



## **Climate Change Impacts on Agriculture and Vulnerability as Expected Poverty of Kampong Speu Province, Cambodia**

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**Abstract** As a developing country that is heavily dependent on agriculture, Cambodia has been severely affected by natural hazards. Since the 1990s, there has been an increase in the frequency and severity of flooding and drought induced or exacerbated by climate change. Literature has demonstrated that Cambodia is very vulnerable to the adverse impacts of climate change. Vulnerability, as posited by the Intergovernmental Panel on Climate Change (IPCC), is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity. This paper measures the vulnerability as expected poverty (VEP), introduced by Shubham Chaudhuri, in a province in Cambodia, Kampong Speu (KPS), using household survey data. The results show that among all of the exposures to natural hazards in Cambodia, drought poses the highest risk for rain-fed agriculture dependent households. The VEP shows that more than 60% of households in the KPS province are vulnerable to climate change with an income threshold of US \$1 per day. Some policy recommendations resulting from this study include building irrigation systems to mitigate the impacts of droughts, ensuring secondary income generation opportunities for poor households so that households do not depend exclusively on agriculture, and increasing the education level of villagers.

**Keywords** Cambodia, climate change, vulnerability, adaptation, education

## **INTRODUCTION**

The main sectors that drive Cambodia's economic growth are Agriculture (including Fisheries and Forestry), Industry and Service. Each sector's share of GDP is 28%, 28.6% and 38.3%, respectively (NIS, 2008). The Strategic National Development Plan (SNDP) places the agricultural sector as the central focus of Cambodian development for the next decade, and it is believed that agriculture sector will be a major contributing factor to inclusive growth (CDRI, 2012). The agricultural sector currently employs 59% of Cambodia's total labor force (NIS, 2008).

The industry that generates the most money in Cambodia is Textile, Wearing Apparel and Footwear (CDRI, 2007). However, the garments produced in Cambodia are created from raw materials supplied from outside of Cambodia, including fabrics. The Royal Government of Cambodia (RGC) believes that once the agricultural sector is developed, Cambodia can produce the raw materials (the agro-industrials) to supply to industry, particularly cotton and rubber. Therefore, the growth of agriculture will contribute to the growth of the industrial sector.

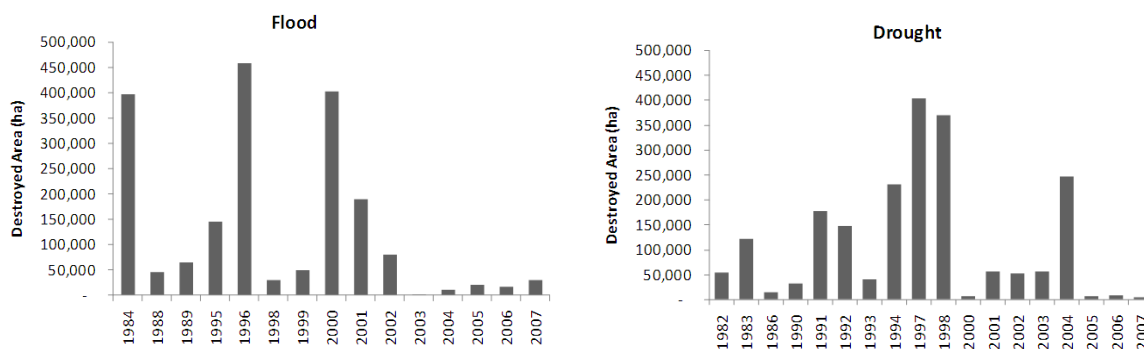
Paddy rice is the central livelihood of rural people. More than 50% of Cambodian workers are employed in the agriculture sector, the majority of whom work in the cultivation and harvesting of paddy rice. Cambodia's 2008 general census (NIS, 2008) showed that more than 80% of Cambodians live in rural area and are engaged in subsistence farming. Approximately 47% of them own less than one hectare of land and have an average of five household members; more than one-fourth of

all households in Cambodia are headed by females (NIS, 2009). The majority of paddy fields are rain fed; therefore, the planting index of rice in Cambodia is around 1.2 per year (MoE, 2005). Cambodia's rice yield is low at around two tons per hectare compared to approximately three tons per hectare in Vietnam and Thailand (Yu and Fan, 2011).

Agricultural activities in Cambodia are not sophisticated and require only low levels of skills and training. Farmers have an average of seven years of education (NIS, 2009). With this level of education, it is hard for agricultural experts to share knowledge and skills about how to use high-tech equipment to improve agricultural practices. Since many farmers are still using traditional methods and tools to cultivate their land, Cambodian farmers are highly sensitive to environmental changes, especially drought.

Frequently, Cambodia experiences floods, drought, windstorms, insect outbreaks, underground water salinisation and seawater intrusion (MoE, 2005). Since the country is heavily dependent on the agriculture sector, these natural hazards have severe effects on the livelihoods of the 80% of Cambodians who live in rural areas (MoE, 2005, NCDM, 2008, Geres-Cambodia, 2009, MoE and UNDP Cambodia, 2011). On a national scale, flood and drought caused crises in three consecutive years from 2000 to 2002. Flooding in 2000 was considered the most severe in four decades and was followed by flooding of a similar intensity in 2001, while in 2002 both flood and drought hit the country (Chan and Sarthi, 2002).

Due to the negative effects of natural calamities caused by climate change on the agricultural industry, achievement of the Millennium Development Goals in Cambodia may be hindered, especially the elimination of poverty and hunger. The United Nations World Food Program (WFP, 2003) identified provinces along the Mekong River as areas prone to flooding and flash flooding, and found that more than 80% of farmers are living in drought-prone areas in Cambodia. This is of great concern as the irrigation scheme is very limited in Cambodia. Assessments from government institutions show that flooding did similar damage to drought (Fig. 1) (MoE, 2006). The Economy and Environment Program for Southeast Asia's (EEPSEA) Framework to Assess Climate Change Vulnerability demonstrated that Cambodia is highly vulnerable to climate change; not because of exposure but because of its low adaptive capacity (Yusuf and Francisco, 2010).



**Fig. 1 Flood and drought damages on rice fields in Cambodia 1982-2007**

*Source: Am, 2010*

Shocks, including natural disasters, are regarded as the driving force that pushes vulnerable people into extreme poverty, especially those who have few assets or savings (World Bank, 2006). A case study by the Analyzing Development Issues (ADI) Team found that the severe floods and drought in Cambodia that occurred in 2000/01 and 2004/05 contributed to crop failure and that people exploited common pool resources (Ang et al., 2007). Droughts have impact when they occur during the three stages of rice production activities: planting (June-July), growing (August-September) and harvesting (October-November) period. At a national level, the National Adaptation Programme of Action (NAPA) has been developed to mitigate the impact of climate change, which includes a proposal for an irrigation scheme and a flood prevention dike (MoE, 2006). NAPA states that the Agriculture and Water resource sectors are the highest priority in both short- and long-term strategies.

This paper investigates the impacts of climate change on farmers in the Kampong Speu (KPS) province, specifically the dynamic impacts on households. It argues that the natural hazards faced by households in this province are the major factors in preventing people from escaping poverty and that integrated policy intervention is necessary to address climate change impacts.

## **METHODOLOGY**

### **Vulnerability framework**

Vulnerability is defined differently in different disciplines. In this study, we adopt the Intergovernmental Panel on Climate Change's (IPCC) definition: "The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" (McCarthy et al., 2001, p. 995).

Exposure to environmental hazards, especially flood and drought, has been well studied in many countries where agriculture is dominant. Methods employed to understand the nature of these climate-induced disasters vary from author to author. Liverman's (1990) study on vulnerability of farmers to drought in Mexico, for example, suggests that using diverse quantitative data makes it possible to identify the places and people who are prone to drought. National Committee for Disaster Management (NCDM) (2003) identified where drought and flooding occurred through examining the affected areas, rice dependency and food security based on rice production in Cambodia.

Vulnerability is conceptualized by many scholars (Adger, 2006, Eriksen and O'Brien, 2007, Smit et al., 1996, Smith et al., 2000, Smit and Wandel, 2006). It can be best understood as an interaction between exposure, sensitivity and adaptive capacity. At any point in time, the greater the exposure (of people, agricultural systems and businesses), the higher the vulnerability. Vulnerability, however, is reduced when the sensitivity of the system(s) is lower. Sensitivity decreases or increases over time due to the adaptation measures taken following the disaster(s). If exposure and sensitivity remain constant from household to household, adaptive capacity of individual households will be highly associated with their vulnerabilities.

This study adopts the approach to measuring household economic vulnerability posited and elaborated in Chaudhuri's (2003) study of household vulnerability. Household vulnerability as expected poverty is defined as the probability that households will move into poverty given certain environmental shocks, current poverty status and household characteristics of respondents. While poverty reflects the current state of deprivation, vulnerability reflects what a household's future prospects are (Elbers and Jan, 2003). Thus, a household's consumption or income can be regressed on household characteristics and shocks in order to obtain the estimated coefficients to be used for further prediction of the household's future poverty. In this regard, households with high predicted poverty are considered vulnerable. Unlike Chaudhuri (2003), who analysed households' monthly per capita consumption expenditure, this study analyses households' monthly income to measure the household vulnerability index due to the lack of expenditure data.

Technically, the household vulnerability index is derived from the difference between the expected log per capita income and the minimum log per capita income threshold, with households having per capita incomes lower than the minimum per capita income defined as vulnerable (poor). The expected log per capita income is estimated using the three-step feasible generalised least squares (FGLS) method.

The predictors of log per capita income used in the analysis include: droughts in the past 12 years (dummy); windstorms in the past 12 years (dummy); floods in the past 12 years (dummy); household size; level of education; possession of motored vehicle (dummy); access to credit (dummy); presence of disabled persons in the households (dummy); and the dependency of livelihood on agriculture (dummy).

## Survey design

The total land area of the KPS province is approximately 653,396 hectares divided into eight districts and 87 communes. The household survey samples were selected from six communes in six districts within two geographical areas: highland areas (two districts) and the lowland area (four districts). Three natural disasters were considered: flash flooding, drought, and windstorms. Areas were defined using Geographical Information Systems, which can be used to produce a Digital Elevation Model. Administrative boundaries were used to define provinces, districts and communes. Natural disaster occurrence was based on information given from key informant interviews from the Sub-national and local authorities. A total of 600 questionnaires were collected from households.

## RESULTS

### Profile of the respondents

Among the six communes we selected, five communes were classified as rural and two communes were located in highland. The majorities of the respondents were female and constituted 60% to 77% of each commune (Table 1). Also, an overwhelming number of respondents reported that they did not rely exclusively on agricultural work. In the rural highland commune of Tasal, the highest number of respondents (13%) identified agriculture as the only source of income. On average, all respondents completed secondary education, and urban dwellers (Chbar Mon commune) have higher education than their rural counterparts. The lowest school attendance was reported in the highland communities of Tasal and Morhasaing.

**Table 1 Sex and occupation of respondents**

Commune	Topography	Number of Respondents	Sex of respondents		Occupation of respondents	
			Female	Male	Agriculture only	Agriculture and others
Chbar Mon	Urban/Lowland	100	65	35	9	91
Kork	Rural/Lowland	100	69	31	7	93
Morhasaing	Rural/Highland	100	73	27	6	94
Peang Lvea	Rural/Lowland	100	61	39	7	93
Rolang Chork	Rural/Lowland	100	65	35	7	93
Tasal	Rural/Highland	100	77	23	13	87
Total number		600	410	190	49	551
Total percentage		100%	68.3%	31.7%	8.2%	91.8%

Source: Survey 2011

### Household Characteristics

There were on average five people within a household within the surveyed areas. This is well above the national average household size (4.7) in 2008 (NIS, 2008). Rolang Chork has the smallest average household size (4.99 people per household on average) and the highest level of education among its population (9.6 years of schooling on average). The Kork and Chbar Mon communes had larger household sizes than the other selected communes (5.64 and 5.59 people per household on average, respectively).

About 60% of respondents reported that their households have at least one motorcycle. There was a large variation in the proportion of households possessing motorcycles between communes, with the Chbar Mon (73%), Peang Lvea (74%) and Rolang Chork (68%) communes having a higher percentage of motorcycle-possessing households than the Tasal (44%), Kork (50%) and Morhasaing (53%) communes. The survey also revealed that 11.7% of respondents live in house-

holds with at least one person with disability. Peang Lvea commune has the highest proportion of households containing a person with a disability (21%), followed by Rolang Chork (13%), Kork (12%), Tasal (11%), Morhasaing (7%) and Chbar Mon (6%).

### Natural hazards and exposure index

The three natural hazards that impact on people's livelihoods in Cambodia including flood, windstorms and drought are investigated in this paper. It is important to note that the indicators of these events are measured as dummy, indicating whether the respondents have experienced drought, flood and windstorm over the last 12 years (1999-2010).

As indicated in Table 2, an overwhelming majority of respondents have reported experiencing drought ranging in the last 12 years. In the rural communities of Morhasaing, Peang Lvea and Tasal, 100 % of the respondents reported experiencing drought. In contrast, the percentages of respondents who have experienced floods or windstorms in those 12 years are significantly lower than those who have experience drought.

Although respondents reported a slight decline in the number of droughts over the 12-year period, they had experienced a number of particularly devastating droughts in 1999, 2000, 2003 and 2004. Villagers from the Pongrek village (Peang Lvea commune, Odung district) stated that the 2010 drought was also a very severe drought which badly affected rice yields.

**Table 2 Households experiencing floods, windstorms or drought in the last 12 years (1999-2010)**

Commune	Urban/ rural	Total number of respondents	% of households		
			Floods	Windstorms	Drought
Chbar Mon	Urban	100	12	5	83
Kork	Rural	100	2	6	99
Morhasaing	Rural	100	9	13	100
Peang Lvea	Rural	100	2	5	100
Rolang Chork	Rural	100	31	12	90
Tasal	Rural	100	4	1	100
Total number		600	60	42	572
Total (%)		100%	10%	7%	95%

Source: Survey 2011

### Vulnerability analysis based on expected poverty

Table 3 presents the results of the FGLS analysis. Among the environmental impacts, only drought was found to have had a significant negative impact on log per capita income ( $b = -0.379$ ,  $p < 0.001$ ). This indicates that households who have experienced drought over the last three years are predicted to have log per capita income 0.379 less than those who have not experienced drought (controlling for other household and individual characteristics in the model). Windstorms and flooding did not have significant impacts on log per capita income.

The windstorms and flash floods that occurred in the period between 2005 and 2010 did not have a significant impact on log per capita income. This may be due to the long period of time over which the occurrences of windstorm and flash flooding were measured in this study. With the exception of drought, the respondents' experience of windstorm and flash floods in the last five years has not changed considerably. It may be difficult to detect environmental impacts that have frequently occur over long periods of time due to people having developed adaptive strategies to mitigate their impacts. Few respondents experienced flash flooding or windstorms in the years prior to completing the survey.

Household size, the possession of motor vehicle and a livelihood dependency on agriculture are significantly and inversely associated with log per capita income. Specifically, the larger the household size, the lower the expected log per capita income (the coefficient is -0.182,  $p < 0.001$ ). In addition, the possession of a motor vehicle is positively related to expected per capita income (the coefficient is 0.312,  $p < 0.001$ ); while households who depend on agricultural work alone tend to have lower per capita income than those households who have an additional secondary occupation (the coefficient is -0.899,  $p < 0.001$ ). In addition, the education attainment of respondents has a positive effect on log per capita income, although the effect is small (the coefficient is 0.044,  $p < 0.001$ ). Access to credit and the presence of person living with disability in the household does not significantly affect log per capita income.

**Table 3 Results of least squares regression analysis of log monthly household per capita income**

	Initial model			FGLS model		
	Coefficient	Standard error	P>t	Coefficient	Standard error	P>t
Drought in past 3 years	-0.143	0.067	0.035	-0.379	0.071	0.000
Windstorm in past 12 years	-0.264	0.133	0.047	-0.199	0.132	0.133
Flashfloods in past 12 years	-0.076	0.113	0.503	-0.137	0.116	0.238
Household size	-0.197	0.017	0.000	-0.182	0.017	0.000
Education	0.047	0.010	0.000	0.044	0.010	0.000
Having motorcycle	0.265	0.071	0.000	0.312	0.072	0.000
Access to credit	-0.091	0.068	0.183	-0.061	0.068	0.375
Presence of person with disability	-0.033	0.105	0.753	-0.026	0.106	0.808
Agriculture plus secondary occupation	-1.103	0.123	0.000	-0.899	0.118	0.000
Constant	3.700	0.138	0.000	3.714	0.139	0.000
<b>Model summary</b>						
Adjusted R-squared		0.339			0.341	
F (9,590)		33.64			33.97	
N		600			600	

Source: Survey 2011

### Household vulnerability

The expected log per capita income obtained from the above FGLS analysis was used to create vulnerability index at a US \$1.00 daily threshold (Cambodia poverty line) and at a US \$1.25 daily threshold. Households are considered vulnerable (or poor in the future) if they score higher than 0.50 on the vulnerability index. Table 4 presents the results of the vulnerability analysis disaggregated by commune.

Given different household characteristics, the overall mean vulnerability is 0.65 using the US\$ 1.00 threshold with some small variation in the mean vulnerability across all six communes (Table 4). The vulnerability incidence is found to be high in highland and low in urban communities. The analysis suggested that contributing factors to vulnerability incidence among households are livelihood (highly depending on agriculture) and low education. In our sample, we found that vulnerability incidence is 70 %. This figure is high compared to the rate generated from general vulnerability assessment in a provincial poverty report (NCDD, 2009).

**Table 4 Vulnerability index and incidence per commune at US \$1.00 daily threshold**

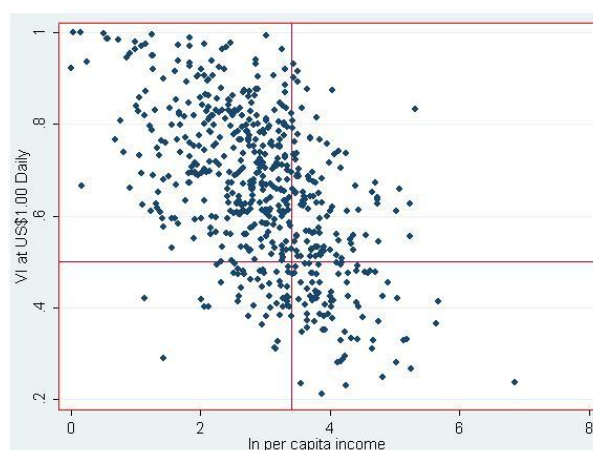
Commune	Mean vulnerability	Standard deviation of vulnerability	Vulnerability incidence (%)	Rank
Chbar Mon	0.63	0.18	73.00	5
Kork	0.68	0.16	82.00	3
Morhasaing	0.64	0.17	76.00	4
Peang Lvea	0.66	0.16	83.00	2
Rolang Chork	0.61	0.17	73.00	5
Tasal	0.70	0.17	85.00	1
Total	0.65	0.17	78.67	

When the threshold is increased to US \$1.25 the mean vulnerability increases to 0.72 and the incidence of vulnerability increases to 90.67% (an increase of 39.5%). This means that with a cut-off point of US \$1.25, more than 90% of these respondents will become poor in the future. The highest percentage of vulnerable households is in Kork (with 98 %), followed by Peang Lvea with 93%, Kork with 92%, Rolang Chork with 89%, Morhasaing with 87% and Chbar Mon with 85%.

Based on the model, it is apparent that poor communes, like Tasal and Kork, as indicated by low percentage of motor vehicle possession, high percentage of villagers depending solely on agriculture and a high percentage of households with a person with a disability, are likely to be vulnerable now and in the future.

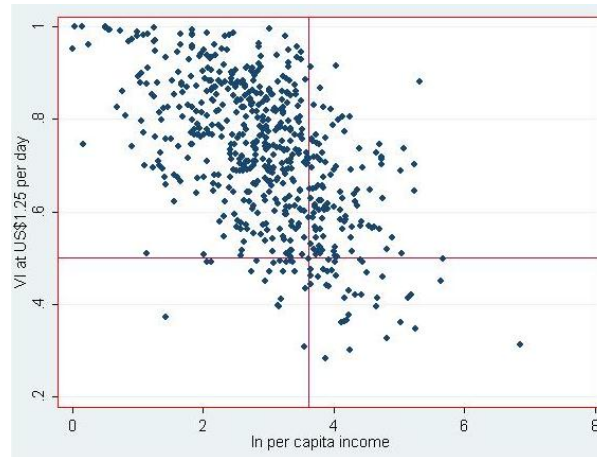
### Vulnerability and per capita income

Each graph below is divided into four sections representing the vulnerability cut-off point and poverty cut-off point at a US \$1.00 threshold in Fig. 2 and at a US \$1.25 threshold in Fig. 3. Dots in the graphs represent the interviewed households. Those households in the upper left quadrant are both currently poor and vulnerable, that is, they are likely to continue to be poor in the future. Those in the lower left quadrant are households that are currently poor but are not vulnerable. Those in the upper right quadrant are households that are currently not poor but vulnerable, meaning that they are likely to be poor in the future. Households that are in the lower right quadrant are neither currently poor nor vulnerable, meaning that they are less likely to be poor in the future.

**Fig. 2 Vulnerability vs log per capita income at US \$1.00 threshold**

Comparing Fig. 2 and Fig. 3, it is evident that increasing the threshold of per capita income from US \$1.00 to US \$1.25 decreases the number of households that are not currently vulnerable and increases the number of households that are vulnerable. This means increasing the per capita

income threshold results in moving more households into future poverty, regardless of their current poverty status. However, the increase in the future incidence of poverty due to an increase in the threshold is more severe among those who are currently poor than among their counterparts who are not currently poor in all communes, with a higher increase in the number of poor and vulnerable in poor communes like Tasal, Rolang Chork and Kork.



**Fig. 3 Vulnerability versus log per capita income at US \$1.25 threshold**

## DISCUSSION

Natural hazards have had multiple impacts on communities in the KPS province. Windstorms had the smallest impact on people, while flashfloods occurred infrequently but caused medium degrees of damage while drought was the most severe and pronounced hazard.

The drought in 2003 decreased rice yields, this means that villagers had inadequate food. Some villagers began eating vines as a substitute for rice. As a result of the impacts of disasters, in every study site commune people migrated to find employment opportunities elsewhere. Among the respondents from the six communes, the percentage of temporary migration is about 30% in Tasal and Kork, about 10% in Morhasaing and Chbar Mon, 20% Rolang Chork, with Peang Lvea having the highest rate of migration at 60%. Many anecdotes were shared in the focus group discussions about children dropping out of school and women bearing health and livelihood burdens due to the impacts of disasters.

Discussions in Kork commune stated that poor families were the most vulnerable to drought in community, especially those with children who consume unclean water, therefore getting sick and incurring an additional cost for their families. During periods of drought some households had the ability to rent pumping machines so they could pump water from nearby sources in order to supply their rice fields with the water necessary for rice production. Others that were short on capital would have to take loans from microcredit institutions and local lenders. For some this resulted in high levels of debt which could not be paid back and hence assets and property were confiscated.

The survey here found that farmers usually undercultivated land and produced low yields (as low as 500 kilograms per hectare during the drought spell). Believing that agricultural adaptation options could increase yield and income as well as food security, farmers have considered many strategies to mitigate drought impacts and increase rice production including changes in crop calendar and crop variety and the increased use of chemical fertilizer. The most urgent adaptation measure in KPS is to provide water for rice fields, especially when there is a prolonged drought during the middle of a wet season. The experts in agriculture of the province highlighted that providing training on modern agricultural methods and small-scale water management are also a priority.

While the model used in this study captures only household characteristics and natural hazards and escaping from disasters are beyond households' capacity and should rest on other stakeholders



such as government agencies, non-governmental organizations (NGOs) and private sectors. Currently, there are a number of stakeholders working to assist farmers such Department of Agriculture but it may not effective in terms of the increasing threats from climate change.

## **CONCLUSION**

Changing climate and climate variability may prevent Cambodia from reaching its development goals, particularly those related to reducing poverty. As indicated by the Ministry of the Environment (MoE), flash flooding and drought are responsible for the reduction in rice production in Cambodia (MoE, 2001, MoE, 2005). At the provincial level, Yusuf and Francisco (2010) indicated that the KPS province is the third most vulnerable province to climate change in the country.

The study aims to identify the impact of environmental shocks (flash floods, windstorms and drought) and household characteristics on per capita income and to create vulnerability indexes to predict future poverty incidence in the communities of the KPS province. Drought is found to be the most common environmental hazard experienced by people in these communities. The study found that, among the three indicators of environmental shocks, only drought resulted in a decrease in the per capita income of households between 2008 and 2010. Drought can be more devastating than either windstorms or flash flood, as it can easily destroy an entire season of crop.

Two of the household characteristics that negatively affected household per capita income are a household size and agricultural dependency. This suggests that households that have many children and do not have other sources of income are likely to be poor and continue to be poor (vulnerable) in the future. In contrast, the education of respondents and households' possession of motor vehicles are positively related to per capita income.

Some policy recommendations resulting from this study include building irrigation systems to mitigate the impacts of droughts, ensuring secondary income generation opportunities for poor households so that they do not depend exclusively on agriculture, and increasing the education level of villagers.

In conclusion, drought is the most severe natural hazard in KPS and farmers reported that they regularly experience a late onset of rainfall. There is a widespread problem of water scarcity and most farmers do not have access to irrigation systems or other technology that can supply water, such as water pumps. Based on the VEP, the study shows that many people are unable to cope with environmental shocks, especially drought. As a result, farmers are not able to fully cultivate their paddy fields and therefore experience reduced crop yields. It is imperative to increase the adaption capacity of farmers who have livelihoods that are highly sensitive to natural hazards. Diversifying livelihoods is also recommended, but it is beyond the scope of this paper. While enhancing adaptive capacity is very critical, there is currently limited intervention from the local government and sub-national government. Whereas NGOs are working to enhance the livelihoods of communities through community risk management, there has only been limited cases of direct resource and knowledge transfers. Farmers have limited access to credit at their locality when they need it most to save their livestock and paddy fields during natural hazards.

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