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Research Paper

Underline Causes and Damage Assessment of Landslide Hazards in Bangladesh: A Case of 2017 event in Rangamati District

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ABSTRACT

Landslide hazard has become a burning issue for Bangladesh that is occurring about every year and causes physical, environmental, economic and social damage with a lot of death and causalities. In last 50 years Bangladesh has lost more than 600 people in landslide hazards. This death toll is increasing day by day as in 2007, 2008, 2010, 2012, 2017 it has lost 135, 43, 60, 115, 163 lives respectively. In June 2017 landslide hazards of Chittagong division have resulted in 160 deaths and 234 injured. Most of the damages occurred in Rangamati district in the last landslide event as it has detached for one month from other districts and lost 120 people that's why Rangamati district has been selected as the study location. The present study attempts to identify the physical and human induced causes of landslide hazards and damage assessment. Through household survey including Participatory Rural Appraisal (PRA) and Focused Group Discussions (FGDs) found that rainfall, weak soil structure, earthquake are the physical causes and hill cutting, deforestation, wrong cultivation systems, leakage in water pipe, unplanned urbanization are the major causes of landslide. Landslide in Bangladesh also occurs in specific time from June to August month of the year.

1. Introduction

Bangladesh is a multi-hazard prone country and landslide is not new phenomenon in Bangladesh. However, it has never been hazardous like the incident of Chittagong on 11 June 2007 (Mahmood and Khan, 2010). Presently landslide is occurring frequently in the hilly regions of the country (Chisty, 2014). In last decade 2007-2017 more than 451 people died. A recent landslide in June 12, 2017 has taken about 175 people lives where in 2012 about 90, in 2010 about 53 and in 2007 about 127 people has died (NDRCC, 2017). **Table 1** has presented the summary of landslide hazards in Bangladesh from the last 50 years. Including huge death toll many houses are damaged and domestic animals died in those landslides.

Understanding the landslide mechanism and underline causes are very important to reduce the damages. To understand landslide disaster properly some steps required more importance like road development process, building structure, construction materials, slope and load management etc. At first it will be the causes of landslide. Causes of landslide are different from place to place, environment to environment and community to community. Then the damage assessments of the particular landslide event will provide

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clear picture which will be given a clear understanding about landslide. And the most important part is to know how to live in the hilly area safely. The objectives of the study are to identify the underline causes, damage assessment and to provide some policy guidelines.

Table 1: Review of previous Landslide in Bangladesh

Year	Place	No. of Death	No. of Injured	Data sources
2017	Khagrachari, Rangamati, Bandarban , Mowlovibazar, Coxbazar and Chittagong	163	234	DDM report
2015	Chittagong, Majhirghona	2	Unknown	Prothom Alo
2013	Ballaghat area, Sylhet	3	2	Daily star
2012	Bandarban, Coxbazar, Chittagong	94	Unknown	Kaler kantho
2011	Batali Hill of Chittagong, Ramjadi, Bandarban	19	Khulsi	ADPC
2010	Coxbazar	60	100	BBC
2009	Lama, Bandarban , Near Habiganj Town, Syltet	22	09	BBC
2008	Lalkhan Bazaar,Cox's Bazaar, Teknaf And Ukhia Upzilas	43	Unknown	Sarwar, 2008
2007	Motijharna, Power Colony, Kushumbagh, Taragate, Devpahar, Chittagong, Lebubagan Of Chittagong	135	213	Banglapedia
2003	Coxbazar	6	2	Bangla-pedia
2000	Chittagong University Campus	13	20	SAARC
1999	Lama Thana, Bandarban	7	Unknown	Bangla-pedia
1997	Chittagong University Campus	13	20	Banglapedia
1990	Rangamati	Unknown	Unknown	Banglapedia
1970	Rangamati	Unknown	Unknown	Banglapedia

Source: Prepared by the authors based on various sources.

2. Methodology

2.1 Selection of the study sites

As the Rangamati district is severely damaged by landslide hazards among others district in 2017, so this district has been selected purposively. The study areas have been selected purposively to consider loss and damage from ward no 06 of Rangamati municipality of Rangamati Sadar Upazila of Rangamati district. These study locations are mostly affected and vulnerable for landslide disaster. One location is dominated bv indigenous people (Chakma tribal community) named Jubo Unnayan Para (JUP) which is located between 22° 39' 02.4" N and 92° 09' 26.48" E. another one is Bengali settler dominated area named West Muslim Para (WMP) located in between: 22° 39' 21.7" N and 92° 09' 12.4" E. Distances between two locations are 874 meter only by road and 740 meter straight line (**Fig. 1**).

2.2 Data collection

A combination process of qualitative and quantitative data collection has been followed to conduct this study. This includes the use of following tools: Interview schedule for the households of two study villages, Focused Group Discussions (FGDs) with active participation of local community in the affected area and Key Informant Interviews (KIIs) from different key personals in relevant sectors. Sample size was 100 for the Household survey where 60 Households from the West Muslim Para (Bengali settler community) and 40 Households form the Jubo Unnoyon Para (Chakma tribal community) of Rangamati Sadar upazila of Rangamati district. The survey was conducted to get the actual information from the local level.

Secondary sources of data and information have been collected from various governmental organizations like DC office, Municipality office, LGED office, land office, weather station, various non-governmental offices. Data collected from relevant articles, books, local and national newspapers, and various types of maps and Shape files collected from Municipality office for GIS analysis.

3. Results and discussions

3.1 Causes of landslide

Landslides occur as a result of changes on a slope, sudden or gradual mass movement, either in its composition, structure or in its hydrology, vegetation. The change can be due to geology, climate, weathering, land use and earthquakes (Sahni et al., 2011).

To measures the respondents' perception they were asked to give rating to the causes in the range of 0-5 scale. They rated the causes according to the magnitude of the cause to occurring landslide. The most responsible cause is rated in higher number to the lower responsible cause. After collecting their rating to the causes they were summarized and ranked following their value.

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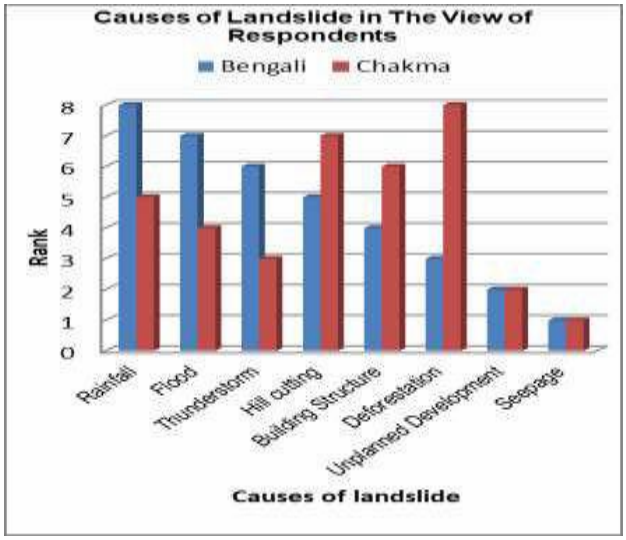

Fig. 2. Causes of Landslide
Source: Field survey by the authors in 2017

This process was applied to the both study areas so that it can be compared between their views.

Fig. 2 shows the different view of both Jubo Unnayan Para and West Muslim Para about the causes of landslide. Their perceptions are quite different in most of the causes. This table make It clear that people form Chakma tribal community are giving priority to the long term causes where people from the West Muslim Para are giving priority to the short term causes. People form West Muslim Para think that heavy rainfall, flash flood and thunderstorms are the major causes of the landslide hazard. But people form the Jubo Unnayan Para thinks that hill cuttings, deforestation, building various structures are the main causes for the landslide. They also think that the seepage water form water pipe and the unplanned development are also responsible for present landslide.

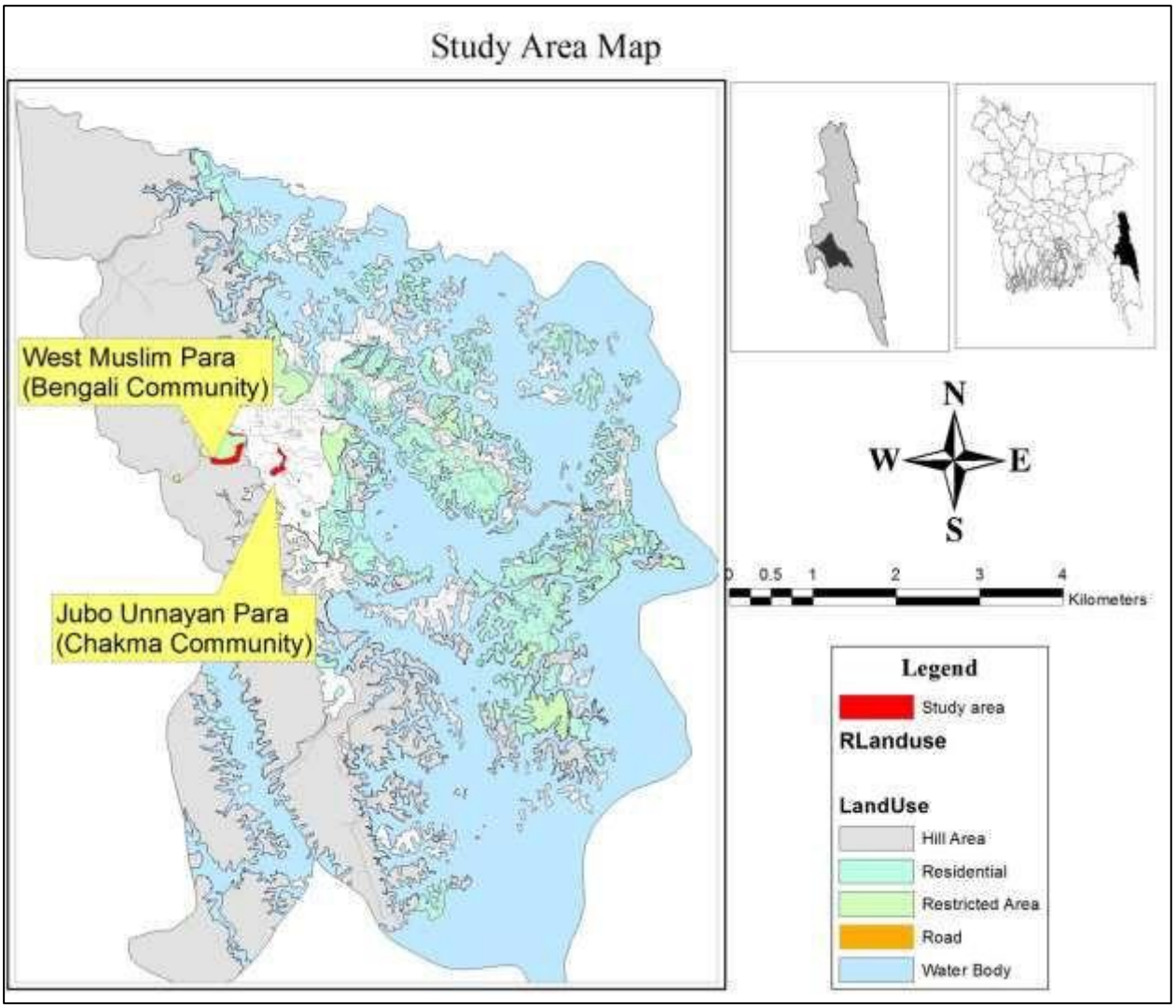

Fig. 1. Study Area Map
Source: Prepared by the Authors based on field survey

3.1.1 Hill cutting

Presently indiscriminate hill cutting is one of the major causes of landslide in Chittagong hill track areas. Hills of Chittagong are being cut for construction, developing residential/housing area, clay and sand mining and developing road network (Mahmood and Khan, 2010).

People of the West Muslim Para are less conscious than Jubo Unnayan Para concerning hill cutting and its consequences. Rate of hill cutting is higher in the West Muslim Para than Jubo Unnayan Para because population density of West Muslim Para is higher than Jubo Unnayan Para that's why they need more houses and built more houses by cutting the hill. On the other side the cutting hill in higher angle is more dangerous. About 6.7 percent people form the west Muslim Para respondent think that hill cutting is not responsible for the landslide rest of the people think it is not a major cause for landslide. On the other hand 77 percent people form the Jubo Unnayan Para think that hill cutting is one of the major causes of landslide. So the peoples' perception is quite different between the Bangali Settler and Tribal community.

3.1.2 Deforestation

Deforestation is also another major cause of landslide in Rangamati district. Vegetation protects the soil and makes slope stable thus reduce the risk of landslides. Large trees provide strong structures in the earth that anchor the soil and protect it from any erosion (Sultana, 2013). In the both study areas deforestation has taken place for building their house. Rate of deforestation is higher in the West Muslim Para. Around 50 percent respondent of Jubo Unnayan Para stated that deforestation as the main causes of landslide in 2017 though only 8.3 percent people believe that deforestation is not a cause for this landslide. Rest of the people states deforestation as the cause of landside.

3.1.3 Seepage of water

Seepage of water is a major cause of Jubo Unnayan Para as observed in field survey 2017 and supported by

25 percent of Chakma respondent. In Jubo Unnayan Para it was found that a water pipe went through the road which was leaded and leached water from the whole of the pipe. This water makes the soil saturated and loses its compactness and causes the landslide. According to the KII findings of the civil engineer observation in Rangamati district, found many landslide spots were found messed with the water pipe or sewerage pipe (**Photo 1**).

Photo 1. Water pipe in spot of Landslide
Source: Field survey in 2017

3.1.4 Unplanned development

Unplanned development of the Rangamati district can be identified as the main man made cause of landslide hazards. As per observation and PRA findings revealed that the government organizations are not following landslide resilient development activities in. Hill cutting, deforestation is the result of unplanned development in Rangamati district. There is no strict hill management policy within the CMA (Ahmed et al., 2014). This bad practice has encouraged outsiders to build their settlements and structures everywhere including the vulnerable area (**Photo 2**). Around 60 percent respondents from Chakma community of Jubo Unnayan para mentioned the unplanned development as the cause of landslide when other people do not go along with this.

Photo 2. Unplanned Settlement at the study site
Source: Field survey, 2017.

3.1.5 Heavy rainfall

Rainfall is the most common cause of landslide either directly or indirectly (Derbyshire, 1976). Landslide has a direct relation with heavy rainfall. When it rains, water dissolves the minerals of the soil of the hills that loosens its compaction. Soils of the hills also turn heavy absorbing rainwater. If rain intensity is too high, minerals of soil dissolve very quickly and the soil turns into mud and becomes very heavy. The steep slope of the hill cannot bear the mass weight of the wet soil or mud that results the landslide (Chisty, 2014).

Most of the respondent of the two study village mentioned that heavy rainfall is one of the main causes of landslide 2017 event in Bangladesh. According to the weather office of Rangamati district recorded the highest rainfall ever. From 12 June 6.00 am to 13 June 6.00 AM it was 343 mm, and 13 June 6.00AM to 14 June 6.00 am it recorded 180 mm rainfall (**Fig. 3**).

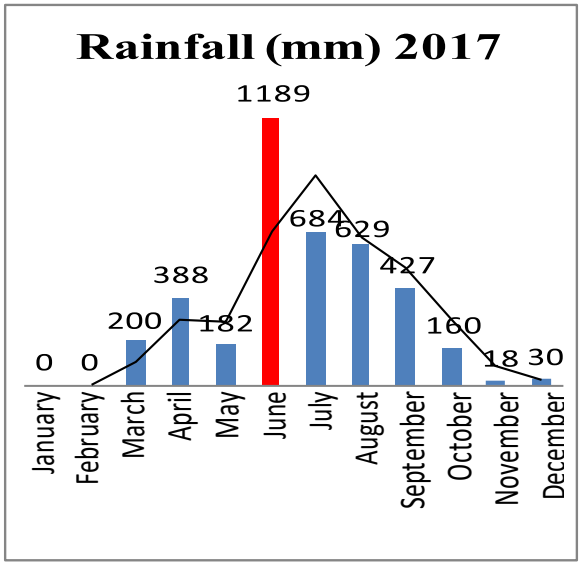

Fig. 3. Rainfall of Rangamati district in 2017

Source: Rangamati Weather Station.

3.1.6 Heavy Thunderstorm

Thunderstorm refers to the friction between rain bearing clouds which produce lights and sound. People of both village community agreed to the same point that heavy thunderstorm was one of the major causes of landslide in 2017. Heavy thunderstorm occurred with heavy rainfall. Sound of the thunderstorm created huge sound which has echoed in the mountains, the vibration of mountain which has loosen the compaction of soils and the heavy rainfall triggered the landslide faster. Weather office of Rangamati district also confirmed that heavy thunderstorm occurred in 12 June when the landslide took places.

3.1.7 Flash flood

Flash flood is one of the major causes of hill cutting. Water form heavy rain fall creates the flash flood. It is a high speed flow of water coming down from the top of the hill and washes away to the ground. Rain water melts away the soil of hill and creates a flow of mud. People of the both Jubo Unnayan and the West Muslim Para stated this flash flood causes the most damages.

When the flash flood occurred ultimately as a result of heavy rainfall it started to wash away trees, houses, various structures, and made the flash flood more dangerous. The eye witness expressed that the depth of the water was more than 3 feet and the speed was so high so that many people could not escape their catastrophe (**Photo 3**).

Photo 3. Flash flood at the West Muslim Para

Source: Rangamati Municipality

3.2 Damage Assessment

Landslide is a very common hazard in this study area. It occurs every year and causes a lot of damages with loss of life. In both study area people usually experience landslide every year. Average rate of facing landslide in the Vedvedi West Muslim Para (WMP) is 2.80 including the maximum value of facing landslide is 6 and lowest is 1. In the Jubo Unnayan Para (JUP) average rate of facing landslide is 3.34 including the maximum value of facing landslide are 15 and minimum is 0.

Fig. 4 shows that Chakma people faced more landslide in their life time than Bengali people because they live in there for a very long time than a Bengali community. It also indicates that Bengali community is less experienced than Chakma community that's why they face more damage in landslide.

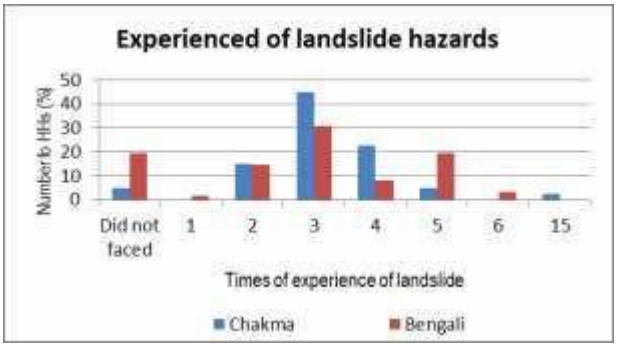

Fig. 4. Times of experience landslide hazards
Source: Field survey in 2017.

For assessment damage in this study "Approach of Schuster and Fleming (1986)" (Petrucci & Gulla, 2009) has used:

$$D = \sum \frac{\sum w(C + H + M + L)}{T}$$

Here, *w* = weighted value of physical elements.
C= complete damage = *cd*1*,
H= highly damage = *hd*.75*,
M= medium damage = *md*.50*,
L = low damage = *ld*.25*.
T= Total quantity of physical elements.

To assess the damages, all kind of physical elements which have damaged in the landslide (**Table 2** & **Table 4**) are given weight form the range 0-1 which is expressed by *w.* Such as House= 1, livestock= 0.3, poultry= 0.1, land =0.75 etc. All weights are comparatively assumed on the basis of FGD and PRA and from the view of participants and experts. Then on the basis of damage quality it is divided into four parts and given weighted such as for completely damage=1, High damage=0.75, Medium damage= 0.50, Low damage=0.25. Damage assessment in particular sector is calculated, Such as total number of completely damaged houses are 90 which is multiplied by 1, total number of highly damaged houses are 13 which is multiplied by 0.75, total number of medium damaged houses are 13 which is multiplied by 0.50. and for low damaged number of houses 05 is multiplied by 0.25. then after addition of all damages for particular sector it is multiplied by its weighted value *w,* such as for house sector, by adding completely, highly, medium and low damaged it is multiplied by its weighted value 1 then it is divided by its total number and it is the total damage of a sector. Finally total damage index will be the summation of sector's damages which is presented in **Table 3** and **Table 5**.

Table 2. Asset Damage of WMP (Bengali Community)

Types of Assets	Complete damaged (*cd*)	Highly damaged (*hd*)	Medium damaged (*md*)	Low damaged (*ld*)
House	90	13	13	05
Livestock (cow, buffalo)(number)	8	2	0	10
Livestock (goat, sheep) (number)	111	4	0	0
Poultry (number)	466	0	0	0
Land (decimal)	140	127		50
Shed (number)	9	5	2	1
Crop (decimal)	37			10
Tree (number)	340	20	9	31
Toilet (number)	27	2	3	3

Source: Field survey by the authors in 2017.

Table 3: Damage Assessment Index of West Muslim Para

Types of Assets	Weighted value (*w*)	Total quantity (*T*)	Complete damaged, *C*(*cd*1*)	Highly damaged, *H* (*hd*0.75*)	Medium damaged, *M* (*md*0.50*)	Low damaged (*ld*0.25*)	Total damage, D = { *w*(*C+H+M+L*)} / *T*
House	1	170	90	9.75	6.5	1.25	0.6323
Livestock (cow, buffalo)(number)	1	40	8	1.5	0	2.5	0.3
Livestock (goat, sheep) (number)	0.3	250	111	3	0	0	0.1368
Poultry (number)	0.1	600	466	0	0	0	0.0776
Land (decimal)	0.75	900	140	95.25	0	12.5	0.2064
Shed (number)	0.5	40	9	3.75	1	0.25	0.175
Crop (decimal)	0.2	100	37	0	0	2.5	0.079
Tree (number)	0.4	1500	340	15	4.5	7.75	0.0979
Toilet (number)	0.1	160	27	1.5	1.5	0.75	0.0192
					Total damage index		**1.724**

Source: Field survey by the authors in 2017.

By using the damage assessment index, **Table 3** shows the total damage index of of Vedvedi West Muslim Para is 1.724.

Table 4: Asset Damage of JUP (Chakma Tribal Village)

Types of Assets	**Complete damaged**	**Highly damaged**	**Medium damaged**	**Low damaged**
	(*cd*)	(*hd*)	(*md*)	(*ld*)
House	69	14	5	6
Livestock (cow, buffalo)(number)	2	0	0	0
Livestock (goat, sheep) (number)	12	0	0	0
Poultry (number)	73	0	0	0
Land (decimal)	93	40	25	4
Shed (number)	10	5	2	
Crop (decimal)	60	15	20	10
Tree (number)	17	10		
Toilet (number)	25	2	1	4

Source: Field survey by the authors in 2017.

Table 5: Damage Assessment Index of Jubo Unnoyon Para

Types of Assets	Weighted value (*w*)	Total quantity (*T*)	Complete damaged, C(*cd**1)	Highly damaged, *H* (*hd**0.75)	Medium damaged, *M* (*md**0.50)	Low damaged (*ld**0.25)	Total damage, D = { *w*(C+H+M+L)} / *T*
House	1	120	69	10.5	2.5	1.5	0.6958
Livestock (cow, buffalo)(n	1	15	2	0	0	0	0.1333
Livestock (goat, sheep) (number)	0.3	150	12	0	0	0	0.024
Poultry (number)	0.1	250	73	0	0	0	0.0292
Land (decimal)	0.75	1200	93	30	12.5	1	0.0853
Shed (number)	0.5	20	10	3.75	1	0	0.3687
Crop (decimal)	0.2	100	60	115	10	2.5	0.1675
Tree (number)	0.4	1000	17	7.5	0	0	0.0098
Toilet (number)	0.1	130	25	1.5	0.5	1	0.021538
					Total damage index		**1.5352**

Source: Field survey by the authors in 2017.

Damage index of Jubo Unnayan Para is 1.5352 (**Table 5**) and West Muslim Para is 1.724 **Table 3**). This indicates that in same criteria damage of West Muslim Para is more than Jubo Unnayan Para.

3.2.1 Casualties

Damage of people is the most dangerous and irreversible damage. Landslide in Rangamati is the most disastrous

because it has lost highest number of people in all record. In the study area it has lost about 20 persons. A lot of person was seriously injured and 5 families were totally vanished. Some people became mentally unstable. Above table shows that, 21.67 percent people died from Bengali community where only 17.5 percent are from Chakma community. On the other side seriously injured in Bengali community is less than Chakma because Chakma people faced the hazard and got seriously injured as 27.5 % people got badly hurt but did not lose their life. About 41.67 % was badly hurt from Bengali community (**Table 6**).

Table 6: Damages of human lives in the study villages

Types of damage	West Muslim Para (Bengali Settler Community)			Jubo Unnoyon Para (Chakma Tribal Community)		
	Total Resp.	No. of Injured people	Injured people (%)	Total Resp.	No. of Injured people	Injured people (%)
Death tolls	60	13	21.67	40	7	17.5
Serious physical damage		25	41.67		11	27.5
Light physical damage		20	33.34		1	2.5
Temporary damage		9	15		0	0

Source: Field survey by the authors in 2017

Around 15 percent from Bengali community shocked temporarily seen the hazard where there is no person in Chakma people who got temporarily shocked because they have enough strength to face the hazard. There are some reasons behind that. Density of the population of Chakma is less than the Bengali which reduces the vulnerability to death to the hazards. Besides this one Chakma people are more aware and experienced than Bengali people and they know how to face this kind of hazard.

3.2.2 Physical damages

Both villages have faced a lot of physical damages for the landslide. **Table 7** shows the damages in two villages and it is clear that the Bengali Para has faced the damage most than Chakma Para in every sectors. **Table 3** has presented the physical damages of two study villages. The West Muslim Para has faced more physical damage compare to the Jubo Unnayon Para.

Table 7: Physical damages of both study villages

Types of damages	WMP (Bangali Settler)	JUP (Tribal Chakma)
Housing structure	90	69
Livestock (cow/buffalo) in number	8	2
Livestock (goat/sheep) in number	111	12
Poultry (hen) in number	466	73
Land (decimal)	140	93
Kitchen Shed (number)	9	10
Crop with land (decimal)	37	60
Tree (number)	340	17
Toilet (number)	27	25

Source: Field survey in 2017.

4. Recommendations and Guidelines

4.1 Re-thinking about construction materials

Above table shows that, more than 90 percent people form Jubo Unnayan Para prefer to use light materials like bamboo, tin, timber for their household structures and not prefer to use heavy building materials like brick, concrete etc. because they think that light materials is less responsible for landslide.

Form the West Muslim Para, Bengali people think that heavy material will save them during landslide. So that more than 90 percent people form Bengali community prefer to build their structure with heavy materials. They also think that the maintenance cost for heavy materials building is less than light materials buildings (**Fig. 5**).

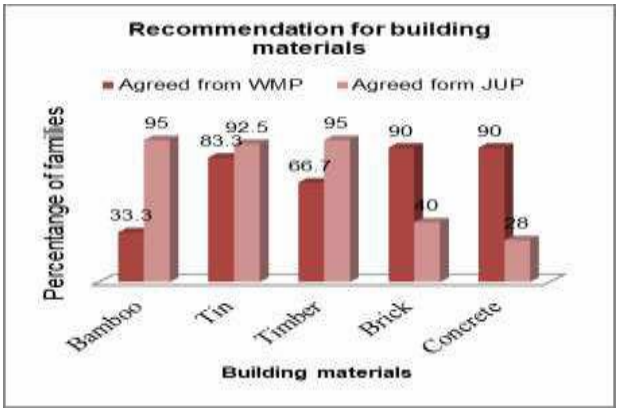

Fig. 5. Peoples' Perceptions for using house construction materials

Source: Field survey in 2017.

4.2 Warning system over the mobile phone

Warning system should be delivered through mike and mobile telephone because during cyclone and landslide or raining warning through mike is not being heard for extreme sound pollution. If the warning system provided through the mobile then it will be easier to notify. The warning through mobile should be included the safe place where they should go, magnitude of hazard, and an emergency number where they should call or take any information about the hazard or something else.

4.3 Light building materials use

People of the Jubo Unnayan Para think that, light materials don't affect the mountain body. That will prevent the landslide. Light materials should be used to build all kind of household structures. Use of light materials reduce the possibility of occurring landslide and will reduce the vulnerability. During the landslide it will be less dangerous than heavy materials.

4.4 House should be away from mountain slope

House should be built far from mountain area. When a house will remain far from the mountain area then it will be safe even during landslide. Distances should be proportional to the height of mountain. Without vegetation steep slope of mountain is vulnerable for making household structure (**Photo 4**).

Photo 4. A vulnerable house at the steep slope

Source: Field survey in 2017.

4.5 Afforestation on the mountain slope

Afforestation on the mountain slope is very important to preserve the soil mass in a mountain slope. As per field survey and observation it was found that there was not significant vegetation which can protect land slide. It is highly needed to aware local people and involves them with afforestation program.

4.6 Peoples' perception regarding land leveling

Most of the People from Chakma ethnicity think that there is no need to leveling of mountain to ensure safety. Some people are agreed with that the mountain should be leveled to make the house and all kind of structure. They think house should be built according to mountain level. Only 24 percent people form Jubo Unnayan Para agreed to level the mountain to create safe and livable place to live where rest 76 percent people are not willing to leveling the mountain because they don't want to interrupt the natural condition of mountain (**Fig. 6**).

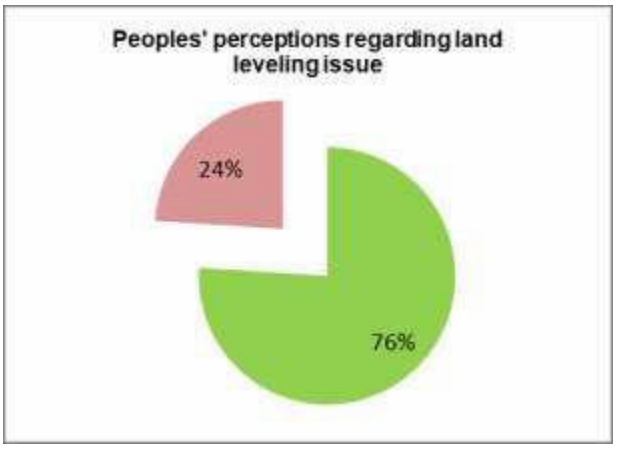

Fig. 6. Peoples' Perceptions regarding land leveling issue

Source: Field survery in 2017

5. Conclusions

Landslide is a natural phenomenon which will be occurred in hilly area in normal process. But it can be controlled sometime by proper planning, implementing proper rules and regulations. The most important issues in this landslide are the awareness in every level of people from the policy maker to the local people. As its trend it can be predict that upcoming days will not be better if the present condition is going on. Determining the livelihood pattern of this hilly area with special rules and regulation for hilly area are the present time demand. The study revealed that the ethnic tribal people are living for long time in this mountain environment. Their loss and damage is lower compare to the Bengali Settler people. Awareness and training program should introduce for the Bengali settler community focusing building housing structure with light local material, maintain mountain slope and drainage system and planting trees and bush on the mountain slope. The government organizations should practice the mountain environment friendly construction and development activities.

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