Loss and Damage: A Case Study of Landslides in Darbung Village, Gorkha District, Nepal'.

Abstract

'Loss and Damage' is a new concept in research of climate induced disaster, which refers to the negative effects of climate variability and climate change that people have not been able to cope with or adapt to. Budigandaki river basin in the study area has been identified as the most vulnerable where landslide occurrence is devastating to the downstream settlements because landslide from the top of the mountain ultimately results in debris flow along with river. A study was conducted with an objective to estimate the loss and damage caused by Khanikhola landslide of Darbung. Primary data collection includes direct observation, key informant interview, household questionnaire survey, and focus group discussion. Revised Universal Soil Loss Equation (RUSLE) was used to predict soil erosion due to landslide using GIS 9.3. Secondary data collection includes reports, factsheets, journals from different institutions, internet. Of the total household, 14%, 72%, 75% and 20% respondents reported loss and damage of livestocks, cultivated crops, lands and houses respectively. The RUSLE model predicted erosion rates with an average value of 36.30 t/ha/y for the study area. The total cost of loss and damage was found to be NPR 452,494,000. To a large extent, the study has established that socioeconomic status play an important role in settlement patterns as well as building a landslide proof houses.

Key words: Climate change, Climate induced disaster, Loss & Damage, RUSLE model.

Introduction

Natural disasters occur and affect people's lives and livelihoods in almost all parts of the world. Some populations are more vulnerable than others and disparity exists between nations and communities within a country. Furthermore, within communities different households may be affected differently and even within households the vulnerability of individual household members may vary (KC, 2013). Among the natural disaster, landslides are significant component of many major natural disasters and are often responsible for greater loss of life and livelihoods than is generally recognized. This is largely because they are often recorded according to the triggering event such as an earthquake or hurricane even though the losses from landslides may exceed all other losses from the overall disaster (Spiker & Gori, 2000).

The adverse effects of climate change undermine the economic development, human security, and people's fundamental rights (UNDP, 2007). It deteriorates the poverty situation and obstructs the achievement of the Millennium Development Goals (MDGs) of the least developed countries, who are highly vulnerable to the climate-induced disasters (Vashist & Das, 2009). Currently the planet is not on track to limit dangerous climate change; in fact, it is rapidly heading towards a world 4 to 6 ^{0}C warmer by the end of this century compare to pre-industrial level (IEA, 2011). Yet the global community remains uncertain as to how it will enter and manage this unknown territory of increasing climate impact and related loss and damage.

Loss and damage is an issue of growing importance for the international community, as no country will escape the impacts of climate change (IPCC, 2014). Loss and damage results from a spectrum of climate change impacts, from extreme events to slow onset processes (Warner et al., 2012). While extreme events are difficult to attribute to climate change, the risks of some climate-related events, such as heat waves, extreme precipitation and coastal flooding are already moderate and are expected to increase as temperatures rise (IPCC, 2014). Loss and damage emanating from climate change impacts can be economic in nature, such as loss of income or damage to property and assets, and non-economic, which include the cultural, social and mental impacts of climate change, as well as the loss of biodiversity and ecosystem services, amongst others (Morissey & Oliver-Smith, 2013).

Objectives

The broad objective of the study was to assess the landslide triggered loss and damage of Khanikhola landslide in Darbung village in Gorkha district of Nepal.

The specific of the objectives of study are:

- To document socioeconomic status of people residing in Darbung VDC,
- To quantify the loss and damage of livelihood and physical assets,
- To estimate the price of loss and damage of private and public assets,
- To identify adaptation measures employed by community against the occurrence of landslides.

Rationale

Nepal's climate is as diverse as the country's topography, which extends from the highest mountains in the world to the rim of the lowland Tarai, almost at sea level. Nepal's varied topography makes it susceptible to climate-related disasters and the country experiences a range of natural hazards, some of which occur yearly (e.g., floods and landslides) whereas others occur less frequently (earthquakes) (UNDP, 2009). Given its vertiginous topography and active geology together with torrential rain during the monsoon season, Nepal experiences frequent water-related disasters including landslides, debris flows and floods. IPCC summary report 2007 indicates that human beings are the main responsible for the increased amount of the greenhouse gases. Developing countries are considered to be particularly susceptible to climate change due to their limited capacity to cope with hazards associated with change in the climate.

Landslides constitute a major natural hazard in Nepal mainly due to the unique combination of active tectonic setting, high rates of weathering and abundant rainfall, aggravated by human interference in the form of rapid urbanization and infrastructure development. Heavy rainfall triggers a landslide event on the mountain, which turn into a debris flow downstream. Furthermore, due to climatic changes and increase in the frequency of extreme events the problem of landslides has aggravated in Nepal. Landslides in Nepal are the country's costliest and most deadly type of natural disaster, but their management is still seen as low priority (IRIN, 2013).

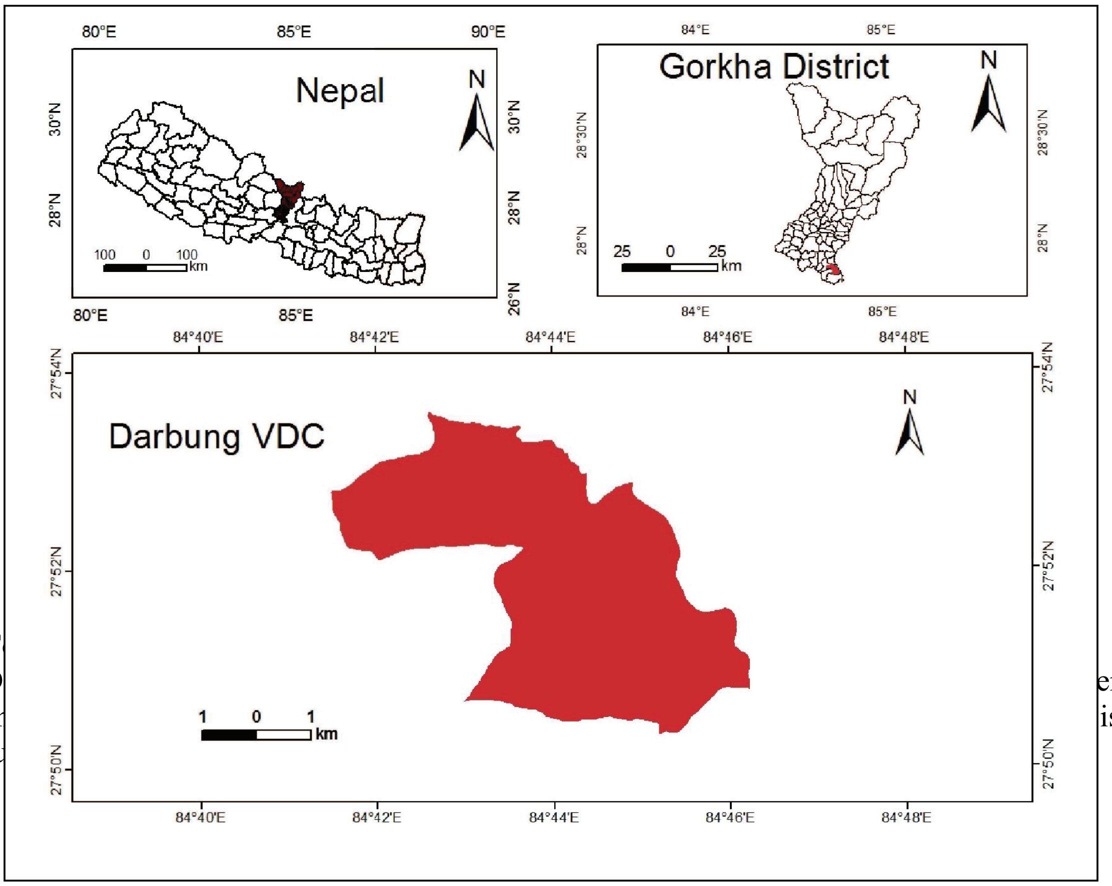
Budigandaki river basin has been identified as the most vulnerable area (ADB, 2012), where landslide occurrence is devastating to the downstream settlements because landslide from the top of the mountain ultimately results in debris flow along with river. However there are only few studies to assess and estimates the effects of the landslide on the community's socio-economic livelihoods. This study endeavors to estimate the total loss and damage due to occurrence of landslides and also establish the ongoing adapting strategies of people towards debris flow in community. More importantly, it is envisaged that the output of the study will be key inputs in designing of sustainable mitigation measures to minimize the impact of landslides and the associated risks.

Materials and Methods

Study Area

Location

The study area is situated at Darbung Village (administritavely Village Development Committee, VDC) of Gorkha district in western Nepal. The study district is bounded by Dhading district in the east, Tanahun, Lamjung and Manang in the west, Tibet of China in the north and Chitwan in the south. The landslide is located at the right bank of Budi Gandaki river, which is at about 9 km from Benighat (Kathmandu-Pokhara Highway) (DWIDP, 2013). Darbung village lies at the elevation of 388 masl.



Climate

There is much variation in altitude and topography of study site resulting in variation of climate including tropical and subtropical (DWIDP, 2013). Average annual precipitation ranges from 200 mm maximum to 60 mm minimum (DHM, 2014).

Vegetation

Variation in vegetation along with climatic variation is observed. There are two types of vegetation in the district namely tropical and sub-tropical forest. Tropical forest occupies the area lying at the altitudes of 500 m to 1000 m which include *Shorea robusta* forest. Subtropical forest occupies the area lying at an altitude from 1000m to 2000m, which includes subtropical riverine forest, subtropical wet forest and *Pinus roxburghii* forest. *Alnus nepalensis*, *Schima wallichii*, *Castanopsis indica, Pinus roxburghii* are the major species. According to the Gorkha District Profile (2005), 39.79 % (881.25 ha) of total area of VDC is recognized as forest.

Demographics

According to CBS (2012), total population of the VDC is 3386 in which 45.2% is male population and 54.8% is female population with sex ratio of 82.44. The total household number is 763 with 4.44 average household sizes, of which 744 households are owned, 16 households are rented, 1 household is institutional and 2 households are categorized as others. People are engaged in agriculture, foreign employment, labor, business, etc. Majority of population is that of Magar (41.84%), followed by Newar (16.09%), Brahman (9.86%), Kami (9.53%), Sarki (9.09%), Damai/Dholi (5.85%), Chhetri (2.21%), Gurung (2.09%) and others (4%).

Agricultural Production

Major livelihood of the district is agriculture which is mostly of rainfed type i.e. almost all farmers depend upon seasonal rainfall for agricultural purposes. Rice, maize, wheat, millet and potato are the major agricultural crops, providing the major staple food for the population and economy of the place. According to Gorkha District Profile, (2005), 39.96% (i.e. 885 ha) of total land is suitable for agriculture.

Transportation and Communication

Darbung is directly linked by road transport to Kathmandu. There is some extension of road transport network in the district in which some vehicle service is available for public transport. However foot trails networks dominate district. Different means of communication such as telephone, e-mail, and internet are available in Benighat. According to the CBS (2012), 561 household have radio, 66 households have television and 404 households have telephone in their house in Darbung VDC.

3.1.8 Utilities and Facilities

In Darbung VDC, 675 households have tap/piped water supply while 21 households depend on covered well/kuwa (water holes), and 65 households depend upon stone spout for water facility. Of the total, 536 households have toilet facility in their own house, 402 household have electricity in their house (CBS, 2012).

Methodology

Primary Data Collection

Direct Observation

Observing the subjects in their normal environment, instead of bringing them to an office or laboratory, provides a unique opportunity to learn what the subjects normally do and how they normally behave. Direct observation is conducted to learn about the normal behavior of surrounding on their natural environments. Direct observation in this study involves careful watching and records of happening action.

Key Informant Interview

A key informant interview is a loosely structured conversation with people who have specialized knowledge about the topic. A key informant is a person with unique skills or professional background on specific issue**.** A good key informant can convey the specialized knowledge therefore they are crucial to the assessment process**.**

Key informant interview was introduced in the study site with the list of questionnaire (Appendix 1) in May, 2014 to explore the subject in depth. These interviews in the study, results in the discovery of information that would not have been revealed in a survey. During the study, chairperson and secretary of Natural Disaster Committee, Darbung, principal of Ratneswor Secondary School, VDC secretary, some affected people who are now are in vulnerable condition were choosen as key informant and interview was proceeded which provided opportunities to identify target populations or issues for further investigation, gathering information, refining data collection, generating recommendations.

Household Questionnaire Survey

According to the disaster report of Darbung (2002), it was found that Khanikhola landslides incident of 2002 had affected four wards (4,6,7and 9) where, 34 household were found as totally damaged, 12 household partially damaged, 173 household were affected and now 500 household were in vulnerable condition. Total of 719 household were found and the households were selected through the stratified random sampling for the survey and was carried out during 3- 7 May, 2014.

Sample Size and Technique

For the household survey, sample size was determined by using following formula (Arkin and Colton's 1963, cited by Sharma, 2000) at 95% level of confidence and 10% level of significance and standard error is 0.05% which is given below.

$$n = \frac{NZ^2 * P(1-P)}{Nd^2 + Z^2 * P(1-p)} \quad (1)$$

Where,

n =Sample size

N =Total number of household

Z = Confidence level (at 95% level Z=1.96)

P=Estimated population proportion (0.5, this maximizes the sample size)

d = error limit of 10% (0.1)

The number of sample for each ward is calculated by the proportional method as in the table below:

Sampling size of households

S.N.	Loss and Damage	Total Households Number	Sampled Households
1.	Totally	34	4
2.	Partially	12	2
3.	Affected	173	20
4.	Vulnerable	500	59
4.	Total	719	85

***Totally- households that have lost their property along with income**

***Partially- households that lost their houses except their income sources**
***Affected- household that have either lost their houses or income**
***Vulnerable-household those are in acute condition of recurrence of landslide**

Focus Group Discussion

Focus Group Discussion (FGD) is a rapid assessment, semi structured data gathering method in which a purposively selected set of participants gather to discuss issues and concerns based on a list of key themes drawn up by the researcher/facilitator (Kumar, 1987). Focus Group Discussion was conducted in May 2014 among the people who are directly affected by the happening disaster due to climate induced landslide.

Average Annual Soil Loss Rate

The Revised Universal Soil Loss Equation (RUSLE) given by Renard et al. (1991) is used to predict erosion due to landslide in landscape/watershed using GIS 9.3(annex 2).

$$A = R * K * LS * C * P \qquad (2)$$

Where,
A=Average annual soil loss in Mg/ha/yr
R=Rainfall/runoff erosivity ($MJ.mm.ha^{-1}.h^{-1}.yr^{-1}$)
K=Soil erodibility (Mgh/MJ/mm)
LS=Soil Length and Steepness Factor
C=Cover-management
P=Support practice factor

Rainfall/Runoff Erosivity (R)

Calculation of the *R*-factor depends on rainfall intensity. On average, 20 years of rainfall intensity data are used to calculate R factor to incorporate natural climatic variations. In the absence of long-term (>20 years) rainfall intensity data, the R- factor is estimated by using mean annual rainfall could be used for at least assessing relative erosion rates for different management, crop, and soil condition (Renard & Freimund, 1994). Equation proposed by Morgan and Davidson (1991) is used to calculate the value of R and its unit is $MJ.mm.ha^{-1}.h^{-1}.yr^{-1}$ (Annex 1).

$$R = P * 0.5 \qquad (3)$$

Where, P is average annual precipitation.

Soil Erodibility (K)

Soil erodibility factor represents both susceptibility of soil to soil erosion and the rate of runoff, which is calculated by using equation 4 given by Wischmeier and Smith (1978). The unit of K is Mgh/MJ/mm.

$$K = 2.1 * 10^{-6} * M^{1.14} * (12 - OM) + 0.025(S - 3) + 0.0325(P - 2) \qquad (4)$$

Where,
M is particle size parameter and equal to [(%silt + %sand)*(100 - %clay)]. For determination of sand, silt and clay %, hydrometric method given by Pradhan (1996) was used. The procedure to determine the sand, silt and clay % by hydrometric method is given below:

1. 100 g of soil was taken in a 250 ml of beaker and sufficient water to cover the soil was added along with 20 ml of Sodium hexaphosphate solution.
2. The solution was then well stirred and leaved for whole night.
3. The solution was then transferred into a dispersion cup and water was added to it to make two third of solution and was well stirred for 10 minutes.
4. The solution was again transferred to the hydrometer jar and the volume of solution was made up the mark of hydrometer.

5. The hydrometer was removed and solution was shook upside down for several times closing its mouth.
6. After the dispersion of solution, it was then kept into the table and finally hydrometer was immersed into the jar and reading was noted at 40 second and after 3 hours.

<u>Calculation</u>

$percent(Silt + Clay) = hydrometer\ reading\ at\ 40\,\text{sec} + 0.3(t - 20)°c$

$percent\ Clay = Reading\ at\ 3\ hrs + 0.3(t - 20)°c$

$percent\ Sand = 100 - percent(Silt + Clay)$

$percent\ Silt = percent(Silt + Clay) - percentClay$

OM is % of organic matter. For the analysis of soil organic matter following procedure have been adopted (Trivedy & Goel, 1984):

1. Oven dried soil sample was taken and passed through a 0.5 mm nonferrous screen.
2. About 0.5 g of soil sample was weighed and transferred to a dried 500 mL conical flask
3. 10 mL of 1 N $K_2Cr_2O_7$ and 20 mL of conc. H_2SO_4 were added and mixed by gentle swirling.
4. The flask was allowed for the mixture to react and was kept for about 30 minutes.
5. After the reaction was over, the content was diluted with 200 mL of distilled water and 10 mL of-phosphoric acid was added followed by 1 mL of diphenylamine indicator.
6. The sample was then titrated with 0.4 N Ferrous Ammonium Sulphate (FAS) till the color changed to brilliant green at the end point.

<u>Calculation</u>

$a)\ percent\ Carbon = \left(1 - \frac{T}{S}\right)\left(\frac{3.951}{g}\right)$

$b) percent\ Organic\ Matter = percent\ Carbon * 1.724$

Where,

g = wt. of soil in gram

S = mL of FAS with blank titration

T = mL of FAS with sample titration.

The factor 1.724 is based on the assumption that carbon is only 58% of the organic matter.

Sis soil structure code (1 - very fine granular; 2 - fine granular; 3 - medium or coarse granular; and 4 - blocky, platy, or massive), and P is profile permeability class (1 - rapid; 2 – moderate to rapid; 3 - moderate; 4 - slow to moderate; 5 - slow; and 6 - very slow).

Slope Length and Steepness Factor (LS factor)

The LS factor (topographic factor) accounts for the effect of topography on erosion in RUSLE. The slope length factor (L) represent the effect of slope length on erosion, and the slope steepness factor (S) reflects the influence of slope gradient on erosion. For this study L is the flow length and S is slope steepness which is given by meter and percent respectively. LS factor is estimated with the incorporation of Digital Elevation Models (DEM). Equation 5 is used to determine this parameter which was recommended by (Morgan & Davidson, 1991.

$$\text{LS} = \sqrt{\text{l}}/22(0.065 + 0.45\text{s} + 0.065s^2 \qquad (5)$$

Where,

l = Slope length in m
s= percent Slope
C- Cover-management and P- Support practice factor can be selected from the literature according to the land use pattern.

Table 1: C- Cover-management and P-Support practice factor

Land Use	C Factor	P Factor
Natural vegetation/ Forest	0.001	1.00
Agriculture/Crop	0.128	0.92
Grass	0.003	1.00
Average	0.056	0.97

Source: Soil and Water Conservation Society, 2003

Location and Extent of Landslide

The landslide is situated at latitude of N 27°51’21.21’’and longitude of 84°44’19.5’’ in the region of Darbung Phant. The landslide area lies on the south-west part of district headquarter. Landslide covers the area of forest at its origin and in base is the agriculture land with residents. Budigandaki river lies in the base, therefore, landslide in the area is considered as vulnerable to create flooding when it reaches to the bottom.

Overall Loss and Damage

Landslide is the major climatic stressor in the study area. Following equation given by Warner and Geest (2013) is used to calculate the overall loss and damage of study area.

Loss and damage (%) = (ES (%) *EI (%) * IdM (%) * AM (%)) + (1-IDM (%)) * ES (%) *EI (%) (6)

Where,
ES=Experienced Stressor
EI=Experienced Impact
IdM=Impact despite Measures
AM=Adopted Measures

Secondary Data Collection

Secondary data as required to fulfill the objectives of the study were collected and reviewed throughout the whole study period to support the primary data obtained from the locals during analysis process. Secondary information included demographic profile and political map from CBS, district profile, topographical map, hydro meteorological data mainly precipitation data of Gorkha stations from DHM, and different reports on the loss and damage scenario from ICIMOD, CARE Nepal, UNDP, World Bank, line agencies of GoN and local governments.

Results and Discussion

Socioeconomic Status

General Description of Respondents

Table 4 presents general descriptions of respondents. In household questionnaire survey total 85 households were selected based on stratified random sampling. Among the respondents, 45 (52.9%) were female and 40 (47.1%) were male. Ethnically 51.8% were indigenous (Magar, Tamang, Gurung, Rai, Newar), 42.4% were Brahmin/Chettri (Khanal, Tiwari, Duwadi, Aryal, Thapa, Rana), 4.70% were Dalit (Sarki), and 1.2% were Muslim

(Miya). 33.33% respondents were illiterate, 33.33% were literate, 19.05% were SLC, 9.52% were intermediate and 4.76% were Bachelor/Master.

Table 2: General description of respondents

	No. of Respondents	Gender (%)		Ethnicity (%)				Literacy Rate (%)	
		M	F	Indigenous	Brahmin/ Chettri	Dalit	Muslim	Illiterate	Literate
HH Survey	85	53	47	51.8	42.4	4.7	1.2	33.33	66.67

Employment and Income

Households engaged in agricultural activities such as cultivating crops, growing fruit trees, raising livestock were 85.9%. The product of these activities is mainly used for household purposes, however in terms of income generation it comprise only about 38.8%.

Figure 2 indicates that remittance was the largest source of household income with 67% of respondents indicating that their household received remittances with the average amount sent per household per month being NPR 15,000. Most remittances were sent by husbands, sons, daughters, brothers, and sisters. Among the respondents, 11.8% rely on service, 9.41% households were involved as labors and 7.06% were involved in small family business.

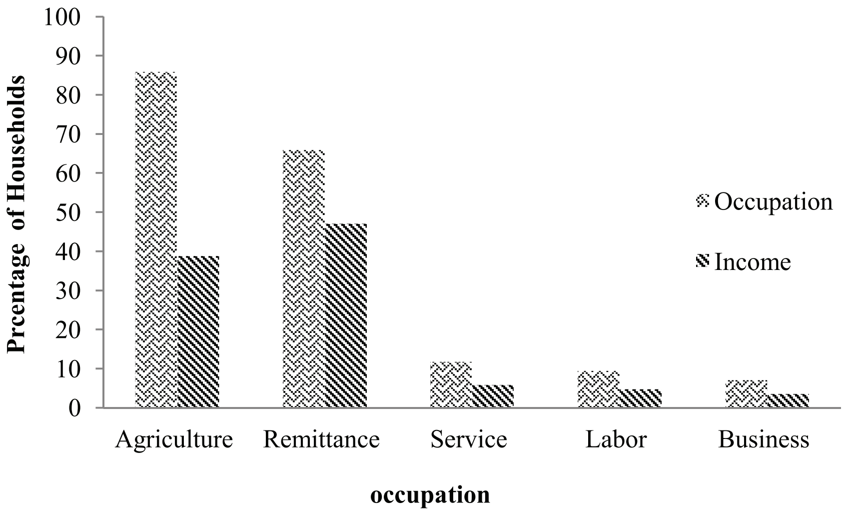


Figure 2: Major occupation and income

Land and Farm

Of the total, 88% of household have their land and house they farm and live in whereas 12% respondents did not have not their own land and house (Figure 3). The average land size per household was 0.29 hectare. Crop production mainly consists of cash crop such as Paddy, Maize, Wheat, Millet and cereals such as black lintel soyabeans (Maas and Bhatmaas). Of those engaged in agriculture, 57.53% have irrigation facility. Crop cultivation is mainly carried out for household consumption, 24.7% of respondents stated that the main purpose of production was for sale. The total average sale of agricultural produce is NPR 4,800 per year per household.

Crop Yield Status

In the survey, 28.8% of respondents said that crop yields were decreasing a lot, and 26% said crops were decreasing a little. The main reason given for this decrease was scarcity of water. 31.5% of the households indicated that crop yields remained the same, whereas 9.6% indicated that crops were increasing a little, and 4.1% indicated that they were increasing a lot (Figure 4). The main reasons given for the increase was increasing uses of chemical fertilizer.

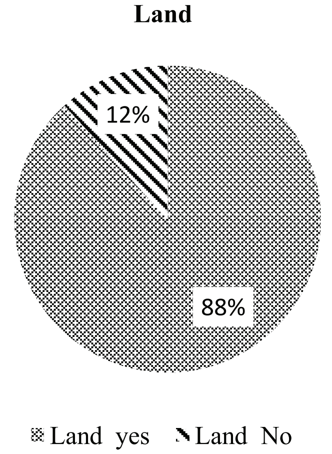


Figure 3: Household having own land and no land

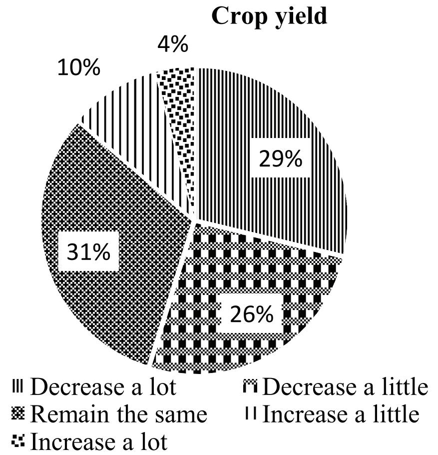


Figure 4: Crop yield status

House Type

Houses were typically built with slate/tin roofs and mud walls. Slate/tin for roofing was used by 58.82% of households, followed by roofs made of natural product (24.70%) and concrete roofs (16.47%) (Figure 5). Mud walls were used by 85%, followed by cement walls (13%) only in a few cases (2%) natural materials were used for the walls. Some households use cement for walls even though the roof is not plastered so as to make the house more resistant to landsides (Figure 6).

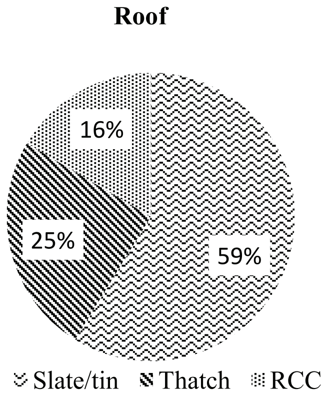


Figure 5: Types of house roof

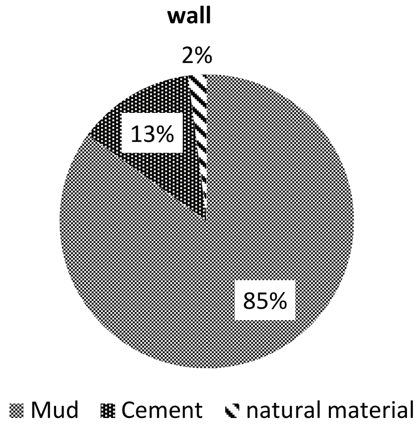


Figure 6: Types of house wall

Livestock Types and Number

Livestock raising was carried out by near th respondents raising buffalos, bull, cow, ox, goat, chicken, pigs. Buffalo rearing was the main livestock activity; 46% of all households own buffalos, with an average number of 2 buffalos per household. Approximately, 45% of the households surveyed owned goat, with

an average of 3 goats per household. Of the total, 40% of household have cow in their house, with an average number of 1 cow per household. Chicken was raised by 28% of household, with an average 4 chicken per household. Pig rearing was done by 25% of household with an average of 2 goats per household and only 7 households, equivalent to 8%, said they raised bulls, with an average number of 2 bulls per household (Figure 7).
Of those who owned livestock, 93% said the main purpose was household consumption; only 7% said livestock were intended for sale. The average income of livestock rearing was NPR 7,000 per month.

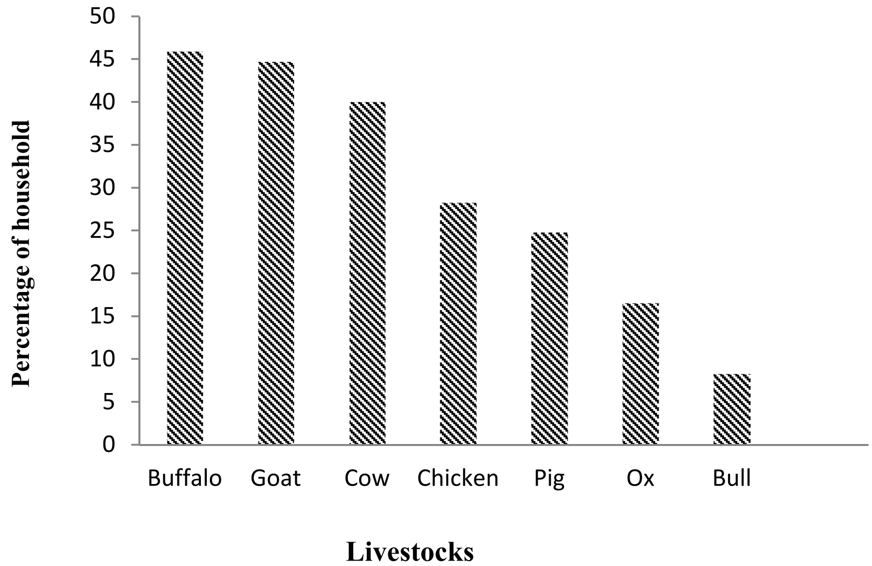


Figure 7: Percentage of households having different livestocks

Utilities and Facilities

Majority of respondents (65%) believed their income was average; 23% believed their household income was below average and 12% believed it to be more than average.

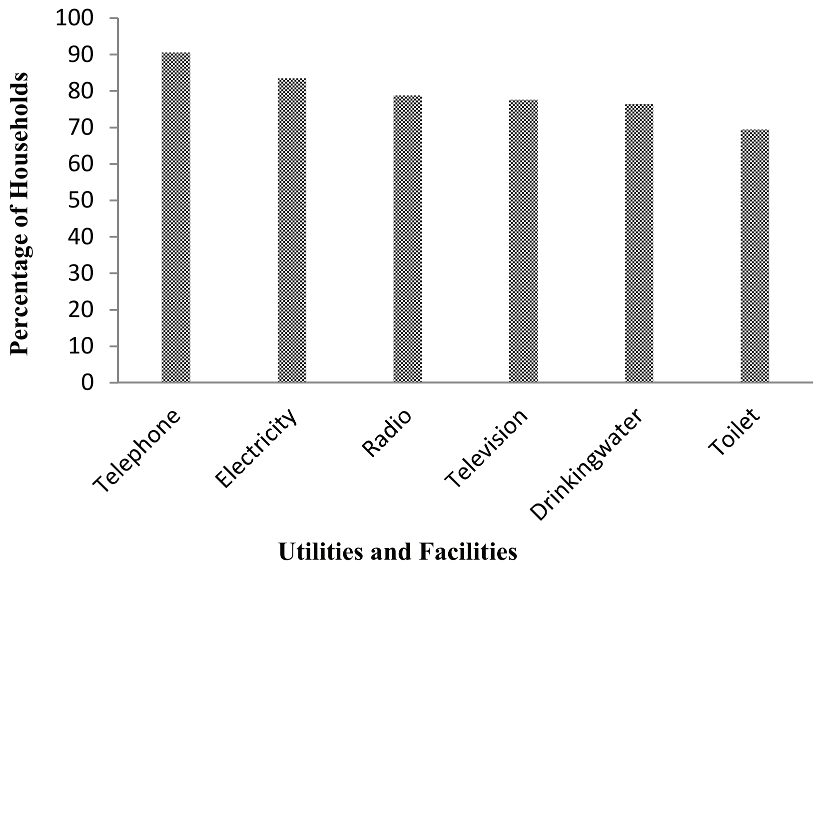


Figure 8: Percentage of household having different utilities and facilities

As an indication of their relative income to utilities and facilities, most households owned electricity (84%) followed by drinking water facilities (76%) and availability of toilet was found in 69% of household. The main assets owned by households were telephones (91%), radios (79%), and televisions (77%) (Figure 8).

Average Soil Loss Rate

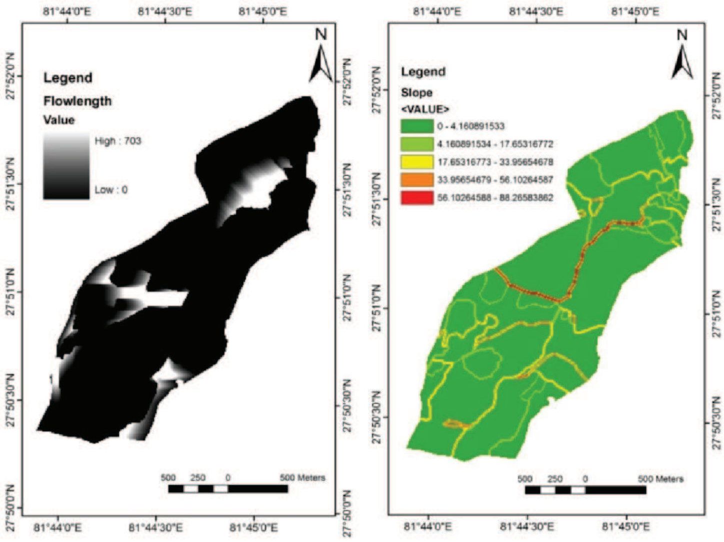


Figure 9: Flow length and slope of landslide area in Darbung, Gorkha

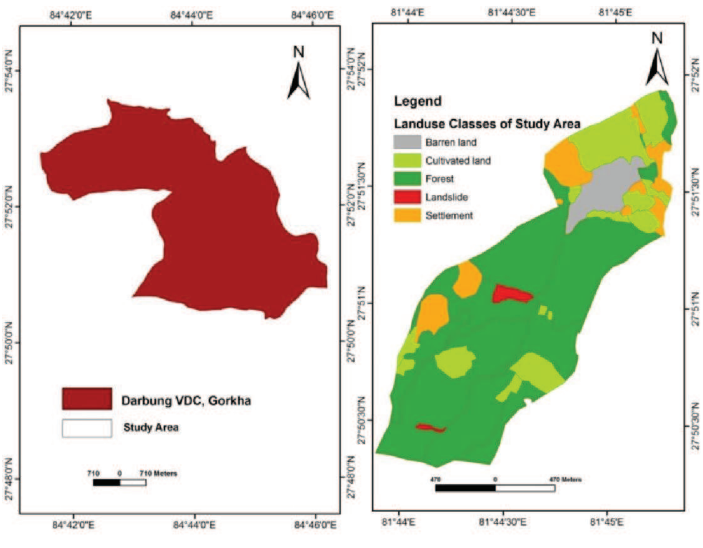


Figure 10: land use pattern adjacent to the landslide in Darbung, Gorkha

Rainfall erosivity, soil erodibility, slope length and steepness, cover management and support practice factors were calculated. The RUSLE calculated the annual average soil loss for the Khanikhola watershed from equation 1 using six factors and it is estimated as 36.30 Mg per ha per yr. (36.30 mega gram per hectare per year) which is equal to 36.30 ton per ha per yr.

4.2.2 Livelihoods Assets

4.2.2.1 Livestock Loss

Of total household, 14% had lost their livestock due to the effect of Landslide, 2002. Total numbers of chickens, pigs, goats, buffalos lost were found to be 25, 17, 3 and 1 respectively (Table 5).

4.2.2.2 Cultivated Crop Loss

Severe landslide had affected cultivated crops of 72% of household. Cultivated crops like paddy, maize, wheat were lost because the month of occurrence of landslides was March, which is the period of cultivation of those crops in the study area. Cultivated crop lost was estimated to be 16,000 kg of paddy, 4,800 kg of maize and 4,500 kg of wheat (Table 5).

Table 3: Livestock and cultivated crop loss

Livestocks	Lost (number)	Cultivated Crops	Lost (kg)
Chicken	25	Paddy	16000
Pig	17	Maize	4800
Goat	3	Wheat	4500
Buffalo	1		

4.2.3 Physical Assets

4.2.3.1 Land and House Loss and Damage

Of total household, 70% reported that their land was lost and 80% of household reported that their land was damaged. The total loss of land was estimated to be 10.68 hectare and that of land damage was estimated to be 12.21 hectare. The categories of land and house loss and damage are shown in figure 11 and 12. By the landslide 40% of households were found to be loss while 4% found to be damaged,

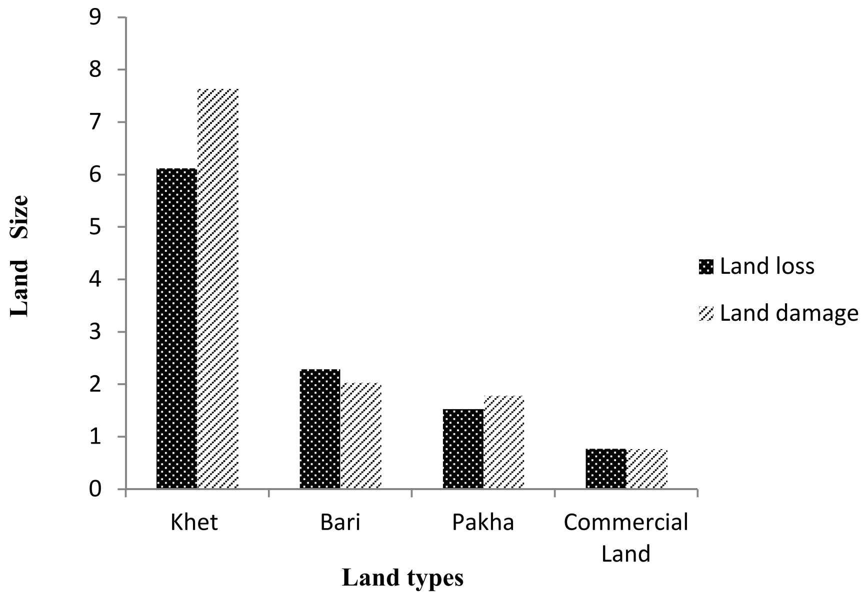


Figure 11: Loss and Damage percentage of land

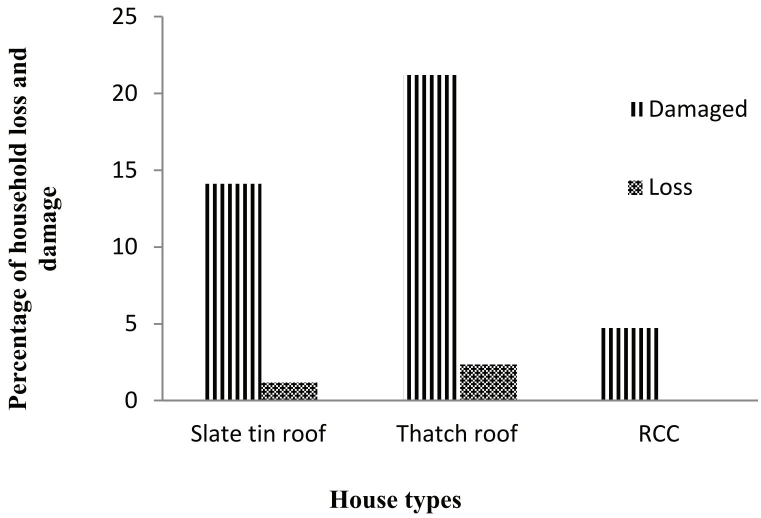


Figure 12: Loss and Damage percentage of house

*Bari: Unirrigated Land, **Khet: Irrigated Land, ***Pakha: Sloppy Land

4.2.3.2 Overall Loss and Damage

The percentage of experienced stressor was 92%, experienced impact was 80%, 45% households adopted coping or adapting measures, 93% of households expressed that they were still in impact of landslide despite some adapting measure. Households' incurring residual loss and damage was calculated using equation 6 which is found to be 71%. The component of overall loss and damage is represented in figure 13.

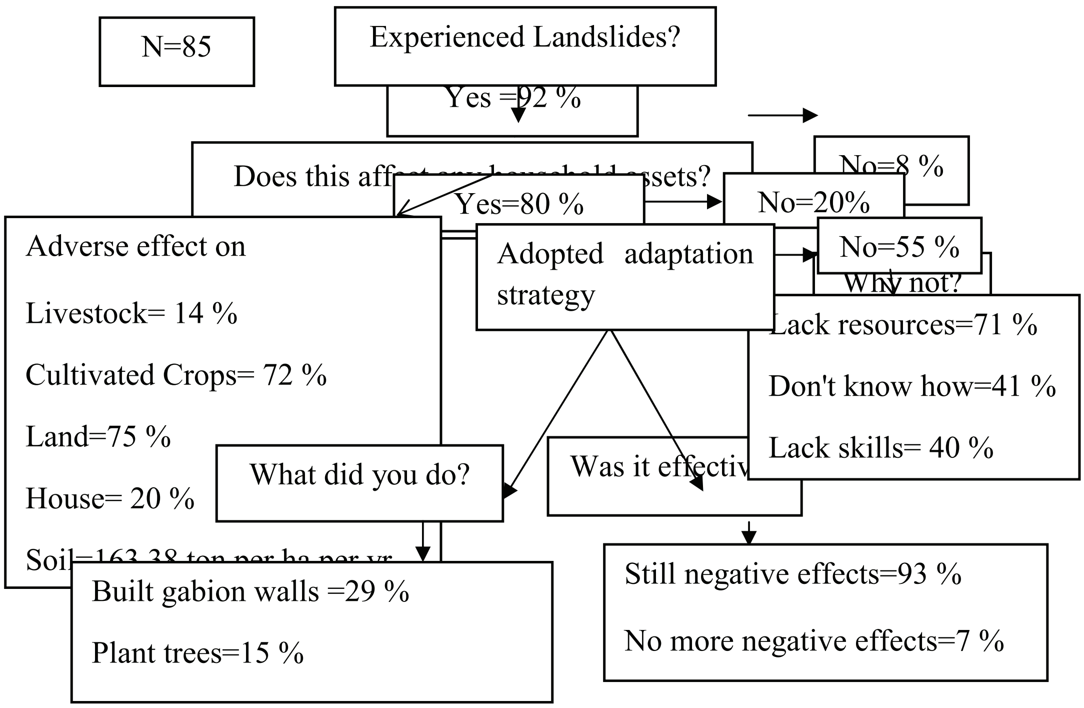


Figure 13: Tree diagram of experience and impact of landslides

4.3 Estimated Valuation of Loss and Damage

Private and Public Assets

Loss and damage of private and assets by the landslides of 2002 are calculated in the current price which was calculated to be NPR 380,994,000 (Table 6) NPR 71,500,000 (Table 7) respectively.

Table 4: Estimated price of loss and damage of private assets

S.N	Assets	Categories	Estimated price of Loss and Damage (NPR)
1.	livestocks	Chicken	13,000
		Pig	34,000
		Goat	18,000
		Buffalo	50,000
2.	Cultivated crops	Paddy	640,000
		Maize	168,000
		Wheat	171,000
3.	Lands	Khet	216,000,000
		Bari	90,000,000
		Pakha	19,500,000
		Commercial Land	36,000,000
4.	Houses	Slate/Tin roofed	7,500,000
		Thached roofed	6,900,000
		RCC	4,000,000
	Total		380,994,000

Table 5: Estimated price of loss and damage of public assets

S.N	Assets	Quantity	Estimated price of Loss and Damage (NPR)
1.	Road	10 km	10,000,000
2.	Post office	1RCC building	1000000
3.	Health Post	1 RCC building with equipment	10,000,000
4.	Mango Garden	Approx 25 ropani	50,000,000
5.	Water Tank	1	500000
		Total	71,500,000

***Rate of each assets is given in Annex 3**

4.4 Adaptation Measures

Figure 13 present a tree diagram of experience, impact of landslide and adaptation measure followed by people. Survey showed that 45% of households adopted adaptation measures. Example of such measures are building small scale gabions around the landslides area, construction of cemented houses, and planting trees around the houses, some are using logs, rocks and other debris to fill in the eroded areas while some are using rocks and then poured cement on the top of rock, although they were commonly carried out in unscientific manner. In total 20% respondents answered that they are contributing labour or economic resources to community-based or government/NGO-gabion wall construction program. These respondents are those who have their houses adjacent to the river, 15% answered they are planting trees in their surrounding and 11% of respondents said that they built their house in effective way to check the effect of landslide. Most people don't have idea about the adaptation mechanisms who indicated that they will somehow manage adopted measures afterwards in anticipation of new events. For some, landslides prevention works were not a priority because of their household's structural poverty.

It was found that 93% of those who have been following adaptation measures indicated that these measures were insufficient. The majority of households i.e. 85% felt that the most effective solution to landslides would be large -scale gabion walls supported by the government as well as communal action, moving to other areas (migration) by 8% of household and planting trees by 7% of household.

Discussion

In the study area of Darbung VDC, the major occupation was agriculture where 85.9% households were engaged in agricultural activities such as cultivating crops, growing fruit trees, raising livestock. Livestock raising being carried out by nearly 93% of the households interviewed, with respondents raising buffalos, bull, cow, ox, goat, chicken, pigs. Of those who owned livestock, 93% said the main purpose was household consumption; only 5% said livestock were intended for sale; the remaining percentage was bull used for mate. The average income of household from livestock rearing was NPR 20,000 per year.Presently, remittances are the largest source of household income with 67% of respondents indicating that their household received remittances with the average amount sent per household per month being NPR 15,000.

In Nepal, nearly 60% of rural households are 'functionally landless' with insufficient land to meet their basic food requirements (Wily et al., 2008). Of total surveyed household, 88% of household own the land and house whereas 12% respondents do not have their own land and house. The average land size per household was 0.29 ha. Houses are typically built with slate/tin and mud walls. Slate/tin for roofing were used by 58.82% of households, followed by roofs made of natural product (24.70%) and concrete roofs (16.47%).Wood walls are used by 85%, followed by cement (13%) only in a few cases is natural material used for the walls. Some households use cement for walls to make the house more resistant to landsides.

The impacts of extreme weather events reinforce the landslides by breaking down protection such as gabions walls, houses are damaged and agricultural land becomes unsuitable. Of total household, 14% of respondents reported the loss of livestock, 72% respondents reported loss of Cultivated Crops, 75% reported the loss and damage of land and 20% respondents reported of having loss and damage to their house.

In the present study, the RUSLE model predicted erosion rates with an average value of 36.30t/ha/yr for the study area. These rates were found lower when compared with the erosion rates found in Shrestha (1997) for the similar watershed conditions, which estimated an average soil erosion rate 56 t/ha/yr in areas under rain fed cultivation. It may be due to fragile geography and lower canopy cover of forest and rainfed agriculture practice in study area.

The high soil loss rates under rainfed agriculture are directly related to the sloping nature of the terraces. Making sloping terraces is cheaper than making level terraces. The cost involved in level terraces is not justified by growing of rainfed crops. Farmers are willing to invest more for growing cash crop, if water supply and temperature conditions are favorable. Rainfed crops are usually grown in a relatively drier environment, in soils with lower organic matter content and reduced structural stability (Shrestha, 1997).

This study has demonstrated that households perceive adverse effect of landslides. Finding in line with other reports (Petley, 2007; DWIDP, 2013) also indicate the significant effect of landslides in Darbung village. Darbung has experienced significant levels of landslides over the past decades; threatening communities and vital infrastructure in the most vulnerable low-lying areas (Darbung Phant). The majority of respondents (92%) have been affected by landslides over the decades. 80% of total respondents indicated that their household economies have been affected

Households still experience 71% of residual loss and damage, 93% of respondents still suffered from negative effects of climate change and was unable to counter the effects of landslides. The ability to carry out adaptation measures was often curtailed by material, technical and financial limitations. The majority of those who did not carry out adaptation strategies indicated this was due to lack of resources, skills or knowledge. In order to improve future adaptation measures, collective, collaboration and planned adaptation measures are necessary, for example relocation and advanced technological defenses should be introduced among locals.

In the study area, the total cost of reconstructing houses, land and infrastructure was estimated to be NPR 244,504,260 (Disaster Report, 2002). From the study, the cost of loss and damage of private property (livestocks, cultivated crops, land and houses) was estimated to be NPR 380,994,000 and the loss and damage of public property was estimated to be 71,500,000 and the total cost of loss and damage was found to be 452,494,000. In comparison to the estimated cost of Disaster Report (2002), the estimated cost of loss and damage due to landslide is higher; the fact behind this may be due to the difference in price rate of then and now. The studies also consist of minor details of loss and damage from each category therefore the total cost estimation was more as compared to other.

Of those households who were affected by landslides, 45% have carried out adaptation measures. They have tried to adapt by building gabions, house, and planting trees. The adaptation measures are self-governing and implemented at household level; and some community and government-planned gabion walls have been built.

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Conclusion

The study showed that the landslide had adverse impact on the socio-economic status of people in Darbung VDC. To a large extent, the study has established that socioeconomic status play an important role in settlement patterns as well as building a landslide proof houses. There could be many reasons why a family becomes unable to cope with climate stressors (i.e. landslides). Among the household sample there were truly poor families; landless, low caste and indigenous group. Structural characteristics such as gender, income, education, ethnicity, among others, all affect a household's vulnerability in relation to landslide.

After one or successive natural disasters, poor families with insufficient financial, land, or other assets are likely to lose the minimal properties they have and face increasing indebtedness and poverty. Such vulnerable populations are disadvantaged in terms of accessing resources, which exposes them to increased risks during disasters and in the wake of climate-related events. These risks include physical dislocation and psychological trauma, the loss of household resources (e.g., livestock, built capital such as paddy walls and structures), and catastrophic harvest failure, among others.

In some cases, families have poor resilience, when a household is living in subsistence economy. For instance, when loss and damage strike a household, the family's savings or subsistence capital can be wiped out. Such households and communities face barriers that erode livelihoods, food security and asset bases and that prevent them from accessing appropriate, sufficient adaptation options to manage climatic risks.

It is also evident that there are varying underlying causes of people's vulnerability to adapt and then poses a challenge for reducing or minimizing vulnerability. Proximity to the landslide prone area further demonstrated that effects of landslides in one sector can affect other sectors of society, for instance as discussed under the loss of biological assets, the soil loss rate of the area was attributed to the impact of landslide which further decreases the crop production rate align with making community highly vulnerable to climatic extremes.

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Annexes

Annex 1: Rainfall data from Gorkha station

Months	Years																				
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
January	8.5	38.2	7.6	60.6	24.7	8.1	0.2	14.4	7.5	48.3	34.2	27	50.2	0	0	18.9	0	4	5.5	24.9	13.8
February	13.1	12.1	41.7	40.2	14.4	12.2	30.4	14	34.2	33.7	64.2	2.5	4.8	0	107.1	0	0	39.9	30.1	76	68.5
March	51.6	94.5	20.2	19.3	32.4	21.3	28.9	28.9	3	13.3	56.8	0	51.7	20.6	44.4	30	24.3	33.4	17.1	3.1	11.7
April	50.1	3.4	94.9	40.6	315.6	9	12.8	94.9	98.5	190	46.4	143.4	106.3	67.6	84.5	145	65.4	147.9	94	116.2	68
May	349.2	217.3	183.6	95	183.6	73.2	359	250.9	241.2	213.9	111	132.7	206.6	125.1	101.1	153.6	141.3	184.2	233.1	78.8	221.6
June	249.1	265.4	886.2	335.6	352.8	181.4	186.6	432.3	360.1	205	346.7	363.8	103.8	227.9	489.3	440.6	208.4	246.6	398.3	463	403.6
July	243.2	628.3	591.3	408	383.7	326.2	705.4	281.9	409.9	497.6	567	411.4	255.5	293.7	363.1	208.6	383	477.2	497.9	494.7	391.7
August	242	745.5	211.7	717.8	127.2	60.8	466.7	473.7	527.5	332.9	333.9	275	293.6	216.7	175.7	405.9	492.3	490.6	517.3	258.6	297.6
September	240	185.3	250.7	138.4	50.2	18.9	161.6	153.7	178.5	174.8	147.4	216.3	105.5	129.3	353	88	52.8	246.8	181.8	365.5	392.1
October	1.1	0	66	80.2	9.8	2.2	49.6	0	2.5	16.2	3	39.3	98.5	1.8	37.6	9.4	107.9	29.4	1.4	14.7	114.8
November	0	0	57.7	0	12.7	0	0	0	9	17.5	0	2	0	2.8	7.3	0	1	0.3	22.5	0	0
December	0	0	5.5	0	37.8	14.8	0	0	0	0	18.3	0	0	28.5	0	0	0	0	0	0	0
Annual Rainfall	1447.9	2190	2417.1	1935.7	1544.9	728.1	2001.2	1744.7	1871.9	1743.2	1728.9	1613.4	1276.5	1114	1763.1	1500	1476.4	1900.3	1999	1895.5	1983.4
Total Annual Rainfall	35875.2																				
Average Annual Rainfall	1793.76																				

Annex 2: Calculation of RUSLE factors

$$R = P * 0.5$$

$$=1793.76*0.5$$

= 896.88 MJ.mm./ha.h.yr

$$K = 2.1 * 10^{-6} \; * M^{1.14} * (12 - OM) + 0.025(S - 3) + 0.0325(P - 2)$$

M= [(% Silt + %Sand)*(100 - %Clay)]

(Silt+Clay)% = Hydrometer reading at 40 sec + 0.3*(t-20°C)

=10+0.3(26-20)

=11.8

Clay % = Reading at 3 hours + 0.3*(t-20°C)

=3+0.3(6)

=4.8

Sand% = 100-(Silt+Clay) %

=100-11.8

=88.2

Silt % = (Silt+Clay)%-Clay%

=11.8-4.8

=7

M= (88.2+7) (100-4.8)

=9063.04

$$percent\ Carbon = \left(1 - \frac{T}{S}\right)\left(\frac{3.951}{g}\right)$$

$$= \left(1 - \frac{20.7}{23.8}\right)\left(\frac{3.951}{1}\right)$$

$$= 3.82$$

$$percent\ Organic\ Matter(OM) = percent\ Carbon * 1.724$$

= 3.82* 1.724

=6.58

S=3

P=2

K= 0.369412 th/MJ.mm

Slope length (L) =23.79 m

Steepness(s) =2.92

$$LS = \sqrt{60.21/22}(0.065 + 0.45s + 0.065(1.92)^2$$

=2.01

Annex 3: Category wise price rate of physical assets

S.N	Assets	Categories	Rate
1.	livestocks	Chicken	520
		Pig	2000
		Goat	6000
		Buffalo	50,000
2.	Cultivated crops	Paddy	40 per kg
		Maize	35per kg
		Wheat	38 per kg
3.	Lands	Khet	800000 per Ropani
		Bari	1000000 per Ropani
		Pakha	300000 Per Ropani
		Commercial Land	1200000
4.	Houses	Slate/Tin roofed	500,000
		Thached roofed	300,000
		RCC	800000