K.C., S. 2013. Community vulnerability to floods and landslides in Nepal. *Ecology and Society* **18**(1): 8.
http://dx.doi.org/10.5751/ES-05095-180108

Research, part of a Special Feature on Education and Differential Vulnerability to Natural Disasters

Community Vulnerability to Floods and Landslides in Nepal

Samir K.C. [1,2]

ABSTRACT. We addressed the issue of differential vulnerability to natural disasters at the level of village communities in Nepal. The focus lay on the relative importance of different dimensions of socioeconomic status and in particular, we tried to differentiate between the effects of education and income/wealth, the latter being measured through the existence of permanent housing structures. We studied damage due to floods and landslides in terms of human lives lost, animals lost, and other registered damage to households. The statistical analysis was carried out through several alternative models applied separately to the Terai and the Hill and Mountain Regions, as well as all of Nepal. At all levels and under all models, the results showed consistently significant effects of more education on lowering the number of human and animal deaths as well as the number of households otherwise affected. With respect to the wealth indicator, the picture was less clear and particularly with respect to losses in human lives, the estimated coefficients tended to have the wrong signs. We concluded that the effects of education on reducing disaster vulnerability tended to be more pervasive than those of income/wealth in the case of floods and landslides in Nepal.

Key Words: *education; floods and landslides; natural disaster; Nepal; vulnerability*

INTRODUCTION

Natural disasters occur and affect people's lives and livelihoods in almost all parts of the world. Some populations are more vulnerable than others and disparity exists between nations and communities within a country. Furthermore, within communities different households may be affected differently and even within households the vulnerability of individual household members may vary. In this study, we empirically assessed the relative importance of socioeconomic factors associated with differential community vulnerability to floods and landslides in Nepal. In this context, our specific research question was to assess the relative importance of different dimensions of socioeconomic status and in particular to try to differentiate between the effects of education and income/wealth. The reason for this effort in the unpacking of socioeconomic status (SES) was that these two dimensions of SES imply quite different policy priorities for reducing household vulnerability: either investing more in education or in strengthening the economic aspects of livelihood.

Empirical analysis of vulnerability to natural disasters' drivers have been conducted at national and subnational levels (Phifer et al. 1988, Yohe and Tol 2002, UNDP 2004, Brooks et al. 2005, Pradhan et al. 2007, Toya and Skidmore 2007, Deressa et al. 2008, Makoka 2008, Shewmake 2008). Brooks et al. (2005), in their macrolevel study, found that at the national level governance, health, and education were the three main determinants of vulnerability. In a multicountry study, Toya and Skidmore (2007) found that both higher income and educational attainment were important measures of development in reducing vulnerability to disasters.

At the microlevel, many studies applied regression analysis to find income as one predictor of vulnerability to natural disaster (Phifer et al. 1988, Pradhan et al. 2007). For example, Pradhan et al. (2007) have shown that the flood related fatality rate for children was very high among families with low socioeconomic status, measured by income-generating land ownership and the type of roof. Most of these studies used community characteristics that could be used to categorize community vulnerability as listed by King (2000): these included demographic indicators, such as size of the population, population aged 0-4, 65+, living arrangements, etc.; household types and structures; and economic indicators such as, unemployed and income level. Few studies considered education as a possible predictor of vulnerability (Phifer et al. 1988, Shewmake 2008). Phifer et al. (1988) chose education as a "rough" indicator of socioeconomic status instead of income, because of the high rate of nonresponse. Shewmake (2008) showed that "years of schooling" of the best-educated person in the household was one of the highest significant explanatory variables in explaining the variation in vulnerability of South African farmers to climate change (Shewmake 2008).

There is a huge body of literature studying the positive impacts of education on a wide spectrum of desirable outcomes. A review of this literature goes far beyond the scope of this paper. It should just be mentioned that recent reviews exist on the strong impact of female education on lowering fertility and population growth (Lutz and K. C. 2011), on assessing the effects of education on economic growth (Lutz et al. 2008) and health (Baker et al. 2011), and even on its effects on the quality of institutions and democracy (Lutz et al. 2010). However, was it meaningful to assume that education also mattered directly for reducing the vulnerability to natural disasters? Deressa et al. (2008) have shown that at the household level, farmers with higher incomes were less

[1]Research Scholar, World Population Program, International Institute for Applied Systems Analysis, [2]Wittgenstein Center for Demography and Global Human Capital (IIASA, VID/OEAW, WU)

vulnerable to climate change. However, because education and income tend to be strongly correlated, it was not clear what was being measured when only one of the two factors was included in the analysis. It was well established that educated people tended to have higher salaries (Lutz et al. 2008), so if educational attainment had a strong positive association with income, then education might lower vulnerability via income. Apart from this economic effect, it may be reasonable to assume that educated people were more aware or better informed of the risks as well as the ways of mitigation and adaptation in case of disasters. Because so few studies have considered education in the analysis of vulnerability, the relationship between education and vulnerability has been largely unknown.

What were the possible causal mechanisms by which education could directly influence the vulnerability to natural disasters? While there had been almost no literature on this topic in the field of natural disasters, there was a significant body of scientific studies on the effect of education on health. And there were good reasons to assume that the effects of education on health and mortality in general were isomorphic to those on mortality to natural disasters, which is just a special kind of mortality. Baker et al. (2011) recently published a comprehensive review and assessment of the causal mechanisms by which education affects human health. It showed that there was strong empirical evidence of the importance of cognitive processes that were a result of education-induced changes in behavior that were protective of the health of the individual and his/her family members. With respect to health-related behavior, it had been shown that already low levels of education resulting in basic literacy could induce significant behavioral changes in terms of avoiding risk and taking precautions based on information about the risks. This effect tended to get stronger the higher the level of education. Contrary to an older assumption that most neurological development was completed before a child entered school, recent research has found that higher-order cognitive skills could be developed by interactions with the environment well into early adulthood. It also showed that exposure to schooling was monotonically and linearly associated with enhanced higher-order cognition (Baker et al. 2011). It was also shown that at higher ages, the mental capacity and ability to learn and adapt to new situations was higher for persons who had received more education, even if this education happened in childhood, many decades ago. These findings have had significant implications for the abilities of individuals and societies to be able to learn and adjust their behaviors based on new information and insights. It put education at the heart of the capacities of societies for learning and changing behavior toward less vulnerability and higher adaptive capacity to environmental change and the associated increased risk of natural disasters.

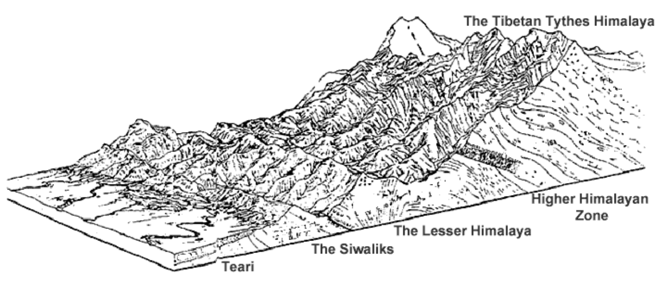
We tested community level education as a predictor of the vulnerability to floods and landslides in Nepal using two sources of data: data compiled annually by the government of Nepal (MoHA 2011) at the village level on losses due to flood and landslides, and a sample of microdata at the individual level from the 2001 census. The result of the analysis would inform us whether the educational level of a community was associated with its vulnerability to floods and landslides. Further, to explore possible causal pathways of this association, and to understand the role of education in reducing community vulnerability to floods and landslides and increasing their adaptive capacity, we conducted in-depth interviews with various stakeholders in a district of Nepal.

METHODS

Setting

Nepal is a country with varying topography starting at the relatively flat and low (80 m) Ganges Plain in the south (see Fig. 1) and steeply increasing to thousands of meters of elevation in the Himalayas. Each year during the monsoon season, massive rain events, some dropping as much as 550 mm of rainfall in 24 hours (Neupane 2008), can send huge flood pulses downstream through the steep and mountainous terrain causing flash floods and landslides in the hilly regions of Nepal. When the flood reaches the plain, known as Terai, inundation of riverbanks causes recurrent and severe flooding in Nepal, as well as in neighboring India (Dixit 2003, Khanal et al. 2007). Soil erosion is another major problem in the Terai caused by flooding. Nepal is administratively divided into 75 districts, 20 Terai and 55 non-Terai, the Hill and Mountain Regions.

Fig. 1. Physiographic regions vis-à-vis major geologic formations of the Nepal Himalaya. (DWIDP 2007)



Data

Data used in the analysis came from two sources. The main data source was a compilation of yearly disaster-related information from all over the country during the period of 2000-2009, and hereafter referred to as “disaster data” (MoHA 2011). The second source, published by the Central Bureau of Statistics of Nepal, was a microsample of the 2001 Census, the latest available, of 2.5 million individuals. These 11% of the total population, belonging to some half a million households of Nepal, were used to obtain various individual and community level variables on population and socioeconomic status (CBS 2008).

The disaster data was compiled by the Ministry of Home Affairs (MoHA) based on reports on disaster-specific losses prepared by the district administrative offices (DAOs) on a total of 75 districts, and then sent to the ministry. Three disaster impact variables were considered in this analysis: deaths, family affected, and loss of animals due to flood and landslides. This information was collected either by the officials from the district level visiting the disaster affected site, or prepared by the Village Development Committee (VDC). In the first step of the process, households and/or livelihoods that were being flooded or hit by the landslides were listed as “family affected.” In the second step, damages to the households or livelihoods, for example, deaths, loss of animal, or property damages, were calculated for the whole VDC and sent to the district administrative office. The information was available at the level of the VDC, around 4000 rural communities or urban municipalities. We combined all the data related to losses due to floods and landslides for the mentioned nine-year period. However, only the data for the periods of 2000-2001 and 2002-2006 were useful for the purpose of the regression analysis with the unit of analysis as single VDC-period.

Significant effort was invested to detect and rectify anomalies and discrepancies in the disaster data. Out of 3436 data points, 1640 (47.9%) VDC/municipality names exactly matched the standard list of names of VDCs and municipalities obtained from the Central Bureau of Statistics, Nepal. Unmatched names (1796 cases, 52.1%) were checked for spelling errors and the 1390 names (39.6%) found were corrected. The remaining 463 data points (12.7%) could not be used. The main problems were (1) many VDCs were lumped together into one group of villages or the data was reported for the whole district, (2) no matching names, and (3) names that could partially match with two or more, thereby creating “confusion” (for details see Appendix 1).

The implication of lumping the multiple records into one and the mismatched names of VDCs was significant. For example, there were 2042 deaths due to floods and landslides during the nine-year period, out of which 33% of the deaths could not be allocated to individual VDCs. These deaths were mostly concentrated in the period 2007-2009, when 22% of the deaths occurred, and in the period 2001-2002 when another 7.1% of the deaths occurred. After excluding the periods 2007-2009 and 2001-2002, the number of deaths in the dataset was reduced to 1215 (60%). Finally, problematic data points within the included periods (2000-2001 and 2002-2006) were further removed. Consequently, the final dataset (referred to as six 1-year periods: 2000-2001, 2002-2006) used in the regression analysis contained 1129 (55%) deaths with 2545 data points out of the initial 3436 data points from the 1449 VDC/ municipalities that remained.

The high number of deaths, 2042 persons in the period 2000-2009, indicated that the population was vulnerable to the risk of dying due to floods and landslides (see Table 1). Around half of the Nepalese population lived in 20 Terai districts, and 19% of the total deaths due to flood and landslides occurred in Terai districts. At the district level, the highest number of deaths, in the nine-year period, in the Terai district, occurred in Chitwan with 87 deaths, and 154 in the non-Terai district of Makwanpur, with 112 deaths in the single year 2002-2003, and 53 deaths in one VDC named Kankada. In 17 districts, the numbers of deaths were less than 10, including the district of Manang, with no deaths.

Table 1. Impact of floods and landslides in all districts of Nepal during 2000-2009 and the size of the population, mean years of schooling in 2001.

Districts	Pop (in 2000)	Mean Years of Education	Deaths	Affected Family	Animal Loss
Hills and Mountains					
Achham	231	1.4	9	1222	47
Arghakhanchi	208	3.0	26	2342	601
Baglung	269	3.7	110	1098	293
Baitadi	234	3.0	23	1333	194
Bajhang	167	1.7	11	681	195
Bajura	109	1.7	47	374	193
Bhaktapur	225	5.0	1	148	55
Bhojpur	203	2.8	23	504	283
Dadeldhura	126	2.7	38	382	122
Dailekh	225	2.6	17	310	381
Darchula	122	2.8	50	930	849
Dhading	339	2.0	59	671	399
Dhankuta	166	4.1	12	74	28
Dolakha	204	2.9	29	395	53
Dolpa	30	1.5	2	72	39
Doti	207	2.5	12	589	154
Gorkha	288	2.4	47	772	171
Gulmi	297	3.0	41	364	223
Humla	41	1.3	17	570	243
Ilam	283	4.5	21	577	240
Jajarkot	135	1.7	29	450	212
Jumla	89	1.8	7	49	9
Kabhre	386	3.6	32	1219	263
Kalikot	106	1.8	9	248	14
Kaski	381	4.7	90	1185	311
Kathmandu	1082	6.4	34	184	48
Khotang	231	2.8	56	2318	451
Lalitpur	338	5.3	14	55	119

(con'd)

Lamjung	177	3.0	30	422	292
Makwanpur	393	3.6	154	1858	556
Manang	10	3.4	0	9	5
Mugu	44	1.6	1	91	14
Mustang	15	2.6	11	37	91
Myagdi	114	2.7	46	378	156
Nuwakot	288	2.5	18	302	243
Okhaldhunga	157	2.2	42	454	247
Palpa	269	4.5	3	351	107
Panchthar	202	3.1	6	200	153
Parbat	158	3.7	2	672	205
Pyuthan	212	2.1	20	94	71
Ramechhap	212	1.6	59	1317	790
Rasuwa	45	1.5	33	148	144
Rolpa	210	1.4	21	748	79
Rukum	188	2.0	21	122	43
Salyan	214	2.6	4	132	161
Sankhuwasabha	159	3.3	31	391	182
Sindhuli	280	2.6	14	390	323
Sindhupalchok	306	1.7	23	358	279
Solukhumbu	108	2.2	22	710	168
Surkhet	289	3.7	7	549	129
Syangja	317	4.2	38	911	210
Tanahu	315	3.7	96	1389	397
Taplejung	135	3.0	46	791	346
Terhathum	113	3.8	10	153	116
Udayapur	288	2.9	24	4503	414
Non-Terai					
Banke	386	4.3	36	58588	114
Bara	559	2.8	13	163	37
Bardiya	383	2.4	5	10643	57
Chitwan	472	4.9	87	3470	525
Dang	462	3.8	20	384	427
Dhanusa	671	3.9	11	3291	220
Jhapa	688	4.6	12	3930	128
Kailali	617	3.3	24	5528	202
Kanchanpur	378	4.0	17	8447	358
Kapilbastu	482	2.6	41	56	5
Mahottari	553	2.4	14	12280	196
Morang	843	3.6	15	2989	44
Nawalparasi	563	3.0	24	9465	269
Parsa	497	2.7	6	780	139
Rautahat	545	1.9	22	7723	344
Rupandehi	708	5.0	8	3016	93
Saptari	570	3.6	4	40353	93
Sarlahi	636	2.3	20	19489	137
Siraha	572	2.5	10	11222	161
Sunsari	626	4.1	5	10478	154

In the nine-year period, there were a total of 248,891 families affected by floods and landslides. In 20 Terai districts, 212,295 (85.3%) families were affected, whereas only 36,596 (14.7%) families were affected in 55 non-Terai districts. This confirmed the general impression that in the hilly districts, flash floods and landslides were more fatal than the effects of rising water in Terai districts where the water was slow enough to give families time to avert deaths and injuries. The highest total of families affected in a non-Terai district was 4503 in Udaypur, and in a Terai district, it was 58,588 in Banke (50,200 in a single year).

A total of 15,814 animals died because of floods and landslides over the nine-year period. The number of animals lost in 20 Terai districts was 1333, and 14,481 were lost in 55 hilly districts. The highest totals, 849, occurred in the non-Terai district of Darchula, and 525 in the Terai district of Chitwan.

Model

We used the Poisson regression to test whether and how the community's vulnerability to floods and landslides was associated with socioeconomic indicators. Poisson regression was a preferred method in modeling the count data, especially when the event (dependent variable) being modeled rarely occurs or has a low probability of occurrence. The dependent variables were the disaster related losses, for example, the number of human lives lost, the number of animals lost, and the number of families affected, that could be considered events with low probability, to a greater extent the number of deaths and to a lesser extent the number of families affected. The Poisson regression was also a member of the family of general linear models (glm) where the predictors had a linear relationship with some function of the response variable; this was a logarithm of the response variable in the case of the Poisson regression.

We applied the Poisson regression model to investigate the relationship between the disaster related losses, e.g., number of human lives lost, number of animals lost, and number of families affected, and the average educational attainment of people aged 15-39 at the VDC level. In the regression analysis, we included the average education of the population aged 15-39 because this was the age in which the improvement in education progression occurred after 1991, when democracy was reinstated in Nepal after 30 years of absolute monarchy. At the same time, it was the population of young adults in this age group who brought about changes in the society faster through the assimilation of new ideas and technologies.

Three sets of models were studied for each of the response variables. Other predictors in the regression models were an income/wealth-related variable represented by the proportion of permanent housing in each VDC, and the number of times each VDC experienced the disaster (flood and landslides) during the period as a representative of exposure to the hazard of floods and landslides in each VDC. Because a VDC's population size was an important factor to consider, we included the size of the population in the regression model. Since we had no reason to believe that there was a nonlinear relationship between the population size and the number of events, we set the population variable as an offset term in the regression model so that the coefficient of the offset term was forced to be 1. Introduction of an offset term also opened a way to use the Poisson regression to model event-exposure rates (for example, death rates with numerator as number of deaths, events, among a population and denominator as total time spent by the population exposed to the event of death) with separate event and exposure variables in the model.

There was the likelihood that two neighboring VDCs might be correlated in terms of socioeconomic and demographic status, as well as the hazards they faced. Although this was true to a large extent for the socioeconomic and demographic factors, this might not have held true for hazards of flood and landslides, which largely depended on the geographic location of the VDCs, especially in hilly districts. Although some VDCs, along certain riverbanks or situated in a river delta might have experienced similar hazards, many of the neighboring VDCs might not share the same hazards. A hazard level of VDCs would be needed to control for this, but the data for this was not available. Under these constraints, we included the hazard score in terms of number of times a VDC had experienced such an event during the study period.

In addition, we ran the analysis separately for Terai and non-Terai (Hill and Mountain Regions) because the two regions differed in terms of types and intensity of hazards and had socioeconomic differentials. It had been mentioned earlier that Nepal has a diverse geography, with Terai being a flat land and the rest being hills and mountains. As a consequence, the occurrences and impacts of floods and landslides were different in these two geographic areas. In the Hill and Mountain Regions, the disasters happened unexpectedly and with greater force of destruction, ending lives and destroying livelihoods. In Terai, in many cases, the disasters could be predicted in advance and the impact was slow, affected a larger area but with fewer deaths. Therefore, we repeated the analysis for the whole of Nepal, the Hill and Mountain Regions (55 districts), and for the Terai region (20 districts) separately.

In-depth interviews

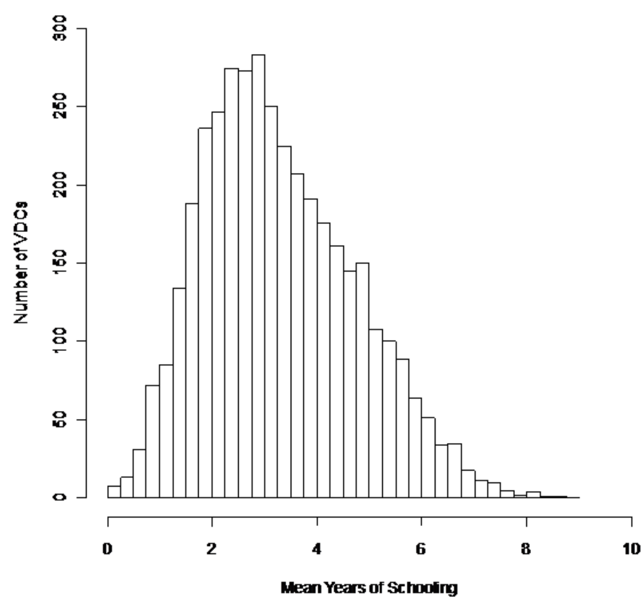
During the monsoon of 2008, to explain possible causal pathways between education and community vulnerability, and to understand the role of education in reducing community vulnerability to floods and landslides as well as increasing the adaptive capacity of these communities, the author visited a district in Nepal to conduct a few in-depth interviews with various stakeholders. District Nawalparasi was chosen because it consisted of both plains and hills associated with Terai and non-Terai districts and could be representative of most of Nepal. In-depth interviews were conducted with individuals at different places: two interviews with farmers at their residences, one interview with a local journalist, one interview with a local politician, one interview with a local Red Cross official, one interview with a government employee at the office of the district administration, and a final interview with a social worker. The interviews lasted between 10 and 50 minutes.

RESULTS

Educational distribution

The level of educational attainment was very low in Nepal (Fig. 2). In the year 2001, the mean years of schooling of the population aged 15-39 (MYS1539) was 4.55 years (3.5 years for ages 15 and over) with a relatively large standard deviation (sd) of 4.64 years (4.52 years for ages 15 and over). We found zero MYS1539 in two VDCs, Bihi VDC in Gorkha district and Bhijer VDC in Dolpa district. It was more likely that the samples from these villages did not include a single person who ever attended school. Kathmandu metropolitan city had the highest educational attainment among those aged 15-39 (8.31 years). The overall average of VDCs/municipalities was 3.3 years (sd 1.45), with 3.50 years (sd 1.49) for the Hill and Mountain Regions and 2.93 years (sd 1.29) for the Terai.

Fig. 2. Distribution of mean years of schooling among youths aged 15 to 39 years in Village Development Committees (VDC) and municipalities in Nepal, 2001 Census.

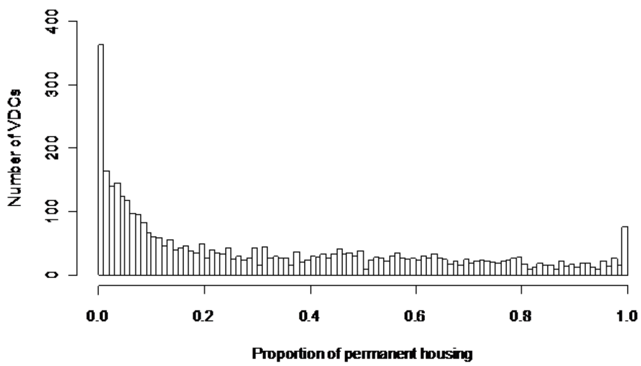


The district of Kathmandu had the highest level of MYS1539 with 7.5 years (sd 4.9), followed by other districts in the Kathmandu Valley: Lalitpur (6.4 years, sd 5.0) and Bhaktapur (6.3 years, sd 4.7, 4th place). Kaski district with Pokhara Valley, a major tourist destination, stood third with 6.3 years (sd 4.3) of MYS1539. The worst districts, in terms of educational attainment, were Humla with 1.8 years; Rolpa, Dolpa, and Achham with 2.0 years each; and Mugu and Kalikot with 2.1 years each.

Proportion of permanent housing

For each VDC/municipality, we estimated the proportion of permanent housing. In Nepal, 42.2% of all the households lived in a house with a permanent structure. In Figure 3, we show the frequency distribution of VDCs/municipalities by proportion of permanent housing. Permanent housing was a symbol of wealth and income because poor people could not afford to build a house with a permanent structure. There were still many villages with no or low proportions of permanent housing. The correlation between the mean years of schooling (MYS1539) and proportion of permanent housing at the community level was found to be close to zero (R-square of 0.007), therefore these two factors could be considered independent.

Fig. 3. Frequency distribution of proportion of permanent housing in Village Development Committees (VDC) and municipalities in Nepal.



Village exposure to hazard

Some villages had a higher level of disaster hazards because of their geographic location and therefore experienced hazards more frequently. To control for the variation associated with the physical vulnerability of the VDCs, we calculated a village hazard index, which was estimated as the number of times in the six 1-year periods a VDC had been affected by floods and landslides. The average of the village hazard scores was 3.99 times with a standard deviation of 4.33 times. Of the VDCs that were affected at least once during this period, more than 50% had been affected less than three times, and more than 25% had been affected at least five times.

Population size of the VDCs/municipalities

The average population size of the VDCs/municipalities in the microdata (approx. 10% of the population) was about 7000 with a large standard deviation of 24,000. About 50% of the VDCs/municipalities had a population size of less than 3440, and about 10% of VDCs/municipalities had a population size of larger than 8000.

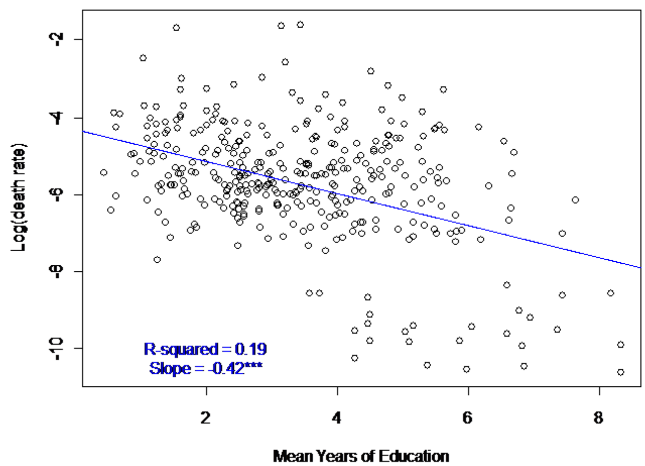
Number of lives lost

Based on the included sample of 2545 data points (VDCs with an event of a flood or a landslide) in the six 1-year periods, there were altogether 1129 deaths due to floods and landslides. In 78% of the reported cases, there were no deaths. In 254 cases, single deaths occurred in the VDCs/municipalities, followed by 106 cases with 2 deaths, 56 cases with 3 deaths, 33 cases with 4 deaths, 29 cases with 5 deaths, and so on. In terms of number of deaths, the 2 outlier maxima were 112 in one village, with 53 deaths in another village being the second largest.

In terms of recurrent deaths, over the six one-year periods, one VDC/municipality experienced deaths in three periods (total deaths = 3), 34 VDCs/municipalities experienced deaths 2 times (total deaths = 83), and 265 VDCs/municipalities experienced deaths 1 time each (total deaths = 844).

In Figure 4, we showed a bivariate plot between the VDC/municipality's specific (log of) death rate and the mean years of schooling for those VDCs that experienced at least one death. Therefore, we looked at the association between these two variables whenever death had occurred. It showed a negative association, which supported the contention that the communities with a lower level of MYS1539 had higher death rates.

Fig. 4. Log of death rate by mean years of schooling of population aged 15 to 39 at the community level.



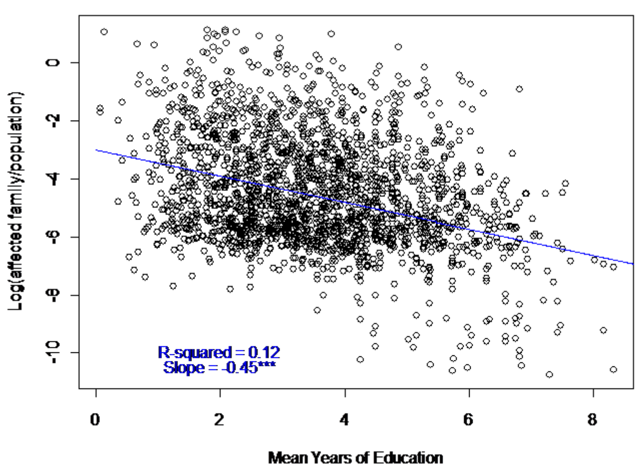
Number of families affected

During the nine-year period, in all of Nepal, a total of 248,891 families were affected by floods and landslides. In the worst year, 2007-2008, 114,668 families were affected. In the Terai region, the worst hit districts were Banke with 58,588 families affected in total and 50,200 in a single one-year period (2007-2008), and Saptari with 40,353 families affected in total and 37,290 in that same one-year period, 2007-2008. By contrast, Udayapur (4503) and Arghakhanchi (2342) were the worst hit districts in the Hill and Mountain Regions. In general, more people were affected in the Terai districts than in the non-Terai districts. However, as seen earlier, floods and landslides were far less deadly in the Terai region because the disaster was more predictable, developed more slowly with more warning, and was less hazardous in force.

At the VDC level, using data from the nine-year period with the 2001 data points, we found that an average of 26 families were affected per event per VDC/municipality with a standard deviation of 93. In 8.7% of the cases, no family was affected, and most of the times (38.1%) only one family per VDC/municipality was affected by the floods and landslides. In more than 25% of the cases, at least 10 families were affected, and the three highest observations for the number of families affected were 1209, 1651, and 1698.

Based on the data from the six 1-year periods, we showed a negative association (Fig. 5) between the fraction of the population affected by disaster (the log of the ratio of numbers of affected family and the size of the population) and educational attainment, as represented by the MYS1539 data.

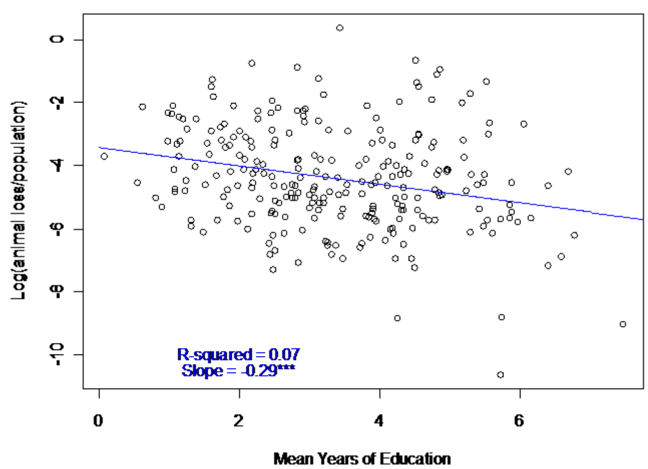
Fig. 5. Log of the ratio of number of affected families and size of the population and the mean years of education of population aged 15 to 19 at the community level.



Number of animals lost

The total number of animals lost during the nine-year period was 45,023 in the whole of Nepal. In the Terai region, the highest losses were experienced in two districts: Banke with 8563 in total in two 1-year periods during 2007-2009, and Sunsari with 6838 in total and 6799 in a 2008-2009 one-year period. Similarly, in non-Terai districts, Khotang experienced 18,027 losses in total and 17,602 in the 2007-2008 period and Makwanpur had 368. They experienced the highest losses in the list. At the VDC level, based on the availability of 4941 observations in total, an average of 1.64 animals were lost per event per VDC/municipality with a standard deviation of 12.8. In 2707 (90.2%) cases, there was no loss of animals due to the floods and landslides. In 22 cases, the number of animal losses exceeded 50, and the three highest numbers of animal losses reported were 220, 275, and 300. Based on the data from six 1-year periods, we showed a negative association (Fig. 6) between the fraction of the animals lost per population (the log of the ratio of number of animals lost and the size of the population) and educational attainment, as represented by the MYS1539. The strength of association was low (R-squared = 0.07) compared to that of the number of deaths and families affected.

Fig. 6. Log of the ratio of number of animals lost and size of the population and the mean years of schooling of the population aged 15-39 (MYS1539).



Poisson regression analysis

We ran three regression models for each of the response variables using the six 1-year data. The first model, Model 1, had only one explanatory variable, e.g., the mean years of schooling of the population aged 15-39. In the second model, Model 2, we introduced the percentage of permanent housing in the VDC, and finally in Model 3, we added the third explanatory variable representing the hazard risk of a VDC to disaster, which was the number of times the VDC had experienced a flood or landslide event over the six 1-year periods. The importance of newly added variables, in terms of explaining the variability in the response variable, could be informed by the change in the value of residual deviance, that is, the lesser the value the higher the amount of explained variation. Results from the various model runs for each of the response variables are presented in Table 2. The first four columns are the coefficients of the Poisson regression. The exponent of the coefficients is presented in parentheses and represents the relative ratio, which is the relative change in the value of dependent variables with respect to a unit change in the independent value. For example, the exponent of the coefficient exp(-0.55) = 0.58 in the case of the response variable Number of deaths - Model 3 - MYS1539 (see Table 2, first block) means a one-year increase in mean years of schooling will bring down the deaths by a factor of 0.58, or a

Table 2. Coefficients (exponents in parentheses) of the Poisson regression analysis of number of deaths, number of families affected, and number of animals lost on mean years of schooling of 15 to 39-years-old and other variables.

Response Variable (Number of)	Models[†]	Constant	Mean year of Schooling of aged 15 to 39	Percentage Permanent Housing	Village Vulnerability	Residual Deviance
				Nepal		
Deaths	Model1	-5.16(0.01)***	-0.72(0.49)***			6696
	Model2	-5.25(0.01)***	-0.76(0.47)***	0.01(1.01)***		6654
	Model3	-4.92(0.01)***	-0.55(0.58)***	0(1)***	-0.29(0.75)***	6183
Affected Families	Model1	-0.79(0.46)***	-0.8(0.45)***			1173
	Model2	-0.68(0.51)***	-0.64(0.53)***	-0.03(0.97)***		1128
	Model3	-0.53(0.59)***	-0.45(0.64)***	-0.03(0.97)***	-0.21(0.81)***	1020
Animal Loss	Model1	-4.06(0.02)***	-0.63(0.53)***			5301
	Model2	-4.01(0.02)***	-0.56(0.57)***	-0.01(0.99)***		5301
	Model3	-3.71(0.02)***	-0.35(0.7)***	-0.01(0.99)***	-0.28(0.76)***	4766
				Terai		
Deaths	Model1	-5.81(0)***	-0.75(0.47)***			275621
	Model2	-5.51(0)***	-1.11(0.33)***	0.04(1.04)***		255045
	Model3	-5.02(0.01)***	-0.88(0.41)***	0.04(1.04)***	-0.46(0.63)***	234551
Affected Families	Model1	-0.03(0.97)***	-0.82(0.44)***			165379
	Model2	-0.32(0.73)***	-0.53(0.59)***	-0.04(0.96)***		155976
	Model3	-0.11(0.9)***	-0.49(0.61)***	-0.04(0.96)***	-0.14(0.87)***	153260
Animal Loss	Model1	-5.29(0.01)***	-0.32(0.72)***			66830
	Model2	-5.65(0)***	-0.09(0.91)***	-0.02(0.98)***		66278
	Model3	-5.28(0.01)***	-0.07(0.93)***	-0.02(0.98)***	-0.19(0.83)***	59529
				Hills and Mountains		
Deaths	Model1	-4.87(0.01)***	-0.72(0.49)***			34586
	Model2	-4.88(0.01)***	-0.72(0.49)***	0(1)ns		34268
	Model3	-4.52(0.01)***	-0.46(0.63)***	-0.01(0.99)***	-0.28(0.75)***	32162
Affected Families	Model1	-2.17(0.11)***	-0.67(0.51)***			14229
	Model2	-2.05(0.13)***	-0.64(0.53)***	-0.01(0.99)***		14055
	Model3	-1.81(0.16)***	-0.41(0.67)***	-0.01(0.99)***	-0.2(0.82)***	13852
Animal Loss	Model1	-3.37(0.03)***	-0.84(0.43)***			19564
	Model2	-3.1(0.05)***	-0.79(0.45)***	-0.01(0.99)***		19154
	Model3	-2.87(0.06)***	-0.47(0.62)***	-0.02(0.98)***	-0.31(0.73)***	17317

[†]Model 1 Response Variable = MYS + Offset(log(population))
Model 2 Response Variable = MYS + Prop.Perm.Housing + Offset(log(population))
Model 3 Response Variable = MYS + Prop.Perm.Housing + Village.Vulnerability + Offset(log(population))
ns > = 0.05; * < 0.05; ** < 0.01; *** < 0.001

42% decline in the number of deaths during flooding and landslides. The last column is the residual deviance for each model, and indicates the level of unexplained variation in the dependent variable.

Number of lives lost

Based on the regression analysis, we found a significant negative association between the number of deaths due to floods and landslides and the mean years of schooling of the population aged 15-39. Adding an income/wealth-related variable increased the explanatory power of the model with a decline in the value of residual deviance (see Table 2). The residual variance declined sharply once the variable representing the village hazard score was added.

It was found that the mean years of schooling of the population, aged 15-39 years, in the communities was related to a higher degree of effectiveness in reducing the deaths in the Terai region more than in the Hill and Mountain Regions. Based on the results of Model 3 (see Table 2), in the Terai region, a one-year increase in the mean years of schooling was associated with a three-fifth (1-exp[-0.88]) decline in flood and landslide related deaths, whereas in the rest of Nepal, the decline amounted to two-fifths (1-exp[-0.46]).

Coefficients for the percentage of permanent housing in the VDC, a change in 1%, reflected mixed results. At the country level, the effect of having permanent housing was negligible, but statistically significant, on the number of deaths per event (Model 3 for deaths, first block, Table 1). However, in the

Terai, the association was positive because a 1% increase in the proportion of permanent housing was associated with more deaths, a 4% increase. The opposite pattern was observed in the Hill and Mountain Regions with a 1% decrease. The results for the Terai municipalities contradicted our hypothesis and need further explanation. A counter argument might be that the flood prone areas had a higher proportion of permanent housing in Terai and therefore resulted in the positive association, whereas in the Hill and Mountain Regions, the unexpected nature of flood and landslides with excessive force made the structure of housing irrelevant.

It was also found that in the villages where disasters were recurrent, the number of deaths was lower and hence these villages were less vulnerable than those where disasters occurred rarely. Vulnerability could be lower because people anticipated the event and were better prepared than the people in places where the events did not happen as often.

Number of families affected

Similar results were obtained for the response variable representing the number of families affected. The model's explanatory power increased significantly when the variable village hazard score was added (Table 2). "Mean years of schooling" was a significant explanatory variable in all models. Based on Model 3, in the Terai, a one-year increase in mean years of schooling was associated with a two-fifths (1-exp[-0.49]) decline in the number of families affected due to floods and landslides, whereas in the rest of Nepal, the decline would be slightly smaller, 0.67 times (Table 2).

The type of housing was important in reducing the risk of being affected, as shown by the negative coefficients (-0.03), especially in the Terai region. As stated earlier, in the Terai region, floods that were less severe and more predictable than in the Hill and Mountain Regions were the risk, hence having a permanent structure reduced the impact.

As found in the case of the number of deaths, fewer families were affected in villages experiencing recurrent events. This was true for all regions in Nepal.

Number of animal losses

In cases where the response variable represented animal loss, similar results were obtained. The associated decline in the number of animal losses with a one-year increase in the mean years of schooling was found to be small, less than one-tenth (1-exp[-0.07]) in Terai, but larger, almost up to three-fifths (1-exp[-0.47]) in the Hill and Mountain Regions.

Having more permanent housing was associated with losing fewer animals. Although the effect was very small, it was consistent over the regions. The result was similar in terms of recurrent events. Villages with recurrent events had fewer animal losses following similar arguments.

DISCUSSION

We have shown, based on the results from the regression analysis (Table 2), that the mean years of schooling of young people aged 15-39 was a statistically significant explanatory variable in explaining different indicators representing losses caused by floods and landslides in all parts of Nepal. With respect to the wealth indicator, the picture was less clear and, particularly with respect to losses in human lives, the estimated coefficients tended to have the wrong signs. We repeated the analysis separately for the Terai plain and the rest of Nepal and found similar results. We found that the increase in mean years of schooling had higher effectiveness in the Terai than in the rest of the Nepal, in the case of numbers of lives lost and numbers of families affected. The effectiveness was almost 50% higher in the Terai than in the rest of Nepal; a one-year increase in educational attainment (MYS1539) was associated with a 59% decline in number of deaths in the Terai and a 37% decline in the Hill and Mountain Regions.

One explanation for the different results in the Terai and non-Terai regions could be that the risk of deaths and injury was higher because of a higher frequency of sudden, violent disasters, e.g., flash floods and landslides. In the Terai, landslides were nonexistent, and floods developed slowly and predictably enough so that people could effectively avoid death and injury. In most cases, people suffered from an overflow of water due to inundation from the river coming to their homes and farms, or in other cases, it could be due to the erosion of the banks engulfing the land into the river. The point is, in the Terai, it was relatively easier to save one's life and livestock from death caused by a flood and a landslide than in the Hills and Mountains, and, through education even more deaths could be avoided.

In the case of the response variable representing the number of animal losses, the effectiveness of education in Hill and Mountain Regions was higher than in the Terai (0.54 vs 0.69, see Table 2). The explanation for this difference was not obvious because it seemed plausible that observations would be similar to those of other response variables. This question requires further analysis that includes more variables associated with animal losses.

A relationship between education and vulnerability was implied by an association between educational attainment and reduced losses caused by floods and landslides in Nepal. This finding was based on the results of a regression analysis. However, the practical relevance of this finding for policy required establishing clear causal relations between human capital, i.e., education, and the effect, i.e., losses due to flood and landslides.

To identify possible causal mechanisms, we used in-depth interviews with seven individuals from different walks of life in the Terai district of Nawalparasi, in Nepal. Most of them were living in an area that was regularly affected by floods.

Based on the interviews, we could infer that education could best reduce losses by increasing awareness regarding different aspects of floods and landslides, e.g., how floods and landslides occurred and what could be done to protect oneself, to mitigate the consequences, or to better adapt to the events of floods and landslides. Respondents suggested that such awareness could be raised in villagers vulnerable to disaster through adult education and literacy programs, through their children, who could be taught in school as a part of a separate awareness campaign, or by including teaching materials in school curricula. Raising this awareness would enable people to make better choices in terms of locations, safe constructions (Toya and Skidmore 2007), and choosing specific types of crops, for example, sugarcane instead of paddy, etc.

In addition to the effects of education on the individual, as highlighted by the respondents, there were two other possible ways in which education could help to reduce vulnerability. Generally, educated individuals in a household were likely to be involved in jobs that were different from the traditional jobs. This helped to diversify the household's income and at times of disaster, would be a lifeline for the regular supply of basic needs. In addition, income was invested smartly by better-educated people with local, as well as nonlocal knowledge, and hence made their lives and livelihoods less vulnerable. However, in the regression analysis we could not pinpoint this effect because a variable measuring income was not available in the data. Instead, we used types of roofs as an indicator of wealth and income in the regression model, and this resulted in a rather unclear effect on the impact of the disaster.

Furthermore, education may have contributed to community level institutions and to leadership. Raschky (2008) suggested that countries with better institutions experienced less deaths and damages from natural disaster and he defined institutions as rules/procedures that clarified how decisions were made within society (political mechanism); formal or informal rules (implementing laws, government) that influenced individual behavior; and groups of individuals that shared a common aim, for example, political parties, NGOs or clubs, companies, and authorities. The level of educational attainment in a community was most likely to affect all three types of institutions. Better-educated communities were likely to organize themselves well, identify problems collectively, find solutions, and represent themselves effectively to the higher-level authorities. This was found to be true to a larger extent in the villages where we conducted interviews, and where people, who mostly never attended school, expressed their helplessness in communicating to the higher authorities as well as stating: "who will talk for us?"

CONCLUSION

In conclusion, we have shown that at the community level, educational attainment of the young adults was a statistically significant explanatory variable in explaining different indicators that represented losses caused by floods and landslides in all parts of Nepal. At all levels and under all regression models, the results showed consistently significant effects of more education on lowering the number of human and animal deaths as well as the number of households otherwise affected.

With respect to the wealth indicator, the picture was less clear, and particularly, with respect to losses in human lives, the estimated coefficients tended to have the wrong signs. Although a clear causal relationship could not be established with the available data, some discussion of possible causal mechanisms, that were corroborated by seven in-depth interviews with different stakeholders in a flood/landslide-prone district in Nepal, suggested that at both individual and community level, education could play an important role in accessing information, in the innovation of ideas, and in the formation of effective groups (e.g., a club, volunteer organization etc.). Education could also play a part in bringing good leadership to work effectively with the local people, and to communicate with higher authorities wherein they could raise their specific concerns and participate expertly in any kind of planning related to community development, including issues related to floods and landslides. In addition, educated people could have an opportunity to diversify their income by taking nontraditional jobs that were not affected by such events.

We concluded that the effects of education on reducing disaster vulnerability tended to be more pervasive than those of income/wealth in the case of floods and landslides in Nepal. Therefore, the need for further analysis with richer data should be acknowledged. An indirect effect of investing in education today could be to lower a community's vulnerability to floods and landslides in the future, and this effect could well transcend to vulnerabilities to other forms of natural disasters, and to the adverse effect of climate change in the long run.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/5095

Acknowledgments:

Funding for this work was made possible by an Advanced Grant of the European Research Council, "Forecasting Societies Adaptive Capacities to Climate Change," grant agreement ERC-2008-AdG 230195-FutureSoc. Author wishes to thank Jeevana KC and Surya Maharjan for their assistance in the cleaning of disaster data, Binita KC for transcribing the in-depth interviews, and Bibek Bidari for providing initial data on disaster.

LITERATURE CITED

Baker, D. P., J. Leon, E. G. Smith Greenaway, J. Collins, and M. Movit. 2011. The education effect on population health: a reassessment. *Population and Development Review* 37(2): 307-332. http://dx.doi.org/10.1111/j.1728-4457.2011.00412.x

Brooks, N., W. N. Adger, and P. M. Kelly. 2005. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change Part A* 15(2):151-163. http://dx.doi.org/10.1016/j.gloenvcha.2004.12.006

Central Bureau of Statistics (CBS). 2008. *National population census 2001: population sample database*. Central Bureau of Statistics, Kathmandu, Nepal.

Department of Water Induced Disaster Prevention (DWIDP). 2007. Disaster Review 2006. Government of Nepal, Ministry of Water Resources (DWIDP). [online] URL: http://www.dwidp.gov.np/uploads/document/file/review_20120213035717.pdf

Deressa, T., R. M. Hassan, and C. Ringler. 2008. *Measuring Ethiopian farmers' vulnerability to climate change across regional state.* International Food Policy Research Institute Discussion Paper 00806, Washington, D.C., USA. [online] URL: http://www.ifpri.org/node/5657

Dixit, A. 2003. Floods and vulnerability: need to rethink flood management. *Natural Hazards* 28(1):155-179. http://dx.doi.org/10.1023/A:1021134218121

Khanal, N. R., M. Shrestha, and M. L. Ghimire. 2007. *Preparing for flood disaster: mapping and assessing hazard in the Ratu Watershed, Nepal*. International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal. [online] URL: http://www.icimod.org/publications/index.php/search/publication/134

King, D. 2000. You're on your own: community vulnerability and the need for awareness and education for predictable natural disasters. *Journal of Contingencies and Crisis Management* 8(4):223-228. http://dx.doi.org/10.1111/1468--5973.00143

Lutz, W., J. C. Cuaresma, and M. J. Abbasi-Shavazi. 2010. Demography, education, and democracy: global trends and the case of Iran. *Population and Development Review* 36(2): 253-281. http://dx.doi.org/10.1111/j.1728-4457.2010.00329.x

Lutz, W., J. C. Cuaresma, and W. Sanderson. 2008. The demography of educational attainment and economic growth. *Science* 319(5866):1047-1048. http://dx.doi.org/10.1126/science.1151753

Lutz, W., and S. K. C. 2011. Global human capital: integrating education and population. *Science* 333(6042):587-592. http://dx.doi.org/10.1126/science.1206964

Makoka, D. 2008. *The impact of drought on household vulnerability: the case of rural Malawi*. MPRA Paper No. 15399, Center for Development Research, University of Bonn, Bonn, Germany. [online] URL: http://mpra.ub.uni-muenchen.de/15399/1/MPRA_paper_15399.pdf

Ministry of Home Affairs (MoHA). 2011. *Yearly disaster report 2000-2009*. Ministry of Home Affairs, Kathmandu, Nepal.

Neupane, N. 2008. *To study the various factors affecting the summer monsoon rainfall in Nepal*. Research Report, The University of Texas at Austin, Texas, USA. [online] URL: http://www.geo.utexas.edu/courses/387h/Lectures/term_Neupane.pdf

Phifer, J. F., K. Z. Kaniasty, and F. H. Norris. 1988. The impact of natural disaster on the health of older adults: a multiwave prospective study. *Journal of Health and Social Behavior* 29 (1):65-78. http://dx.doi.org/10.2307/2137181

Pradhan, E. K., M. Baumgarten, P. Langenberg, B. Handwerger, A. K. Gilpin, T. Magyari, M. C. Hochberg, and B. M. Berman. 2007. Effect of mindfulness-based stress reduction in rheumatoid arthritis patients. *Arthritis Care & Research* 57(7):1134-1142. http://dx.doi.org/10.1002/art.23010

Raschky, P. A. 2008. Institutions and the losses from natural disasters. *Natural Hazards and Earth System Sciences* 8:627-634. http://dx.doi.org/10.5194/nhess-8-627-2008

Shewmake, S. 2008. *Vulnerability and the impact of climate change in South Africa's Limpopo River Basin.* International Food Policy Research Institute Discussion Paper 00804, Washington, D.C., USA. [online] URL: http://www.ifpri.org/publication/vulnerability-and-impact-climate-change-south-africas-limpopo-river-basin

Toya, H., and M. Skidmore. 2007. Economic development and the impacts of natural disasters. *Economics Letters* 94:20-25. http://dx.doi.org/10.1016/j.econlet.2006.06.020

United Nations Development Program (UNDP). 2004. *Reducing disaster risk - a challenge for development*. United Nations Development Programme, New York, New York, USA.

Yohe, G., and R. S. J. Tol. 2002. Indicators for social and economic coping capacity-moving toward a working definition of adaptive capacity. *Global Environmental Change* 12(1):25-40. http://dx.doi.org/10.1016/S0959-3780(01)00026-7

APPENDIX

Cleaning Disaster Data

The original reports sent by the district administrative office are in Nepali and someone at the Ministry of Home affairs entered data in EXCEL in English without any standard list of names which have caused the misspelling. Many names did not match with the official names. The reason could be the use of different names by locals for a certain VDCs. Or the disaster could have occurred in one of the ward of the VDC (out of 9 wards) and the name of the ward might have been used.

The lumping of records (for VDCs) into one might have either happened at the district level (possible reasons: due to Maoist insurgency proper assessment was not done and/or administration was not serious about the data) or could have happened at the Ministry (person who entered might have grouped multiple records into one, this however seems to be unlikely as data for some of the districts are available at the VDC level for the same year). This problem persists in later years of the study period as the data for earlier years are finer. The implication of lumping of multiple records in one and mismatched VDC names is significant. For example, regarding deaths due to flood and landslides, in total, 33% of total deaths could not be allocated to individual VDCs during the 9 years period. For example, in a one year period 2007-2008 (year 2064 Bikram Sambat in Hindu Calendar) 186 (86%) deaths were clustered in 58 (73%) such data points; followed by the year 2008-2009 with 107 (80%) deaths recorded in 41 (41%) data points; in 2001-2002 with 61% deaths in 15% of points, in 2006-2007 32% deaths in 21% data points, and for the rest of the periods, 2 to11% deaths in 8-12% data points.