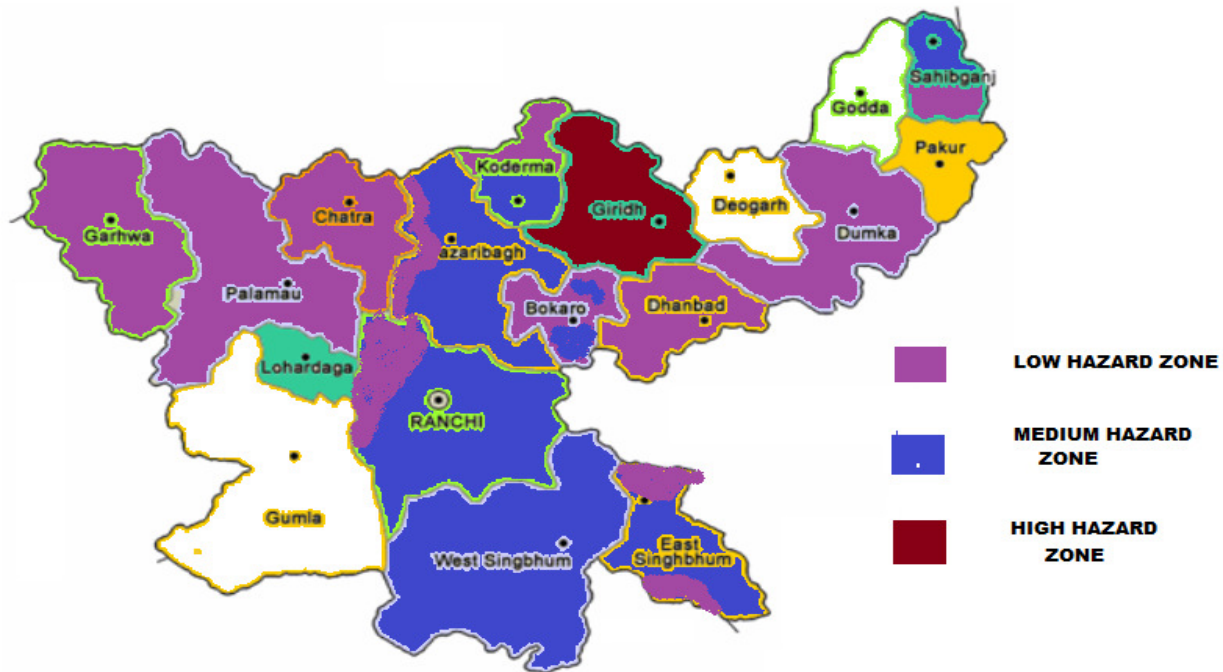


Fig. 2. Landslide hazard zonation maps of Jharkhand hilly areas

#### 4. CONCLUSIONS

Finally landslide hazard zonation map of Jharkhand area has been prepared with the help of IS code 14496. We conclude that some Jharkhand areas like GARHWA, PALAMU, CHATRA, BOKARO, DHANBAD and DUMKA lie in low hazard zone. Some areas of Jharkhand like RANCHI, EAST SINGBHUM, WEST SINGBHUM, HAZARIBAGH, KODERMA and SAHIBGANJ lie in medium hazard zone. Only GIRIDH area lies in high hazard zone. Hence, we should avoid for making engineering constructions around that area.

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