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Livelihoods of Mountainous Sites in Vietnam and Philippines: Are They Threatened from Cold Spell and Typhoon?

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***Abstract*— The purpose of the study is to develop a new Livelihood Vulnerability Index (LVI) model, which can assess and compare the vulnerability of farming communities to different extreme climate events. The method of constructing LVIs aims at allowing the comparison of livelihood vulnerability to cold spell and typhoon. A survey of 600 farming households from three provinces in Vietnam and Philippines was conducted to determine the level of livelihood vulnerability using sixteen components that measures adaptive capacity, sensitivity and exposure. These components include competency, education, financial condition, livelihood strategy, social networks, socio-demographic profile, housing, water, energy, health, financial status, communication, climate extreme impact, geographic location, risk index and warning system. Results show that although facing different climate extreme events, the livelihood vulnerability of upland farming communities in Vietnam and in the Philippines share a great deal of similarities. In fact, they are moderately vulnerable on aggregate and are similar in competency, livelihood strategy, social networks, water and communication. However, the LVIs indicate that the upland farming communities in the Philippines are slightly more vulnerable than those in Vietnam. Interestingly, food security and financial condition are the key components that the local authorities should focus on to reduce the vulnerability of the communities, regardless of the extreme climate events that could happen.**

***Keywords*— livelihood vulnerability index; extreme climate events; upland farming communities.**

I. INTRODUCTION

Asia-Pacific is the most at-risk area to natural catastrophes and extreme climate events [1]. The region accounted for roughly 45% of the disasters worldwide and 75% of the people affected by natural disasters in 2018 [2]. According to the Long-term Climate Risk Index (CRI), Vietnam and the Philippines were among the top 10 countries most affected by climate risks from 1995 to 2014 [3]. CRI statistics showed that Vietnam suffered from 225 extreme events, including storms, floods, droughts, temperature extremes and mass movements (e.g. heat spells and cold spells). Climate events cost Vietnam 5 percent of its Gross Domestic Product (GDP) in 2010 and this number could increase up to 11 percent by 2030 [4]. Meanwhile, the cost in the Philippines is 6.5 percent of the country's GDP in 2015 [5]. Moreover, intensity, frequency, and prolongation (exposure time) of the extreme climate events are expected to increase due to climate change, concerned as serious threats to livelihood in the two countries.

The Intergovernmental Panel on Climate Change (IPCC) emphasized that risks of extreme climate events are more significant for disadvantaged people and communities in countries at all levels of development [6]. In addition, IPCC found that coastal and mountainous communities are generally the most vulnerability to climate change, especially in developing countries. The main reasons are not only due to the uncertain, sensitivity and vulnerability of the countries' environmental systems but also that livelihoods of the mountainous communities are highly dependent on natural conditions, with low-level technologies. Therefore, the communities' adaptive capacity to climate change in general and extreme climate events could be limited.

Many studies have been drawn to research the vulnerability of poor communities to extreme climate events. However, they have mostly focused on coastal areas and deltas while livelihood in mountainous areas, has been, to a certain extent, overlooked. Mountainous areas are, in fact, homes of many poor communities and ethnic groups. The "unprecedented" cold spells in the north mountainous areas of Vietnam in winter 2016 and winter 2017 and the impacts of typhoon "Nina" in late 2016 and "Urduja" in late 2017 on the mountainous Bicol of the Philippines raised the need for more attention to such areas. The losses were large, thousands of cattle were killed, and thousands of hectares of crops were severely damaged in only a week's time.

In addition, to provide sensible policy suggestions, it is useful to compare the livelihood vulnerability among different areas. As different areas might face different types of extreme climate events, there is a need for a livelihood vulnerability index that can account for the difference but can still give room for reasonable comparison among the areas. Such index has not been found in literature.

This study aims at filling up the gaps by providing a new Livelihood Vulnerability Index (LVI) that can be used to assess and compare the livelihood vulnerability of mountainous communities, which are facing different extreme climate events. two provinces in the northern mountainous region of Vietnam (including Son La and Lao Cai) and one province of the Philippines (Camarines Sur), are chosen for case studies.

The assessment of livelihood vulnerability to climate change refers to the mixture framework of vulnerability to climate change and the sustainable livelihood framework. The IPCC in 2007 proposed climate change impacts, adaptation and vulnerability (CCIAV) approach to assess household adaptive capacity to climate change by collecting the composite indices [7]. This approach included assessments of current and future adaptations to climate variability and change, adaptive capacity, social vulnerability, multiple stresses and adaptation in the context of sustainable development. These composite assessments (also called as IPCC-LVI) were categorized into 3 major components, including exposure to climate variability and change, sensitivity to climate shocks and stresses, and adaptive capacity of communities. After that, based on the same IPCC vulnerability framework, the Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) approaches on IPCC Special Report 2012 considered more "the role of development in trends in exposure and vulnerability", and demonstrated more the interactions between disasters, extreme climate events and development [6].

Hahn et al. in 2009 [8] combined IPCC-LVI framework, which includes three major contributing components to vulnerability – exposure, sensitivity and adaptive capacity, with the Sustainable Livelihood Approach [9] to develop a Livelihood Vulnerability Index (LVI). This method successfully analyzed in depth the factors affecting household livelihood vulnerability in the community of Mozambique. After that, the LVI were adopted to assess livelihood vulnerability of communities in various areas, including Chhekampar VDC, Gorkha District of Nepal [10], the wetland communities in Trinidad and Tobago [11], Northern Ghana [12], Bihar [13] and the Hindu Kush Himalayas region [14]. These studies applied the LVI into some contexts of their research areas by adding to or removing from the previous LVIs. For instance, Shah et al [11] added the components of housing and land tenure into their LVI analysis. However, these reports did not mention the contribution of developmental elements, typically the application of agricultural technologies, smart-climate agricultural model, smart crop systems into the dimensions of LVI. In terms of the agricultural context, the LVI was also adopted in Nepal, the world's fourth most vulnerable country to climate change, by Lamichhane in 2010 [15], The study suggested site-specific development entry points to reduce the vulnerability of small-scale farming to climate change. In addition, Simane, Zaitchik and Ozdogan further applied the LVI to assess the agro-ecological system at the communities of Choke Mountain in Blue Nile Highlands of Ethiopia [16].

Another approach to formulate LVI was suggested by Ognjen et al. in 2017, which mostly relied on secondary data, such as Gross Domestic Product per capital, unemployment rate, road length per square kilometer, slope and soil depth [17]. This approach allowed comparing the vulnerability between different areas. However, it did not account for the local livelihood, which often required primary data.

In Vietnam, the LVI by Hahn et al. was preferably adopted to analyze local vulnerability to different climate risks. They were the context of disasters in Tam Hai Commune in 2012 [18], flooding in the Mekong Delta of Vietnam in 2013 [19], and climate variability in the northwest region of Vietnam [20]. However, the studies did not allow a vulnerability comparison between the communities, mostly due to the different lists of components and indicators, which were designed to fit with the different climate risks.

In the Philippines, LVI has not been used in particularly assessing household livelihood vulnerability at sub-community and community levels in mountainous areas. A vulnerability index may be applied to describe the livelihood of the coastal communities [21]. However, several variables that are not taken into account may further demonstrate the vulnerability of households. Climate change vulnerability was also assessed in disaster-prone in the Philippines but used only three components were employed to assess vulnerability – sources of livelihood, loss and damage, and knowledge and perceptions of people [22]. However, in order to fully understand the components that characterize the livelihood vulnerability of the poor farming communities, a comprehensive approach must be conducted at the local level [23]. Most importantly, there has been no study assessing the livelihood vulnerability of upland farming communities that allows comparison of the vulnerability to different extreme climate events.

II. MATERIAL AND METHOD

A. Some conceptual bases

Firstly, extreme climate events, extreme weather events and climate extremes are interchangeable terms. They are defined as "the occurrence of a value of a weather or climate

variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable' [24]. They include drought, floods, heat waves, cold waves (cold spells) and tropical cyclones (typhoons, hurricanes). It is noteworthy that "character and severity of impacts from climate extremes depend not only on the extremes themselves but also on exposure and vulnerability" [7]. These statements are fundamental to formula the components of Livelihood Vulnerability Index. Secondly, the definition of vulnerability, exposure, sensitivity and adaptive capacity employed in this study are as follows.

Vulnerability is "the degree to which a system is susceptible to, or 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 variation to which a system is exposed, its sensitivity, and its adaptive capacity" [25]. Exposure is "the nature and degree to which a system is exposed to significant climatic variations" [25]. Sensitivity is "the degree to which a system is affected, either adversely or beneficially, by climate related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise)" [25]. Adaptive capacity is "The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" [25].

B. Formulating the LVIs

The formulation of LVI was anchored from 07 LVI components introduced by Hahn et al. [8], which included Socio-Demographic Profile, Livelihood Strategies, Social Networks, Health, Food, Water, and Natural Disasters and Climate Variability. We also adopted the LVI-IPCC to construct the LVI of this study (composite index approach). Accordingly, modifications were made to the list of indicators considering the nature of the livelihood systems of the upland communities and the original definitions of vulnerability, exposure, sensitivity and adaptive capacity by IPCC [25].

The method of constructing LVIs aims at allowing the comparison of livelihood vulnerability to different climate extreme events. Thus, some specific indicators on extreme events, such as a few typhoons in a year, the period of cold spells, etc. are converted to comparable indicators (e.g., damage costs, geographic location and exposure time). Indeed, it is not logical to compare the number of typhoons with the number of cold spells, but it is sensible to compare their damages costs, exposure time or geographic location.

The applicability of the LVI indicators is then further tested and refined after field surveys and consultations. The result is three vulnerability components (including Adaptive capacity, Sensitivity and Exposure) and 18 sub-components (including Competency, Education, Livelihood Strategy, Resource Ownership, Social Networks, Socio-Demographic Profile, Financial condition, Health, Food Insecurity, Housing, Water, Energy, Communication, ECE Impacts, ECE Warning, Geographic Location and Exposure time (Refer to Annex for more details).

C. Research Sites and Sampling

In Vietnam, Dien Bien, Son La, Lao Cai, Yen Bai are among the most disaster-prone mountainous provinces, with highest overall Hazard Potential Index [26]. In terms of extreme cold, the Northern mountainous area experiences roughly 20 - 22 cold spells per year, and the number is increasing, with more frequent occurrences and prolonged in recent years. It is estimated that cold spells are the reason of over ten thousand deaths of livestock each year in the area, mainly cows and water buffaloes. Cold spells are considered the main extreme climate event in the provinces. *In the Philippines*, Camarines Sur of Bicol is also one of the poorest and the most disaster-prone areas. Agriculture in this region is characterized by a myriad of smallholder farmers. In the latest national survey of poverty incidence, almost half of the poor are farmers. Smallholder farmers are largely vulnerable to typhoons. From 2005 to 2016, the average number of typhoons that entered the Philippine area of responsibility was 18.

A total sample size of 600 farming households, consisted of 200 households in each research sites of Son La, Lao Cai and Camarines Sur. Farmers were randomly selected from these communities. The districts/municipalities covered in each site are Thuan Chau district, Mai Sơn district; Van Ho district and Moc Chau district in Son La Province; Simacai District, Sa Pa District and Muong Khuong District in Lao Cai Province; Sipocot, Bula, Garchitorena and Presentacion in Camarines Sur province.

D. Data Collection Procedure

The study employed primary data from farmers surveys to construct the index. Several indicators were used to examine the insights of the vulnerability of the farming community's livelihood. The formulation of index was anchored from seven livelihood vulnerability components introduced by Hahn et al. [8] which includes socio-demographic profile, livelihood strategies, social networks, health, food, water, and natural disasters and climate variability. The LVI-IPCC approach was used to construct the composite index. However, modifications were made to the list of indicators considering the nature of the livelihood systems of the upland communities and the original definitions of vulnerability, exposure, sensitivity and adaptive capacity by IPCC (2001). The method of constructing LVIs aims at allowing the comparison of livelihood vulnerability to different climate extreme events. Thus, some specific indicators on extreme events, such as several typhoons in a year, the period of cold spells, etc. are converted to comparable indicators (e.g., damage costs, geographic location and exposure time). Indeed, it is not logical to compare the number of typhoons with the number of cold spells, but it is sensible to compare their damages costs, exposure time or geographic location.

The applicability of the LVI indicators was further tested and refined after field surveys and consultations. The result is 3 vulnerability components (including Adaptive capacity, Sensitivity and Exposure) and 18 sub-components (including Competency, Education, Livelihood Strategy, Resource Ownership, Social Networks, Socio-Demographic Profile, Financial condition, Health, Food Insecurity, Housing,

Water, Energy, Communication, ECE Impacts, ECE Warning, Geographic Location and Exposure time.

E. Data Analysis

The LVIs were calculated using the composite index approach used by Hahn [8]. Accordingly, the weighting scheme of the indicators and components was also of equal footing. Indicators are standardized to a common scale:

$$Index_{I_p} = \frac{I_p - I_{min}}{I_{max} - I_{min}} \quad (1)$$

where $Index_{I_p}$ is the standardized value for the indicator, I_p is the original value of the indicator for province P, and I_{min} and I_{max} are the minimum and maximum values, respectively, for the data across all provinces.

Once values for each of the 18 sub-components for a site were calculated, they were averaged using the formula below.

$$LVI_P = \frac{\sum_{i=1}^{n} W_{M_i} M_{P_i}}{\sum_{i=1}^{n} W_{M_i}} \quad (2)$$

where LVI_P is the Livelihood Vulnerability Index for province P.

The composite index was calculated using the LVI-IPCC formula considering the components of exposure – *E*, sensitivity – *S* and adaptive capacity – *A*.

The LVI-IPCC of province P is calculated as:

$$LVI - IPCC_P = (E_p - A_p) * S_p \quad (3)$$

The LVI-IPCC is then scaled from -1 (very low vulnerable) to 1 (very highly vulnerable).

TABLE I
LVI AND LVI-IPCC SCORES AND LEVEL OF VULNERABILITY

LVI scores	LVI-IPCC scores	Level of Vulnerability
0 to 0.2	-1 to -0.4	Very Low
0.2 to 0.4	-0.4 to -0.2	Low
0.4 to 0.6	-0.2 to 0.2	Medium
0.6 to 0.8	0.2 to 0.6	High
0.8 to 1	0.6 to 1	Very High

Source: Adapted from Sugiarto, Atmaja, & Wibowo [27]

However, it is noteworthy that very few areas could score to the scale of "very high" vulnerability in Table 2. Even the Mekong River Delta of Vietnam, which is one of the world's three most vulnerable deltas to climate change and flooding [7, 28], only scored up to 0.5 according to Can, Tu, & Hoanh [19]. Thus, the "Medium" in Table 2 implies a considerable vulnerability.

III. RESULT AND DISCUSSION

The first major component of adaptive capacity includes six sub-components as competency, education, livelihood strategy, social networks, socio-demographic profile, and financial condition. In comparison between Son La, Lao Cai and Camarines Sur provinces, respectively, Son La province is the most vulnerability in livelihood strategy (0.498; 0.429; and 0.405), and socio-demographic profile (0.417; 0.030; and 0.224); Lao Cai province is the most vulnerability in competency (0.365; 0.415; and 0.230), and financial condition (0.657; 0.721; and 0.559); Camarines Sur is the most vulnerability in social networks (0.490; 0.390; and 0.529). (Table 2)

In Son La province, although farmers recognize that it is necessary to respond to extreme climate events (the positive attitude indicator is 0.173), but they are not mostly aware of government programs related to extreme climate events and did not actively have an action to respond them (0.589 and 0.333, respectively). Similarly, they are not truly active participating in social activities (0.470). It probably leads to the situation that they are did not receive livelihood assistance from external sources as well as receive warnings of extreme climate events (0.607 and 0.512, respectively). Notably, the average dependent ratio in Son La is 0.735, very higher than that in Lao Cai, as 0.06, and Camarines Sur, as 0.332. The pressure of farmers on daily life can be explained for their inactive attitude on making social networks.

The vulnerability of livelihood strategy in three research areas are similar (Son La is 0.498, and Lao Cai is 0.429, Camarines Sur is 0.405). In there, the average livelihood diversity index in Lao Cai province (0.255) is less vulnerability than Son La and Camarines Sur (0.480 and 0.493). Lao Cai is also the least vulnerable in terms of indicator 10 - cropping cycle per year (0.030, compared to 0.470 (Son La) and 0.635 (Camarines Sur), and indicator 11 - status of landless (0.060, compare to 0.161 (Son La) and 0.175 (Camarines Sur). This implies that the degree of land use in Lao Cai higher than others. An explanation could be the development of tourism in Lao Cai province, which is highest among the three provinces can help reduce the vulnerability of the area.

Camarines Sur is less vulnerable than other two provinces in Average agricultural diversification index (0.296) and Income during the period of extreme climate events (0.435) in comparison with Son La (0.315 and 0.768) and Lao Cai (0.315 and 1.000). Farmers in Camarines Sur do not only rely on one crop but grow other plants or even raise animals to supplement their income. The extra income they obtain from other livelihoods explains a lower source of vulnerability than from the farmers in Son La and Lao Cai. The indicator of attending in training related to both extreme climate events and agricultural/forestry/natural resources in Son La (0.732 and 0.560) and Lao Cai (0.720 and 0.625) is higher vulnerability than that in Camarines Sur (0.515 and 0.285). This implies that Philippines does better than Vietnam in providing the agricultural-related and ECE-related knowledge to local communities. Moreover, Philippines also does good to deliver the agricultural-related knowledge and technique but need to improve in providing the knowledge and technique related to extreme climate events for localities.

Financial condition is very high vulnerability in both of three provinces, of which, highest in Lao Cai (0.721), then

Son La (0.657) and Camarines Sur (0.559). Without saving and ability to borrow for farming activities appeared to be popular in these research areas, especially in Son La province. Camarines Sur has higher vulnerability source than Son La and Lao Cai in the average cash diversification index (0.573; 0.455; and 0,453, respectively). This means that farmers in Son La and Lao Cai have more passive income sources than the farmers in Camarines Sur. But in terms of financial condition, the latter is better off than the former as manifested by their capacity to save (**Figure 2**).

The second major component of sensibility consists of 7 sub-components as health, communication, food security, housing, water, energy, and ECE impacts. Three provinces are low vulnerability in communication and extreme climate events' impacts. Regarding the indicator of ECE impacts, Son La has a higher value of ratio between loss by ECE and income per year (0.336) but a lower value of status of stop farming due to ECE (0.147). This situation is inverted in Lao Cai province (0.143 and 0.340, respectively)

TABLE II
LVI'S INDICATORS AND SUB-COMPONENTS FOR VIETNAM AND PHILIPPINES

No	Indicators	Son La	Lao Cai	Camarines Sur
A	**ADAPTIVE CAPACITY**			
1	**Competency**	**0.365**	**0.415**	**0.231**
	(1) Awareness of government program related to climate extreme events	0.589	0.100	0.294
	(2) Responded actively to the extreme climate events	0.333	0.145	0.299
	(3) Positive outlook/attitude toward extreme climate events	0.173	1.000	0.100
2	**Education**	**0.275**	**0.560**	**0.560**
	(4) Passed primary school	0.275	0.560	0.560
3	**Livelihood strategy**	**0.498**	**0.429**	**0.405**
	(5) Attending training related to extreme climate events	0.732	0.720	0.515
	(6) Attending training related to agriculture/forestry/natural resources	0.560	0.625	0.285
	(7) Average livelihood diversification index	0.480	0.255	0.493
	(8) Average agriculture diversification index	0.315	0.315	0.296
	(9) Income during the period of extreme climate events	0.768	1.000	0.435
	(10) Farming with more than one cropping cycle per year	0.470	0.030	0.635
	(11) Status of landless	0.161	0.060	0.175
4	**Social Networks**	**0.490**	**0.390**	**0.530**
	(12) Being members of a social organization	0.393	0.435	0.551
	(13) Actively participating in community/village activities	0.470	0.315	0.435
	(14) Receiving livelihood assistance from the government or others	0.607	0.420	0.603
5	**Socio-demographic profile**	**0.417**	**0.030**	**0.224**
	(15) Dependency ratio	0.735	0.060	0.332
	(16) Female heads of households	0.100	0.000	0.115
6	**Financial condition**	**0.657**	**0.721**	**0.559**
	(17) Liquid savings (e.g. cash)	0.833	0.910	0.648
	(18) Illiquid savings (e.g. investments)	0.661	0.975	0.665
	(19) Borrowing from external sources	0.679	0.545	0.35
	(20) Average cash diversification index	0.455	0.453	0.573
B	**SENSITIVITY**			
7	**Health**	**0.283**	**0.015**	**0.468**
	(21) Getting illness/injuries due to extreme climate events	0.554	0.000	0.235
	(22) Holding health insurance	0.012	0.030	0.700
8	**Communication**	**0.223**	**0.125**	**0.203**
	(23) Two-way communication means (phones, mobiles)	0.131	0.000	0.275
	(24) One-way communication means (tv, radio)	0.315	0.250	0.130
9	**Food security**	**0.548**	**0.935**	**1**
	(15) Percent of households who are food insecure	0.548	0.935	1
10	**Housing**	**0.077**	**0.090**	**0.575**

	(26) Households with solid shelter	0.077	0.090	0.575
11	**Water**	**0.480**	**0.378**	**0.348**
	(27) Safe drinking water (quality)	0.119	0.315	0.055
	(28) Status of enough drinking water (quantity)	0.637	0.420	0.675
	(29) Status of adequate water for farm production (quantity)	0.685	0.400	0.315
12	**Energy**	**0.345**	**0.375**	**0.503**
	(30) Status of enough energy supply	0.327	0.175	0.175
	(31) Status of shutting-off power due to extreme climate events	0.363	0.575	0.830
13	**ECE Impacts**	**0.242**	**0.242**	**0.271**
	(32) The ratio between loss by extreme climate events and income per year	0.336	0.143	0.290
	(33) Status of stop farming due to extreme climate events	0.147	0.340	0.252
C	**EXPOSURE**			
14	**Warning**	**0.512**	**0.340**	**0.020**
	(34) Receiving warning of extreme climate events	0.512	0.340	0.020
15	**Exposure locations**	**0.770**	**0.939**	**0.694**
	(35) The exposedness of location to extreme climate events	0.770	0.939	0.694
16	**Exposure time**	**0.386**	**0.340**	**0.529**
	(36) The exposedness of time to extreme climate event in the last 3 years	0.386	0.340	0.529

Notes: 0 = least vulnerable

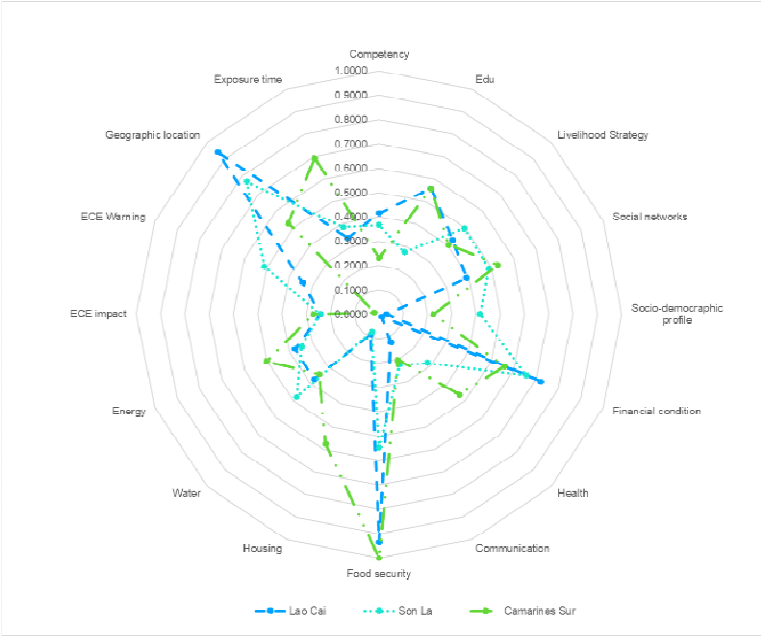
Camarines Sur is very higher vulnerability in health (0.468) and housing (0.575), and a little higher vulnerability in energy (0.503) in comparison with Son La (0.283, 0.077, and 0.345) and Lao Cai (0.015, 0.090, and 0.375). This may be related to different nature of damage of extreme climate events between cold spells and typhoon. Although the Vietnam government provided electric power for almost mountainous areas, to compare with Lao Cai, Son La is worse in power supply (0.327 and 0.175, respectively) but more stable during the operating period (0.363 and 0.575, respectively).

The indicators of water in Son La is more vulnerability than Lao Cai and Camarines Sur (0.480, and 0.378, 0.348, respectively), especially in status of adequate water for both drinking and farming (0.637 and 0.685). Camarines Sur also has a highly vulnerable value in status of enough drinking water (0.675). From the field-trip observation, in Son La, almost households depend on the natural water from a spring flow out from the mountain for each group of people, for daily and for farming. Also, Son La locates in karst topography, the natural water is frequently in shortage, especially in the dry season. Farming households in the mountainous areas in Camarines Sur use the traditional shallow tube wells as drinking water which comes from the spring. The distance to the National Waterworks Sewerage Authority (NAWASA) source points makes it expensive to set up a private drinking water line.

Food security explains the ability of households to have enough food in terms of quantity and quality. The data shows that Camarines Sur and Lao Cai have a very highly vulnerable value of food security (1.000 and 0.935). Although having a lower value (0.548), Son La still stands at moderate degree of vulnerability. It is very common in the 3 provinces that households might have enough food for their needs, but not so healthy and nutritious, or not diverse. For example, some farming households in the mountainous areas of Lao Cai province only rely on corn for their survival in winter or other households in Son La province often use pumpkins or vegetables for their additional food along with rice, even during Tet Holidays (Lunar new year festival) and family parties. The difference of food security indicator between three provinces is due partly to the way to choose the sub-provincial research areas in Son La. The survey was almost equally conducted in multi-level economic status in Son La province. The almost extremely vulnerable value had also been observed in under-economic communes in Son La province.

The third major component of exposing contains three sub-components as warning, exposure locations and exposure time. Both of three provinces has a highly exposure value in the indicators of exposure locations and time, especially in Camarines Sur. However, Son La and Lao Cai is very higher vulnerable than Camarines Sur in the indicator of warning (0.512, 0.340 and 0.020, respectively).

Generally, the LVI results demonstrate that food security and financial condition are the key components that the local authorities should focus on to reduce the vulnerability of the provinces, regardless of the extreme climate events that could happen.



Notes: 0 = least vulnerable

Fig. 2 Vulnerability spider diagram of the major components of the LVI for the 3 research sites

In terms of country-to-country comparison, the up-land farming communities in Vietnam and in the Philippines are intriguingly similar in competency, livelihood strategy, social networks, water and communication (**Figure 3**). This could be explained by the fact that they are having similarity in culture, especially farming culture since both are tropical countries. Camarines Sur may have more livelihood options but is poor in farm diversification. This may be an effect of not knowing too much on farm technologies as manifested by the poor attendance to training on agriculture. In responding to extreme climate events, the Philippines has better warning system, but worse in housing and health (e.g. insurance for upland farming communities). The energy (mostly electricity) in the Philippines is not as good as in Vietnam. The reason might be that there are many islands and isolated farming communities in the Philippines and so it is hard for electricity infrastructure development.

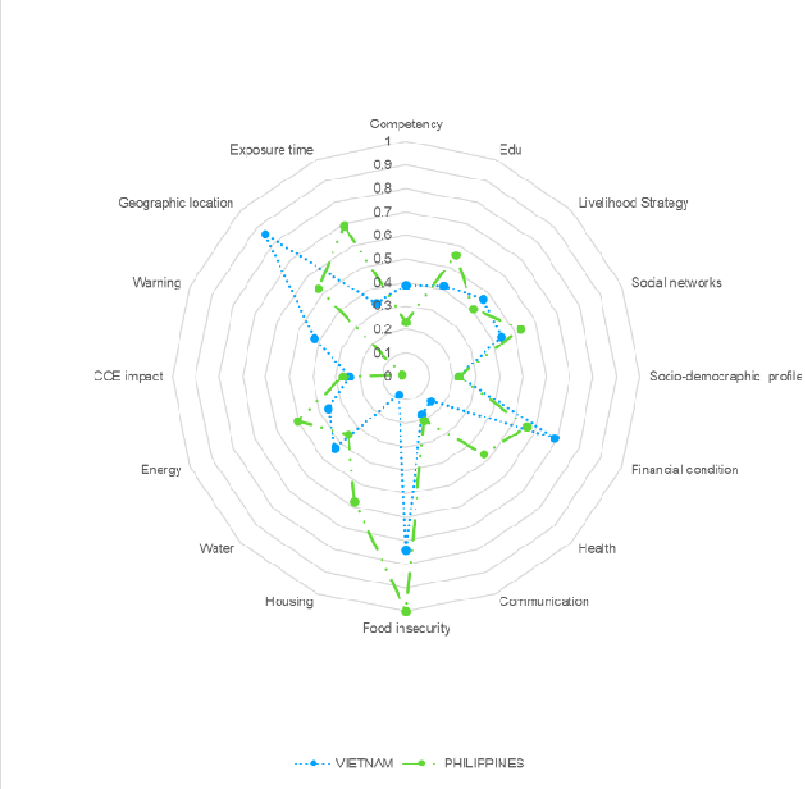


Fig. 3 Vulnerability spider diagram of the major components of the LVI for Vietnam and the Philippines

Table 3 summarizes the LVI and LVI-IPCC scores in 03 research sites. LVI-IPCCs illustrated that the livelihood vulnerability to the local extreme climate event of all 03 provinces are "Medium", which is considerably vulnerable.

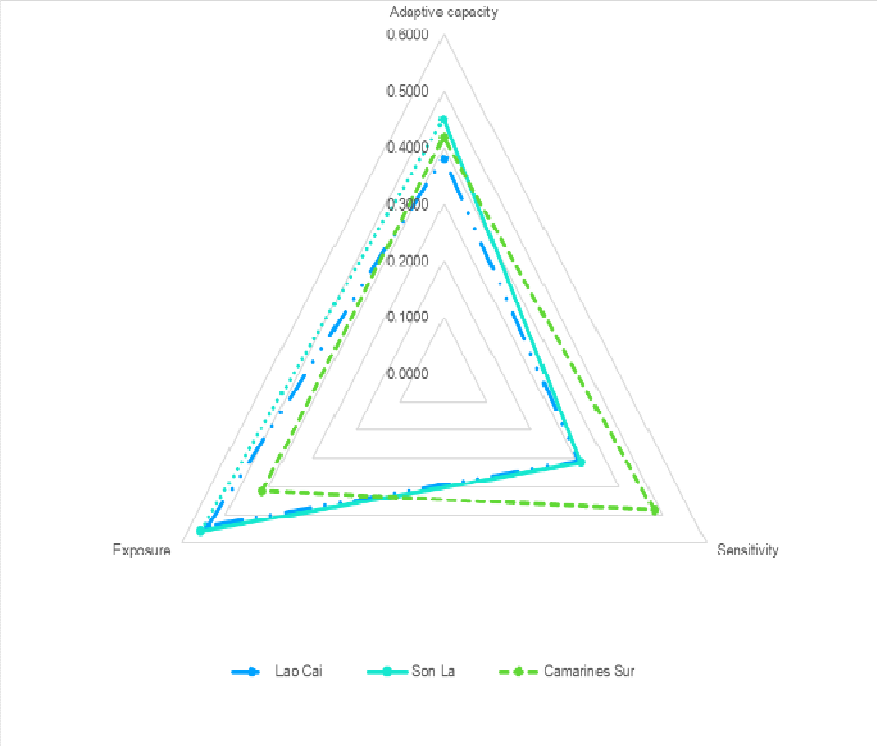
TABLE III
LVI AND LVI-IPCC SCORES OF VIETNAM AND PHILIPPINES

	Lao Cai	**Son La**	**Camarines Sur**
Adaptive capacity	0.3809*	0.4503**	0.4180**
Sensitivity	0.3086*	0.3140*	0.4810**
Exposure	0.5396**	0.5559**	0.4145**
LVI	0.4097**	0.4401**	0.4378**
LVI-IPCC	-0.0245**	0.0020**	-0.0806**

*Notes: * is Low; **is Medium*

The LVI-IPCCs also provide some noticeable insights. As can be seen on **Table 3**, Son La is the most vulnerable province followed by Camarines Sur and Lao Cai. Among the three sites, Son La is the most exposed and also the worst in terms of adaptive capacity. This may be attributed to the ruralness of area and do not have much economic activities (mostly small scale) compared to Lao Cai and Camarines Sur. Lao Cai seem to adopt better with the best in terms of adaptive capacity and the least sensitivity, even it is the high exposure (a little smaller than Son La province) (**Figure 4**).

Meanwhile, the Camarines Sur of the Philippines is one of the least exposure to typhoons but the communities there are often damaged heavily by typhoons (highest sensitivity). Some reasons could be that adaptive capacity of the communities is not high or it is hard to response to typhoons when they occur; lack of resources (e.g. energy, fresh water, etc.).



Notes: 0 = least vulnerable

Fig. 4 Vulnerability triangle diagram of the contributing factors of the LVI–IPCC

The results of the livelihood vulnerability assessments may be integrated to effectively craft adaptation policies in the disaster development plans of the local government units. The practical adaptation measures that may be developed will further increase the climate literacy of upland farmers, thus, improving the livelihood resiliency of the communities. Such impact may trigger the development of climate-smart villages in both countries.

IV. CONCLUSIONS

Vietnam and Philippines encounter different extreme climate events (i.e. cold spells and typhoons) but there are some common issues that make the livelihood of the areas vulnerable. The results showed that in the Philippines, the top source of vulnerability comes from food security component while in Vietnam, exposure location topped the list of components with the highest sources of vulnerability. Overall, food security and financial conditions were found to be among its leading livelihood vulnerability components (Table 2 and Figure 2).

The income generated from farming is not appealing such that they resort to engaging in other forms of livelihood. In the Philippines, particularly, the annual income from upland farming is estimated at 695 USD. Such amount is not even sufficient to feed a household of five. Hence, they turn to trading goods such as putting up a small retail stores in their

villages. Some were into motorbike services and rental businesses while others seek contractual employment.

Son La and Lao Cai experienced greater exposure in terms of location. They are prone to the adverse effects of cold spell because of their elevation higher. Farmers' ownership of mobile phones has somehow helped in minimizing the effects of climate change extremes for both countries. Communication has helped them prepare towards unfavorable circumstances before cold spell and typhoon occurs. Farming communities in Camarines Sur, Philippines have the highest time exposure to typhoons in the last three years but due to an effective warning system employed by the local government, effects were minimized at the farming household level.

Son La and Lao Cai provinces in Vietnam and Camarines Sur in Philippines are exposed to extreme climate events such as cold spells, landslide, flood and flash flood, ice rain, dry spells, or typhoons etc. The detail comparison between two countries shows that Camarines Sur (Philippines) is the lowest exposure but has the highest level of sensitivity. Son La (Vietnam) has the highest level of exposure but has the worst adaptive capacity among the three. Lao Cai (Vietnam) is effectively working in adaptation to extreme climate events with the best adaptive capacity and the smallest degree of sensitivity, even though it is a high degree of exposure. The in-depth comparison of LVI sub-components and LVI's indicators between Son La, Lao Cai and Camarines Sur carries out that enhancing social networks, increasing livelihood diversity, increasing crop cycle for more effective land use and reducing dependent ratio are the essential factors to help households be better adaptive capacity and less exposure. Additionally, the adequate provision of health care system and water supplies help communities less sensitivity. Similarly, the good and update warning system also help communities less exposure. Based on the current condition of socio-economic activities in Lao Cai and Son La provinces (Vietnam) and Camarines Sur (Philippines), the role of the agricultural business' development, mainly related to tourism-developed activities in Lao Cai provinces, can influence on the increase of household's adaptive capacity and reducing of livelihood's exposure and sensitivity. More evidences should be studied in further researches.

Not even policy makers can prevent the occurrence of cold spell and typhoons. Climate extremes have become a part of the farming ecosystem. Hence, to minimize its impact, the ability to consciously adapt should likewise form part of a farmer's livelihood. Diversification is the key to increasing the adaptive capacity and reducing vulnerability. And while financial condition has continuously been impairing the human capacity to adapt to climate extremes impact, strengthening its literacy may find its way of minimizing the adverse effects brought by cold spell and typhoon.

The livelihood vulnerability indicators encompass the five livelihood assets such as natural, physical, social, human and financial. Though the LVI was comprehensive enough to assess the livelihood system of the mountainous sites, the result showed some limitations. Due to the different level and nature of climate extremes between the two countries, it was difficult to exactly identify separately the net impacts of climate extremes occurring simultaneously in the same area. More so, the paper did not discuss about the resiliency problem when cold spells, or typhoon, and other extreme climate events occurred together.

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ANNEX

		Indicators	References	Explanations	Survey questions
Adaptive Capacity	Competency	(1) Awareness of government program related to climate extreme events	Authors	Percentage of households that have at least one family member who knew about the government programs related to extreme climate events. We assume that if they know about these programs, they can be better prepared for adaptation.	Are you aware of any government programs related to extreme climate events?
		(2) Responded actively to the extreme climate events	Authors	Percentage of households that have an activity to respond to extreme climate events. A household with any family member has an action to prepare or adapt to extreme climate events will be counted as actively responding.	How have you responded to extreme climate events?
		(3) Positive outlook/attitude toward extreme climate events	Christensen, R., & Knezek, G. (2015)	Percentage of households that have at least one family member reported that she/he thinks it is necessary to respond to extreme climate events	Do you think it is necessary to respond to extreme climate events?
	Education	(4) Passed primary school	Hahn, 2009	Percentage of households that have at least one family member who qualifies as secondary school or higher education	What is the highest educational attainment of each family member?
	Livelihood strategy	(5) Attending training related to extreme climate events	Siders, 2019 (check again to original author)	Percentage of households that have at least 1 family member who attended a training course/workshop/seminar related to extreme climate events	Have you or any of your family member attended training or seminar related to extreme climate events?
		(6) Attending training related to agriculture/forestry/natural resources	Siders, 2019	Percentage of households that have at least one family member who attended in a training course/workshop/seminar providing knowledge/skills in agriculture/forestry/natural resources	Have you or any of your family member attended training or seminar related to AFNR (agriculture, forestry, and natural resources)?
		(7) Average livelihood diversification index	Marschke, 2006	The inverse of (the number of livelihood activities +1) reported by household. All agricultural livelihood activities are counted as one. E.g. A household that farms, has non-agricultural business will have Livelihood Diversification Index as 1/(2+1) = 0.333	What are your other sources of income aside from farming?
		(8) Average agriculture diversification index	Hahn, 2009	The inverse of (the number of agricultural livelihood activities +1) reported by household. E.g., A household that plants rice, plants peach, raises cattle, raises chicken will have Agricultural Livelihood Diversification Index as 1/(4+1) = 0.2	What kind of agricultural commodities do you plant or raise in your farm
		(9) Income during the period of extreme climate events	Can, 2013	Percentage of households reported that they are without income from any family member during extreme climate events	Do you have any income (or farm produce) during the period of extreme climate events?
		(10) Farming with more than one cropping cycle per year		Percentage of households reported that they are planted more than one crop cycle in the last year. For the long-term plants, each time to provide agricultural products per year will be counted as one crop cycle.	How many cropping cycles do you have in a year?
		(11) Status of landless	Madhur& Bhowmick, 2014, Thorpe, et al, 2007 Shah, 2013	Percentage of households reported that they are without land for farming purposes	Do you own a land?
	Social Networks	(12) Being members of a social organization	Hahn, 2009	Percentage of households that have at least one family member who is a member of the local government or a social organization	Are you a member of any organization in your community?
		(13) Actively participating in community/village activities	Can, 2013	Percentage of households reported that they are actively joined in the community activities in the last 12 months	How often do you actively participate in your community or village activities?

		(14) Receiving livelihood assistance from the government or others	Hahn, 2009	Percentage of households reported that they, or at least 1 family member, received any livelihood assistance (as money, seed, land-rented assistance, etc.) from government or others in the last 12 months	Have you ever received livelihood assistance/help in the past 12 months?
	Socio-demographic profile	(15) Dependency ratio	Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009)	The ratio of the population under 15 and over 65 years of age to the population between 19-64 years old. Because there are a few of households in research areas (including disability)	How many of your household members belong in the following age categories?
		(16) Female heads of households	Hahn, 2009	Percentage of households that head of household is female. The head of household is the family member who recorded as household head in the household registration book.	What is the sex of the head of the household?
	Financial condition	(17) Liquid savings (e.g. cash)	Hahn, 2009	Percentage of households reported that at least 1 family member has liquid savings, e.g. cash	Do you save money?
		(18) Illiquid savings (e.g. investments)	Hahn, 2009	Percentage of households reported that at least 1 family member has illiquid savings, e.g. investments	Do you invest your savings?
		(19) Borrowing from external sources	Hahn, 2009	Percentage of households reported that at least one family member who borrowed money from any formal or informal sources, for example, bank, government assistance programs, friends, neighbors, relatives, etc.	Have you borrowed money in the past 12 months?
		(20) Average cash diversification index		The inverse of (the number of cash-received flows +1) reported by household. All income from livelihood activities are counted as one. E.g., A household receives money from income, pension, interest from the investment will have Cash Diversification Index as 1/(3+1) = 0.25	Aside from your income, do you have money sources from any of these?
Sensitivity	Health	(21) Getting illness/injuries due to extreme climate events	Hahn, 2009	Percentage of households that have at least one family member getting illness/injuries because of extreme climate events in the last 12 months	Have you or your family member ever felt ill or sick in the past 12 months due to extreme climate events?
		(22) Holding health insurance	Hahn, 2009	Percentage of households that have at least one family member who has without health insurance	Do you and your family members have any health insurance?
	Communication	(23) Two-way communication means (phones, mobiles)		Percentage of households reported that they often communicate with others by phones, mobiles, etc.	Do you have a phone/mobile; Television; Radio
		(24) One-way communication means (tv, radio)		Percentage of households reported that they often update news from television, radio, etc.	Do you have a phone/mobile; Television; Radio
	Food security	(25) Food security	Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009)	Percentage of households reported that they worried about the shortage of food or money to buy food in the last 12 month. For a series of questions about food security in the questionnaire, any answer "Yes" for each question will be counted as insecure food situation.	worry that your family may run out of food before you have money to buy again? worry that you may not be able to afford to buy adequate food? wish you could buy more food if you had more money? ır family ever run out of food because you do not have more money to buy food? ır family ever eaten the same type of food for several consecutive days because you do not have enough money to buy different food? ou ever eaten less than you want because you do not have enough money to buy food? our children, according to you, not had enough to eat because you do not have enough money to buy food? have enough money to buy healthy and nutritious food for your children? 9/ Has your body weight

					dropped in the last year because of the lack of food?
	Housing	(26) Households with solid shelter	Shah, 2013 Hahn, 2009	Percentage of households reported that their house has been built popularly by cement, wood and can be totally protected family members from bad impacts of extreme climate events	What type of house do you have?
	Water	(27) Safe drinking water (quality)	Hahn, 2009	Percentage of households reported that they are using safe water to drink daily. The quality of water is assessed from family members' view	Are the sources of your drinking water supply safe to drink? If No, where do you get potable water?
		(28) Status of enough drinking water (quantity)	Hahn, 2009	Percentage of households reported that they did not experience the shortage of water for daily purposes	Are households' drinking water shortage or interruption
		(29) Status of adequate water for farm production (quantity)		Percentage of households reported that they did not experience the shortage of water for farming purposes	What is the level of water for farm production?
	Energy	(30) Status of enough energy supply	Hahn, 2009	Percentage of households reported that they did not experience the shortage of energy supply	Is your power sufficient for your farm and household needs?
		(31) Status of shutting-off power due to extreme climate events	Shah, 2013	Percentage of households reported that they experienced the shutting-off condition of energy supply during extreme climate events	Average duration (days) that no power during extreme climate events?
	CCE Impacts	(32) The ratio between loss by extreme climate events and income per year	Shah, 2013	The ratio between the total cost that household lost due to extreme climate events and their income in the last year	Average income from farm per year How much cost/loss do you incur during the extreme climate events in a year?
		(33) Status of stop farming due to extreme climate events	Authors	The numbers of days that household does not have farming works during the period of extreme climate events happened. This indicator is calculated by standardized formula.	How many days that you have to stop farming during the extreme climate events in a year?
Exposure	Warning	(34) Receiving warning of extreme climate events	Hahn, 2009	Percentage of households reported that they, or any family member, did not receive the warning of extreme climate events from any channel (from local government staff, community radio, neighbors, etc.)	Did you receive any warning before the extreme climate events happened?
	Exposure locations	(35) The exposedness of location to extreme climate events	Authors	The average elevation in research areas. This indicator is calculated by standardized formula, with minimum value is 0. The temperature is lower in the higher elevation, starting from 0 m in comparison with sea level. Cold spells are highly affected by elevation.	Secondary data by using Google Earth
	Exposure time	(36) The exposedness of time to extreme climate event in the last 3 years	Modified from Shah at el., 2013	The ratio between days in last 3 years exposed to the extreme climate events and total days in 3 years. In Vietnam, the average annual temperature is from 22 to 27 ^{0}C degree. Therefore, days exposed to the extreme climate events are defined as days in months with average temperature is under or equal 22 ^{0}C degree.	Secondary data from Hydro-Meteorological Stations