Determinants of flood disaster household's vulnerability in Nepal

Bista, Raghu Bir

10 February 2018

DETERMINANTS OF HOUSEHOLD VULNERABILITY IN NEPAL: ANALYSIS OF CLAMATIC INDUCED FLOOD DISASTERS

Dr. Raghu Bir Bista[1],
Associate Professor, Department of Economics, Tribhuvan University[2], Nepal
e-mail: bistanepal@gmail.com

Abstract

Almost extreme socio-economic vulnerabilities relate to climatic disasters and its economic loss at household level. This generates a curiosity about determinants and levels of vulnerability at micro level for exploring policy options. This paper measures empirically the determinants of vulnerability of natural disasters at household level based on primary data sets collected from household survey in Sot Khola water basin by using multiple econometric models. The descriptive analysis shows a huge loss with a worth 13,344,000 Rupees including crops, assets and physical infrastructure. Despite its small worth, life was worst due to loss of house, crops, clean drinking water, electricity, documents, foods, communication, displacement etc. Furthermore, the result of the model shows rural orthodox society having indigenous knowledge and skill, conservative agrarian family, traditional labor force, primitive technology etc. Loss and income of household have positive relationship but labor, early warning and knowledge of disasters have negative relationship. Knowledge of disasters have made household resilient to reduce economic loss and then household vulnerability. Households in the geography of Gadhi and Lekhagaon are more resilient than of Kunathari. Therefore, climate resilience is urgent issue to minimize household vulnerability for household income and welfare.

Key words: *climatic disasters, vulnerability, income, poverty, climate resilience Nepal,* etc

---

[1] Raghu Bir Bista is Associate Professor of Economics Department appointed by Tribhuvan University in 2002. He joined as research associate working in contract in 1999. He teaches policy economics, public economics and macroeconomics. He did Masters of Philosophy(MPhil) in Economics from Jadavpur University, India in 2010 and his research title was *Global Role of Nepalese Forest: A case of Reduction Emission from Deforestation and Degradation(REDD)* published by Lambert publication in Germany in 2011. He was a SANDEE fellow at that time. He did PhD in 2017 on *Economics of Climate Change Vulnerability and Household Adapatation in Sotkhola Water Basin in Surkhet, Nepal*. He was University Grant Commission Fellow. (see his webpage: www.linkedin.com/dr-raghu-bir-bista ; www.researchgate.net/Raghu Bir Bista; ; www.facebook.com/raghu.b.bista

[2] Tribhuvan University is a public university established by the Government of Nepal in 1959 A.D with an objective of higher education promotion and production of highly qualified human resources. The university is the oldest university in Nepal and the tenth largest in the world in terms of enrollment. Till 2018, it has 60 constituent campuses and 1084 affiliated colleges across the country (see its details in websites: tribhuvan-university.edu.np).

1. Introduction

Vulnerability is a wider and deepening spreading issue in the world. World Bank (2016) calculates $ 520 billion economic loss of natural disasters in annual consumption and enforces about 26 million people into poverty per year. In another words, disasters produce a large vulnerable population all over the world. In addition, the vulnerable population heavily pays more than non-vulnerable population in the study of 117 countries because the poor people have a limited ability to cope with natural disasters. It is 60 percent costs in annual consumption. In Bangladesh, disasters facts reveal 219 natural disasters destroying $ 16 billion loss and millions of homes, devastated livelihoods and led to the spread of disease (IEDRO, 2010).

In 2004, floods on the Ganges, Brahmaputra, Jamuna, and Meghna affected 30 million people and submerged 40% of Bangladesh's capital, Dhaka. In 2009, tropical Cyclone Alia forced the evacuation of half a million people, damaged or destroyed half a million houses, and destroyed hundreds of thousands of acres of cropland. Worst, however, was the 1970 Bhola cyclone. Estimates put the death toll at 500,000 people, making it the deadliest tropical storm in recorded history (IEDRO, 2010). Similarly, more than 80 percent of the total population of Nepal is at risk of natural hazards such as floods, landslides, windstorms, hailstorms, fires, earthquakes and Glacial Lake Outburst Floods (GLOFs) (Bista, 2016 and MoH, 2017). Thus, vulnerability is a central issue of social sciences and development economics.

A large number of social scientists and economics scholars have recently focused on vulnerability to natural disasters and climate change to find out alternative policy measures for building resilient development and community for reducing vulnerable population in the world. A group of literatures has conceptualized vulnerability to be understood in depth. It is understood as helpless socio economic and political human condition leads to exposure to natural disasters more than other higher socio economic human condition. Extensive research over the past 30 years has revealed that it is generally the poor who tend to suffer worst from

disasters (Twigg, 2004; Wisner et al., 2004; UNISDR, 2009b). In simple, it can be explained as the poor section of people. Wisner et al. (2004) has similar argument that vulnerability is not simply about poverty, but Poverty is both a driver and consequence of disaster risk (particularly in countries with weak risk governance) because economic pressures force people to live in unsafe locations (*see exposure*) and conditions. Twigg (2004) explains it as human dimension of disasters and as the result of economic, social, cultural, institutional, political and psychological factors that shape people's lives and the environment that they live in. Thus, we can draw it as the people having 'fragility', 'weakness', 'deficiency' or 'lack of capacity'. In another words, it is "susceptibility to harm" or "exposure to natural hazards".

Similarly, on vulnerability, Birkmann, (2006) explains its concerns the wider environmental and social conditions that limit people and communities to cope with the impact of hazard. These processes produce a range of immediate unsafe conditions such as living in dangerous locations or in poor housing, ill-health, political tensions or a lack of local institutions or preparedness measures. IPCC (2012) elaborates its determinants by historical, political, cultural and institutional and natural resource processes that shape the social and environmental conditions people find themselves existing within.

Vulnerability is a set of conditions that negatively affect the ability of people to prepare for and withstand disaster (Warmington 1995, Lewis 1997, 1999, Alexander, 2000, Clark, Cash, Corell, Dickson, Hall and Parson, 2000 and UNDP, 2004). Turner II et al. (2003) mentions it as the inability to withstand the effects of a hostile environment. Hodinott and Quisumbing (2003) provided socio economic dimension of vulnerability in which the study used household data for quantification of risk and vulnerability for focusing three dimensions: expected poverty, expected low utility and uninsured exposure to risk. In simple, it is the capacity to be wounded i.e. the degree to which a system is prospectively to feel harm in the exposure to a hazard. It has different variables, relationship and perceptions of the people, although it is itself a complex, its dynamic nature and its multi-dimension (Birkmann, 2007). Similarly, Cardonna (2003) explain it to refer to risk or to define disadvantaged conditions by explaining the relationship between shock and vulnerability towards risk. Chambers (1989) mentions external side (risks, shocks and stress to individual) and internal side (defenseless of individual (physically weaker, economically improvised, socially dependent and psychologically

humiliated)-no means to cope without damaging loss). Differently but similarly, Watts and B0hles(1993) argue like as Chambers (1989), Blaikie, 1994, Varley,1994, Bolin and Stanford, 1998, Brooks 2003 and Adger, Brooks, Bentham, Agnew and Eriksen, 2004, Blaikie, Cannon, Davis and Wisner (1994). Differently, Adger, (2000) and Adger, (2006) argue it in terms of exposure and susceptibility to and harm by social and environmental stress, and can be associated with the capacity to cope with the impending or existing disaster. Similarly, the United Nations Environment Program (UNEP) (2003) argues it as shock's consequences including loss of human lives, malnutrition, income losses, water stress, and environmental degradation.

Gradually, recent literatures have focused on the relationship between vulnerability and natural disasters in the world. In Nepal, none literatures have covered on the relationship between vulnerability and natural disasters. Therefore, this study is urgent need to contribute valuable policy inputs and to fill up such gap for policy measures in pre and post disasters for building resilient individual household and community for coping adverse effects of natural disasters.

2. Objectives and Method

The paper has main objective to estimate the effects of socio economic variables on household vulnerability in Nepal. Its specific objectives are to assess natural shock and household vulnerability level, to identify socio economic characteristics of households and to assess their effects on household vulnerability in Nepal.

3. Methods

3.1. Analytical Framework

Numerous theoretical and empirical literatures (Shen et al. 2011) on vulnerability mentions income loss of household as measurement of vulnerability. This paper follows similar analytical framework in different variables (socio economic and natural shocks) in different country, Nepal because of its relevancy. Scientifically, vulnerability depends on socio economic condition of households and natural shocks. If households have a better socio economic condition, they will have less vulnerability, despite homogeneity in their exposure to natural disasters. If not, vulnerability will be more at poor socio economic condition. Therefore,

vulnerability and socio economic condition have inverse relationship and vulnerability and natural disasters have positive relationships. Its theoretical function is an equation (i) below.

$$Y_{Til} = f\,(X_h, C, \varepsilon)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(i)$$

Where

Y_{Til}=household's total income loss,

X_h= socio economic bundle (income, literacy, asset, family size, land holding etc),

C= climate shock (flood, cyclone, landslide)

ε =error term

3.2. Econometric Models

In order to capture above the curiosity, the semi log econometric model includes nine variables. Household vulnerability is in terms of income lost. Log form income loss of household (ln Y_{TIL}) is dependent variable. Similarly, the proportion of agricultural labor (X_{1agl}), type of house (X_{2th}), the proportion of agricultural income (ln X_{agli}), D_{0m} (member of organization), D_{1ew} (Early warning), D_{2kd} (knowledge of disaster), D_{3G} (Gadhi), D_{4L} (Lekhagaon), and D_{5K} (Kunathari) are independent variables where D_{0m} (member of organization), D_{1ew} (Early warning), D_{2kd} (knowledge of disaster), D_{3G} (Gadhi), and D_{4L} (Lekhagaon) are dummies. There are eight estimators: β, β_1, β_2, β_3, β_4, β_5, β_6, β_7, and β_8. Based on above theoretical equation (i), semi log econometric model (equation ii) is built as
as follows:

$$\text{Ln}\ Y_{TIL}= \beta + \beta_1\ \text{Ln}\ X_{1agl}+ \beta_2 X_{2th}+ \beta_3\ \ln X_{agli}+ \beta_4 D_{0m}+ \beta_5\ D_{1ew}+ \beta_6\ D_{2kd} + \beta_7\ D_{3G} + \beta_8\ D_{4L} + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(ii)$$

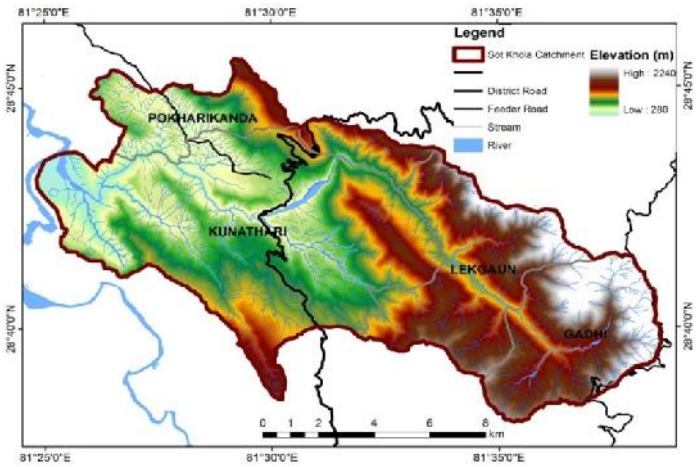
3.3. Study Area

This paper is based on the study undertaken in the Sotkhola water basin and its catchment areas (Figure 1) in the northern part of Surkhet, the western Nepal. The water basin is a tributary of a big river, Bheri (Figure 1). Its length is about 30 km originated from Chandane, Gadhi VDC and ends to Rakseni, Kunathari VDC (Figure 1)(DDC, 2015). Its water level seems to be

permanent character but its fluctuation occurs in the different seasons from monsoon to winter. In winter, its water level is unexpectedly lower. Thus, the river is a monsoon lover.

Geomorphological of the water basin has mainly three catchment areas having 28 square spread from sea level to Mahabharata range: Gadhi VDC (Upper stream), Lekhagaon VDC (middle stream) and Kunathari VDC (downstream) (DDC, 2015). Such hilly and mountainous landscape is rich for heterogeneity and diversity in wildlife and ecosystem. Demographically, population size is about 3369, out of which main castes are Magar (37.7 percent), Brahmin (30.6 percent), Cheetri (17.1 percent), Sunwar (5.7 percent) and others (22.6 percent). Others include Kami, Sarki, Thakuri, Gurung, Damai, Sherpa, etc (VDC, 2015). b) Lekhgaon village spreads 110 km length and 30 km breadth of 2451 square km (249016 hectare) from 198 meter (Tata pani) to 2369-meter (Matela gurase) altitude (Figure 1). Hill with 84 percent dominates to 16 percent valley. Population size is 3999 (651 households) (DDC, 2015). c) Kunathari is another study village lying between 600 meter and 1200 meter (Figure 1). It is 20 km far from district headquarter). Population size is 3413 (CBS, 1991) and (DDC, 2015). This water basin is a source of clean drinking water, irrigation water and water and terrestrial ecosystems to the catchment households. This study area is purposively selected by i) its climatic variation and disasters event as flooding and landslides in 2014, ii) its huge vulnerability at the catchment areas, iii) its morphological structural change, iv) its aquatic and terrestrial ecosystem and biodiversity and v) its agricultural lifeline and its risk.

Figure 1: Sotkhola and its catchment study Area



Source: *GIS map of Study area based on field survey, 2015*

3.4. Data Sets

To understand the effect of natural disaster on household income and then poverty and inequality to minimize adverse effects of disasters and to control drivers of disasters, this study uses primary and secondary data. In primary data, household level data of UNDP's Household Survey conducted

during from September 2015 to October 2015 are used. The household survey funded by UNDP Nepal is the first sample survey conducted in Sot khola water basin and its catchment areas (Gadhi VDC, Lekhagaon VDC and Kunathari VDC)(figure 1) with an objective to collect reliable and accurate data and information about climatic events and disasters and its vulnerability to install hydrological monitoring system, alert system, infrastructure and building adaptation capacity. As supplementary data related to metrology, inequality and poverty, secondary data is collected from Department of Metrology and Central Bureau of Statistics.

3.5. Data Collection Method

Data for this study is collected from household survey, Focused Group Discussion (FGD) and Key Informant Interview (KII). Firstly, the study followed two-stage sample method by using cluster sampling method covering 3310 households over all 3 rural catchment villages(Gadhi, Lekhagaon and Kunathari) in Sot khola river water basin of the western Nepal. In the first stage, the survey made 9 clusters to these three villages based on altitude, location and place. In the second stage, the survey used random sampling method to select 642 sample households (19.3%) from out of such nine clusters.

The study collected the primary data and information by using structural questionnaire having four different sets questionnaire related to socio economic information about household, climatic events and vulnerability, agriculture activity and adaptation capacity, behavior and decisions in wheat production. Socio economic data from household provided basic information about household land holding, income level, source of income, size of family, gender, age, caste are used in this study to understand heterogeneous socio economic characteristics of the farmers. Similarly, climatic events and vulnerability set of questionnaire provides information, experience and perspective about climatic events, its types, natures, patterns and vulnerability level. Agricultural activity related data include data related to agriculture activity, farm revenue, types of crops, crop cycle, inputs, infrastructure and markets. Lastly, adaptation capacity, behavior and decisions set provides data set related to income, information, technology, experience, indigenous skills, application and loss reduction. Further, the effects of disasters on household income loss are analyzed and identified by using semi log econometric model.

3.6. Estimates

3.6.1.Estimates of independent variable's coefficients

Above semi log econometric model includes three types of variables in which household's income loss (Y_{TIL}) is dependent variable and Socio economic bundle and natural disaster are independent variables. Their relationship is empirical curiosity. In this paper, we focus two questions:

- What is contribution of socio economic condition and natural disasters on household's total income loss (vulnerability)?
- What is independent variables share producing household vulnerability?

The paper uses disaggregate household level data sets collected from household survey 2016. Above the model answers quantitatively both questions. Furthermore, it answers how much vulnerability occur in the low income household.

4. Results and Discussion: Analysis of the factors influencing Household Vulnerability

4.1. Household Vulnerability in terms of Income loss

As discussed earlier about coverage of household vulnerability in the study areas through CVI explains the occurrence of 69 percent vulnerable households including extreme one, along with its levels and areas. In other words, it is like higher degree of the damage or harm to a system caused by the climate change induced disaster: flood and landslide in the Sot Khola sub water basin and the catchment areas. Further, it is determined by sensitivity and adaptive capacity (IPCC, 1996). This section presents degree of damage at household level of the study area due to the flood and landslide of Sot Khola sub water basin and catchment areas in 2014. It employs not only household property, agricultural crop and household income (Table 22).

Table 1: Damages and Loss of Household Asset and Income from Hazards

Items		Affected Household		Total Damage (Rs)	Mean(Rs)	Max(Rs)
		No	%			
Household Asset	Houses	43	6.7	3,344,000	167,000	500,000
	Asset	20	3.1	10,000,000	293,000	3,120,000
Crops/product	Crops	152	23.75	798,777	5,255	100,000
	Livestock	11	1.7	410,000	37,272	60,000
Lost income	Salary	9	1.4	88,650	9,850	30,000
	Business income	10	1.5	266,200	4,840	115,000
	wages	55	8.5	101,000	10,100	100,000
	agriculture	138	21.5	3,455,800	25,000	500,000
Total				18,464,427		

Source: *Field Survey, 2015*

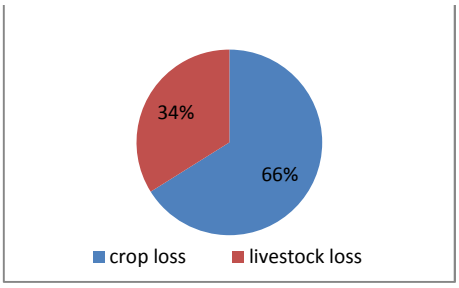
- **Household Property Damages and Loss**

  Table 22 shows the result of damage and loss of household property, asset and income from hazard as collected from household survey 2015 and secondary information of DDC of Surkhet 2015. The result is the evidence of higher degree of household property damage and loss in which there were 6.7 percent two story house and 3.1 percent asset fully and partially damaged. In the survey, there were Rs. 3,344,000 house damaged and Rs.10,000,000 asset damaged. In total, there was Rs. 13,344,000 household and property loss (Table 1). Surkhet is considered as lower Human Development Index along with higher Poverty Index. In addition, such calculated damages and losses are sufficient evidence for the growth of poverty level and inequality in the study area.

- **Damages to Household production and products**

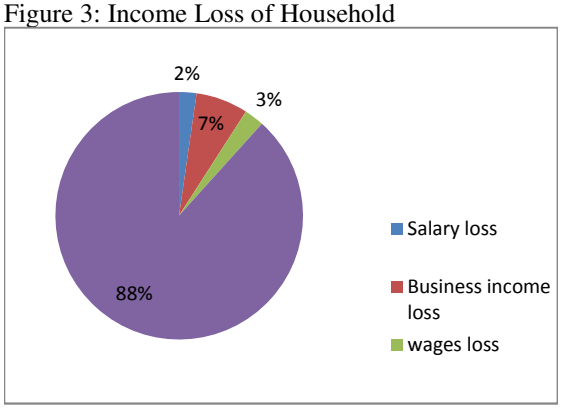
  Table 2 shows damage to household production and agro products as collected and calculated in the household survey 2015 and secondary information of DDC of Surkhet 2015. The result is the evidence of degree of household production and agro product in which about Rs. 798,777 worth of agricultural crop, along with the large units of fertile land were damaged by climate change induced disaster: flood and landslide in 2014. Similarly, it killed 41 livestock (cow, buffalo and goat) with the worth of Rs. 410, 000. In total, crop damage share was 23.75 percent meanwhile livestock loss share was 1.7 percent. Out of total household production and agro product loss, crop loss share dominated with 66

Figure 2: Loss of Household Crops & Products



Source: *Field Survey, 2015*

Figure 3: Income Loss of Household



Source: *Field Survey, 2015*

percent to 34 percent livestock loss (Figure 2). Therefore, there was a huge damage and its cost to Gadhi VDC, Kunathari VDC and Lekhagaon VDC. Thus, such disaster induced the higher level of household vulnerability.

- **Income loss**

  Table 2 shows the result of damage and loss of household property, asset and income from hazard as collected from household survey 2015 and secondary information of DDC of Surkhet 2015. The result is the evidence of higher degree of household due to income loss. During the period of climatic shock, off farm sector (business and entrepreneur activity) was damaged. The opportunity cost of labor was nearly zero. Such climate shock had damaged fully household economic activity in three VDCs such as Gadhi, Lekhagaon and Kunthari. Its result was the loss of household income in which agriculture income loss share was 88 percent and then share of business income loss was 7 percent. It is followed by share of wage (3 percent) and share of salary loss (2 percent) (Figure 3). In total, there was Rs. 3,911,650 income loss during the flood.

- **Injury and loss of life**

  The result of household survey 2015 shows no warning system in the higher intensity of the flood and landslide due to heavy monsoon rainfall in 2014. Household had not found sufficient time and place to family to move at safe places. In the severe situation, human individual tried to be safe and made to safe all other people. There were possible to injury and to loss of life. Such injury had huge medical expenses. Such loss of life had a huge value. However, life loss of one person was only recorded in Kunathari.

4.2. Characteristics of Household Vulnerability

Table 2: Geographical Setting of Households

Distance (Meter)	No of HHs	Vulnerable level
0-50	21	Higher
50-100	18	Moderate
Above 100	17	lower

Source: *Field Survey, 2015*

Depth analysis of above level and status household vulnerability needs its characteristics. To understand such household vulnerability's characteristics across VDCs of the study areas, there were employed about three variables such as geographical setting, the permanent of house and income structure. The result of Household Survey 2015 is presented as below.

- **Geographical setting**

Geographical setting is an important variable to measure household vulnerability. The result of Household survey 2015 shows the heterogeneous geographical setting including slop and plain land in which Lekhagaon and Gadhi occurred at 30^0 slop land in which traditional method and local material (mud and stone) used two story house was constructed. In Kunathari, there were low land and no sloppy. In case of flood, there were only two houses near distance (0-50 meters) with Sot Khola and its tributaries. They were highly vulnerable. Between 50 and 100 meters, there were three houses categorized into moderate vulnerable. In the above 100 meters distance, these houses were categorized into lower vulnerable. However, all houses lied into the different level of vulnerability. Table-2 shows household vulnerability against distances in which about 21 houses were in highly vulnerable from the occurrence of climate shock. It is followed by 18 houses lying moderate vulnerable and 17 houses having lowered vulnerable. In total, 56 houses were vulnerable.

- **Types of houses**

Table 3: Types of Houses

Construction Materials	%
Mud made	95
Cement made	5
Total	100

Source: *Field Survey, 2015*

Table 3 shows the type of house contributing household vulnerability. If house is constructed by mud made, it is not considered as permanent house. If it is constructed by cement made, it is considered as permanent house. Table 24 shows 95 percent house constructed by only mud and stones by following traditional method and indigenous knowledge. Such house could not be considered as strong and instable. They had more vulnerability due to its material and technique. Only 5 percent house was constructed by cement and bricks by using nontraditional method. It was less vulnerable. In the absence of engineering design and method, both types of house might be vulnerable.

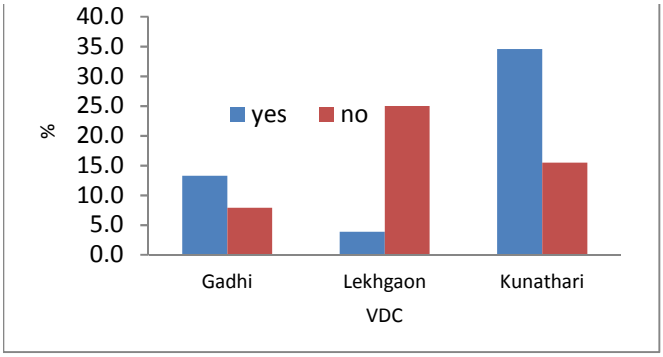
- **Income structure**

Figure 21 shows divergent income loss. It shows the divergent income sources of household. In Figure 32, it shows such impact more on the larger land holder than lower land holder in case of flood. In this sense, the rich person was more vulnerable than the poor. In case of landslide, it damaged more of the rich than of the poor.

4.3. Analysis of the factors Influencing Household vulnerability in Income Loss

- Awareness about flood and landslide is prerequisite to all household living in the vulnerable place to minimize the potential loss and damages. Thus, it can influence the impact fully on household vulnerability.

Figure 4: Knowledge about Natural Hazards



Source: *Field Survey, 2015*

The survey shows 35 percent having knowledge about natural disaster in Kunathari against 15 percent having no knowledge. In Gadhi, about 13 percent had but about 8 percent had not. In Lekhagaon, about 25 percent had but about 3 percent had not (Figure 4). Therefore, Kunathari was more vulnerability and risk from the potential risk than Gadhi and Kunathari.

- Perception of household on the impacts of flood and landslide is another variable building a belief on its possible reduction or mitigation. Then after, their potential impact could be minimized. Otherwise, loss might be unaccountable.
- Assessment of damage related to flood and landslide provides valuable input to think and prepare adaptive and mitigation measure in which household can reach at safe place and also protect valuable asset. Thus, household could protect themselves from loss and damage from flood and landslide. The immediate assessment was conducted by District administration for relief purpose.
- Reasons for more severe climate change related damage in the future should be understood by in depth analytical study and discussion. The community had opined for climate change in terms of increasing temperature trend and decreasing rain fall trend but intense rain fall within the short time period. Further, they thought environmental degradation for climate change. Despite literate, they got such information through radio and television.

- In the resilient society, preparation for the future is vital and valid variable to reduce the potential damage and loss. It is based on the principle of prevention is better than care. In order to prevent natural disaster, there were constructed Gavin wall in the different parts of corridor of Sot Khola from upstream to downstream to protect crop land by reducing its speed and damage. Similarly, such construction with bio engineering was initiated to control landslide induced soil erosion. In addition, almost household had preferred to move to safe place for protection.

4.3.1. Estimation

4.3.1.1. Model Hypothesis

Indigenous and exogenous variables have influence on household vulnerability. In this study, the proportion of household income that was lost due to climate shock induced flood was used as an indicator of household vulnerability. The household vulnerability was influenced by different socio economic variables (family member, landholding, knowledge, experience, member of organization, help, house type, number of labor, agricultural income and geographical areas) and geographical areas. This study to construct an econometric model has the following hypothesis below.

- The proportion of household labor has an inverse relationship with household vulnerability. Its basic argument is that large or additional labor means additional physical and mental resources having capacity to earn wage income or to mobilize property and asset at the safe place. Naturally, household vulnerability will be lower.
- House if is strong and permanent; house is able to save human being, asset and financial resource from the damage of flood. Thus, the strong and permanent houses are inversely related with household vulnerability**.**
- The proportion of agricultural income has positive relationship with household vulnerability. If the proportion of agricultural income increases, income loss will increase and then household vulnerability will increase. Therefore, the proportion of agricultural income and household vulnerability is supposed to be positive.
- Knowledge and experience about climate shock and flood makes household capable to use effectively and efficiently skills and technology in the course of adaptation activity against the flood. Thus, it reduces household vulnerability. Therefore, knowledge and experience have inverse relationship with household vulnerability.

- The society has different community organizations working social and economic activity. As per an objective of family, household takes their membership for accessing financial and physical support. When household is in disaster or the community is in disaster, such organization will support financially and physically to reduce vulnerability by promoting adaptive activity. Therefore, their membership and their help have inverse relationship with household vulnerability.
- Early warning makes household their preparedness and alertness. It provides time to household to reach decision to move at safe place. In this way, household vulnerability will fall down. Therefore, the early warning system has inverse relationship with household vulnerability.
- Geography has different characters such as topography and elevation influencing the vulnerability and adaptive capacity of household. Therefore, different geography has the different level of household vulnerability.

4.3.1.2. Estimates of Vulnerability coefficients

Data set of semi log econometric model includes nine variables in which household vulnerability in terms of income lost in log form income loss of household ($\ln Y_{TIL}$) is dependent variable and the proportion of agricultural labor (X_{1agl}), type of house (X_{2th}), the proportion of agricultural income ($\ln X_{agli}$), D_{1ew} (early warning), D_2kd (knowledge of disaster), D_{3G} (Gadhi), D_{4L} (Lekhagaon), and D_{5K} (Kunathari) are independent variables, where D_{1ew} (early warning), D_2kd (knowledge of disaster), D_{3G} (Gadhi), D_{4L} (Lekhagaon), and D_{5K} (Kunathari) are dummy variables. There was a curiosity how independent variable influencing household vulnerability dependent variable. In this study, we focused on two questions:

- how adaptive capacity of household influenced on household vulnerability in different geographical areas and
- what were coefficient values of independent variables? Above Semi log econometric model was used for the estimation of parameters of the model.

Cross sectional data of Gadhi, Lekhagaon and Kunathari in 2015 was used to answer quantitatively above five questions from econometric model after the estimations of coefficients -β, β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8, and β_9 of independent variables. From this model, we could interpret the effect of above independent variable on the vulnerability of household.

4.3.1.3. Estimates of vulnerability of household determinant coefficients

Data set of semi econometric model includes nine variables in which household vulnerability in terms of income lost in log form income loss of household ($\ln Y_{TIL}$) is dependent variable and the proportion of agricultural labor (X_{1agl}), type of house (X_{2th}), the proportion of agricultural income ($\ln X_{3agli}$), D_{1ew} (early warning), D_{2kd} (knowledge of disaster), D_{3G} (Gadhi), D_{4L} (Lekhagaon), and D_{5K} (Kunathari) are independent variables, where D_{1ew} (early warning), D_{2kd} (Knowledge of disaster), D_{3G} (Gadhi), D_{4L} (Lekhagaon), and D_{5K} (Kunathari) are dummy variables. This model estimates determinants of vulnerability of household (income loss of household) through the estimation of β, β_1, β_2, β_3, β_4, β_5, β_6, and β_7 for understanding dependency of vulnerability of household in the watershed areas of Sot Khola, Surkhet. In the study, we focused the following questions:

- What would be unknown coefficient "β_1" of agricultural labor, "β_2" for type of house, "β_3" for the proportion of agricultural income, "β_4" for early warning, , "β_5" for knowledge of disaster for understanding how much socio economic and adaptive variables contribute to vulnerability of household?
- What would be unknown coefficient "β_6" of Gadhi and "β_7" for Lekhagaon for understanding how much geographical variable contribute to vulnerability of household?

4.3.1.4. Results

Table 25 presents mean and standard deviation of key variables in multiple semi log regression model estimation. In column 1, there are 8 variables in which household vulnerability in terms of income loss of household ($\ln Y_{TIL}$) is dependent variable and the proportion of agricultural labor (X_{1agl}), type of house (X_{2th}), the proportion of agricultural income ($\ln X_{agli}$), D_{1ew} (early warning), D_{2kd} (knowledge of disaster), D_{3G} (Gadhi), D_{4L} (Lekhagaon), and D_{5K} (Kunathari) are independent variables, where D_{1ew} (early warning), D_{2kd} (knowledge of disaster), D_{3G} (Gadhi), D_{4L} (Lekhagaon), and D_{5K} (Kunathari) are dummy variables. Standard deviations of these variables from mean are no so far significant. The mean of above these variables represents properly household data collected from primary sources.

Table 4: Mean and Standard Deviations: Semi Log Regression Model

Variables	Mean (Standard Deviation)
Income lost ($\ln Y_{TIL}$)	4.94 (5.25)
Agriculture labor (X_{1agl})	1.96 (1.47)
Agricultural income ($\ln X_{agli}$)	4.32 (5.4)
Early warning (D_{1ew})	0.06 (.25)
Knowledge of Disaster (D_{2kd})	0.52 (.51)
D_{3G} (Gadhi)	0. 13 (.341)
D_{4L} (Lekhagaon)	0.22 (.42)
D_{5K} (Kunathari)	0.63 (.48)

Table 26 provides the results of semi log regression model of dependent variable, income loss of household ($\ln Y_{TIL}$) is dependent variable and the proportion of agricultural labor (X_{1agl}), type of house (X_{2th}), the proportion of agricultural income ($\ln X_{agli}$), D_{1ew} (early warning), D_{2kd} (knowledge of disaster), D_{3G} (Gadhi), D_{4L} (Lekhagaon), and D_{5K} (Kunathari). There are ten parameters: β, β_1, β_2, β_3, β_4, β_5, β_6 and β_7.

In the results of econometric model, parameter (β) represents constant, "β_1" as marginal change of agriculture labor, "β_2" as marginal change of type of house, "β_3" for the proportion of agricultural income, "β_4" as marginal change of early warning, "β_5" as marginal change of knowledge of disaster, "β_6" as marginal change of Gadhi, "β_7" as marginal change of Lekhagaon (as alternative of marginal change of Kunathari).

Table 5: Results of Semi Log Regression Model

Dependent variable: income loss			
Regressor	Coefficient	Std. Error	P value(significance)
Constant	32.41	4.87	0.00
Ln Aglabor(X_1)	-5.24	1.58	0.007
LnTotal Income (X_2)	0.37	0.28	0.206
Lnagincome (X_3)	0.44	0.32	0.204
D_1Knowledge of disaster(kd))(yes=1, 0=others)	-5.43	1.43	0.003
D_2Early warning)(yes=1, 0=others)	11.07	3.91	0.016
D_3(Gadhi))(yes=1, 0=others)	-13.65	3.70	0.004
D_4 Lekhagaon)(yes=1, 0=others)	-21.81	4.53	0.001
R^2=0.78	F value=5.024		
Df =8, 11	N=642		

4.3.1.5. Discussion and Conclusion

Above result of semi log econometric model provides sufficient and necessary evidence on coefficient of independent variables on household vulnerability (income loss of household).

Estimation of coefficient explains how much the change of household vulnerability is affected by the change of adaptive capacity, geography and climatic shock (the flood). In the result of the model, R^2 value is 0.78. It means approximately 78 percent variation of vulnerability (household income loss) explained by above independent variables. In another words, it indicates higher goodness of fit to the data. There is still 3.71 percent error term which includes the different unobserved variables. It indicates higher goodness to fit. $F_{cal\ (8,\ 11)}$ is 5.02. It is compared with $F_{Table(8,\ 11)}$ value(3.28). It is found value of $F_{cal\ (8,\ 11)}$ R> value of $F_{Table\ (8,\ 11)}$. It shows that the difference in variance between and within variety is significant at 5 percent. Further, there is no difference between sample means. Similarly, P_{value} is calculated 0.008 at 5 percent significance level. It shows no reasonable reason to reject no difference between sample means.

Ln total income loss (vulnerability) = 32.41-5.24 Ln (ag labor) + 0.376Ln (total income) + 0.44 ln ag income - 5.43 knowledge of disaster + 11.07 early warning -13.65 Gadhi -21.187 Lekhagaon

Let us suppose that there are three factors: socio economic status and development, adaptation capacity and geographical factors. In the evidence of Sot Khola watershed areas, there was natural hazard happened in 2014 that is called flood. In that situation, there was available socio economic status contributing vulnerability of household and also showing adaptive activity in different VDCs (Gadhi, Lekhagaon and Kunathari).

Household vulnerability is a threat to be controlled to household for peace, happy and normal livelihood. Above independent variables have either positive or negative relationships with household vulnerability in those three VDCs: Gadhi, Lekhagaon, and Kunathari. Let us present one by one independent variable influencing household vulnerability.

- Household lose income in disaster, when agricultural income occurs. Therefore, agricultural income has impact (0.44) on household vulnerability. Let us assume that other variable remain constant, the loss proportion in total household income will increase by 44 percent when the proportion of agricultural income increases by 1 percent. It shows that agriculture is sensitive to the impact of flood and landslide.
- When we talk about total household income. It has also impact (0.37) on household vulnerability in terms of income loss. When 1 unit of total income increase, household

vulnerability will increase by 37 percent. Therefore, the sources of total income of household are more sensitive to the impact of natural hazard.

- Early warning system reduces household vulnerability through preparedness and alertness. How much time earlier so much household will have time to move at safe place. In case of occurrence of early warning system, early warning system has not directly linked with household income loss. Therefore, early warning system has increased the cost of preparedness to reduce household vulnerability by 11 percent.
- The knowledge of disaster through either traditional method or experience or training will reduce household vulnerability because such knowledge provides skill to reduce the negative impact of natural hazard. In case of the occurrence of knowledge of disaster, household will reduce household vulnerability by 543 percent if other variables are remaining constant. Therefore, the knowledge of disaster has negative relationship with household vulnerability.
- Agricultural labor has the inverse relationship with household vulnerability. This hypothesis is rejected by the model. Agricultural labor has not been mobilized or has not capacity to move property or asset at the safe place. Therefore, agricultural labor has no effect on household vulnerability.
- There are three study areas such as Gadhi, Lekhagaon and Kunathari having household vulnerability. These areas have different household vulnerability. In above socio economic conditions, household vulnerability between Gadhi, and Lekhagaon are -13.65 percent and -21.18 percent respectively. It indicates different household vulnerability due to geographical factors. In Gadhi and Lekhagaon, household will have more resistance or resilient than Kunathari in case of disaster.

The result of above question from the model clearly indicates the dependency of vulnerability on agricultural income, total income and type of membership. Agricultural labor and knowledge of disaster have negative relationship with household vulnerability. Geography of Gadhi and Lekhagaon has resistance but Kunathari has no resistance. Therefore, resilience socio economic characteristic, adaptive preparedness and resilient geography are urgently needed for future. Based on above finding, alternative hypothesis for objective 3 is accepted.

6. Reference

Adger, W. N. (2000). Social and ecological resilience: Are they related?. *Progress in Human Geography,* 24(3), 347-364.

Adger, W.N., Brooks, N., Bentham, G., Agnew, M. and Eriksen, S. (2004). *New indicators of vulnerability and adaptive capacity.* London: Tyndall Centre for Climate Research.

Adger, W. N (2006). Vulnerability. *Global Environmental Change,* 16 (3), 268-281.

Bista, R.B. (2016). *Economics of Nepal*: *Observation, Experience and Discussion* published by New Hira Books, Kirtipur, Nepal

Birkmann, J. (2007). Risk and vulnerability indicators at different scales: Applicability, usefulness and policy implications, *Environmental Hazards,* 7(1), 20-31.

Blaikie, P., Cannon, T., Davis, I., and Wisner, B. (1994). *At risk: Natural hazards, people's vulnerabilities and disasters*. (Ist ed.), London: Rutledge.

Bolin, R. and Stanford, L.(1998). *The Northridge earthquake: Vulnerability and disaster.* London: Rutledge.

Brooks, N. (2003). *Vulnerability, risk and adaptation: A conceptual framework*. Norwich: Tyndall Centre for Climate Research.

Cardonna, O. D. (2003). The need for rethinking the concepts of vulnerability and risk from a holistic perspective: A necessary review and criticism for effective risk management. Chapter 3 of book *Mapping vulnerability*: *Disasters*, *development and people*, 2003, G. Bankoff, G. Frerks, D. Hilhorst (Ed), London: Earthscan Publishers.

Central Bureau of Statistics (CBS).(1991). *Population census*. Kathmandu:CBS

Central Bureau of Statistics (CBS).(2011). *Population census*. Kathmandu:CBS

Chambers, R. (1989). Vulnerability, coping and policy. *IDS Bulletin,* 20(2),1-7.

Clark, W.C., Cash, D., Corell, R., Dickson, N., Hall, J.M., and Parson, E. (2000). *Assessing vulnerability to Global environmental risks*. Unpublished manuscript

DDC (District Development Committee) (2015). *District Profile*. Surkhet: DDC

Hoddinott, J. and Quismbing, A. (2003). *Methods for Micro econometric risk and vulnerability assessments*. Social Protection Discussion Paper Series No. 324.

IEDRO (2010). Bangladesh Named Country Most Vulnerable to Natural Disasters, *the report*. Bangladesh: IEDRO derived from http://iedro.org/articles/bangladesh-named-country-most-vulnerable-to-natural-disasters/

IPCC (2012) Managing the risks of extreme events and disasters to advance climate change adaptation. Cambridge: IPCC

Ministry of Home(2017). Nepal Disasters Report 2017: Road to Sendai. Kathmandu: Ministry of Home

Shen, Y, Zhu, Z, Li, L, Lv, Q, Wang, X and Wang, Y(2011). Analysis of household vulnerability and adaptation behaviors to Typhoon Saomai, Zhejiang Province, China. Thailand: EEPSEA

Turner II, B. L., Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen,L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A and Schiller, A (2003). A framework for vulnerability analysis in Sustainability Science. *PNAS (Ist Ed.)* Publication in 2002 retrieved from http://www.pnas.org/content/100/14/8074.full.pdf+html

Twigg, J. (2004) Disaster Risk Reduction: Mitigation and preparedness in development and emergency programming, Good Practice Review 9. Humanitarian Practice Network (HPN), London: ODI

UNDP (2004). *Reducing disaster risk a challenge for development*. Global Report, New York: UNDP Bureau for Crisis Prevention and Recovery.

UNEP (2004). *Fresh water in Europe–facts, figures and maps*. Châtelaine, UNEP/DEWA~Europe.

UNISDR (2009b) UNISDR Terminology on Disaster Risk Reduction. Geneva: United Nations International Strategy for Disaster Reduction (UNISDR)

Warmington, V. (1995). *Disaster reduction: A review of disaster prevention, mitigation and preparedness.* Ottowa: Reconstruction and Rehabilitation Fund of the Canadian Council for International Cooperation.

Watts, M. J. and Bohle, H. G (1993). The Space of vulnerability: the causal structure of hunger and famine. *Progress in Human Geography*, 17(1), 43-67.

World Bank (2016). The press release. Marrakesh: World Bank http://www.worldbank.org/en/news/press-release/2016/11/14/natural-disasters-force-26-illion-people-into-poverty-and-cost-520bn-in-losses-every-year-new-world-bank-analysis-finds