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ESTIMATING THE IMPACT OF ADAPTIVE CAPACITY ON VULNERABILITY IN NEPAL

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ABSTRACT

The adaptive capacity of households is an effective instrument for minimizing climate change-induced vulnerability. Varying adaptive capacity across different income and socio-strata of households make different vulnerability impacts. This paper assesses the impacts of adaptation capacity on household susceptibility index and ranks in Nepal employing an explorative method. In the explorative method, the household vulnerability index as a composite index and multiple regression model are analytical methods. The data set is collected from the questionnaire survey of 642 households in the Sotkhola Water Basin Gadhi, Lekhagaon, and Kunathari through a regression model. As a result, a flood disaster is terrible more than a landslide. By cluster, its intensity is deeper in Gadhi than in Kunathari and Lekhagaon in terms of destruction of assets and non-assets. Total income loss magnifies household vulnerability 7 times deeper. The distribution of vulnerability level falls to poor households three times more than rich households in accordance with headcount poverty and food sufficiency poverty measures. The composite index shows adaptive capacity plays a key role in household vulnerability. Therefore, adaptive capacity is an instrument of resilience to household safety and welfare. In the context of poverty alleviation, preparedness, and climate change initiatives, this result will be valuable to improve the adaptive capacity of the socioeconomically vulnerable population for disaster and climate resilience, further development, and future disaster risk management policy implications.

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INTRODUCTION

Varying the intensity of climatic variables in physiographical and human livelihood induced unexpected extremes in the vulnerability level of households in the community in recent years, which is an emerging issue that deepens poverty in developing countries like Nepal. The socioeconomic factors and dimensions measure vulnerability level in households. One of the socioeconomic measurements is the poverty level. As per the absolute level of poverty, a household's vulnerability will be extreme and critical. However, the relative poverty level reveals the normal vulnerability level of households. The vulnerability relates to the socioeconomic factors of households. In general, it is synonymous with poverty and anonymous with prosperity. In the world, about 10 percent of the population (734 million populations) is below the global poverty line of 1.90 USD earnings per day. The poverty line is 5.50 USD per day, and 3.4 billion populations are not able to meet their basic needs. In Africa and Asia, poverty is a major ingredient puzzle of their countries. World Bank (2019) figured out its picture of 783 million populations, of which 33 percent of the extremely poor population lives in South Asia. Nepal's level is claimed to have declined to 16.7 percent in 2020, but its multiple poverty analysis shows more than 50 percent of the population below the poverty line of basic needs (NPC, 2020; MoF, 2020). It reflects the household's vulnerability level.

Like COVID-19, natural hazards–floods, landslides, and earthquakes have complicated household vulnerability levels. 2020, OXFAM (2020) predicts the growth of 50 percent poverty in the world due to the growth of the unemployment level. Its severity will be greater in Asia and Africa. Similarly, its effect in Nepal will backfire on poverty alleviation achievement at 25 percent poverty level (Bista, 2016). Besides, floods and landslides in 2020 have killed about 130 people more than COVID-19 and destroyed tangible and intangible assets of the people. As a result, household vulnerability is a big barrier to achieving SDG by 2030.

Nature and characteristics of vulnerability level at the household level are divergent across the country and socioeconomic variation. Geographical, ecological, and infrastructure factors are key determinants of vulnerability (Bista, 2018b; Bista, 2019a; Bista, 2020). Talk about Nepal, where three ecological and geographical belts have three distinct vulnerable characters and natures. In the higher geographical and ecological belts, glacier bursts and snow melting induced snow flood disasters. On the hill, landslides, and floods are major disasters. Similarly, in the Terai, floods, hot waves, cyclones, and insects are major disasters. Thus, multi-hazards are key factors of vulnerability because these disasters disrupt the socioeconomic system of the community. Fortunately, infrastructure reduces such disaster's multilayer effects on the community. Bista (2018a) found three major observations regarding a vulnerability in the study area. In his thesis, he observed that in case I- the core area of the disaster was the community settlement. It looked like foolishness. It was a real observation. Relatively, the community was socio-economically vulnerable-poverty, marginal, and unproductive more than the community living in the non-core disaster areas. Thus, the distance between the community and disaster areas determines

the vulnerability level of the community. Similarly, Case II- infrastructure development was an adaptive measure against the intensity of disaster and vulnerability. If not, it was also a driver of vulnerability and disaster. Furthermore, in Case III- different geography was observed. The hill landscape, Gadhi, and Lekhagaon where landslides were more prone than the plain land, Rakshin, Kunathari, whereas the plain valley, Rakshin, Kunathari was flood-prone more than the hill landscape, Gadhi and Lekhagaon. Despite different landscapes, there was no difference in the level of disaster because of multi-hazards. Thus, the nature and characteristics of vulnerability at the community level depend on geographical, ecological, and infrastructure.

The vulnerability level of the community is a relevant issue for policy understanding, response, and intervention for minimizing the vulnerability of the community, and the risk of the community can be measured by the vulnerability index (VI) method. In 1999, UN agencies initiated this method in Africa to assess vulnerability at the country level with a focus on food aid (Frankenberger et al., 2005). This UN endorsement made it popular. Then, multi-dimensional vulnerability variables were employed widely in different areas of development practices-food, agriculture, disaster, poverty, HIV/AIDS, security analysis, and livelihood (Chaudhuri and Christiaensen, 2002; Frankenberger et al., 2002; Chaudhuri et al., 2002; Turner et al., 2003; Hoddinott and Quisumbing, 2003; Chiwaka and Yates, 2005; Petty and Seaman, 2004; Cannon et al., 2005; Ajayi, 2006; Gallopin, 2006; Banerjee et al., 2007; Holzmann et al., 2008; Jha & Dang, 2009; Lawrence et al., 2008; Naude et al., 2008; O'Brien et al, 2009; Naude et al., 2009; Casale et al., 2010; Fanrpan, 2011; Kalibala et al., 2012; UNICEF, 2012, Kureya, 2013; Bista, 2018b; Bista, 2019b; Bista, 2020). Thus, the vulnerability index is a popular measure to assess disaster-induced vulnerability at the household and community level.

Theoretically, vulnerability assessment methods are multiple (Turner et al., 2003; Hoddinott & Quisumbing, 2003; Petty and Seaman, 2004; Cannon et al., 2005; Gallopin, 2006; Banerjee et al., 2007; Holzmann et al., 2008; Lawrence et al., 2008; O'Brien et al, 2009; Naude et al., 2009; Casale et al., 2010; Kalibala et al., 2012; UNICEF, 2012, Kureya, 2013; Bista *et al*., 2018; Bista, 2019c; Bista, 2020). They are a) Local Vulnerability Assessment Method (LVAM), b) Livelihood Vulnerability Assessment Method, c) Household Vulnerability Assessment Method (HVAM), d) Household Livelihood Security Analysis Method (HLSAM), and e) Climate Vulnerability Assessment Method (CVAM).

In Nepal, few kinds of literature (Bista, 2018b; Bista, 2019b; Bista, 2019c) have employed the Vulnerability Index Method to assess the vulnerability of households and the community based on secondary and primary data and information. In climate change, there are rare, except the studies (Bista, 2018b; Bista, 2019b; Bista, 2019c). Besides, all these methods are used only for assessing the vulnerability level of the community. Literature is silent on its relationship with socioeconomic variables. Still, there is a literature and methodological gap to which this study is relevant and aims to fulfill it with objectives: whether climate change vulnerability level is intense at the household level, whether households across different income levels and regions are resilient, whether household vulnerability level is different across different households and villages, and whether household resilience level reduces climate change vulnerability level. This research's output may have valuable outcomes at the policy level and the scientific research, particularly climate change, vulnerability, and climate change vulnerability modeling, along with developing climate change vulnerable areas in the catchment areas: Gadhi, Lekhagaon, and Kunathari for the implementation of community-based disaster management approach. Furthermore, it would be valuable input to explore an alternative strategy of adaptation and mitigation to improve the household adaptation capacity, behavior, and actions so that climate change vulnerability level can be minimized in the next 20 years in the study areas and also at a national level.

This study's broad objective is to assess Nepal's climate-induced household vulnerability level. Specific objectives are as follows: a) assessing climate change vulnerability in the study area, b) measuring the effects of socioeconomic factors of households on the climate change vulnerability index of households in the study area, and c) identifying problems and policy inferences.

METHODOLOGY

Theoretical Model

Households are also vulnerable to different structures, infrastructure levels, and geography. The vulnerability level of households to natural disasters can be measured through household income loss. It varies when household characteristics, infrastructure, and geography are different. This can be captured through household income loss.

Hoddinott and Quisumbing (2003) have used three approaches to vulnerability such as expected poverty (VEP), low expected utility (VEU), and uninsured exposure to risk (VER). They assess the damage to a household's well-being.

Besides, we employ a composite index of household vulnerability (HVI) to evaluate vulnerability at the household level due to climatic shocks (variability). The multivariate econometric model was used to capture the relationship between household vulnerability level with climatic shocks (variability) and household adaptive capacity and behavior. The mathematical form (Equation 1) was as follows.

$$VI_H = f(X_h, \varepsilon) \quad (1)$$

Where,

VI_H = Household Vulnerability Index,

X_h= socio-economic bundle (agricultural income, literacy, agricultural labor, knowledge, etc.),

ε =error term

Econometric Model

As supplementary, an econometric model is used to examine research queries: a) how adaptive capacity affects vulnerability at the household level across heterogeneous elevated areas and how much value of parameters contributes to the vulnerability index. In the model, the household vulnerability index in log form ($lnVI_H$) is a dependent variable, whereas the proportion of Family Size (X_{1FS}), Number of Labor (X_{2NL}), Total Labor Income (X_{3TLI}), Farm Income (X_{4AgI}), Total Income Loss (X_{5TIL}), Landholding (X_{6LH}), Literacy (D_1), Climate shock (D_2), D_{3G} (Gadhi) and D_{4L} (Lekhagaon) are independent variables. There are ten estimators: β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8, β_9 and β_{10}. Its mathematical form of a semi-log econometric model (Equation 2) is presented below.

$$\text{Ln } VI_H = \alpha + \beta_1 \text{Ln}X_{1FS+} \beta_2 \text{Ln } X_{2NI} + \beta_3 X_{3tli} + \beta_4 \text{ln } X4f_i + \beta_{5X5tIL+} \beta_{6lh} + \beta_7 D_{1l} + \beta_8 D_{2cs} + \beta_9 D_{3G} + \beta_{10} D_{4L} + \varepsilon \quad (2)$$

The model estimates the value of estimators and finds out the influence on VI_H.

Where,

α =Constant

$\beta_{1=}$ marginal coefficient of family size

$\beta_{2=}$ marginal coefficient of the number of labor
$\beta_{3=}$ marginal coefficient of total labor income
$\beta_{4=}$ marginal coefficient of farm income
$\beta_{5=}$ marginal coefficient of total income loss
$\beta_{6=}$ marginal coefficient of landholding
$\beta_{7=}$ marginal coefficient of literacy
$\beta_{8=}$ marginal coefficient of climate shock
$\beta_{9=}$ Marginal coefficient of Dummy (1= Gadhi, 0 =others)
$\beta_{10=}$ marginal coefficient of Dummy (1=Lakhagaon, 0=others)

Study Area

The study area is commenced in the Sotkhola Water basin: Gadhi, Lekhagaon, and Kunathari in Surkhet, Nepal (Figure 1). Upstream is a highly elevated area, Chandane, Gadhi VDC, whereas its downstream is a lower elevated area, Rakseni, Kunathari VDC (Figure 1) (DDC, 2015). This 30 km long river basin is a tributary of a big river, Bheri (Figure 1). Hydrologically, the water level is consistent in all seasons, except monsoon season, because of its glacier feeding. In monsoon, rain-fed water makes it wild, and aggressive flooding is disastrous and stressful.

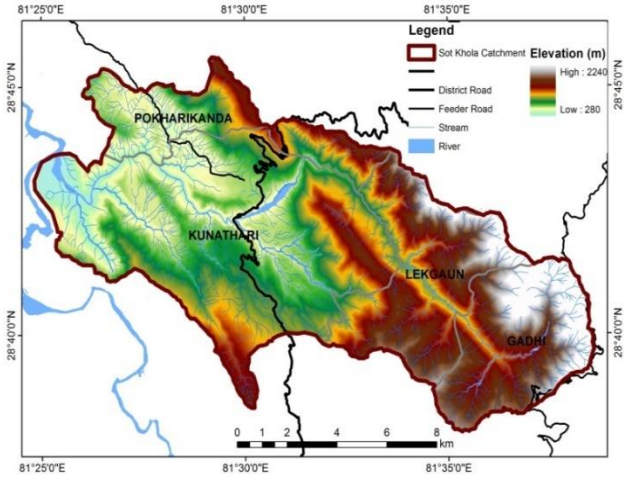

Figure 1. Sotkhola and its catchment study Area; Source: GIS map of Study area based on field survey, 2022.

Covering beautiful geomorphological features in different elevations (DDC, 2015), the study area spreads from the sea level to the high mountain range. a) Gadhi is located in a high mountain range of 1200 meters elevation (Figure-1). This landscape is only 28 square km and is located about 9 km on the north side, far from Surkhet. b) Another catchment area is Lekhgaon village. Its elevation is from 198 meters (Tata pani) to 2369 meters. Its area is 110 km in length and 30 km in breadth of 2451 square km (249016 hectares) (Figure 1). Geo-physical character is 84 percent of the hill and 16 percent of the valley. The inhabitants are 3,999 (651 households) (DDC, 2015). c) Lastly, Kunathari is a downstream village located between 600 meters and 1200 meters (Figure 1). This valley is 20 km away from Surkhet in the remote areas, where 3413 people live (CBS, 2022) and (DDC, 2015). village attributes with similar elevations and landscapes, along with a richness of natural resources and wildlife. The use of the water basin, including clean drinking and irrigation, is popular in households.

The rationale behind selecting this study area include as follows i) record-breaking erratic rainfall in monsoon-induced flooding and landslides in 2014, ii) extreme exposure and sensitivity of households, iii) steep elevation, huge risk and vulnerability at the catchment areas, iv) changing morphological structure, iv) river and land-dwelling ecosystem and biodiversity loss, v) huge economic loss including cultivated land and yield loss and vi) initiation of community-based disaster management (CBDM).

Data and Data Collection Method

An analytical approach, which was quantitative in nature, was designed. Cross-sectional and discrete data sets related to household vulnerability, disaster events, and flood and landslide events were collected from local government offices and the Ministry of Home (MoH). Similarly, the data was collected from the follow-up survey from September 2022 to October 2022 for socioeconomic information, climatic hazards, exposure and sensitive information of flood and landslides, alert systems, preparedness, and monitoring. For validation and reliability, there was employed a supplementary tool called as Key Informant Interview (KII).

Cluster and random sampling methods are sampling procedures and techniques. In 2022, two-stage sampling was designed. In the first stage, choosing the study area using elevation, geophysical location, and demography place, the lottery method was used to select representative households of 642 sample households (19.3%) from these clusters. In the second stage, the sample household was further randomly selected using income, caste, sex, and vulnerability for the best, wider, and logical representative.

A household survey is a key tool of the data collection method. A questionnaire is the main instrument of the survey. The questionnaires are related to household adaptation, climatic disaster, and vulnerability.

Estimations

Analysis of factor influencing household vulnerability level by vulnerability index

Vulnerability index measures vulnerability at the household level. It represents household vulnerability level. Its level is influenced by the household's adaptive characteristics and level. If a household enriches a higher adaptive capacity level, the household vulnerability level will be lower. If not, the household vulnerability level will be higher. Thus, household vulnerability and adaptive capacity level are inversely related.

Maintaining a lower household vulnerability level is required for higher household safety and security and their welfare and prosperity. It is possible when a household can improve its adaptive capacity, including awareness, membership, education, income, alert system, and knowledge about a disaster. The factors that are identified in the study areas influence household vulnerability level.

Model hypothesis

HVI is a composite index of three dimensions: adaptive capacity, sensitivity, and exposure. The index and adaptive capacity of households (awareness, literacy, family size, farm income, farm labor, and climate shock) control vulnerability at the household level. The model assumes hypotheses as follows.

1. The proportion of family size, numbers of labor, total labor income, landholding, and farm income inversely relates to vulnerability at the household level. Its functional sign is negative (-).
2. Literacy and awareness about disaster inversely relate to vulnerability in the household. The functional sign is negative (-).
3. Total Income loss and climate shock directly and positively relate to household vulnerability because both factors increase sensitivity and exposure. Its functional sign is positive (+).

4. Different geographical elevation relates to vulnerability at the household level.

Estimates of vulnerability coefficients

The data set of the semi-econometric model includes ten variables. Household vulnerability in terms of income lost in log form vulnerability index of household ($lnVI_H$) is a dependent variable. Meanwhile, the proportion of Family Size (X_{1FS}), Number of Labor (X_{2NL}), Total Labor Income (X_{3TLI}), Farm Income (X_{4AgI}), Total Income Loss (X_{5TIL}), Landholding (X_{6LH}), Education(D_1), Climate shock (D_2), D_{3G} (Gadhi) and D_{4L} (Lekhagaon) are independent variables, where Education(D_1), Climate Shock (D_2), D_{3G} (Gadhi) and D_{4L} (Lekhagaon) are categorical variables. We have a curiosity about how adaptive variables control vulnerability at the household level as the dependent variable. In this study, we focused on two questions:

1. How does the adaptive capacity of a household affect the household vulnerability index (HVI) across different elevated areas and
2. What are the values of parameters?

We transfer the above questions further as follows:

1. What would be unknown coefficient "β_1" of Family Size (X_{1FS}), "β_2" for No of Labor (X_{2NL}), "β_3" for Total Labor Income (X_{3TLI}), "β_4" for Agricultural Income(X_{4AgI}), "β_5" for Total Income Loss(X_{5TIL}), "β_6" for Landholding (X_{6LH}), β_7 for Education(D_1), β_8 for Climate shock (D_2), for Education (D_{2e}) for understanding how much socioeconomic and adaptive variables contribute to the vulnerability of household?
2. What would be the unknown coefficient "β_9" of D_{3G} (Gadhi) and "β_{10}" for D_{4L} (Lekhagaon) for understanding how much geographical variables contribute to household vulnerability?

RESULTS AND DISCUSSION

Table 1 presents the mean and standard deviation of key variables in the model. In column 1, there are 11 variables including vulnerability index (VI_H), the proportion of Family Size (X_{1FS}), Number of Labor (X_{2NL}), Total Labor Income (X_{3TLI}), Farm Income (X_{4AgI}), Total Income Loss (X_{5TIL}), Landholding (X_{6LH}), Literacy (D_1), Climate shock (D_2), D_{3G} (Gadhi) and D_{4L} (Lekhagaon). In column 2, their standard deviations from their means are not significant so far. The mean of these variables represents proper household data. Its details are below in Table 1.

Table 2 provides the result of the model of a dependent variable, income loss of household (lnY_{TIL}) as dependent variable and the proportion of Family Size (X_{1FS}), No of Labor (X_{2NL}), Total Labor Income (X_{3TLI}), farm Income (X_{4AgI}), Total Income Loss (X_{5TIL}), Landholding (X_{6LH}), Literacy (D_1), Climate shock (D_2), D_{3G} (Gadhi) and D_{4L} (Lekhagaon). There are ten estimators: β, β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8, β_9 and β_{10}.

Table 1. Mean and standard deviations.

Variables	Mean (Standard Deviation)
Vulnerability index (VIH)	1.03 (2.16)
Family Size (X1FS)	4.85 (1.32)
No of Labor (X2NL)	0.19 (0.15)
Total Labor Income (X3TLI)	0.04 (0.075)
Agricultural Income (X4AgI)	0.40 (0.17)
Total Income Loss (X5TIL),	5.15 (0.33)
Landholding (X6LH),	0.84 (0.39)
Literacy (D1e)	0.85 (0.37)
Climate Shock (D2cs)	0.53 (0.51)
D3G (Gadhi)(Yes=1, Others=0)	0.31 (0.48)
D4L (Lekhagaon) (Yes=1, Others=0)	0.69 (0.48)

Table 2. Results of the model.

Dependent Variable: Ln Vulnerability Index (VI_H)

Regressor	Coefficient	Std. error	P value
Constant	-6.101	2.36	0.082
LnFamily Size (X_{1Fs})	-5.331	1.61	0.046
Lnlabor (X_{2l})	2.012	0.69	0.062
Ln totalabor income (X_{3tli})	-3.15	0.77	0.027
Lnagincome (X_{4ai})	-3.92	0.58	0.007
Lntotal incomeloss (X_{5til})	7.07	1.24	0.011
Lnland (X_{6lag})	1.48	0.49	0.58
$D_{1:}$ Education (Yes=1, No=0)	2.479	0.568	0.022
$D_{2:}$ Climate Shock (CS) (yes=1, 0=others)	-1.007	0.18	0.011
$D_{3:}$ Gadhi (yes=1, 0=others)	1.99	0.23	0.003
$D_{4:}$ Lekhagaon (yes=1, 0=others)	-1.99	0.23	0.003
R^2=0.974		F value=12.55 (p-value:0.031)	
Df=9,3		N=642	

Discussion

The result of the model provides sufficient and necessary evidence on the coefficient of the independent variable affecting the household vulnerability index (HVI). In the model, the coefficient of values explains what a functional relationship and variation of HVI are in the variation of adaptive capacity, location, and climate shock. The result of the model is that the R^2 value is 0.97. It means approximately 97 percent variation of the vulnerability index explained by the above model. It indicates the perfect goodness of fit to the data. is still a 0.23 percent error term which includes the different unobserved variables. It indicates higher goodness to fit. $F_{cal(8,5)}$ is 21.08. is compared with $F_{Table\ (8,5)}$ value (3.69). The value of $F_{cal\ (8,5)}$ R> value of $F_{Table\ (8,5).}$ shows that the overall fitness of the model is statistically significant. It means the model has explanatory power.

Ln Vulnerability Index (VI_H)=-6.101 - 5.33Lnfamily size + 2.01 Lnlabor + -3.15 Ln Total Labor Income - 3.92Lnfarmincome + 7.07 LnTotal Income Loss+ 1.48 Lnlandholding + 2.47 literacy+ -1.007 climate shock +1.99 Gadhi -1.99 Lekhagaon

Let us suppose there are three factors: adaptation capacity, geographical factor, and climate shock affecting HVI in different VDCs (Gadhi, Lekhagaon, and Kunathari) in natural hazards, including floods and landslides.

Since vulnerability is a threat to livelihood, vulnerability should be reduced as much as possible for happiness. In this way, negative signs of adaptive capacity reduce HVI in the study areas. Let us present one-by-one coefficient values of parameters affecting household vulnerability.

Family size is a powerful demographic variable depending on family planning, family fragmentation, and family composition. Big family size and higher fertility power are sources of labor. It ensures employment. Big family reduces HVI by 533 percent. The reason is labor power and labor income. This is significant, too.

Similarly, farm and non-farm incomes are major income sources of households in the water basin. This income has an adaptive capacity to cope with the impact of disaster. In the real world, rich people have a higher adaptive capacity than poor households. This means that the poor are more vulnerable than the rich. Total labor income and farm income can reduce household vulnerability by 3.15 percent and 3.92 percent, respectively. The rich will be vulnerable less than the poor by 3.00 times., labor has no direct linkage with household vulnerability.

Total income loss is a synonyms of household vulnerability. If disasters trigger asset and not asset losses, vulnerability will increase. This significant coefficient value of 7.07 percent increases HVI if there is a 1 percent increment of household income loss. In the case of land, the land is sensitive to disaster. When we have land, there is a higher possibility of exposure. Therefore, it also contributes to vulnerability by 1.48 percent through land exposure and sensitivity (landslide, bank cutting, soil erosion, etc.).

Literacy is the power to access information and learning. When family members are literate, their adaptive capacity can find alternatives to minimize vulnerability. Let us assume that other variables remain constant; the vulnerability level of a household will decrease by 247 percent when the proportion of family size increases by 1 percent. It shows that the illiterate is sensitive to the impact of floods and landslides.

Climate shock raises HVI through sensitivity and exposure. If climate shock induced exists, so much HVI will increase by 1.00 percent. In the case of other (landslide), HVI will be less by 1.00 percent. Thus, a flood is more terrible than a landslide, although both are more impactful to HVI.

Geographical categorical variables are Gadhi, Lekhagaon, and Kunathari. Geographically, vulnerability is heterogeneous. HVI is 1.99 percent in Gadhi and -1.99 percent in Lekhagaon. Comparatively, households in Gadhi are more vulnerable than in Kunathari and Lekhagon.

CONCLUSIONS

This paper assesses the impacts of adaptive capacity on HVI and ranks in Nepal based on the calculated value of the household vulnerability index from the primary data collected from the household survey in the Sotkhola Catchment Areas: Gadhi, Lekhagaon, and Kunathari through regression model. As a result, family size and vulnerability are negative. Large family size reduces vulnerability by 533%, although the large family size is more sensitive to the impact of natural hazards. Similarly, labor and agricultural income have a significant negative impact on household vulnerability by 3.15 % and 3.92 %, respectively. The rich will be less vulnerable by 3.00 times., labor has no direct linkage with household vulnerability. Natural disasters such as floods are more terrible than a landslide, although both are more impactful to household vulnerability. Geographically, in Gadhi, the household vulnerability will be higher than in Kunathari, and household vulnerability in Kunathari will be higher than in Lekhagaon. Thus, a flood is more terrible than a landslide. Its intensity is higher in Gadhi than Kunathari and then Lekhagaon., It destroys assets and non-assets. Total income loss increases 7 times due to household vulnerability. Its vulnerability level falls 3 times more to the poor than the rich. Therefore, adaptive capacity is an instrument of resilience to household safety and welfare. In the context of poverty alleviation, preparedness, and climate change initiatives, this result will be valuable to improve the adaptive capacity of the socioeconomically vulnerable population for disaster and climate resilience, further development, and future disaster risk management policy implications.

Declaration

Competing Interest: the author declares that he has not competing interest financially and non-financially.

Funding: rainfall and temperature data sets are freely available. In addition, the design of the study and collection, analysis, and interpretation of data and in writing the manuscript had not fund.

Author's contribution

The author was a responsible to conduct the whole research project including data collection, analysis, methodological development, data analysis and write up the manuscript. Therefore, the author's contribution was full to this paper.

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