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RESEARCH ARTICLE

Assessment of Climate Change induced Household Vulnerability in Nepal: Application of Index Method

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Abstract: This study examines the relationship between the magnitude of climate variability and household vulnerability in the catchment areas of Sot Khola sub-water basin in the western mountainous Surkhet, Nepal by constructing a theoretical climate vulnerability index based on household-level data collected from 642 Household covering adaptive, sensitive, and exposure. Its result is the climate vulnerability index (CVI) of households living in Sot Khola sub water basin's catchment areas, which provides sufficient evidence of heterogeneity in climate variability and vulnerability of households across location and altitude of the catchment areas. In all clusters, all households are vulnerable at a different level. Households have the heterogeneous adaptive capacity in which about 40 percent of households have less adaptive capacity indicating potentially vulnerable households, although 60 percent of households have higher adaptive capacity. The majority of households (52.7%) are sensitive to Climate-induced disasters: landslides and floods due to their socio-economic status and food insufficiency. But about 47.4 percent of households are less sensitive. Since households' locations are far from flood and landslides patches, about 4.4 percent of households are higher exposure but 95.6 percent of households are in less exposure. The composite index of climate vulnerability index shows 50 percent moderate and higher vulnerable household from climate-induced disaster: landslide and flood. It was supplemented by additional 17.0 percent moderately vulnerable households. Thus, in total, about 67 percent of household is vulnerable at a different level from moderate to extremely higher vulnerable. The remaining (33 percent) is least vulnerable.

Keywords: climate change, vulnerability, water basin, water-induced disasters, flood

1. Introduction

The intensity of climate variability and vulnerability distributes unevenly concerning geographical location and altitude. In Nepal, fact sheets of the metrological database (2019) provide strong evidence, like life experiences and observations. Empirical and theoretical literature shows unilateral directional relationships. Still, its relationship at the household level seems to be relevant. When we talk about the catchment areas of the water basin and its socio-economic dimensions (income, literacy, awareness, etc.), there is sufficient room to be observed. We assume climate variability induces vulnerability but its magnitude depends on the locations of the catchment areas and also the income level of the household because of the different magnitude of climate vulnerability. Therefore, there should be some extent correlation between climate vulnerability, location, and income level



of the household to increase the magnitude of climate vulnerability at the household level. Therefore, this study estimates empirically this relationship in the catchment areas of the water basin.

Climate vulnerability in the world is widely accepted as a big threat. UNFCCC (2007) provides scientific evidence of extreme and gradual changes of climate variables such as increasing temperature, declining rainfall, severe drought, forest fire, and diseases and their impacts on households.

It is due to extreme and gradual changes of climatic variables such as increasing temperature, declining rainfall, severe drought, forest fire, and diseases (UNFCCC, 2007). Theoretical Literature has observed theoretically dimensions, elements, characteristics of climate vulnerability in which UNFCCC (2007) and Fussel and Klein (2006) mention the susceptible, inability of geophysical, biological, socio-economic systems to cope with, and adverse impacts of climate change. It just mentions the trade-off situation between resilience and climate change's effect. If it increases in local areas, there will make higher vulnerability to the community. In another word, this is the vulnerable situation of geophysical, biological, and socio-economic systems. Its examples are the low lying of the water basin, coastal areas, and islands. Such vulnerabilities depend on key impacts of climate change. Watts and Bohle (1993), Blaikie et al.(1994) and Kelly and Adger(2000) highlighted social and environmental vulnerability. Theoretical and empirical literature (Smit et al., 2001; Corfee-Morlot and Höhne, 2003; Hare, 2003; Oppenheimer and Petsonk, 2003, 2005; ECF, 2004; Hitz and Smith, 2004; Leemans and Eickhout, 2004; Schellnhuber et al., 2006) have mentioned key impacts on social, economic, biological and geophysical systems, like as the literature of IPCC(2001a) and UNFCCC(2007). Its vulnerabilities associate with climate-sensitive systems including food supply, infrastructure, health, water resources, coastal systems, ecosystems, global biogeochemical cycles, ice sheets, and modes of oceanic and atmospheric circulation.

There is a large literature on the Magnitude and timing of climate impacts and vulnerability distribution across regions, sectors, and population such as Corfee-Morlot and Agrawala, 2004; Schneider and Mastrandrea, 2005; Yamin et al., 2005; Rayner and Malone, 1998; Adger, 2001 and Gupta et al., 2003. This literature argues the magnitude of climate change and its vulnerability is determined by its scale (e.g., the area or number of people affected) and its intensity (e.g., the degree of damage caused).

Literature is largely talking about its measurements to understand the magnitude of climate impacts. There is quantitative literature (Nordhaus and Boyer, 2000; and Nicholls et al. 2005) providing different monetary units such as welfare, income or revenue loss, cost of adaptation, and willingness to pay to avoid. In addition, Indicator and qualitative literature (Barnett, 2003; Arnell, 2004; Parry et al., 2004; Van Lieshout et al., 2004; Schär and Jendritzky, 2004; Stott et al., 2004) have also explored their space to measure the magnitude of climate impacts by measuring food and water shortages, morbidity and mortality from diseases and forced migration, along with heritage and biodiversity loss. Thus, vulnerability is measured by the magnitude and timing of impacts, the system at risk, uncertainty of impacts, and potentiality to adapt.

Indicator Method to assess Climate Vulnerability is widely employed by including heterogeneous indicators as per requirement and availability in the different locations, geographical settings, and income groups. Therefore, there are available diverse indicators based Index of vulnerability. Whatever, Kelly and Adger(2000) and Eriksen and Kelly (2007) believe it as a source of reference point for evaluating framework for development, as a provider of information for developing adaptation and mitigation plans, and as the standard of measures. Indicator measurement is one of the qualitative and quantitative measures to measure vulnerability to climate change for understanding its status, nature, process, distributional pattern and intensity over time, location, income, and geographical setting and also the impacts of climate change, along with understanding the effectiveness

of development and climate-resilient policy and programs in across locations, geography and income groups.

Literature shows two approaches in vulnerability Index construction and application in climate change and environmental disciplines. They are deductive and inductive approaches in the construction of the Climate Vulnerability Index (CVI). In large literature, a theory-driven (deductive) conceptual framework was constructed and followed to identify relevant indicators for determining their relationships through the construction of the Index. Similarly, in many cases, a data-driven approach (inductive) was used to select vulnerability indicators based on their statistical relationship with observed vulnerability outcomes (Eriksen and Kelly, 2007). The application of the inductive approach was specific climate-sensitive systems in which the deductive approach could not be applied in the absence of a well-defined vulnerability outcome. In general, for the urgency of coping with climate change vulnerability, the inductive approach was popular to be used.

Literature reveals three types of indices in practice such as global, national, and regional for different objectives: rank of vulnerability and areas and priority of adaptation strategy and finance and mitigation. Sullivan and Meigh (2005) developed a Climate Vulnerability Index comprised of six indicators encompassing resource, access, capacity, use, environment, and geospatial dimensions to assess CVI of water to Mongolia for analyzing large data sets. They suggest their index has applicability and comparability across various scales of analysis from small island developing nations (SIDS) to the national level. However, there is no theoretical discussion of indicator choice or the specific indicators.

Eriksen and Kelly (2007) have assessed the vulnerability level across countries in 2007 under the United Nations Framework Convention on Climate Change (UNFCCC) by developing five quantitative national level indices of social vulnerability to climate change: vulnerability resilience indicators (VRI), Environmental Sustainability Index (ESI), Dimensions of Vulnerability (DV), Index of Human Insecurity (IHI) and Predictive Indicators of Vulnerability (PIV). The study finds that “a lack of a clear theoretical and conceptual framework for the selection of indicators has hampered the robustness, transparency and policy relevance” of these indicator studies, and they note “a serious deficiency in existing studies, the limited testing and verification of indicators and of the validity of underlying conceptual frameworks” (p. 504). As a result, the three indices that provide a ranking of countries show “relatively little agreement regarding which particular countries are the most vulnerable, with only five countries ranked among the 20 most vulnerable in two or more of the studies and only one country ranked among the 20 most vulnerable in all three. This finding [...] firmly underlines the challenge in making objective judgments about which countries are more vulnerable than others as a basis for allocating of funding” (p. 502). Kim (2010) evaluated the climate vulnerability index (CVI) of 16 local governments in South Korea by identifying local scale 36 sub-indicators to measure the performance of water management. The study seems to be an inductive approach based on the availability of data, although there is a lack of a theoretical framework. In addition, the study has not provided strong judgments in selecting sub-indicators. In the selected sub-indicators, there is missing data. However, it has a higher possibility of policy implication.

Eakin and Luers (2006) express serious concerns regarding the validity of national-scale vulnerability assessments noting that “Ranking and comparing vulnerability across countries [...] is challenged by everything from the quality of the available data, to the selection and creation of indicators, to the assumptions used in the weighting of variables and the mathematics of aggregation. There are also problems in the interpretation of indices”.

Other studies found that several aggregated vulnerability indices express strong sensitivity to the selection of specific proxy variables as well as to variations in the mathematics of index construction (Moss et al. 2001, Gall 2007, Schmidlein et al. 2008). Hahn et al., (2009) employed the LVI to understand livelihood and climatic vulnerability in small island developing states (SIDS).

Despite available international literature on Climate Vulnerability and Climate Vulnerability Index (CVI), the literature on Nepalese context are handfuls, which have not focused in western mountainous Nepal, have not applied indicator method including CVI. In this context, this study estimates climate vulnerability level in the catchment community and locations of Sot Khola Sub water basin in Surkhet, Nepal, where climate variability particularly rainfall was recorded in the rainfall stations of Surkhet and its induced heavy disastrous flood disaster event were badly experienced by the catchment areas and the community in 2014. Available literature has not covered such issues, except the correlation between climate variability and vulnerability. Still, there is a query whether the heterogeneous level of disasters in the catchment areas occurs or not, whether the heterogeneous level of vulnerability in the catchment areas occurs or not, and whether the correlation between disaster and vulnerability occurs or not.

The paper examines climate vulnerability in western mountainous Nepal by building a climate vulnerability index (CVI) and analyzes the extremity of climate vulnerability and its distribution across altitude and geographical settings.

This paper is organized into the following sections: Section 1: Introduction, Section 2: Life-threatening climate vulnerability in Nepal, Section 3: Methodology and Data, 4: Results, and Section 5: Discussions and Conclusion.

2. Life-threatening Climate Vulnerability in Nepal

Nepal is the fourth most vulnerable country in terms of climate risks and 30th in terms of water-induced disaster (UNFCCC, 2007), although her GHG emission share is only about 0.025 percent of the total annual GHG emissions of the world (Karki, 2007). There are climate risks: increasing dry periods, intense rainfall, floods, landslides, forest fires, glacier outburst flood, etc. among which about 13 cases of Glacier Outburst Flood (GLOF) have damaged substantially the people's lives, livestock, land, environment, and infrastructure. Further, the National Adaptation Program of Action (NAPA) (2010) is the national policy document of climate change adaptation verifies it by explaining Nepal as highly vulnerable to climate change. Further, it projects 10 million populations in climate risk. Out of such a population, about 1.9 million populations are highly vulnerable to climate change. It finds its higher intensity in mid and far western regions. For example, Surkhet, where water-induced disasters, the flood happened in 2014. The flood unexpectedly and severely damaged houses, assets, crops, bridges, roads, and life all over Surkhet (DDC, 2015). MOH (2015) estimated 10 billion in Rs worth loss of physical assets, along with 37 deaths and 3867 households affected.

In Surkhet, the flood of Sot Khola sub-water basin with 10 feet's wild and high-sounding water level unexpectedly happened due to the heavy and intense rainfall continuously in three days and three nights. It carried everything in its course. It had affected its catchment areas (Gadhi, Lekhagaon, and Kunathari) from the upper catchment areas to the downward catchment areas. Since the settlement of the community was the top hilly areas, the flood had not swept houses, except crops, banks of the river, agricultural land, water wheel, life, and infrastructure (road, clean drinking water, irrigation drainage, bridge, etc.). The estimated loss of the catchment areas of Sot Khola was 1, 33, 44,000 in Rs of house and asset, which was 0.13 percent of the total loss of Surkhet (MOH, 2015). In addition, there was a loss of crop, income, and life. Thus, there was about 67 percent of households vulnerable from the upper catchment areas to the downward catchment areas. Therefore, the higher intensity of the flood disaster occurs in the catchment areas of Sot Khola sub-water basin in the different locations and altitudes.

3. Methodology and Data

3.1. Theoretical Framework of Climate Vulnerability Index (CVI)

The climate vulnerability index (CVI) is a quite popular method to calculate socio-economic vulnerability due to climatic variation. Hahn et al. (2009) developed this approach covering three indicators of livelihood vulnerability (i.e., exposure, sensitivity, and adaptive capacity) to risk from climate vulnerability. Shah et al. (2013) and Turton (2000), Knutsson (2006) applied Climate Change Vulnerability (CVI). Its basic assumption was IPCC's definition of vulnerability as a function of exposure, sensitivity, and adaptive capacity (IPCC, 2001). It is called a balanced approach because it covers 1) the level of exposure of livelihoods to climate variability 2) socio-economic characteristics influencing their ability to adapt and 3) the sensitivity of households to climate change. Its mathematical form is as follows

$$CVI_c = (e_c + s_c) - a_c \quad (1)$$

However, we followed the model applied by Dressa et al. (2008) to measure the climate vulnerability index (CVI). In this model, the sum of sensitivity (S) and exposure (E) provides us with the impact of the climate-induced disaster. When it is higher, vulnerability is higher. If the adaptive capacity (AC) is higher, vulnerability (V) will be lower. It is

$$V = (E + S) / AC \quad (2)$$

Where e_c = the calculated exposure of the household
 a_c = the calculated adaptive capacity of the household
 s_c = the calculated sensitivity score of the household

To analyze vulnerability level of household and VDCs, we employed the factors of the catchment areas: Gadhi, Lekhagaon and Kunathari for adaptive capacity of household, sensitivity of household and exposure of household as follows: 1) Adaptive capacity has the following factors: proportion of economically active population, Proportion of literate people, Proportion of people employed in off-farm activity, Proportion of household having more than one member involved in off-farm activity, 2) Sensitivity has the following factors: Gini coefficient of inequality in income of the communities, Proportion of household having less than 6 months food sufficiency in a year, Proportion of household having no access to clean drinking water, Proportion of household having less than 3 km distance to access health post and Proportion of household with old age people, 3) Exposure has the following factors: Per household crop loss (in kg), Per household livestock damage (in number), Proportion of land loss in the community in kata and Proportion of house damage in the community.

The above factors were calculated by using actual values and then using a standardized method for calculating scores of exposure, sensitivity, and adaptive capacity separately. In CVI, each component was computed after getting a standardized value from the actual value by using the standardized value method given below. Secondly, all standardized values of adaptive capacity, like sensitivity and exposure were the sum and divided by total component. It gave the score of adaptive capacity, sensitivity, and exposure separately. Finally, values of these three were kept above the equation for getting CVI.

3.2. Data sets

The data set for the construction of CVI were primarily nature collected from Household Survey 2015 through the structured questionnaire. Its sample size was 642 households. The collected and proceeded data were computed by three indices and their bundle indicators (13). Based on the above indicators mentioned in the factors of CVI, three indices (adaptive index, sensitive index, and exposure index) were computed to measure the respect level of the household of the catchment VDCs (Gadhi, Lekhagaon, and Kunathari) by cluster and household level as follows.

4. Results

4.1. Adaptive Capacity Index

This Index tool measures the adaptive capacity of household level in the subwatershed basin and catchment areas (Gadhi, Kunathari, and Lekhagaon) to climate change-induced natural disasters including floods and landslides. This household capacity is comprised of individual capacity, institutional capacity, and resources. In this index study, there were employed four factors: literacy rate, economically active population, the proportion of people engaging in off-farm activity, and proportion of people more than one engaging in the off-farm activity. The analysis for the construction of the index was to measure the coping capacity of climate change-induced disaster: flood and landslide.

Adaptive index Figure 16 shows the adaptive capacity of the household as the composite index of already mentioned four factors: literacy rate, economically active population, the proportion of people engaging in off-farm activity, and proportion of people more than one engaging in the off-farm activity. Household of the study areas had their heterogeneous character and status.

Table 1. Adaptive Capacity by Household

Adaptive Capacity category	Household Situation	Adaptive Capacity Index	% of Household
Extremely higher capacity	Extremely higher ability to cope	>1 to 0.8	34.9
Higher capacity	Higher ability to cope	0.8 to 0.5	24.1
Moderate capacity	Moderate ability to cope	0.5-0.2	29.9
Less capacity	Less ability to cope	0.2 to 0/(-)	11.1
Total			100

Source: *Field Survey, 2020*

In Table 1, the adaptive capacity of the household was heterogeneous. In Table 1, about 34.9 percent of households laid the highest adaptive capacity between 0.8 and > 1. It was followed by about 24.1 percent of households lying higher adaptive capacity between 0.5 and 0.8, about 29.9 percent household lying moderate adaptive capacity between 0.2 and 0.5, and about 11.1 percent household lying least adaptive capacity. It indicated 11.1 percent of households cannot cope with vulnerability. It is followed by 29.9 percent of households having moderate capacity (the details in Annex-VII). Thus, about 40 percent of households would be potentially vulnerable households (Figure 1).

4.2. Sensitive Index

Households are in different levels of sensitivity in climate-induced disaster-prone areas. The sensitivity index measures its degree in the study areas.

Based on that four factors (proportion of household (HH) with food sufficiency for less than 6 months, proportion of HH without piped water, distance to health facility, and proportion of old aged people), a sensitive index of the study area could be constructed (the details in Annex-VII). It analyzes household sensitivity levels. The average standardized value of the individual four factors contributes to its composite score (Figure 2).

Figure 2 shows the sensitive index calculated as a composite index of the above-mentioned factors through the use of the above-mentioned methods. The result of the sensitive index is presented in Table 2. The result is evidence of different household sensitivity levels. About 3.3 percent of the household was at higher sensitivity between 0.5 and 0.8. It was followed by about 49.4 percent moderately sensitive households lying between 0.2 and 0.5, about 47.4 percent less sensitive households lying between 0.0 and 0.2. It indicated 52.7 percent moderate and higher sensitive households from climate-induced disaster: landslide

and flood (the details in Annex-VII). It is followed by 47.4 percent less sensitive households (Table 2).

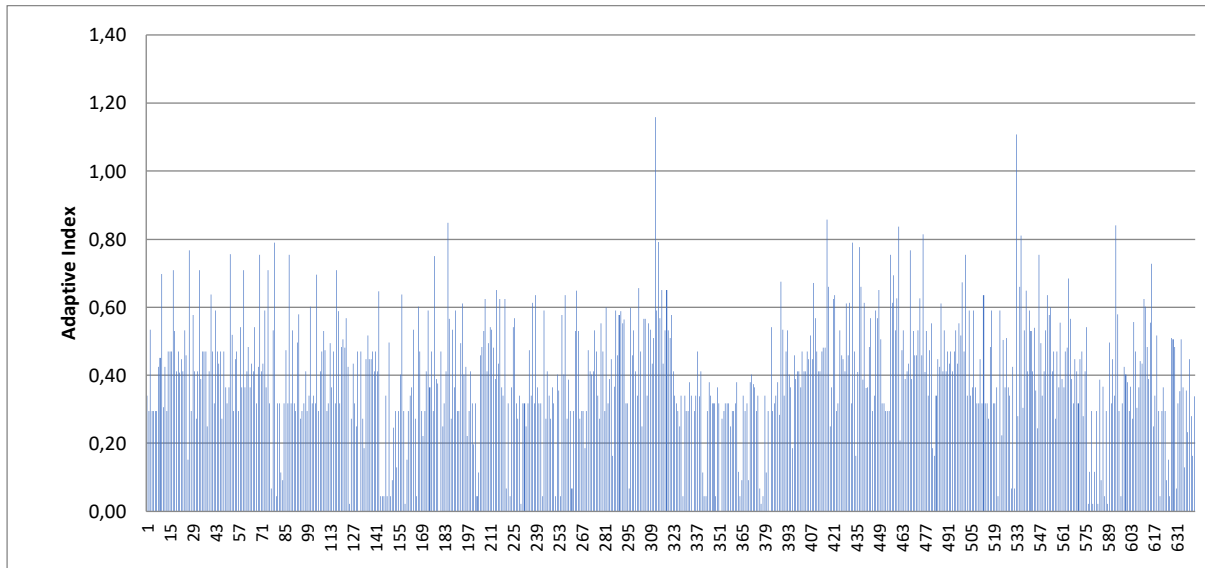


Figure 1. Adaptive Index by Household
 Source: *Field Survey, 2020*

Table 2. Sensitive Index by Household

Sensitive category	Household Situation	Sensitive Index	% of Household
Extremely higher Sensitive	Extremely higher sensitive	>1 to 0.8	0
Higher Sensitive	Higher sensitive	0.8 to 0.5	3.3
Moderate Sensitive	Moderate sensitive	0.5-0.2	49.4
Less Sensitive	Less sensitive	0.2 to 0/(-)	47.4
total			100

Source: Field Survey, 2020

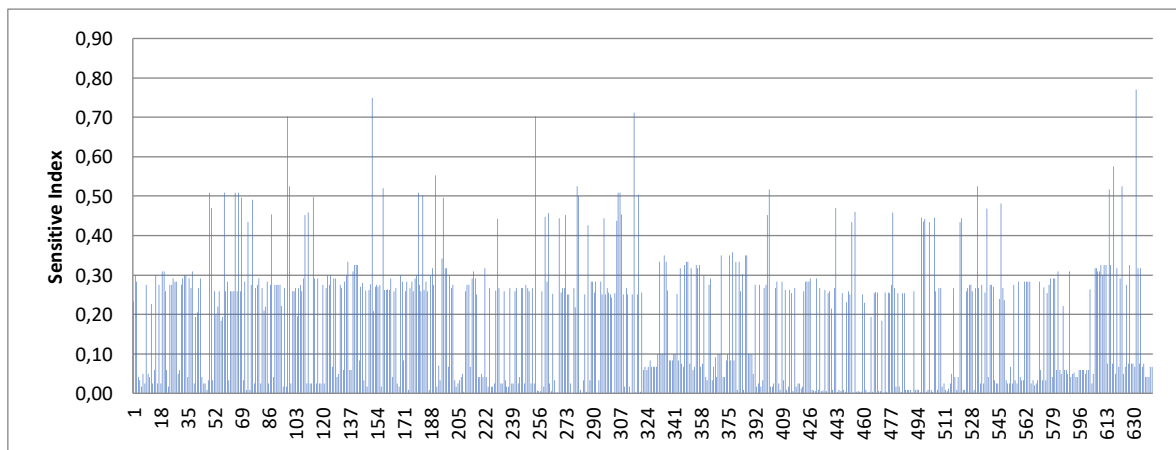


Figure 2. Sensitive Index by Household
 Source: *Field Survey, 2020*

4.3. Exposure Index

In climate-induced disasters, the household is indifferent to exposure levels. The exposure index measures its degree. In this study area, there was a loss and damage of household as exposure in a different level. Based on four factors (crop loss, livestock loss, household



damage, and land loss), the exposure index was constructed. Its value analyzes the exposure level of the household. The average standardized value of the individual four factors contributes to the composite score of exposure index and rank. The index provides the exposure level of different households in the areas of the watershed.

Table 3. Exposure Index by Household

Exposure category	Household Situation	Exposure Index	Percent of Household
Extremely higher Exposure	Extremely higher exposure	>1 to 0.8	0
Higher exposure	Higher exposure	0.8 to 0.5	1.1
Moderate exposure	Moderate exposure	0.5-0.2	3.3
Less exposure	Less exposure	0.2 to 0/(-)	95.6
Total			100

Source: *Field Survey, 2020*

Figure-18 shows the exposure index calculated as a composite index of the above-mentioned factors through the use of the above methods. The result of the sensitive index is presented in Table 3. The result is evidence of different household sensitivity levels. In Table 20, about 1.1 percent of the household was higher exposure between 0.5 and 0.8. It was followed by about 3.3 percent moderately exposed household lying between 0.2 and 0.5, about 95.6 percent less exposed household lying between 0.0 and 0.2. It indicated 4.4 percent moderate and higher exposure household from climate-induced disaster: landslide and flood..

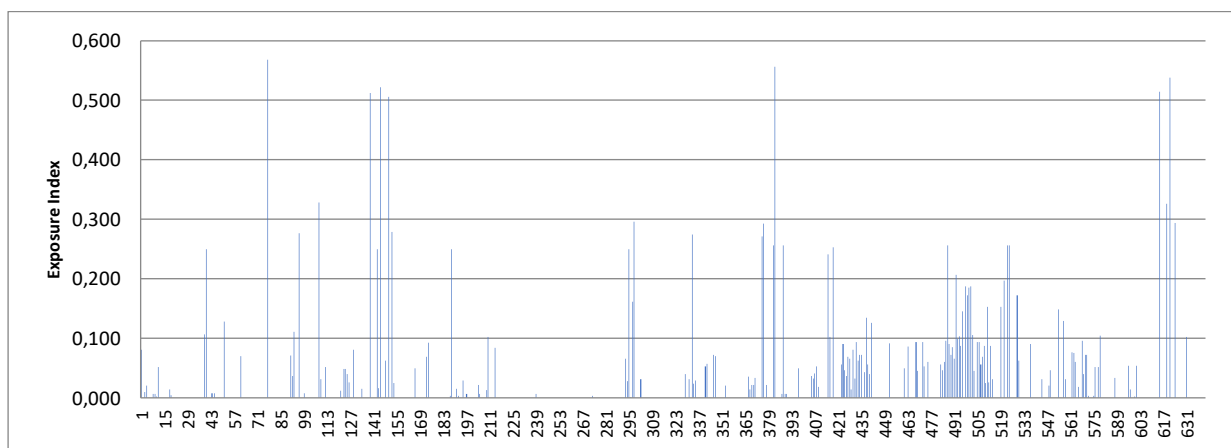


Figure 3. Exposure Index by Household

Source: *Field Survey, 2020*

4.4. Vulnerability Index of Household-level

Based on the above three indices: adaptive capacity index, exposure index, and sensitive index, climate vulnerability index (CVI) at household level is calculated as a composite index. In general, the composite index is constructed by the sum of exposure and sensitivity divided by adaptive capacity. The result of the composite index is evidence of the higher and lower vulnerability of households due to climate-induced disasters. If the composite index has a higher score, its vulnerability level will be higher. If it has a lower score, its vulnerability will be lower.

Figure-2 shows the climate vulnerability index (CVI) calculated as a composite index of the above-mentioned factors through the use of the above-mentioned methods (the details in Annex-VII). The result of CVI is presented in Table 4 below. The result is evidence of different household vulnerability levels of the household. In Table 21, about 29.1 percent of the household was extremely higher vulnerable lying between 0.8 and >1. It is followed

by 20.9 percent of households higher vulnerable between 0.5 and 0.8. about 17.0 percent moderately vulnerable household lying between 0.2 and 0.5, about 33.0 percent less vulnerable household lying between 0.0 and 0.2. It indicated 50 percent moderate and higher vulnerable households from climate-induced disaster: landslide and flood. It was supplemented by additional 17.0 percent moderately vulnerable households. Thus, in total, about 67 percent of household is vulnerable at a different level from moderate to extremely higher vulnerable. The remaining (33 percent) is least vulnerable.

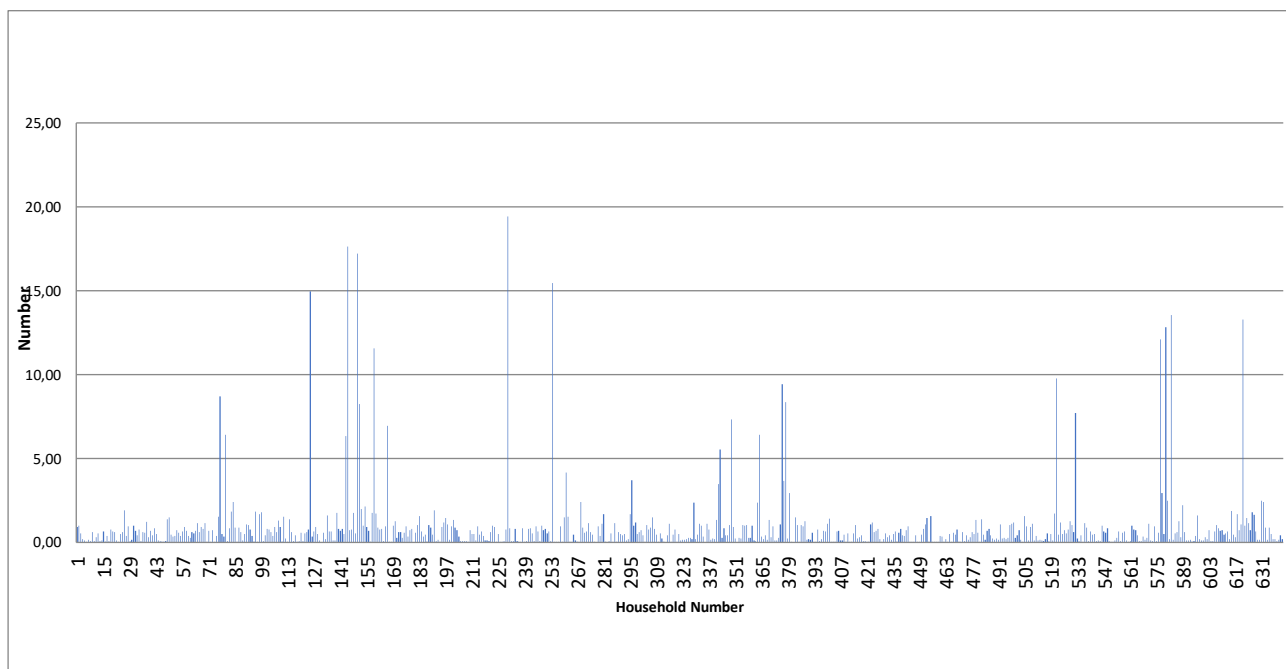


Figure 4. Vulnerability Index by Household
 Source: *Field Survey, 2015*

Table 4: Vulnerability Index by Household

Vulnerability category	Household Situation	Vulnerability Index	% of Household
Extremely higher vulnerable	Extremely higher urgency level	>1 to 0.8	29.1
Higher vulnerable	Higher Urgent level	0.8 to 0.5	20.9
Moderate vulnerable	Urgent level but temporary external assistance to recover	0.5-0.2	17.0
Less vulnerable	Vulnerable situation but still able to cope	0.2 to 0/(-)	33.0
Total			100

Source: *Field Survey, 2020*

5. Discussions and Conclusion

The above result provides strong evidence on the status and rank of adaptive capacity of households lying from zero scores to nearly 1 (100 percent) score. It provides the evidence of heterogeneity at household adaptive capacity based on the selected four indicators: literacy rate, economically active population, the proportion of people engaging in off-farm activity, and proportion of people more than one engaging in the off-farm activity. In the range from 0 to 1, how much score moves towards zero, so much adaptive capacity will be lower. In reverse, how much score moves towards 1, so much adaptive capacity will be higher. Its lower score means poor effectiveness of development policy and initiation of the government and need for external assistance. It further shows the ineffectiveness of development policy and initiation of the government. In other words, these households are

poor. If not, it further shows the effectiveness of development policy and initiation of the government. In other words, these households are well off.

The above result provides evidence of the heterogeneous adaptive capacity of households in which about 40 percent of households (Table 19) have lowering adaptive capacity. It means nothing to a household having poor capacity in terms of literacy and resource. Thus, this household can be considered as a potentially vulnerable household in the absence of coping capacity. This is a critical issue to minimize the impact of the climate-induced disaster. It indicates the need for urgency short- and long-term support of the government to improve their adaptive capacity as preparedness to adapt to climate vulnerability. In the case of the higher score of adaptive capacity of 60 percent (Table 2), it indicates households having the coping capacity to vulnerability and occurrence of lower vulnerability. Still, it needs only short-term support for temporary management.

The above result of the sensitive index of households in the study area provides evidence of heterogeneity to climate-induced natural disasters: floods and landslides. All households are sensitive to vulnerability above a lower level. In Table 2, about 52.7 percent of households are higher and moderately sensitive. Highly and moderately sensitive households have a higher threat of vulnerability. If these households are not responded to urgently, there will be a problem of safety of household and population. Meanwhile, Table 19 shows 47.4 percent of households in the study area as less sensitive. They do not need an urgent response for improving the safety of the household and the population.

Similarly, the above result provides evidence of the heterogeneous exposure index of households in the study area due to climate-induced natural disasters: floods and landslides. All households are exposure to vulnerability above the lower level. In Table 20, about 1.1 percent of households were at higher exposure. It was followed by about 3.3 percent moderately exposed households. It indicates these households have higher vulnerability levels. If these households are not responded to urgently, there will be a problem of recovery of household and population. Meanwhile, 95.6 percent households of in the study area are less exposed. They need not urgent response for recovering household and population.

Based on the heterogeneity of adaptive capacity, sensitivity and exposure and based on the above result of the climate vulnerability index (CVI) in the study area, there is sufficient evidence of heterogeneous household vulnerability level. The characters of all households are vulnerable at a different level. Except for less vulnerable household (33.0 percent), about 67 percent of households (Table 4) are vulnerable households in which extremely higher and higher vulnerable households (50 percent) has dominated. The majority of vulnerable household indicates their occurrence of unusual climate-induced natural disaster: flood and landslide in the study area due to changing pattern and intensity of annual rainfall, particularly changing monsoon rainfall and also increasing temperature. Household sensitivity and exposure levels are greater than the adaptive capacity of the household because of lower literacy and poor resources. In addition, the development policy and program of the government along with terrible preparedness and management are ineffective. Thus, the annual frequency of disasters has contributed to an increase in depth poverty and inequality in the study area. In the absence of proper responding resilient local governance and resource, the vulnerability level is still as it is. Its negative contribution may be in the HDI and GDI of the study area. Based on the above findings, an alternative hypothesis for objective 2 is accepted.

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