Institut für Lebensmittel - und Ressourcenökonomik

Rural Households' Vulnerability and Strategies to Overcome Flash Floods and Landslides in the Northern Mountainous Regions of Vietnam

Inaugural-Dissertation

zur

Erlangung des Grades

Doktor der Agrawissenschaften

(Dr.agr.)

der

Landwirtschaftlichen Fakultät

der

Rheinischen Friedrich-Wilhelms-Universität Bonn

von

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Bonn 2021

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Tag der mündlichen Prüfung: 21.01.2021

Acknowledgements

I would not have been possible to accomplish this dissertation without the help and support of many kind people around me.

Foremost, I am very grateful to VIED and UNU-EHS for their funding and for covering my study expenses. I am heartily thankful to my supervisors, Prof. Jakob Rhyner and Prof. Matthias Garschagen, for allowing me to carry out my study under their supervision. Their understanding, patient guidance, advice, and intensive argument throughout my Ph.D. period contribute significantly to the success of my work. I would like to express cordial gratitude to Prof. Siegfried Bauer for his follow-up, endless support, and spiritual encouragement during my research work.

I thank all my colleagues at UNU-EHS, especially from VARMAP, EVES, and FAU teams, for their sharing and supports in various ways, not only in Ph.D. work discussions but also in social activities beyond the scientific field. Furthermore, I wish to extend my gratefulness to my fellow Ph.D. researchers at UNU-EHS: Hoai, Sari, Ayu, Tu, Jose, and Gianna for their encouragement and supports. I am also thankful to my wonderful fieldwork assistants (Hao, Chiem, and Hien), interviewees, local officials, and organizations for their help and facilitations during the field surveys in Van Yen district, Yen Bai province.

My special commendations go to Dr. Duy Nong for his kind cooperation. Joining me at the last phase of my research, yet his constant advice and working passion have been invaluable in my publications' success and inspiring me to keep following up with my research career. I am deeply grateful to have the opportunity to work with him.

Keeping the most important to the last, I own my sincerest thanks to my lovely family. Being a mom of two daughters, Minh An and Anh Duong, during my Ph.D. is one of the most remarkable experiences I have been achieved. Thanks to them, my Ph.D. journey becomes meaningful with many unforgettable moments I have ever had. Lastly, my soulmate friend-husband, Trung Tran, without you, I would never have made it.

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1. Introduction

1.1 Research background and problem statement

Vietnam is a long narrow country located in South East Asia, lengthening north latitude from $23^0$23' to $8^0$27' and east longitude from $102^0$08' to $109^0$28'. The country comprises a land region of approximately 331,000 km^2 and a sea area of 1,000,000 km^2 with a coastline of 3,260 kilometers. Fundamentally, the country´s diverse topography, which decreases in attitude from the Northwest to the Southeast, is characterized by low tropical lands, flat deltas, central highlands, and the northern mountainous regions. Making up three-quarter of the country's areas, hills and forests are considered as the main terrains of Vietnam. At an altitude of 3,143 meters above sea level, Fan Si-Fan situated in the Northwest region is the highest peak in Southeast Asia. There are two significant deltas called "rice bowls" lying in the Red River Delta in the North (the Northern Delta) and the Mekong River Delta in the South (the Southern Delta). These two deltas make up nearly one-fourth of the area of the country's territory and are the most populous regions. Connecting these two main deltas is a chain of low-lying, narrow coastal plain stretching from the Ma river basin in Thanh Hoa to Phan Thiet province with a total of 15,000 km^2.

The country is more dependent on natural resources than other middle-income countries in the region and is dominated by the agricultural sector. Agriculture is becoming amongst the most important economic sectors in the country. Over the past two decades, agriculture´s contribution to the GDP has tended to decrease. In 1990, the contribution of agriculture to the GDP was 38%, and agriculture generated employment for 73% of the workforce. By 2015, the contribution of the agriculture sector to the GDP has fallen to 18%, and 44% of the labor force involved in this sector. Natural disasters and climate change are the main drives escalating to the instability and decline of the contribution of the agriculture sector to the economy. For example, in 2016, rice production in the Mekong Delta significantly reduced due to drought and salinity intrusion, causing losses of about 15,000 billion VND (equivalent to $646 million) to the Vietnamese economy. As a result, many farmers had to leave their fields and seek jobs in urban areas.

Land is considered as an indispensable resource of household in agriculture production. However, it is a relatively scarce source in Vietnam. On average, each farmer owns 0.11 hectares that equivalent to one-sixth of the world average (Marsh & Macaulay, 2006). Vietnamese farming is strongly affected by the small size of landholding due to "Doi Moi" (Renovation) reform launched in 1986 with the aim of creating a "socialist-oriented market economy". The goal of this policy is to establish equity in the land tenure regime for each household; on the contrary, it has resulted in land fragmentation and low agricultural productivity. There are approximately 11 million small

household farms and 75 million plots of land for the whole country; thus, on average, each farm had around 7 to 8 parcels of land with average farm size around 0.16 hectares per household (Pham et al., 2007). Consequently, creating sustainable livelihoods and generating opportunities for livelihood improvement for farmers are major challenges that resulted from this issue. Yet, the status of land fragmentation varies from region to region. It is exacerbated by geographic conditions; therefore, in the Northern regions, each household owns averagely from 10 to 20 plots of land while in the South, land fragmentation is not as widespread as in the North. For instance, many households had only one to two parcels of land in the Mekong Delta (Marsh & Macaulay, 2006).

Natural hazards are assumed to be amongst the most significant challenges that a human being is facing nowadays. The country is frequently and severely influenced by a number of natural disasters, such as floods, flash floods, storms, drought, and landslides (IPCC, 2001; Marconi et al., 2011; World Bank, 2011). The annual average temperature has increased about $0{,}26^0$C per decade since the 1970s, while yearly precipitation has changed across regions with a decreasing trend in the Northern but rising tendency in the Southern (MONRE, 2016; Nguyen et al., 2014). According to World Bank (2013), the Central Coastal regions and the Mekong River Delta have the highest level of exposure, while the North-West and Central Highland areas are the most sensitive regions due to the effects of climate change. In addition, it is estimated that over the past two decades, there have been significant losses caused by these natural disasters, including more than 13,000 mortalities (World Bank, 2017) and average annual asset damage in excess of $6.4 billion equivalent to 1.5% of country's GDP (MONRE, 2017; World Bank, 2017). Unfavorable changes in climate directly have a great impact on the progress of economic growth, particularly in the agricultural sector since this sector is strongly exposed as well as subjected to climatic conditions. In such situations, empirical researches have been conducted to investigate the effects of natural disasters on agriculture (Benson, 1997; Châu, 2014; Nguyen, 2008; Nguyen, 2016; Yu et al., 2010b; Zhai & Zhuang, 2009). Agrarian productivity could reduce from 2% to 15% due to climate change (Zhai & Zhuang, 2009). Besides, the mean yield of rice of the Mekong River Delta is estimated to fall by 1.4% – 8.3% by 2030; rice production will be decreased by approximately 2.7 million metric tons annually (Yu et al., 2013). On average, the amount of annual damaged paddy by natural disasters was over 340,000 ha. The most severe damage occurred in 1996, with the loss of nearly 1 million ha of paddy due to severe storms and flooding (World Bank, 2010). Natural disasters obviously have adverse consequences to the agricultural sector, not only damaging crops and agricultural infrastructure but also causing food shortages, subsequently increasing people's sensitivity and vulnerability to natural hazards. Hence, agriculture, one of the major pillars of the rural households´ livelihoods in the country, is acknowledged to be the most affected and

vulnerable sector by natural disasters. However, to what degree natural hazards influence on agricultural production varies among crops, agricultural systems, and regions.

Among the most impoverished regions, the Northern Mountainous Regions are more prone to natural disasters due to its poverty, marginalization and limited access to information, and production means and resources. The regions, furthermore, are home to more than 30 different ethnic groups, comprising over half of the ethnic minority inhabitants in the country. Agriculture is the primary source of household´s income. Around 80% of the household´s income derives from agriculture, forestry, and fishery production activities, whereas only 10% of the revenue comes from waged activities, and less than 3% of the income is from non-farm activities (Do et al., 2013). In addition, most agricultural production is run by the family farming system that is principally based on the family's manual and animal labor, as well as is limited to the application of modern farming techniques (Tran, 2003). With a high dependence on agriculture and natural resources, along with inferior production equipment, any change in weather conditions will profoundly affect productivity and then food security resulting in decreasing the resilience of communities as well as limiting their ability to adapt to natural hazards. Therefore, despite the nationwide remarkable economic growth, the Northern Mountainous Regions is still lagging behind other regions in terms of economic growth and poverty alleviation.

Flash floods and landslides have been considered to be serious natural hazards mainly distributed in the Northern Mountainous Regions. There were numerous flash floods and landslides recorded in the regions (MONRE, 2017). Among the Northern Mountainous Regions, Yen Bai is one of the most influenced provinces to these natural hazards (Table 1.1) since the province had been witnessed an increasing number of these natural disasters during the past years and also strongly depend on agriculture which is the most sensitive sector to impacts of natural hazards (Parry et al., 2007). The province also became unreachable and isolated in the aftermath of such events not only because of its rugged terrain but also due to its poor infrastructure. Such an isolated situation makes people more vulnerable since they had to face multiple problems such as food shortage, lack of healthcare services, and without external assistance. The impacts of flash floods and landslides in the region, of course, are emerging and pressing issues and are expected to be more severe in the rural areas as people residing in these areas are characterized by a low level of education, high poverty rate, inadequate access to infrastructure and technologies, and great dependence on natural resources.

Table 1.1: Ten provinces with the highest risk of landslide.

No.	Province	No. of landslide areas	No. of landslide areas by the scale				
			Small	Medium	Large	Very large	Extra large
1	Bac Kan	700	285	281	123	9	2
2	Ha Giang	967	522	288	145	4	8
3	Lao Cai	534	316	162	53	3	0
4	Son La	1694	795	622	266	11	0
5	Lai Chau	970	337	325	280	18	10
6	Dien Bien	673	335	181	139	12	6
7	Tuyen Quang	248	144	91	11	1	0
8	Thanh Hoa	864	620	178	65	0	0
9	Nghe An	1290	671	420	187	6	6
10	**Yen Bai**	**2326**	**1165**	**580**	**385**	**187**	**9**
	Yen Bai City	42	21	6	8	7	
	Nghia Lo Town	14	7	0	4	2	1
	Luc Yen	240	120	67	30	20	3
	Mu Cang Chai	573	287	171	82	31	2
	Tram Tau	153	77	36	29	11	0
	Tran Yen	100	50	26	20	4	
	Van Chan	298	149	86	47	16	
	Van Yen	**598**	**299**	**150**	**103**	**45**	**1**
	Yen Binh	308	155	38	62	51	2

Source: (MONRE, 2014)

Given that fact, the study of flash flood and landslide impacts on the livelihoods of rural farmers is particularly important. In that respect, a number of recent studies had been taken to understand the effects of natural disasters on agricultural production activities (Ahlheim et al., 2008; Benson, 1997; Châu, 2014; Do et al., 2013; Nguyen, 2016), to assess the vulnerability among rural households (Adger, 1996; CARE, 2013; Duy Can et al., 2013; Few & Tran, 2010; Huynh & Stringer, 2018; McElwee et al., 2010; McElwee et al., 2017; Son, 2013; The Cong et al., 2016; Vo Van, 2014), and to examine factors underlying farmers´ perception and decisions to adapt to natural hazards (Hermann et al., 2018; Hoa Le Dang et al., 2014; McElwee et al., 2010; McKinley et al., 2016; Pham, 2011; Tran et al., 2015). Yet, quite all these studies mainly concentrate on the two Deltas (Red River Delta and Mekong River Delta) and the central region, along with natural

disasters such as flood, salinity intrusion, sea-level rise, drought, or climate change in general. In contrast, in the context of Vietnam, the Northern Mountainous Regions which are heavily susceptible to flash floods and landslides have not yet attracted the attention of researchers. Hence, there is a high demand for research that explores particularly how vulnerable of indigenous people in rural areas, as well as how they perceive and respond to flash floods and landslides. Against this background, the study of *"Rural households' vulnerability and strategies to overcome flash floods and landslides of rural households in the Northern mountainous regions of Vietnam"* is conducted with the expectation to fill a fundamental knowledge gap and to add further information and insights in the existing literature in explaining the impacts of these natural hazards on rural households' vulnerability, their cognitive process, and their decision-making behaviors. Thus, the findings of the present study will be useful for designing appropriate policy practices in order to enhance farmers' capacity and resilience toward future natural disasters not only in Vietnam but also in other countries having similar economic, social and geographical contexts.

1.2 Research objectives

The general objective of this study is to gain a comprehensive picture of the rural households' livelihoods, to explore the vulnerability level of farm households, and to investigate major factors driving to their perception and adaptation processes regarding flash floods and landslides in the Northern Mountainous Regions of Vietnam.

The overall objective is divided into the following four sub-objectives:

- To figure out the households' resources/households' socio-economic characteristics;

- To explore rural households' livelihoods and to disclose the factors affecting their vulnerability to flash floods and landslides;

- To draw out to what extent local people have been affected by flash floods and landslides; as well as to examine main determinants underlying how rural farmers perceive changes on such natural hazards;

- To pinpoint how farmers had been adapted to flash floods and landslides and to expose impediments during the adaptive implementation process, and in addition, to evaluate key drivers impacting farmer´s adaptation responses to flash floods and landslides.

1.3 Research hypotheses

The research hypotheses are as follows:

- Local households in the surveyed areas are severely prone to flash floods and landslides.

- The farmers' vulnerability level by negative impacts of flash floods and landslides differs between the research areas.

- Farmers are aware of changes in flash floods and landslides. Socio-economic characteristics of households influence their perceptions of these natural disasters.

- Farmers have been applying multiple measures to adapt to flash floods and landslides. These adaptation strategies are changes in cropping patterns, crop diversification, altering crop varieties, land use changes, and crop management and protection methods (soil and plant).

- Farmer´s perception of flash floods and landslides, the literacy, ethnicity of households´ head, farm income, market availability are the main determinants impacting on adaptation strategy preference of farmers to flash floods and landslides.

1.4 Organization of the study

The study is organized into seven chapters. Chapter 1 presents the research background and problem statement, research objectives, and research hypotheses. Chapter 2 provides the empirical results drawn on primary data from the field study. It includes information on five main capitals of the surveyed households: Human capital, social capital, natural capital, financial capital, and physical capital. In chapter 3, the household´s vulnerability under the impacts of flash floods and landslides is analyzed. This chapter was published on the journal *Climate Risk Management* as a peer-review paper entitled *"Vulnerability Assessment of Households to Flash Floods and Landslides in the Poor Upland Regions of Vietnam".* Chapter 4 explores the impacts of flash floods and landslides and analyses the main drivers of the perceptions of local households to these natural disasters. This chapter was published to the journal *Science of the Total Environment* as a peer-review paper entitled *"Natural Hazard´s Effect and Farmers´ Perception: Perspectives from Flash Floods and Landslides in Remotely Mountainous Regions of Vietnam".* Chapter 5 addresses the question of how farmers have been responded to flash floods and landslides and challenges for controlling the adverse impacts of such natural hazards. This chapter was published on the journal *Journal of Environmental Management* as a peer-review article entitled *"Farmers´ Decisions to Adapt to Flash Floods and Landslides in the Northern Mountainous Regions of Vietnam"*. Chapter 6 provides a general conclusion drawn from the previous chapters and some recommendations for policymakers and future researchers. Finally, a summary of the research is presented in both English and German in chapter 7.

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2. Descriptive statistics of households' characteristics

This chapter provides the main findings of the field survey conducted from February to April 2016 in An Binh, An Thinh, and Dai Son communes, Van Yen district, Yen Bai province. The findings are prescribed in different five types of both tangible and intangible capitals, including human capital, social capital, physical capital, financial capital, and natural capital.

2.1 Human capital

2.1.1 Household head´s features

- Gender

The household's head has a crucial role in the decision making of any family, especially in the rural area, as he/she often takes responsibility for the household activities. Most of the interviewed households are headed by men (about 90% of respondents). Women only become head of household if they are widowed or divorced. It is illustrated by the survey results that 28 widowed and three divorced women are household heads in a total of 38 female-headed households. This also explains why the number of female-headed households accounts for a tiny proportion in three surveyed communes.

Table 2.1: Gender of the household's head.

Gender	An Binh		An Thinh		Dai Son	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Male	134	87.01	96	91.43	137	93.84
Female	20	12.99	9	8.57	9	6.16

Source: Field survey, 2016

- Age

The respondents range in age from 22 to 88 years old. On average, the age of the household's heads in the research sites is 45.94 (± 10.83) years old for men and 54.37 (± 13.62) for women. Most of the women are heads of households when their husbands pass away. As a result, female-headed households are usually older than male-headed households. Furthermore, the result from Wilcoxon Mann-Whitney test indicated that age of household head is significantly different among each commune at different levels (P = 0.08; P = 0.00 and P = 0.05 at An Binh, Anh Thinh, and Dai Son, correspondingly) and in the whole area at P = 0.00.

Table 2.2: Average age of respondents.

Study areas	Gender	Mean (years)	Std. Deviation	Z	Sig.
An Binh	Male	46.84	10.27	-1.775	0.0759
	Female	51.85	13.26		
An Thinh	Male	47.34	9.93	-3.116	0.0018
	Female	63	14.86		
Dai Son	Male	44.08	11.74	-1.958	0.0502
	Female	51.33	10.45		
The whole area	Male	45.94	10.83	-3.714	0.0002
	Female	54.37	13.62		

Source: Field survey, 2016

(P-value according to Wilcoxon Mann-Whitney test)

- Level of education

The head of the household is often responsible for making decisions in the household activities. Education level, thus, is one of the most critical criteria to access the awareness of the household head as well as to understand the decision in choosing livelihood strategies in production activities in each family. Hence, the higher education background, the broader knowledge and information can be achieved.

Table 2.3 presents the education level of household head in research areas. Overall, the education level of the respondents is comparatively low. A large number of household heads did not participate in primary school, accounting for nearly 50% in both An Binh and Dai Son communes. Remarkably, there are approximately 30% of illiterate household heads in An Binh. The proportion of household heads completing primary, secondary, and high school education is relatively evenly among those communes. However, An Thinh has the highest percentage of household heads attending secondary school (almost 40%). In the whole sample, there are only two respondents (making up 0.49% of total surveyed households) in Dai Son attaining a university education. The illiteracy rate is most commonly observed in Khe Trang, Khe Mang, and Khe Rong villages, An Binh commune. Especially in Khe Rong, the majority of interviewed households had to use their fingerprint to sign the questionnaire.

Table 2.3: Education level of household's head.

	An Binh		An Thinh		Dai Son	
	Frequency	%	Frequency	%	Frequency	%
Unlettered	46	29.87	11	10.48	20	13.70
Know how to read, write	28	18.18	18	17.14	46	31.51
Primary school	38	24.68	30	28.57	37	25.34
Secondary school	28	18.18	41	39.05	29	19.86
High school	13	8.44	5	4.76	11	7.53
Higher	1	0.65	0	0	3	2.05

Source: Field survey, 2016

- Ethnicity

Vietnam has 54 ethnic groups, in which the majority is Kinh people who live mainly in the plains, near rivers, and in urban areas; on the other hand, most ethnic minority groups occupy in the Midlands and the mountainous regions (McElwee et al., 2010). Compare to the Vietnamese majority (Kinh people), ethnic minority groups are more reliant on staple goods and traditional agriculture; furthermore, they are also less diversified and do not make adequate investments in agriculture (World Bank, 2009a). It is noteworthy that ethnic characteristic has a significant influence on the customs and production methods of each household.

The interviewed households consist of four different ethnic groups, including Kinh, Dao (Black Dao and White Dao), Tay, and Hoa. It can be seen from Table 2.4 that ethnic minority groups make up a larger proportion of the whole study area. These ethnic minority groups are characterized by not only relatively low income but also deficient education levels, limited access to the health care facility and necessary infrastructure, which hinder the ability of minorities to interact with others and take advantage of outside resources. Among these minority groups, Tay people are considerably better-off than others and experience living standards relatively close to Kinh people (Do et al., 2013). Most of the respondents in Dai Son are Dao people (80% of the surveyed households), while the majority of interviewed households in An Thinh are Kinh people (61.90% of surveyed households). The ratio between Kinh (48.05% households) and ethnic minority people (51.95% households) is more balanced in An Binh than in An Thinh and Dai Son.

Table 2.4: Farmer's ethnicity (% of all respondents in each commune).

Ethnicity	An Binh (%)	An Thinh (%)	Dai Son (%)
Kinh	48.05	61.90	6.85
Dao	46.10	22.86	80.14
Tay	4.55	15.24	13.01
Hoa (Others)	1.30	0	0

Source: Field survey, 2016

- Experience in agricultural activity

Agricultural experience is determined by the period that the household head started working in agriculture. The respondents in An Thinh have more experience than those in 2 other communes. On average, the household heads have 27.01 (± 11.84) years of experience in agriculture. Moreover, there are statistically significant differences in average years of experience in agriculture among three communes ($P = 0.0283 < 0.05$).

Table 2.5: Average number of years of experience in agriculture.

	Mean (years)	Std. Deviation
An Binh (N = 154)	24.94	11.27
An Thinh (N = 105)	28.89	11.55
Dai Son (N = 146)	27.19	12.69
Average	27.01	11.84

Source: Field survey, 2016

2.1.2 Household structure and household labor force

The family includes all members of a family who share a common kitchen, all members who contribute to family income, and all who use benefit continuously from the family income. The family structure has a significant role in the livelihood of farmers in the areas because it can show the availability of labor for farm and non-farm activities in the family. The maximum number of members of a household is nine persons, while the minimum family size is only one person. On average, the family size is 4.29 people. Dai Son has the largest household size, 4.38 persons/household compare to 4.28 persons/household in An Binh and 4.18 persons/household in An Thinh. However, there are no significant differences among the three communes in terms of household size ($P = 0.49$). The adult group includes both men and women who are more than 15

and less than 65 years of age and are the labor source in the family. It is obvious from Table 2.6 that this group is the main element in households, 3.03/4.29 persons on average. In which, the number of men is slightly higher than that of women, 1.57 persons and 1.47 persons/family, respectively. Children are those whose age is less than or equal 15 years old, while elders are those who are more than or equal 65 years old. Both children and elders are considered as dependent members in households. The number of elders is much lower than that of children, 0.20 person/household compare to 1.05 persons/household. In addition, while number of adults, men, children and elders are not statistically different among 3 communes (P = 0.75, P = 0.18, P = 0.34 and P = 0.73, respectively), there is significant different in number of women in 3 communes at P = 0.06.

Table 2.6: Household structure (means, standard deviations and P-value for differences).

Characteristics (Person/household)	An Binh (N = 154)	An Thinh (N = 105)	Dai Son (N = 146)	Average	Sig.
Household size	4.28 (1.32*)	4.18 (1.38)	4.38 (1.32)	4.29 (1.33)	0.4908
Adults	3.08 (1.27)	2.96 (1.18)	3.04 (1.20)	3.03 (1.22)	0.7519
Men	1.64 (0.90)	1.60 (0.91)	1.47 (0.68)	1.57 (0.83)	0.1809
Women	1.44 (0.71)	1.36 (0.62)	1.58 (0.82)	1.47 (0.74)	0.0641
Children	0.98 (0.94)	1.05 (1.09)	1.14 (0.89)	1.06 (0.96)	0.3361
Elder	0.22 (0.51)	0.17 (0.45)	0.20 (0.49)	0.20 (0.49)	0.7284

Source: Field survey, 2016

(*): Numbers within parentheses are the standard deviation.

P-value according to one-way ANOVA analysis

2.2 Social capital

2.2.1 Organization membership

In each commune, there are some organizations that farmers can participate in to achieve information in different aspects such as production activities, irrigation, credit, extension services, and updated social and economic policies. These organizations are also considered as a bridge for people to share their experience in production activities and express difficulties they struggle in their life, through which people may able to find a way to support each other.

More than half of respondents join in at least one organization in their community. While the majority of household heads in An Binh and Dai Son are not members of any organization, An

Thinh, on the contrary, has the highest rate of participation in commune's groups (65.09%). Youth´s Union, Farmer´s Union, Women´s Union, and Religious Group are key organizations farmers participated in.

Table 2.7: Participation of respondents in organizations.

	An Binh (%)	An Thinh (%)	Dai Son (%)	Average (%)
Not a member of any organization	50.65	34.91	55.86	47.14
A member of at least one organization	49.35	65.09	44.14	52.86

Source: Field survey, 2016

2.2.2 Contact with extension official

The number of extension staff in each commune depends on whether the commune is an upland commune or a low-land commune. There is one extension official in an upland commune, while one extension staff has to take responsibility for two low-land communes. The connection between farmers and extension staffs in the research areas has not been closely linked, proving by the visiting frequency of extension officials to households in the last 12 months. Only 23.51% of respondents reported that local extension staffs came to their house to disseminate/transfer information related to agricultural production; on the contrary, a considerable proportion of households did not receive any information from extension officials in the last year (76.49%).

Table 2.8: Visiting frequency of extension officials to households.

	An Binh		An Thinh		Dai Son		Average
	Frequency	%	Frequency	%	Frequency	%	%
No visit	103	66.88	88	83.81	115	78.77	76.49
Visit at least one time	51	33.12	17	16.19	31	21.23	23.51

Source: Field survey, 2016

2.2.3 Social networks

Good social relationships are positive factors influencing the recovering ability of each family when they suffer difficulties in their life, especially for rural households due to their great reliance on agricultural production. While 80.74% of respondents are ready and willing to support others when their neighbors have troubles, only 67.41% of them get aids during difficult times. There are several kinds of support recorded in the surveyed areas, for example, labor support, money lending,

spiritual encouragement, and rice and seed supply. The proportion of households who did not obtain help from others is relatively high (around 33% of respondents on average). Among the three communes, Dai Son has the highest percentage of respondents (30.87%) who did not provide their supports to other households.

Table 2.9: Connection between respondents and others during difficult times.

	Receive helps		Don't receive help		Give help		Don't give help	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
An Binh	103	66.88	51	33.12	131	85.06	23	14.94
An Thinh	73	69.52	32	30.48	93	88.57	12	11.43
Dai Son	97	66.44	49	33.56	103	69.13	43	30.87
Total	273	67.41	132	32.59	327	80.74	78	19.23

Source: Field survey, 2016

2.3 Natural capital

2.3.1 Crop production

- Cropping pattern and farming calendar

Rice and maize are two major crops commonly grown in the research areas. These crops are mainly produced for home consumption. There are three seasons of crop per year: the first season is Chiem rice or Winter-Spring (from January to between of May), the second season is Mua rice or Summer-Autumn (from between of May to September), and the third season is maize (from October to December). In which, Chiem rice and Mua rice are the two main crops cultivated in low-lands by all households, and maize is the additional crop that local authorities encourage farmers to grow to increase the household´s income. Maize grows both on slopes and low-lands. In addition, the cultivation of rice and maize depends significantly on the availability of accessing water for irrigation – an indicator of the quality of the land. Land with no access to the irrigation system or with an inappropriate irrigation scheme is only able to cultivate one crop per year. Hence, production is significantly reliant on the timing of rains (CARE, 2013). In contrast with rice and maize, cassava is typically grown on hilly land, mostly seen in An Binh and Dai Son commune. Cassava is cultivated in February and gathered in December. Cassava and maize are main feed sources for livestock and commercial purpose. Cassava is normally rotated with other forestry trees: 1 cycle of forestry trees (from 5 to 8 years) followed by 2-3 cycles of cassava (from 2 to 3 years). Cassava is grown either as a mono-crop or as an intercrop in young forest plantations. However, because of the fluctuation of market price and degradation of soil, around ten years up to now, instead of planting cassava, cinnamon has become a staple tree in these communes. In

2014, the price of 1 kg cinnamon leaf was 4.000VND/kg, almost double than the price in 2010 (2.100VND/kg), while the price of cassava is precarious. Notably, in 2015 many households did not harvest cassava; they still kept it in their hilly land. Because they calculated that the expense to hire labor for harvesting and to rent a car for transportation would be higher than the selling price they can earn. One of the critical advantages of growing cinnamon is its economic efficiency since farmers can use or sell almost all parts, from the bark to the timber, branches, and leaves. Of which, cinnamon bark is the primary product and generates approximately 70% of the total income from the cinnamon crop. Cinnamon is harvested two times a year: in March and in August (according to Lunar calendar).

Table 2.10: Seasonal calendar of key crops in research areas.

Crops	No of season	1	2	3	4	5	6	7	8	9	10	11	12
Paddy rice	2												
Maize	1												
Cassava	1												

Source: Field survey, 2016

Of 405 sample households, nearly 89% of respondents grow rice in their field, following by maize and cassava (61.48% and 54.57% respectively). Approximately 95% of surveyed farmers in An Thinh grow maize. Cassava is cultivated the most in An Binh (85.06%) and the least in An Thinh (27.62%), while the portion of grown rice is almost equal in An Thinh and Dai Son (around 95%). Farmers in the research zones usually grow cassava on their small plots of hillsides or in poor soil plots, where only a few crops can be cultivated because cassava can grow well despite low rainfall, poor soil fertility.

Table 2.11: Major crops in research sites.

	Rice	Maize	Cassava
An Binh (N=154)	121 (78.57%)	88 (57.14%)	131 (85.06%)
An Thinh (N=105)	100 (95.24%)	99 (94.29%)	29 (27.62%)
Dai Son (N=146)	139 (95.21%)	62 (42.47%)	61 (41.78%)
	360 (88.89%)	**249 (61.48%)**	**221 (54.57%)**

Source: Field survey, 2016

2.3.2 Land use

Land is considered as a foremost asset of the households, especially for those who rely on agriculture as the main source of income. Land helps people to fulfill and satisfy basic demands on food and shelter. It, furthermore, will determine the household capacity in agricultural production activities. In the places where the soil is degraded, the livelihood of people is considerably influenced. For example, due to reduced soil fertility, the output of cinnamon, rice, and cassava in recent years is substantially decreased. Farm size, moreover, has decreased and fragmented overtime in low income or developing countries due to the increase in the population (Lowder et al., 2016). That issue will then affect the efficiency of resource allocation and productivity (Chayanov, 1996) and is one of the major obstacles that hinder the application of new technology to increase production efficiency. The average landholding size is 62,35 Sao per household, and the biggest farms are found in Dai Son commune (about 88 Sao/household). There are two common kinds of land use in the research sites: agricultural land and hilly land. The statistical results indicated that hilly land accounts for a large proportion of the total land area of the households and are less fragmented than agricultural land. Fragmentation of land, caused by rapid population growth and scarcity of land, is the main constraint in land management and mechanization in these regions. Yet, on average, the distance from the house to hilly land (2,01 km) is much further than this to agricultural land (1,22 km). In terms of land quality, the results from focus group discussions and the household survey indicated that land degradation is putting more stress on local farmers. The lands located in the foothill and valley bottom are usually more fertile than those on the top.

Table 2.12: Land structure in the research areas.

	An Binh		An Thinh		Dai Son	
	Mean	Std.D	Mean	Std.D	Mean	Std.D
- Farm size (Sao/household)	61.47	52.24	37.92	41.75	87.65	92.34
- Agricultural land:	3.32	3.41	3.76	2.17	3.22	1.84
+ Number of plots	4.63	5.14	3.75	2.37	4.81	3.44
+ Average distance to the house	1.70	2.62	1.31	1.37	0.65	0.69
- Hilly land:	58.15	51.49	34.16	41.43	84.43	91.70
+ Number of plots	1.72	1.29	1.23	0.76	3.18	2.40
+ Average distance to the house	1.98	2.34	2.12	2.83	2.07	4.20

Source: Field survey, 2016

1 Sao = 360 m2

2.3.3 Property rights on land

- Access to land

Table 2.13: Land accessing of respondents.

Commune	How did your household acquire this land?						Total
	Given by state/commune	Inherited from parent	Purchased	Cleared and occupied	Rented or borrowed	Others	
An Binh	86	108	75	150	24	2	445
An Thinh	102	116	31	55	9	0	313
Dai Son	192	160	32	42	2	4	432
Total	380 (31.93%)	384 (32.27%)	138 (11.60%)	247 (20.76%)	35 (2.94%)	6 (0.5%)	1190

Source: Field survey, 2016

Of the total land using by households (including residential land), most of the lands are acquired through inheritance from their parents or are given by State/Commune, 32.27%, and 31.93%, respectively (in 1993 the Government implemented a policy called “giving farmland for the farmer”, then each household was received 1.3 acres of farmland per person). In addition, households getting lands through the process of land reclamation also account for a significant proportion (around 21%).

- Rights to land (Red book)

In Vietnam, in order to prove the land ownership, the landowner must have a land certificate called Red Book. About 72.5% of the land of surveyed households have the Red Book, while the number of lands without Red Book makes up 27.5%, mainly concentrated on An Binh Commune, especially in Khe Mang and Doc Do group, Khe Trang village. The main reason for this issue is that previously, these land areas belong to Yen Bai forestry farms; since 1995, people themselves came and built houses without permission from the local government. Presently, they have to submit required documents to relevant authorities in sequence from commune to district and province. Based on that, the province committee will make a decision whether they will abolish the ownership of the forestry farms and issue a Red Book for households. Yet, local households are either afraid of doing it or already do it but have not obtained the certificate because of its complicated process. The other reason, as aforementioned, is due to land fragmentation situation. Most of the surveyed households own many separate plots; however, the Red Book is issued for the total holdings, not for individual plots. Consequently, most farmers have no land certificate for the plots inherited from parents.

2.3.4 Irrigation

Since 2009, the Vietnamese government has issued/launched the Decree 15 with the aim to exempt all farmers in Van Yen district from irrigation fee, helping people reduce from 3% to 10% of the total agricultural production costs. Yet, the irrigation scheme is not available for all land areas. The government only invested canal systems for either plots/fields of cooperative or private plots/fields in concentrated areas. Irrigation canals are typically constructed by concrete with the size 0.25m x 0.3m. The water sources of irrigation canals are from streams and watersheds.

The surveyed results indicated that only 3.1% of agricultural land is not irrigated, however, in 96.9% irrigated farming land, the portion of the field did not have sufficient water accounting for 36.8%, mostly happened in An Thinh commune (52.38% in 405 sample households responded the amount of irrigation water was not sufficient for their fields). The source of irrigation water that households used for their plots is primarily from the canal system, making up 57.74% of total irrigated lands. However, not all fields of the respondents in the region have access to irrigation canals. It is because most of those fields were reclaimed by local people, and they are fragmented; thus, the State did not build the canal system. As a result, 24.17% of farmers in the study zone often exploit natural water sources from groundwater, rivers, rainfall, lakes to water their fields.

2.4 Financial capital

2.4.1 Access to credit

In the study areas, there are two kinds of loan sources, including formal and informal sectors. The formal sector comprises of major banks: Social Policy Bank, Agriculture and Rural Development Bank, and People´s Credit Funds, while the informal sector includes shops (especially agriculture input shops), money lenders, friends, and relatives (Ministry of Agriculture and Rural Development, 2016). The preference for choosing whether formal or informal credit sources entirely depend on the farmer´s interest and financial capacity. For example, while households who have more assets prefer to have loans from formal sources, low-income/poor families naturally prefer to get credits from informal organizations. It is due to the fact that formal credit often requires collateral properties, which the poor are often less able to own. Besides, World Bank (2009a) pointed out that access to credit and financial services is not even in ethnic minority areas. On average, Kinh people reported more loans and bigger bank loans than minorities, whereas more ethnic minorities reported a need for credit.

Regarding access to credit, there are many obstacles reported by local farmers in the study areas. Fundamentally, interviewed households borrow money from a social bank in their commune to take advantages in terms of the interest rate and the loan term, following local authorities' policy.

However, approximately 52% of total households stated that they do not have any impediments in accessing credit. In contrast, a proportion of 36.11% of the respondents stated their concerns on the subject matter because of some reasons, for example, (1) limited and modest loan amount, (2) complicated applying procedures, (3) required collateral, (4) high-interest rate, (5) obligatory poor household. The remaining respondents have no demand for loans; hence, they are not able to give their opinion on whether access to credit is adequate or not. Currently, there are two main packages of loans from the local policy bank: (i) 8 million VND with interest rate almost 0% in 5 years: Farmers often use a small amount of the loan in cultivation, a small part in husbandry, and the rest in home improvement. In fact, this amount of loan is not sufficient for poor households to certainly invest in production; (ii) 30 million VND with interest rate 0.65% per year in 3 years: Although farmers can borrow with a more considerable amount of money, there are only few households dare to borrow. The reason is that they do not know what to do and how to use the loan effectively.

Table 2.14: Difficulty in accessing to credit.

Has your family had difficulty in accessing to credit?	An Binh (N=154)		An Thinh (N=105)		Dai Son (N=146)		Average
	Frequency	%	Frequency	%	Frequency	%	%
Don't know	14	9.09	15	14.29	18	12.33	11.90
Difficult	67	43.51	40	38.10	39	26.71	36.11
No difficult	73	47.40	50	47.62	89	60.96	51.99

Source: Field survey, 2016

2.4.2 Households' savings

Together with access to credit, savings also play a vital role in managing both agricultural production activity and farmer´s daily life. The ability to save money is mostly determined by how farmers are able to organize and manage the income, from both farm and non-farm activities, and their expenses. However, saving among respondents in the research areas has not frequently observed due to their low-income levels. Only 7.16% of interviewed households have savings, in which An Thinh has the lowest proportion. Farmers commonly deposit their savings into the social bank, keep savings in cash, gold, or lend to other households.

Table 2.15: Different types of household savings in the research areas.

Households savings	An Binh (N=154)		An Thinh (N=105)		Dai Son (N=146)		Average
	Frequency	%	Frequency	%	Frequency	%	%
Social bank	6	3.9	1	0.95	5	3.42	2.96
Cash, gold	1	0.65	2	1.9	3	2.05	1.48
Lending	5	3.25	2	1.9	1	0.68	1.98
Others	2	1.3	1	0.95	0	0	0.74

Source: Field survey, 2016

2.4.3 Households' durable goods

Households´durable goods reflect the wealth level of a household. In addition, farmers are able to sell or mortgage these assets to get liquid cash in order to meet the family´s basic demand during challenging times. The main durable goods of households in the research areas include (1) television (93,5% of surveyed households), (2) mobile phone (96.3% of surveyed households), (3) fridge (58% of surveyed households), (4) motorbike (88.15% of surveyed households). Some of the other durable assets, such as tractors, vehicles, and agricultural equipment, are owned by very few households (12,84%, 3,70%, and 4,11%, respectively).

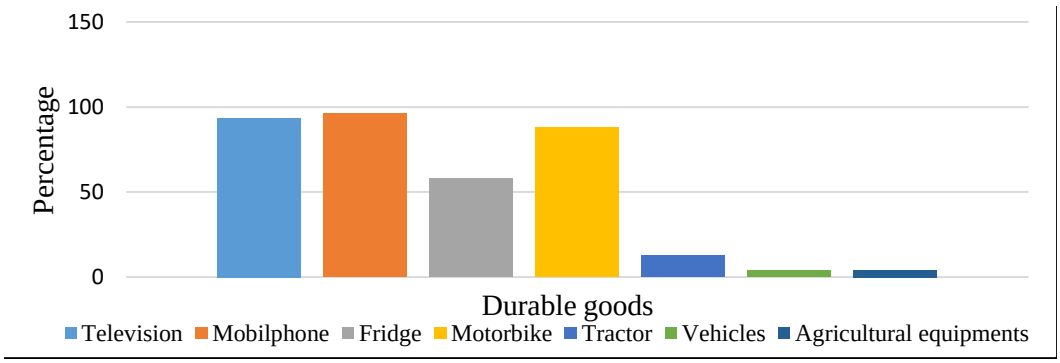

Fig. 2.1: Ownership of households´ durable goods.

Source: Field survey, 2016

2.4.4 Livestock production

Livestock is considered as amongst the most essential mobile assets of rural households. It not only provides food needs but also can be quickly sold/exchanged when households need money to pay for their other daily demands.

About 90.62% of the respondents raise cattle (cow, sheep, and buffalo), pig, and poultry (chicken). However, most of the farmers just raise the livestock with a small-scale, mainly serve for family

demand. It is presented through the average ownership rate per household of each livestock: 0.16 cow/household, 0.75 buffalo/household, 0.2 sheep/household, 3.58 pigs/household, and 31.36 chickens/household. It is important to point out some foremost reasons why the households did not feed livestock, for example, pig or chicken, with a large scale. The first is that crop yields in recent years have been significantly decreased. Thus, if farmers want to raise more livestock, they have to purchase feed from outsiders. As a result, they will have to face one more problem - budget constraints. The second but very important is that local people do not have knowledge of animal husbandry, so when livestock have diseases, they do not know how to treat, leading to a series of cattle died and causing substantial economic losses in households. The combination of free grazing and man-herded grazing is the most common practice of raising cattle in these communes. Free-grazing is often applied in crop-free cultivated lands and forest lands. Yet, waste from animal husbandry has not been treated, thus causing pollution-related problems to the environment, water resources, and climate (Pham et al., 2015).

Currently, Yen Bai province has some policies to support farmers raising livestock; for instance: the province funded 35 million VND for a household or a Unit if they raise buffalo and cow with the size of 10 or more in 2 years in 2014 and 2015. During this time, Yen Bai province already disbursed for 20 households with total funding 700 million VND (approximately 30,000 Euros).

2.4.5 Family income

Family income consisting of farm and non-farm income is considered as the main criteria to access the success of family in terms of economic. Table 2.16 shows that family income is different across the three communes. Of which, farm income has a greater share of family income compared to the non-farm income. It is due to the fact that the livelihoods of almost households in the study regions are greatly associated with the agricultural field; thus, income from farm activities will contribute as the main source of family income. It is noted that farm income is calculated by subtracting the farm revenues and farm expenses. Non-farm income, in contrast, is derived from non-farm activities such as commune officials, employers in private companies, traders, field workers, and building workers.

Table 2.16: Farm and non-farm income in the research areas.

	An Binh	An Thinh	Dai Son
Farm income	43,42 (±39,43)	58,32 (±81,95)	67,39 (±106,07)
Nonfarm income	27,50 (±38,17)	43,80 (±41,97)	36,53 (±43,23)
Family income	70,92 (±56,09)	102,12 (±92,22)	103,92 (±109,29)

Source: Field survey, 2016

Numbers within parentheses are the standard deviation.

2.5 Physical capital

2.5.1 Source of energy and access to information

In the whole research areas, there are only few households that are not able to access electricity (0,99% of respondents). About 0,5% of households used oil as fuel for lighting, while the remaining respondents used electricity for this purpose. Firewood is the main fuel source used by households for cooking (accounting for 94% of households). Firewood can be considered as dirty fuel due to its high emissions leading to respiratory and heart diseases, lung cancer, and eye irritations. Furthermore, with a large proportion of households consumption firewood, it not only places more pressure on the natural resource but also puts more stress on labor-intensive work due to carrying wood from hills or forests to their houses. Beside firewood and electricity, gas is also used by few households for cooking (making up 6% of respondents).

Nowadays, the internet has become one of the most indispensable channels providing information for people all around the world. Among 405 interviewed households, while 99% of sample households can access to electricity, only 2,72% of them have the internet at home. This figure is meager compared to the proportion of the population using the internet in Vietnam by 2015 (52% of the population). Therefore, this is considered as a significant barrier for local farmers in receiving updated information and knowledge.

2.5.2 Source of water

Table 2.17 displays the source of drinking water used by households in the study areas. It is noted that there are no clean water schemes for people in the surveyed regions. There are two principal sources of water, including water from creeks and water from wells. In which, a significant proportion of respondents obtain water from creeks (making up 69,14% on average). Households usually build their own water tanks, and water from the ravines will be directed to these tanks through small water pipes. In the rainy season, these water pipes are often congested by rock and soil from the top of the hills or mountains. Subsequently, water shortage for daily needs becomes an inevitable problem for local people. Besides, around 32% of the respondents used water from wells, and only 1% of them used water from the river, streams, ponds, or lakes. It is important to point out that households did not apply any treatment methods for all these water sources before using them. From such a fact, local people are more exposed to water-borne diseases such as cholera, diarrhea, and measles.

Table 2.17: Source of water used by sample households.

Sources	An Binh (N=154)		An Thinh (N=105)		Dai Son (N=146)		Average
	Frequency	%	Frequency	%	Frequency	%	%
Water from creek	111	72.08	41	39.05	128	87.67	69.14
Wells	38	24.68	63	60.00	18	12.33	32.34
River, stream, pond or lake	3	1.95	1	0.95	0	0	0.99

Source: Field survey, 2016

2.5.3 Housing and sanitation

In the household´s physical capital, housing is recognized as one of the most critical physical assets of households since it provides accommodation for people. The average housing area of the surveyed households is 74.92 m^2. There are many different types of materials used to construct houses. In this study, based on the primary materials of walls, floors, and roofs, housing is divided into two types: solid and unsolid (or precarious) house. The survey results pointed out that major construction materials for building houses are brick and wood, whereas cement, marble tiles, and tiles are the most used ingredients for making floors. Straws and leaves, and cement panels are used by almost 37% and 29% of the surveyed families for constructing roofs, correspondingly.

Table 2.18: Materials used by sample households for building the house.

Types of walls, floors, and roofs	Frequency	Percent
Types of walls		
Leaves/branches/bamboo	23	5,68
Wood	173	42,72
Earth	1	0,25
Galvanized iron	52	12,84
Fired brick, stone	138	34,07
Concrete	13	3,21
Others	5	1,23
Types of floors		
Bamboo	10	2,47
Wood	10	2,47
Earth, lime, and ash	30	7,41
Cement	244	60,25
Marble, tile	111	27,41

Types of roofs		
Straw and leaves	149	36,79
Wood	2	0,49
Panels	119	29,38
Galvanized iron	51	12,59
Tile	38	9,38
Concrete, cement	46	11,36

Source: Field survey, 2016

In this research, the type of toilet in each household is a standard to evaluate sanitation facilities. Approximately 11% of households have no toilet facility, 10% of them use toilet directly over the water, and 79% of the remaining respondents have flush toilets with septic tanks or sewage pipes. It is the fact that households with moderately good economic life often build sanitary schemes while low-income families often have temporary hygienic schemes or nothing (Centre for Sustainable Rural Development, 2010).

Table 2.19: Sanitation facilities in research areas.

Type of toilets	Frequency	Percent (%)
No toilet	44	10,86
Toilet directly over the water	41	10,12
Flush toilet with septic tanks/sewage pipes	320	79,01

Source: Field survey, 2016

2.5.4 Infrastructure

Sufficient access to infrastructure is one of the favorable factors to help people in rural areas lifting out of poverty and isolation circumstances. To date, out of 180 communes and wards in the province, 160 communes have road access to centers, 88 communes have telephone connections, all communes have clinic centers, and 55% of the households in the province have electricity. The region is characterized by a complex topography with steep slopes and rough terrains. Also, road systems are in poor-quality conditions, especially for the inter-village roads. Thus, in the rainy season or in the time being of flood floods and landslides, many villages are unable to contact and disconnected to people outside of the village, and vice versa.

Table 2.20 displays the distance from the house to some nearest places such as all-weather road, People´s Committee, commune health care station, hospital, primary school, junior high school,

high school, and commune market. The nearer the distance, the more convenient and accessible to the household.

Table 2.20: Infrastructure in the study regions.

Distance from house to the nearest (kilometer)		Standard deviation
a. All-weather road	1,25	1,41
b. People´s Committee	2,70	1,77
c. Commune health care station	2,75	1,83
d. Hospital	8,88	5,64
e. Primary school	2,36	1,49
f. Junior high school	3,21	1,92
g. High school	4,93	3,39
h. Commune market	3,74	2,68

Source: Field survey, 2016

2.6 Summary

The household characteristics are described in five major capitals: Human capital, natural capital, physical capital, social capital, and financial capital. Most of the households are headed by men (95%) with an average age of almost 46-year-old. The education level in the whole research area was found very low, with a majority of respondents are unlettered (18%). Approximately 62% of interviewers belong to ethnic minority groups such as Dao, Tay, and Hoa. The incapability to read, write, or even speak Vietnamese is a stumbling block preventing ethnic minorities from being integrated into the economy and taking benefits of the new opportunities or new policies. For example, Son (2013) and World Bank (2009a) stated that Kinh people have raised their concerns in diversifying practices within the agricultural sector, such as relying more on industrial and perennial crops, and have often supplemented their farm income with trading or services. While ethnic minority groups tend to be locked into staple and traditional agriculture, less diversified, and much lower rates of agricultural investment. The average family size is 4,29 persons per household, with 3,03 of them in working age. Furthermore, the average experience in agriculture of the household heads is about 27 years.

Over 50% of respondents participate in at least one organization such as Youth Union, Women Union, Farmer Union. However, a large number of farmers (almost 77%) did not have contact

with extension officials. Approximately 81% of households interviewed are willing to help others, while only 67% of respondents get aids during difficult times.

Rice, maize, and cassava are the principal crops in the research areas. The interviewees are smallholder farmers with 62,5 Sao per household on average. Two common types of land are agricultural land and hilly land. It is indicated that the distance from the house to agricultural land (1,22km) is closer than to hilly land (2,01km). 36,8% of agricultural land was found to have problems in accessing to irrigation water. Most of the lands are acquired through heritage from parents or are given by State. About 27,5% of respondents did not have a land certificate.

About 36% of the respondents stated that they are facing difficulties in accessing credit, while only 7% of total interviewees have savings. Livestock such as pig, chicken, cow, and sheep are raised with small-scale, mainly serve for family demand. Most households have access to electricity (99%), but most of them still consume firewood as a leading source of cooking and even heating in the winter. In addition, only about 3% of respondents have the internet at home. Noticeably, about 69% of interviewees are using water from creeks without any treatment process, and 62% of them are living in precarious houses with the average housing area is 74,92 m2. The survey also revealed that people´s access to the hospital is limited because of the long distance.

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3. Vulnerability Assessment of Households to Flash Floods and Landslides in the Poor Upland Regions of Vietnam

Originally published as: NTT Pham, D Nong, AR Sathyan, M Garschagen, 2020. Vulnerability assessment of households to flash floods and landslides in the poor upland regions of Vietnam. Climate. Risk. Manag. https://doi.org/10.1016/j.crm.2020.100215.

Abstract

Increased frequency and intensity of flash floods and landslides in the Northern Mountainous Regions of Vietnam represent the most damaging hazards to the production activities and livelihoods of rural households, which are heavily reliant on agriculture. Assessing households' vulnerability therefore becomes critical and urgent to help policy-makers in Vietnam in facilitating the implementation of adaptation strategies for households living in this area. Thus, this paper employed the Household Vulnerability Index method along with the qualitative data analysis to evaluate the vulnerability level of smallholder farmers under the effect of these hazards. Data was collected from 405 households in three communes of Yen Bai province, one of the poorest provinces in the Northern Mountainous Regions of Vietnam with a high proportion of ethnic minorities who have extremely low incomes and education levels. Food and fresh water quality and security are also relatively low in this region. The empirical results indicate that ethnicity, diversified sources of income, organizational membership, health insurance, food security, land tenure documentation, water resources, and locational dimensions are the key factors affecting the vulnerability of farmers under the impacts of flash floods and landslides. Results also suggest that the livelihoods of farmers in the Dai Son commune are the most vulnerable to these natural hazards identified by the Social Network, Socio-Demographic Profile, and Water component factors. We subsequently identify and prioritize measures to ensure sustainable livelihoods for local farmers through practices, such as improving people´s literacy, enhancing production systems, and strengthening natural resource management strategies.

Keywords: Vulnerability; Flash Floods and Landslides; Livelihood vulnerability index; Yen Bai province; North Mountain; Vietnam.

3.1 Introduction

Natural hazards are considered to be one of the major drivers causing the recent increases in global prevalence of undernourishment and food insecurity, particularly in developing countries since farmers´ livelihoods are more exposed and vulnerable to climate-driven disasters (FAO et al., 2018). In addition, it is acknowledged that natural hazard-induced disasters heighten the livelihood vulnerability of smallholder farmers while reducing households´ capacity to resist risks, shocks,

and stresses. Although climate-induced change is considered to be a global problem, its impact level is different for each region, as well as for each specific system, family, and community. Consequently, the vulnerability of each object is not identical (Adger et al., 2004). From such a fact, there are numerous scholars suggesting that assessing vulnerability to climate variabilities should be localized (Below et al., 2012; Deressa et al., 2009). Understanding the livelihood vulnerability of rural households, therefore, has been found as an urgent need in order to develop adaptation strategies and have proper solutions/policies in reducing climate-associated risks and improving households´ resilience, especially in countries that rely heavily on agriculture.

Studying one of the most prone agricultural countries in the Asia Pacific region to natural hazards like Vietnam (IPCC, 2014; Marconi et al., 2011; World Bank, 2017) is therefore highly important given limited studies on this issue in the country and particular sub-national regions. It is estimated that over the past two decades, these natural hazards have caused significant losses in Vietnam, including more than 13,000 mortalities (World Bank, 2017) and average annual asset damage in excess of $6.4 billion that is equivalent to 1.5% of GDP (MONRE, 2017; World Bank, 2017). Of these, more than 80% of the country´s population is exposed to risks from the direct impacts of natural disasters (FAO, 2012). In particular, around 59% of the country´s total land area and approximately 71% of the total population are frequently affected by typhoons and floods (World Bank, 2017). This is because annually around six to ten typhoons and tropical depressions generated in the Western North Pacific Ocean hit Vietnam's coastline, resulting in heavy rains and floods over large areas, particularly in the northern and central parts of the country. Also, these typhoons often result in flash floods and landslides (FF&LS) in the mountainous regions of the country.

In this regard, FF&LS have been considered serious natural disasters[*] in the Northern Mountainous Regions (NMR) of Vietnam (Table 1), which substantially affect production levels and daily activities (FAO, 2012; Socialist Republic of Vietnam, 2012). More importantly, households in this area have relatively low income and the infrastructure is not well developed. As a result, it would take a long time and more financial resources to recover from the effects resulted from these natural disasters. The provinces such as Lao Cai, Ha Giang, Yen Bai, and Son La are among the most frequently affected provinces by FF&LS, of which Yen Bai, located along the Red River, has the highest number of landslide events in the NMR (MONRE, 2014).

[*] There were numerous FF&LS recorded in the mountainous areas of the country (MONRE, 2017). According to the Socialist Republic of Vietnam (2012), these events resulted in more than 880 dead and almost 1,500 injured people. They also destroyed more than 6,000 houses out of 120,000 flooded houses and flooded around 132,000 hectares of rice and crops. It is noted that flash floods and landslides are two events that usually take place simultaneously in the research area, this study therefore bases on an assumption that these two disasters are a single event strongly affecting household´s livelihood (Pham et al., 2019).

Table 3.1: Common hazards and vulnerability levels in the NMR.

Disasters	The vulnerability levels by geographical regions	
	Northwest Mountainous Region	Northeast Mountainous Region
Storms	+	+++
Flood	++++	++++
Flash flood and landslide	++++	++++
Whirlwind	++++	++++
Drought	+++	+++
Inundation	-	-
Forest fire	++++	++++
Earth quake	+++	+++
Failure of water reservoir	+++	+++

Source: FAO (2012) and MONRE (2017).

Note: ++++: Very severe; +++: Severe; ++: Medium; +: Light; -: None

Yen Bai, located between the Northeast and Northwest (see Fig. 1), is more prone to these natural hazards not only because of the increasing number of FF&LS during the past years but also due to its heavy reliance on agriculture and natural resources which are the most sensitive sectors to climate change-induced impacts (Parry et al., 2007). Furthermore, Yen Bai is one of the top ten poorest provinces characterized by a high percentage of ethnic minorities; who are especially vulnerable to natural hazards due to their limited access to areas that are fit for safe and healthy habitation and profitable livelihood opportunities (Adger, 2003; Parry et al., 2007). Particularly, as reported by the Ministry of Natural Resources and Environment in 2018, there were 15 natural disasters occurred in Yen Bai, killing 21 people, missing 1 person, injuring 25 people, damaging 5,800 houses, and affecting nearly 4,500 ha of rice and vegetable fields, along with having road, irrigation systems, and schools extremely damaged[†]. Besides, economic losses caused by natural disasters are estimated to be over 1,000 billion VND (around $476 million), while annual per capita income in this area is about 1.4 million VND (around $54). In 2005, for example, this province experienced five noticeable FF&LS events, which resulted in soil erosion of 75,000 m^3 and a loss of seasonal paddy and vegetable growing areas totaling 2,607 ha. Noticeably, one flash flood swept away and damaged 181 houses, while 57 other houses were entirely destroyed. In

[†] http://dwrm.gov.vn/index.php?language=vi&nv=news&op=Hoat-dong-cua-dia-phuong/Yen-Bai-Huong-ung-Tuan-le-Quoc-gia-ve-phong-chong-thien-tai-8125

addition, 50 people died in the flash flood. Recently, the province had been witnessed three continuous events of FF&LS in 2017 that results in 32 deaths and injuries, 50 houses washed away.

Although the region and communities are highly exposed to frequent and intense FF&LS, studies on the vulnerability of the region to these natural hazards are scarce. Previous studies on the vulnerability of rural households to climate variability were only conducted at farm level in different regions in Vietnam (Duy Can et al., 2013; Huynh & Stringer, 2018). These studies, as with most other natural hazard-related studies, just explore the factors influencing farmers´ vulnerability in the context of climate change in general, and mainly focus on the two Deltas (Red River Delta and Mekong River Delta) and the Central Region. Given the fact that the economic, infrastructure, population density, and natural environments are significantly different between regions in Vietnam, the impact of a particular natural hazard on the NMR is highly different from the impact in other parts of the country. In addition, this area is home to multiple minor ethnic groups with extremely low incomes and poor healthcare and fresh water services. They also often experience substantial food shortage and low food quality due to natural hazards. Furthermore, this is a highly hilly remote area with poor infrastructure, which causes significant transportation difficulties to nearby cities or centrals of main towns for shopping, attending schools, and seeking assistance or services, such as healthcare services. For these reasons, a study that focuses on the NMR is particularly important. This is because findings associated with this region would explicitly help policymakers develop appropriate strategies to support households and minor ethnic communities in the region to reduce poverty and to ensure sustainable development. In addition, as most previous studies examined general natural hazards, there is a high demand for research that focuses particularly on the most pressing hazards in the region, i.e., FF&LS. This is also the motivation and main objective of this present study which aims to explore the livelihoods of local people and disclose the factors affecting rural household vulnerability to FF&LS by developing and applying the Livelihood Vulnerability Index (LVI), with a case study in Yen Bai province. This study also makes major contributions to the literature, as the findings are replicable for assessing the vulnerability of smallholder farmers in other hazard-prone areas and provide good references for policymakers to have timely supporting policies to help people living in similar economic and natural regions.

The proceeding sections of this paper are organized as follows: Section 2 provides the material and methods of the research; Section 3 presents the results and discussion and in Section 4 we present some concluding remarks and policy implications based on the findings of the research.

3.2. Material and Methods

3.2.1 Study area and household surveys

The study was carried out in the Van Yen district located in the North of Yen Bai province. There are 26 communes and one town in Van Yen district, of which 13 are located in the highlands, and 8 belong to the group regarded as "especially difficult communes" specified under "Program 135" by the Vietnamese Government‡. The total natural area of the district is 1,391.54 km^2, and it is divided into three economic regions: the rice intensification (13 communes), fruit and crop (6 communes) and cinnamon areas (8 communes).

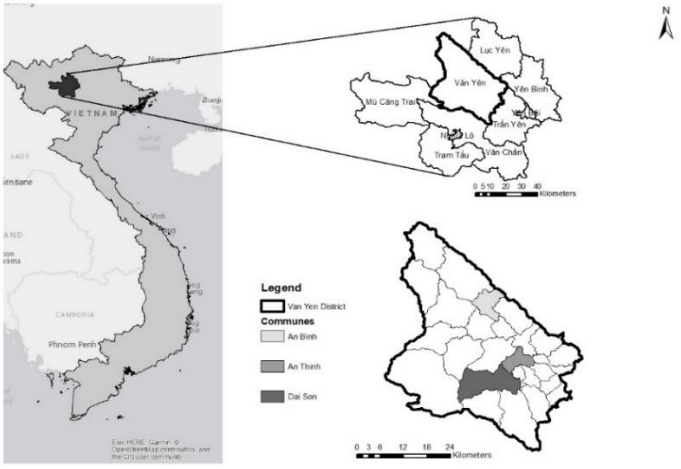

Fig. 3.1. Map of study areas.

The district has many streams, most significantly the Red River which traverses the length of the district. There are 17 communes and 9 communes on the right and the left sides of the river, respectively. As a result, these locations often experience frequent occurrences of extreme weather, such as flash floods, whirlwinds, cyclones, landslides, and inundation.

Three of communes in Van Yen district, namely An Binh, An Thinh, and Dai Son, were purposively chosen for the research, whereby An Binh is representative of a cassava growing area, while An Thinh and Dai Son are typical rice and cinnamon regions, correspondingly (Table A1 in Appendix A).

The survey was administered in two periods: from September to November 2015 and from February to April 2016. In the first survey, in-depth interviews with experts in different organizations, including the Departments of Irrigation and Flood Control, Meteorological Center, Statistical Departments, Agriculture Department, and the People's Committee, were conducted at

‡ Program 135 is 'the program for the socio-economic development of extremely difficult communes in ethnic minority and mountainous areas' and is one of the poverty reduction programs in the country implemented by the Vietnamese Government in 1998 (according to the Decision 135/QD-TTG).

both provincial and district level. The primary purpose was to get a better understanding of the research´s context as well as the situation of FF&LS in the region and then to determine the specific research areas in Van Yen district (not only at commune but also at village level). In-depth interviews focus on asking questions related to livelihood activities, weather conditions, the situation of FF&LS in recent 15 years, what the main causes of FF&LS are, and which areas and who are mostly affected by these natural disasters. As a result, three study communes are chosen since they are characterized by: (1) geographical zone; (2) FF&LS situation; (3) economic pattern; (4) ethnic minority groups. Three focus group discussions (FGDs) were then organized with farmers at commune level. Each FGD included 10 to 15 people and lasted around 3 hours. The main purpose of doing FGDs was to capture the timeline of village history, main livelihood activities, cropping calendar, challenges for agricultural activities, the role of weather and other factors such as health, access to market, information and knowledge to agricultural production, the extent of flash flood and landslide impacts, and taken measures before, during, and after FF&LS. At the same time, a list of indicators related to a vulnerability assessment of these natural hazards was given to local officials and experts in the field of agriculture and climate for the expert selection of relevant indicators suited to the locality. These indicators were then revised for the household survey in the next stage of fieldwork, and are provided in Table A2 in Appendix A. A total of 405 households were interviewed in Van Yen district. Based on the size of land and population, 154 households in An Binh, 105 households in An Thinh and 146 households in Dai Son commune, were selected for the interviews. The sampling in each commune was selected based on the level of impact[§] of FF&LS on livelihood and production activities[**] of the household. Only the response of the head or main laborer of the household, in case the head was not at home, was recorded. Each interview lasted from 1 hour to 1.5 hours on average and followed a detailed questionnaire (Pham et al., 2019). A total of 35 key variables applied in calculating the Livelihood Vulnerability Index as shown in Table 2. In addition, secondary data on monthly rainfall were aggregated from the National Meteorological and Hydrological Center from 1980 to 2015.

3.2.2 Approaches to measuring vulnerability

The vulnerability measurement can be conducted by various ways and methods, depending on fields of specialization. For evaluating the impacts of climate change and hazards, vulnerability is often measured by constructing an index of vulnerability. Commonly, the vulnerability index of a certain system is defined as a function of three typical components: (1) Exposure (Exp), (2)

[§] The impact level is determined based on the extent of both human and financial damage that people experienced through flash floods and landslides in recent years as reported by commune officials.

[**] Since the scope of this research is to analyze the vulnerability of households towards flash floods and landslides, only households with livelihood activities associated with agriculture, for example growing rice, maize, cassava, cinnamon, and acacia or rearing pigs, cows, chickens, or buffalo, are selected to conduct the survey.

Sensitivity (Sen), and (3) Adaptive Capacity (Ada.Cap) (for example, see Adger, 2006; IPCC, 2001). It is noted that the method can be used to measure the vulnerability subject to any natural hazzards. However, the object (i.e., kinds of natural hazzards) are often determined in advance through the questionaire design in the surveys targeting to particular natural hazzards. In this study, the survey was designed to study the impacts of flash floods and landslides; hence, the vulnerability index is measured as a function of exposure, sensitivity, and adaptive capacity conditional upon the flash flood and landslide events. The equation below expresses the function, while details are provided in Appendix B.

$$\text{Vulnerability} = f(\text{Exp}; \text{Sen}; \text{Ada.Cap}) \mid (\text{Flash flood and Landslide})$$

The present study further employs an indicator-based vulnerability assessment method (Hahn et al., 2019), the Household Vulnerability Index (HVI_{FL}), with the rationale provided in Appendix B. This method has been used widely in different study contexts to evaluate the disparate impacts of natural hazards on a region or community (Duy Can et al., 2013; Panthi et al., 2016; Shah et al., 2013). In particular, the HVI_{FL} index, which is based on the vulnerability concept defined by the IPCC, is used in coupled with the qualitative data analysis to analyze households´ vulnerability to FF&LS and to determine which factors contribute most to such vulnerability.

3.2.3 HVIFL: a composite index

The HVI_{FL} contains eight key components that are (1) Socio-Demographic Profile (SDP), (2) Livelihood Strategies (LS), (3) Social Network (SN), (4) Health (H), (5) Food (F), (6) Water (Wa), (7) Housing (Ho), and (8) Hazard Impacts (HIz). “Housing” (#7) is a newly introduced major component while considering previous vulnerability index studies, as it plays an important role in helping households to avoid injury and damages to property during FF&LS.

In addition, each key component is divided into specific indicators (see Table A2 in Appendix A). Based on a review of existing literature, a field survey, consultation from numerous experts and local officials, 35 indicators (in Table 2 and Tables A2 and A3 in Appendix A) were selected to assess the vulnerability level under the impact of FF&LS.

The HVI_{FL} is subsequently calculated by using a balanced weighted average approach[††]. This means each indicator contributes equally to the overall index although the number of indicators in

[††] Our main purpose of using this method is due to the fact that assigning weight for each component in the index is quite tricky since it could lead to bias problem in assessing the importance of each component in the overall index. Therefore, in the study, these components are assumed that they have an equal contribution to the overall vulnerability index. This also helps to make the interpretation process simpler and easier to understand.

each key component is different. Furthermore, as many of the indicators are measured using different units, e.g., numbers, percentages, or pre-existing indices, it is indispensable to standardize each indicator so that the index can be compiled and each indicator made comparable. In this study, this is computed by following the method used to calculate the Human Development Index (HDI) (UNDP, 1990), that is:

$$\mathbf{Index_{sd}} = \frac{\mathbf{S_d - S_{min}}}{\mathbf{S_{max} - S_{min}}} \quad (1)$$

where,

S_d is the primary indicator for the commune; and

S_{max} and S_{min} are the upper and lower bound values, respectively.

After normalizing indicators as shown in equation (1), each key component (M_{di}) is computed as follows:

$$\mathbf{M_{di}} = \frac{\sum_{j=1}^{n} \mathbf{Index_{sdj}}}{\mathbf{n}} \quad (2)$$

where,

M_{di} represents each key component (eight components) of the commune;

$Index_{sdj}$ is the indexed indicator value of each key component M_{di} for the commune; and

n refers to the number of indicators of each key component.

Then the average value for each of the eight key components for the commune is obtained according to equation (3):

$$\mathbf{HVI_{FL\_d}} = \frac{\sum_{i=1}^{8} \mathbf{w_{M_i} M_{di}}}{\sum_{i=1}^{8} \mathbf{w_{M_i}}} \quad (3)$$

where,

W_{M_i} is the number of indicators making up each key component for the commune; meanwhile M_{di} is the average value of each key component calculated in equation (2).

Hence, HVI_{FL_d} can also be expressed as shown in equation (4).

$$\mathbf{HVI_{FL\_d}} = \frac{\mathbf{w_{SDP}SDP_d + w_{LS}LS_d + w_{SN}SN_d + w_H H_d + w_F F_d + w_{Wa}Wa_d + w_{Ho}Ho_d + w_{Hz}HIz_d}}{\mathbf{w_{SDP} + w_{LS} + w_{SN} + w_H + w_F + w_{wa} + w_{Ho} + w_{HIz}}} \quad (4)$$

These calculations (in eq. (1-3)) result in the final value for the HVI_{FL_d} and each of its dimensions in the range from 0 to 0.5. A higher end value for the HLI_{FL_d} denotes more vulnerable systems.

3.2.4 HVI_{FL_d} calculation based on the IPCC's method

Based on the IPCC definition of vulnerability, an alternative approach to calculate the HVI_{FL_d} index, so-called the HVI_{FL_d-IPPC}, is used in which the vulnerability is defined as a function of three distinguished components, namely exposure, sensitivity, and adaptive capacity (IPCC, 2001). Of these components, exposure includes Hazard Impacts; adaptive capacity comprises of Socio-Demographic Profile, Livelihood Strategies, and Social Network; and sensitivity consists of Health, Food, Water, and Housing. Specifically, exposure is quantified by (1) the mean standard deviation of monthly average rainfall (from 1980 to 2015), (2) the proportion of households not receiving any notices or warnings about FF&LS and (3) the percentage of households with problems, such as losing housing/property, agricultural land damaged or illness/injury/death of a family member due to FF&LS. Adaptive capacity is quantified by (1) the Socio-Demographic Profile of the community, (2) the Livelihood Strategies that households are using, and (3) the cooperation of the Social Network. Sensitivity, meanwhile, is computed by considering the recent status related to (1) Health, (2) Food, (3) Water, and (4) Housing in the community.

The vulnerability is defined, which includes the mentioned key components, by using a linear function explicitly represented in equation (5):

$$\mathbf{HVI_{FL_d-IPCC}} = (\mathbf{e_d} - \mathbf{a_d}) * \mathbf{s_d} \quad (5)$$

where:

e_d , a_d, s_d is the calculated exposure, adaptive capacity, and sensitivity score, respectively. These scores are equivalent to differently specified factors for each commune and are identified based on a so-called IPCC-defined contributing factor $\mathbf{CF_d}$, as shown in equation (6):

$$\mathbf{CF_d} = \frac{\sum_{i=1}^{n} \mathbf{w_{M_i}} \mathbf{M_{di}}}{\sum_{i=1}^{n} \mathbf{w_{M_i}}} \quad (6)$$

Where,

$\mathbf{M_{di}}$ is the average value of each key component;

$\mathbf{w_{M_i}}$ is the weighting factor of each key component; and

n is an integer value representing the total number of key components in each contributing factor.

The calculated values of HVI_{FL_d-IPCC} represents the vulnerability level of each commune, ranging from -1 to 1, i.e. from least to most vulnerable level.

In this research, we use the HVI_{FL_d} results calculated from these two methods to strengthen the analysis. It also helps support the validity of our survey information if HVI_{FL_d} results computed from these two methods are consistent.

3.3. Results and Analysis

3.3.1 Household Vulnerability Index

Table A3 in the Appendix A shows the actual values and the minimum and maximum values of indicators for each commune. Table 2 shows the indexed indicators (resulting from eq. 1), major components (shown in eq. 2) and the Livelihood Vulnerability Index (shown in eq. 3) for An Binh, An Thinh and Dai Son. It is noted that the LVI here is calculated by using the composite index method, while the LVI calculated by using the IPCC framework approach is provided later in Section 3.2. Overall, the results show that Dai Son has the highest HVI_{FLd} (i.e., 0.325), indicating that this commune is the most vulnerable area to the impacts of FF&LS when compared with An Binh (0.320) and An Thinh (0.290). It is noticeable to point out from the research data that there are only minor differences in the household vulnerability indices for FF&LS in these three communes. Hence, the index is complemented with a qualitative analysis to facilitate a deeper understanding of which household attributes contribute most to the vulnerability to FF&LS in different communes.

Table 3.2: Indexed values for the indicators, key components, and overall HVI_{FLd} for An Binh, An Thinh and Dai Son.

Key components	Indicators	Units	Index Sd			Md		
			An Binh	An Thinh	Dai Son	An Binh	An Thinh	Dai Son
Socio-demographic profile	1. Proportion of dependency	Ratio	0.130	0.137	0.147	0.258	0.178	0.353
	2. Households headed by a female	Percent	0.130	0.086	0.062			
	3. Average age of households´ head (only for female)	1/#years	0.361	0.205	0.370			
	4. Household heads having no education	Percent	0.481	0.276	0.452			
	5. Household heads who are ethnic minorities	Percent	0.520	0.383	0.959			
	6. Poor households	Percent	0.188	0.162	0.479			
Livelihood Strategies	7. Average diversification index of farming	1/# livelihoods	0.049	0.055	0.024	0.357	0.342	0.334
	8. Households experiencing jobless during FF&LS season	Percent	0.779	0.810	0.952			
	9. Households who exploite natural resources during FF&LS	Percent	0.039	0.029	0.007			
	10. Households whose a member working in various community	Percent	0.234	0.276	0.123			
	11. Households whose incomes mainly from forestry/agricultural activities	Percent	0.682	0.543	0.562			
Social Network	12. Households without any help/support during FF&LS	Percent	0.331	0.305	0.336	0.312	0.242	0.343
	13. Households who did not provide help to any others	Percent	0.149	0.114	0.295			
	14. Household head does not belong to any organization	Percent	0.506	0.343	0.562			
	15. Households who borrow money for lending to others	Ratio	0.260	0.207	0.180			

Health	16. Average distance (house to the nearest health center (or hospital))	Km	0.102	0.153	0.373	0.277	0.348	0.272
	17. Households whose at least one member has a chronic illness	Percent	0.351	0.219	0.260			
	18. Households who do not have an insurance card	Percent	0.152	0.319	0.025			
	19. Households who are not afforable to pay off the costs of health care	Percent	0.505	0.700	0.429			
Food	20. Households experiencing insufficient food produced from their farm	Percent	0.344	0.476	0.336	0.344	0.337	0.327
	21. Households experiencing decreased production of food	Percent	0.617	0.524	0.562			
	22. Crop diversification index	1/# crops	0.194	0.194	0.283			
	23. Households not raising livestock	Percent	0.221	0.152	0.130			
Water	24. Households experiencing problems to access irrigation water	Percent	0.299	0.552	0.322	0.416	0.340	0.429
	25. Households experiencing problems to access potable water	Percent	0.208	0.067	0.089			
	26. Households using water from a natural resource	Percent	0.740	0.400	0.877			
Housing	27. Households having no Red book	Percent	0.436	0.205	0.160	0.364	0.322	0.309
	28. Households having no toilet facility	Percent	0.104	0.076	0.137			
	29. Households without stabilized houses	Percent	0.552	0.686	0.630			
Hazard impacts	30. Households experiencing house lost or property damage caused by FF&LS	Percent	0.357	0.385	0.219	0.296	0.280	0.269
	31. Households experiencing agricultural land damage casued by FF&LS	Percent	0.896	0.990	0.966			
	32. Households who did not receive FF&LS warnings	Percent	0.117	0.029	0.116			
	33. Households whose a member becomes ill or injured due to FF&LS	Percent	0.104	0.029	0.014			

	34. Households having a recent death casued by FF&LS	Percent	0.019	-	0.007	
	35. Mean standard deviation of monthly average precipitation (1980-2015)	Millimeters	0.285	0.250	0.291	
	HVI_{FLd} An Binh	0.320				
	HVI_{FLd} An Thinh	0.290				
	HVI_{FLd} Dai Son	0.325				

Source: Field survey, 2016.

3.3.1.1 Adaptive capacity

3.3.1.1.1 Socio-Demographic Profile

Although the percentage of households headed by females is lowest in Dai Son, this commune had the highest vulnerability on the Socio-Demographic Profile component (Dai Son: 0.353, An Binh: 0.258, An Thinh: 0.178). This is mainly because Dai Son has the highest percentage of household heads that belong to ethnic minority groups (i.e., Yao, Tay, H'Mong) (Dai Son: 0.959, An Binh: 0.520, An Thinh: 0.383). Furthermore, 47.95% of respondents in Dai Son reported that they are poor households[1] according to the government's standard, while the percentage of poor households in An Binh (18.83%) and An Thinh (16.2%) is much lower than in Dai Son. It is due to the fact that Dai Son, an ethnic minority and mountainous area, was recognized as an exceptionally difficult region since 2011 under "Program 135" of the Vietnamese Government. Data from household surveys also show that Dai Son has the largest household size at 4.38 persons/household compared to 4.28 persons/household in An Binh and 4.18 persons/household in An Thinh. In addition, with a higher proportion of the dependent members who are under 15 and over 65 years, the dependency ratio is also highest in Dai Son (0.147), followed by An Thinh (0.137) and An Binh (0.130).

3.3.1.1.2 Livelihood Strategies

Survey results show that the greatest vulnerability on the Livelihood Strategies is in An Binh with an index value of 0.357. However, this value is not significantly different among the three communes (e.g., An Binh 0.357, An Thinh 0.342, Dai Son 0.334). The highest percentage of households that lost their jobs during the flash flood and landslide season are found in Dai Son, following by An Thinh and An Binh (i.e., 95.21%, 80.95%, and 77.92%, correspondingly). The livelihood strategies of the surveyed households in this study include growing crops, raising animals, and forestry. On average, the respondents in Dai Son report that they employ 2.80 ± 0.45 livelihood strategies, while 2.62 ± 0.60 and 2.54 ± 0.57 livelihood strategies are reported by households in An Binh and An Thinh, respectively. As a result, the average agricultural Livelihood Diversification Index (LDI) is highest in An Thinh (0.055) compared to the other communes (An Binh: 0.049, Dai Son: 0.024). The result also reveals that Dai Son has the lowest percentage of both households with a family member working in different communities (12.33%) and households exploiting natural resources during FF&LS (0.69%). An Binh, on the other hand, has the highest proportion of these sub-components (23.38% and 3.90%, correspondingly). Noticeably, over 50%

[1] Based on the income criteria, the Vietnamese Government defines a poor household as having an income of 700,000 VND (around $30) per person per month for rural areas and 900,000 VND (around $39) per person per month for urban areas.

of respondents across all research sites reported that their major source of income is from and mostly depends on agriculture.

3.3.1.1.3 Social Network

The Social Network component shows that the percentage of households receiving assistance is less than the proportion of households providing help to others during FF&LS across the whole research area. Labor support, money lending, spiritual encouragement, and help with seed supply are different kinds of assistance recorded in the three communes. Furthermore, the results show that high percentage of household heads have not participated in any organization in both An Thinh and An Binh (56.16% and 50.65%, correspondingly). Thanks to the lowest percentage of households that have not been a member of any organization (34.29%), An Thinh has the lowest vulnerability index regarding the social network component as explained in the following section.

3.3.1.1.4 Interaction between farmers´ adaptive capacity and ethnicity, farming activity/occupations, and organization membership

"*There are six members in our family. However, only two of us (I and my wife) are working on our five (5) Sao (equivalent to 0.18 ha) of agricultural land and three (3) ha of hilly land. I just finished elementary school, while my wife does not know how to read and write. So we can do nothing without agriculture, and we have no interest in joining any organization*" – A Dao-ethnic and poor household in Village 3, Dai Son commune.

a. Ethnic minorities

In general, ethnic minority communities are marginalized geographically, socially, economically, and politically, not only in the surveyed communes but also generally in the NMR of Vietnam. They typically live in remote regions and their livelihoods greatly depend on natural resources, often on low productivity land (CARE, 2013). According to a farmer in Khe Rong village, An Binh commune: "*Our inter-village road is extremely poor and so difficult to travel, with more than 5 km of muddy road with high steep and too many rocks, our village is often isolated during the rainy season*". Consequently, geography, working environment, and resource difficulties result in high poverty rates among ethnic minorities, though there have been remarkable reductions in the national poverty rates in recent decades. In other words, the gap between ethnic minority groups and the ethnic majority group has expanded (Dang, 2010). Compared to Vietnam´s ethnic majority, the 'Kinh' people, ethnic minority groups in the research areas are much poorer with lower levels of education and higher dropout rates from school, resulting in higher levels of illiteracy and a lack of fluency in the main language (i.e., Vietnamese), especially among elderly household heads,

which holds minorities back when interacting with other people and taking advantage of outside resources (Fig. 2). An interviewee in Dai Son commune stated that: "The *commune officials often disseminate new local policies, such as loan procedures, as well as information related to agricultural production at commune meetings. Although involved, I often do not understand the full content of the meeting. If the officer distributes the material for reading, then it is also a problem for me because I am illiterate*". In addition, because of poverty the local farmers also experience numerous troubles in seeking enough financial resources to pay for their children´s schooling. Furthermore, even though the Government has a policy that each family should have only one or two children, ethnic minorities tend to have more children, which results in greater dependency rates among ethnic minority families than the 'Kinh' families. Combining all of these factors, ethnic minority characteristics have been considered as some of the key elements that cause the reduce community adaptive capacity to FF&LS.

Fig. 3.2. Respondents using fingerprints as their signatures.

b. Diversity of source of income

Research conducted by Paavola (2008) pointed out that diversity in crops and income sources allows farmers to build a portfolio of livelihoods with diverse risk distributes so that risks, such as those posed by natural hazards or climate change, can be managed, making recovery easier and quicker. In addition, it is also assumed that a farmer who earns income from various sources has a higher adaptive capacity than one with fewer income sources (Abdul-Razak and Kruse, 2017). In this regard, the household´s livelihood in the three communes mainly relies on agricultural farming. There are two main sources of income among the surveyed households, including farm and non-farm income, such as crop production (rice, maize, cassava, cinnamon), animal rearing (chicken, pig, cow, buffalo), waged labor, and trading. In general, most households in An Binh are engaged in agriculture and forestry. The commune has also experienced the most exploited natural resource groups of the three surveyed sites. An interviewee in Khe Ly village, An Binh commune – Mr. Dao Lang Tap - acknowledged that: "*The main livelihoods of my family with two children and my father are rice, cassava, and cinnamon cultivation. We have no income from off-farm jobs. Hence, it is challenging for us to be able to secure our family income once affected by FF&LS"*.

c. Organization membership/Farmer´s participation in organizations

The key factor influencing adaptive capacity is found to be social networks (McElwee et al., 2010). There are a number of organizations that support farmers in their livelihoods in these communes, for example, the Farmer´s Union, the Women´s Union, Farmer Interest Group, and an Agricultural Cooperative. Joining these groups can help farmers get useful information related to agricultural production, such as new varieties, pest and disease status, price changes, as well as information on natural disasters, such as FF&LS. At the same time, participation in these organizations also allows people to have more intimate social ties with other communities and individuals, thereby facilitating them in seeking help or assistance when they are in trouble. In the study area, people often receive in-kind assistance from local government organizations, such as rice, seeds, livestock, or financial support, such as cash. These subsidies are not much, yet also contribute somewhat to helping the households overcome the consequences of natural disasters. In addition, in the country as a whole and in the particular research areas, networks with relatives can be effective channels to gain new information and seek mutual assistance, such as sharing works in crops (Hoang et al., 2006). People also can seek help from their friends or neighbors in the communities, normally in terms of providing loans and labor (i.e., working days).

3.3.1.2 Sensitivity

3.3.1.2.1 Health

Among the three research communes, An Thinh displays the highest sensitivity in terms of Health component. The survey results indicate that in total, almost 32% of the interviewed households in An Thinh did not have a health insurance card. As a result, the commune has the highest percentage of households who could not afford health care costs (70% of surveyed households), although the proportion of households having family members with a chronic illness is lowest in An Thinh. In addition, it is important to point out that people in Dai Son have the longest distance from their houses to the hospital (14.82 km), but this commune has the lowest proportion of households without a health insurance card (2.5%). The reason behind this is that most of the respondents in Dai Son belong to ethnic minorities[2]. Therefore, they are provided ethnic health insurance entitling them free treatment at the hospital according to government policy. The survey results also show that the highest percentage of households with a family member that has a chronic illness (35.07%) is in An Binh commune, followed by Dai Son (26.03%) and An Thinh (21.09%).

[2] The three research communes are home to ethnic minority groups, such as Dao (Black Dao and White Dao), Tay, and Hoa. However, of those, most of the respondents (94%) in Dai Son are ethnic minorities, while the percentage of interviewed households belonging to ethnic minorities in An Binh and An Thinh is lower (62% and 40%, correspondingly)

3.3.1.2.2 Food

Although there is no significant difference between the Food component among the three communes, it is by no means identical. An Binh is the most vulnerable commune regarding the Food component (0.344). It is noted that 100% of households in these three communes use pesticide, fertilizer, and plant protection products in the production process. The highest proportion of respondents (61.69%) in An Binh reported that the actual usable size of crop yields has decreased in recent years due to the impacts of FF&LS. An Thinh, on the other hand, has the greatest percentage of households with insufficient food from the farm (47.62%) due to these natural hazards. While An Binh respondents reported they grow 2.23 ± 0.74 types of crop, An Thinh households plant fewer types of crops (2.17 ± 0.56) and the least is in Dai Son (1.79 ± 0.87). Of these, the two crops commonly grown in the field are rice and maize and are mainly produced for home consumption. There are also three major harvests per year: the first is for producing Chiem rice in Winter-Spring (from January to middle of May), the second is Mua rice in Summer-Autumn (from middle of May to September), and the third is for Maize (from October to December). In contrast with rice and maize, cassava is normally grown on hilly land, mostly in An Binh and Dai Son communes, and cassava is cultivated in February and gathered in December each year.

3.3.1.2.3 Water

Regarding the Water component, over 55% of households in An Thinh responded that the amount of irrigation water was not sufficient for their fields, while this rate is much lower in An Binh and Dai Son (29.87% and 31.19%, respectively). The source of irrigation water households used for their plots is primarily from canal systems, making up 57.74% of total irrigated lands. However, not all fields owned by the respondents in the region have access to irrigation canals. This is because many fields were reclaimed illegally by deforesting, which were also located in many different places across hills. The Government, therefore, did not build the canal system for these fields; hence 24.17% farmers in the study zone often use rainwater from ravines in order to irrigate their fields. Water scarcity was found in all three communes, and many farmers even have to compete to get more water for their farms. As a result, it has severe impacts on crop productivity. For example, farmers in Hoa Nam and Cau Cao villages in An Binh commune claimed that the irrigation system is very poor. Thus, they are highly dependent on the weather, and many households in these villages do not plant a winter maize crop due to lack of water. In addition, the result also indicates that An Binh has the highest percentage of households (20.78%) with a problem accessing potable water (lack of water for daily demands), while An Thinh has the lowest proportion of households that face this problem (6.67%). A majority of respondents in Dai Son

reported that they are using natural water resources, such as rainwater, water from ravines or from springs or rivers to cook and drink every day, accounting for 87.67% of all respondents. Households usually build their own water tanks and divert water from ravines to these tanks through small water pipes (Fig. 3). In the rainy season, these water pipes are often blocked by rocks and soil from the top of the hills or mountains. As a result, households in these areas do not often have enough water for their daily lives. Remarkably, all these water sources are used directly by families without any treatment process, making them vulnerable to water-borne diseases, such as cholera, diarrhea, and measles. Overall, when the sub-indicators are integrated, Dai Son has the greatest water vulnerability score (0.429) compared to the other communes.

Fig. 3.3. Irrigation canals and water pipes in the research areas.

3.3.1.2.4 Housing

In terms of Housing component, in general, there are slight differences in the three communes. For instance, An Binh has the highest vulnerability score of the Housing component (0.364). Over 43% of households in An Binh have no land certificate (called the 'Red Book' in Vietnam). This is due to the fact that in the past these land areas belonged to Yen Bai forestry farms but since 1995 people began to come and build houses without permission from the local government. Currently, if people want to have a land certificate, they need to submit the required documents to the commune, district, and provincial offices. From there, the province committee will decide whether to abolish the ownership of the forestry farms and issue a certificate of land use for households. People, however, are either afraid of doing it or already do it but have not received the certificate because of the complicated nature of the process. The other reason, as mentioned, is because of land fragmentation situation. In this regard, the certifications of land use rights were only issued for total land held by households, without certifying any individual plots. However, households in this region tend to have multiple plots allocated in different places. As a result, most of the lands inherited from parents does not hold the land certificate. Without the Red Book, local people are facing difficulties in accessing financial institutes to mortgage their lands to borrow money.

The survey results also indicated that wood and brick are the main construction materials of houses while the key materials for building floors are cement, marble tiles, and tiles. About 37% of the study households have roofs made from straw or leaves and 29% had cement panels. To define whether housing is stabilized or unstabilized, each type of wall, floor, and roof was scored. The higher the score, the stronger the house. The results show that approximately 62% of respondents owned unstabilized houses, in which An Thinh commune has the highest percentage of households with precarious houses (69% of sample households). The data from household surveys also highlight that Dai Son has the highest proportion of households without a toilet (13.70%), while this percentage is lowest in An Thinh (7.62%). In fact, households with moderately good economic life often build sanitary schemes, whereas low-income families normally have temporary hygienic schemes or nothing (Centre for Sustainable Rural Development, 2010).

3.3.1.2.5 Who is more sensitive?

a. Living without health insurance

Serious illness of family members is always a major concern of a family, as it affects the morale and spirit of other members, and in terms of economic perspective it has an undesirable and substantial influence on consumption and income. There are two significant financial/economic outflows due to illness: additional expenses for medical care and reductions of income due to a shortage of labor force. In low-income households, these unexpected and unpredictable costs may result in increased rates of poverty and poor health. As a result, these consequences cause households to become unrecovered during periods of major illness, especially for those who are faced with the negative impacts of natural hazards in developing countries where having health insurance is not common. According to the Ministry of Health of Vietnam & Health Partnership Group (2013), without health insurance cards, households may face significantly devastating consumptions, as well as higher impoverishment due to high expenses for health, even though they have lower out-of-pocket spending for health care. In addition, findings by Vo (2016) suggested that the need of increasing health insurance registration rate is essential for reducing the vulnerability of households. As outlined by a farmer in Goc Nu village, An Thinh commune: *"The health insurance fee is costly for us (600.000VND (or $26)/person/year); hence, we live without insurance. When there are health problems, we often do not have enough money to go to the hospital or buy drugs/medicine. Instead, we often use herbs, or our experience to heal ourselves,,*. Therefore, due to a large proportion of people living without health insurance, even though An Thinh commune has the fewest households with chronic illnesses and is nearer to health facilities, this commune still had the highest vulnerability in terms of Health component.

b. Inadequate food

As pointed out by Son (2013), the income of approximately 90% of the population in upland regions depends on agriculture or forestry activities. Also, food insecurity still remains a key issue at the household level in the NMR. Food shortage is often found in households in remote areas where natural resources are scarce and where land cultivation and climate conditions are difficult (Pham et al., 2015). In the study areas, households facing food shortages are those who have little farmland available for cultivation and poor access to the irrigation system. An interviewee in An Thinh commune stated that: *"Our farms are fragmented, and the irrigation system is extremely poor in my village, so we have insufficient food from our farm, especially in case we are affected by FF&LS".* The survey results showed that regarding the Food component, An Thinh is highly vulnerable because almost 50% of the households have insufficient food from their farm while in both An Binh and Dai Son it is about 34%.

c. No land tenure document

According to one farmer in Khe Trang village, An Binh Commune: *"The procedure of making land certificate has taken so long time, the commune official came to my house sometimes to measure my land. We even entertained them with great meals. However, so far we still have no land tenure document. Hence, it is so difficult for us to borrow money from the banks,,*. A large proportion of households (almost 44%) in An Binh commune have not been granted land tenure certificates, although they have all been cultivating land since their settlement. Owning land tenure rights is very important for the local households to ensure their livelihoods, since it is considered a means of furthering sustainable natural resource management by increasing the incentive for landowners to invest in long-term soil improvement (Jakobsen et al., 2007). Furthermore, in the research areas, ownership of land use rights is one of the most important assets to help households access credit sources. In addition, this helps households ensure food security because they have capital to invest in agricultural production. In this regard, although An Binh commune has a lower percentage of interviewed households with precarious houses and without toilet facilities, it is a leading commune in terms of households without the land certificate, which is a major factor affecting vulnerability. Consequently, An Binh displays the highest vulnerability towards the Housing component.

d. Relying upon natural water sources

The ability to access clean drinking water is one of the key factors which affects vulnerability to health problems caused by weather and/or other factors. In addition, lack of water resources is one of the most important barriers to poor people´s adaptation in the NMR. However, in the study areas,

it was acknowledged by most of the farmers in Dai Son commune that: *"Our village has no clean water schemes, my family, as well as most of my neighbors, are using water from creeks without water treatments, leading to health diseases. Furthermore, during the dry season, we do not have enough water for cooking and drinking".* Water supply is one the most frequently mentioned needs in the commune because they still do not have access to this service. The household survey indicated that almost 90% of the households in Dai Son commune utilize natural water resources for both their daily lives and agricultural production. As a result, it leaves people in the commune more vulnerable to health-related problems due to lower levels of food and water security (because of the water shortages), and water-borne diseases associated with low water quality.

3.3.1.3 Exposure

3.3.1.3.1 Hazard Impacts

Although the percentage of households who did not receive FF&LS warnings is lowest in An Thinh (2.86%), this commune has the highest proportion of households who had their house or property damaged due to FF&LS (38.46%). However, it is important to point out that most of the respondents reported that their agricultural land was damaged due to FF&LS (more or less 90%), especially in An Thinh (99%). The results also show that the greatest proportion of respondents with an illness/injury (10.39%) or a recent death (1.95%) due to FF&LS reside in An Binh. Among the three communes, Dai Son received more average rainfall between 1980 and 2015. Combining the value of the sub-elements, the overall vulnerability index of Hazard Impacts is highest in An Binh (0.296) (Fig. 4).

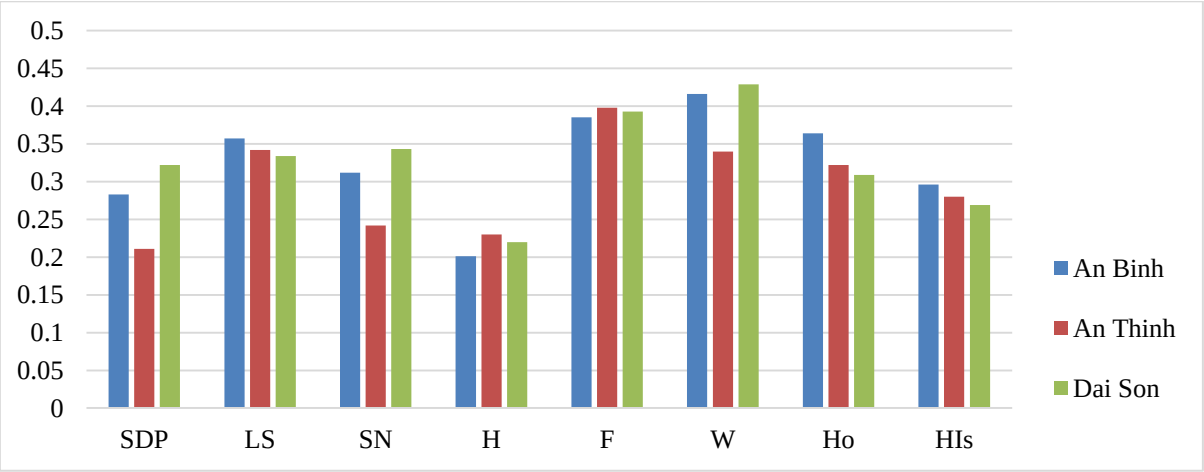

Fig. 3.4. Major components of the LVI for An Binh, An Thinh, and Dai Son.

Note: SDP: Socio-Demographic profile; LS: Livelihood strategies; SN: Social network; H: Health; F: Food; W: Water; Ho: Housing; and HIs: Hazard Impact

3.3.1.3.2 Household exposure – Locational dimensions are closely linked with a households´damages

The physical location of a household is one critical influence in relation to the distribution of hazard effects (Few & Tran, 2010). For example, households situated alongside the river or stream networks are considered to be more vulnerable to flash floods and bank erosion. Mr. Lich – a former village head in Goc Nu village, An Thinh commune stated that: *"The flash flood occurs every year from May to August in our village because we located alongside with the Ngoi Buc river. As a result, there are so many households in the village suffering flash floods that their fields have been turned into streams due to flash floods".* In An Binh commune, many households located at the foothill´s edge are more vulnerable to landslide conditions. As Mr. Ly Van Sang in Khe Trang village, An Binh Commune remarked: *"My wife was passed away by the landslide in 2008 while working on the hill. A nine years old buffalo and one ton of fertilizer were swept away due to the flash flood. Also, 1 ha of our hilly land could not recover after the landslide,,.* Furthermore, as pointed out by Few and Tran (2010), the location of households is also a key factor affecting their abilities to prepare for and prevent impending hazard events. In the research areas, households can get information related to warnings and risk by different channels, including the announcement by digital means, such as village speakers, television or in-person public meetings in the village. Therefore, for those who are situated at remote areas of rural villages, they may be unable to reach the audible range of loudspeakers, disconnected to the media, or uninformed of public meetings (Fig. 5). As an interviewee in An Binh indicated: *"My family has a television, but I rarely watch it. Because the signal here is not good and I often spend my whole day on the field or in the forest. Furthermore, we are not at the reach of the loudspeaker in the village because we are too far away from it".*

Fig. 3.5. Inter-village road in the research sites.

3.3.2 HVIFLd– IPCC

The result related to the HVI_{FLd} from using the HVI_{FLd} – IPCC approach is consistent with the calculated HVI_{FLd} based on the composite index method. It shows that Dai Son is the most vulnerable commune due to FF&LS (-0.0739), following by An Binh (-0.07408) and An Thinh (-0.083) (shown in Table 3). It also indicates that An Binh is more exposed to flash flood and landslide impacts (0.296) than An Thinh (0.280) and Dai Son (0.269). Furthermore, An Binh is also considered the most sensitive commune regarding Health, Food, Water, and Housing under the impacts of these climate and weather-related events among the three communes. Based on the results from the Socio-Demographic Profile, Livelihood Strategies, and Social Network components, Dai Son has the lowest adaptive capacity (0.488) compared to An Binh (0.513) and An Thinh (0.537). To summarize, although Dai Son has the least exposure to the impacts of FF&LS, due to its high sensitivity and low adaptive capacity, this commune is still the most affected area.

Table 3.3: HVI_{FLd}-IPCC contributing factors in An Binh, An Thinh, and Dai Son

Contributing factors	An Binh	An Thinh	Dai Son
Adaptive capacity	0.513	0.537	0.488
Sensitivity	0.342	0.323	0.338
Exposure	0.296	0.280	0.269
Overal HVI_{FLd}-IPCC	-0.074	-0.083	-0.073

3.4. Discussion and Conclusion

Flash floods and landslides (FF&LS) are serious natural hazards in the NMR in Vietnam. People living in this area are also mainly from minority ethnic groups with lower levels of education and income, and poor housing systems. This is also a highly hilly remote area with poor infrastructure, which causes significant difficulties for transport to nearby cities or centrals of main towns for shopping and seeking assistance or services, such as healthcare. In addition, households in this region are extremely poor and lack food and freshwater used for daily life and production activities. They also mainly rely on their own agricultural produce for daily meals. Hence, they are highly vulnerable to the FF&LS that occur frequently in this region. This study considers this issue to determine what are the most influential factors contributing to their vulnerability so that policymakers in Vietnam can be provided with useful information to issue appropriate policies or assisting programs for the timely support of people in this region. The importance of the findings

is highlighted by the fact that the research area (three communes in Van Yen district, Yen Bai province) in this study is regarded as one of the extremely difficult and poor regions specified under "Program 135" provided by the Vietnamese Government, which would need special support from the Government and public.

This research uses the HVI_{FLd} and a substitute approach (HVI_{FLd} – IPCC) in combination with in-depth qualitative data to assess rural household´s vulnerability to FF&LS in three agro-ecological areas in Van Yen district. The HVI_{FLd} and HVI_{FLd} – IPCC and corresponding indicators used in this study are also replicable with necessary modifications for assessing the vulnerability of smallholder farmers in other hazard-prone regions having similar geographic. Each approach provides a detailed description of the determinants that affect the vulnerability of the household. These approaches, however, also reveal their limitations, particularly in terms of subjectivity in the selection of the sub-indicators comprising the index, as well as a lack of precise information on FF&LS. The results of this study point out which key factors affect the capacity of households to adapt to FF&LS, and identify who are likely to be more sensitive and are more exposed to these events. The overall indices show that households in Dai Son commune are the most vulnerable, although there is a slight difference among three communes. However, upon zooming in detail in each principal component, many exciting findings are found.

We particularly found that ethnicity, diversified source of income, and organization membership are the most critical factors influencing the Adaptive Capacity of smallholder rural households in the research areas. We also observed that most families in Dai Son belong to ethnic minority groups (Dao, Tay, Hoa) with a low education level and a high dependency rate. These factors impede people´s ability to receive/absorb information and policies from local authorities and thus weaken their adaptive capacity. Also, their diversity of livelihood income is extremely low due to great dependence on agriculture and forestry. Ensuring income levels of households affected by FF&LS is also a great challenge, thereby leading to intensive exploitation of natural resources of local people in the region.

We also found that participating in social organizations such as the Farmer´s Union, the Women´s Union, Farmer Interest Group, and Agricultural Cooperative not only provides people useful information for agricultural activities but also helps them to have a close connection with the community. Obviously, non-participation in any organizations leads to inefficient social links/networks for local people in the region; for example, it is difficult to receive support from the community. There is evidence that in-kind support (e.g., rice, seeds, livestock or exchanging working day) and spiritual assistance have commonly witnessed in the study areas. In terms of

Sensitivity, health insurance, food security, land tenure document, and water resources are recognized to be the key components in increasing people´s sensitivity under the impacts of FF&LS. We also observed that living without insurance pushes local people to face difficulties in paying for health-related expenses. Since the majority of people in An Thinh commune are Kinh people (the only major ethnic group in Vietnam), who are not eligible for free social insurance under the Government´s policy; hence, An Thinh has the lowest percentage of households with health insurance in the research areas. Meanwhile, the inefficiencies of the irrigation system and the shortage of arable land have left rural households with insufficient food and caused them to become more sensitive to the effects of FF&LS. Abuse of fertilizers and pesticides has also been reported throughout the study area, which not only affects the reduction of soil fertility but also seriously influences people´s health. Besides, water availability is also an important factor since most households are relying upon natural water resources for both daily life and production activities, leading them to become more exposed to health-related diseases and often face water shortages in the dry season (it sometimes happens during the rainy season when the water pipes are buried by rocks). Furthermore, lack of land certificate hinders local people´s access to credit, which in turn leads to food insecurity, consequently increasing people's sensitivity to natural disasters. Land fragmentation was also considered to be a major obstacle in accessing land certificate. Regarding Exposure, housing location as well as arable land, including agricultural and forest land, were found to have a strong relationship in affecting households´ exposure to FF&LS. The favorable location facilitates people in accessing information from a variety of sources, including through the media as well as through village meetings. To sum up, both employed approaches demonstrated that households in Dai Son commune, a highland region characterized by cinnamon growing, are the most vulnerable to the impacts of FF&LS, despite this commune being the least exposed area to these natural hazards. Thanks to its highest adaptive capacity, including the Socio-Demographic Profile, Livelihood Strategy, and Social Network components, An Thinh was found to be the least vulnerable region among the three communes.

To reduce household vulnerability in the research areas, we recommend a wide range of policies that need to be implemented/considered. Firstly, it is necessary to improve people´s literacy by opening free literacy classes. At the same time, the local government should help farmers by organizing vocational classes, such as handicrafts (knitting, sewing, etc.); and by guiding them on how to process agricultural products to reduce their dependence on agricultural production. This would also have a positive impact by improving people´s income, thereby helping them escape poverty. Thirdly, the government may also need to encourage people to use different measures to protect their cultivated lands, such as planting grass strips or making stone embankments alongside

fields, ditches, and rivers. In addition, there is a need to improve drinking water quality by providing clean water sources, building water tanks and conducting water treatment before people use it. We also basically recommends local authorities to facilitate people in the process of issuing land use right certificate through the reduction of related paperwork. Since small and fragmented plots are mentioned as the reason hindering farmers to get the land certificate, policy interventions should also consider reducing fragmentation by promoting exchanging agricultural land plots between households. It is also important to notice that to help farmers reach updated information on FF&LS, upgrading infrastructure, such as public transportations, roads as well as media protocols, is essential. Lastly, supporting policies and considerable financial supports should also be provided to upgrade irrigation systems to ensure sufficient water during the dry season and to protect soil in the rainy season. Since our focus in this research is to find out the livelihoods of local people and to reveal the factors affecting rural household vulnerability to FF&LS, there is a room for future research to pay attention to understanding and analyzing which livelihoods are appropriate and able to help people reduce their vulnerability to these natural disasters.

Appendix A:

Table A1. Key characteristics of the study areas.

Category	An Binh	An Thinh	Dai Son
Total area (km^2)	36.14	26.37	83.75
Location	Middle land	Low land	Highland
Number of villages	8	18	8
Major crops	Cassava	Rice	Cinnamon
Total population (person)	4,142	9,000	3,249
Population density (person/km^2)	115	274	28
Minority ethnic groups	Dao	Tay, Dao	Dao

Source: Field survey, 2016.

Table A2: List of the key components and indicators comprising the HVI_{FL}.

Key components	Indicators	Additional explanation	Assumed funtional relationship
Socio-demographic profile	1. Proportion of dependency	Proportion of people between 0-14 and over 65 years old to the people aged 15 to 64 years old	The higher the dependency ratio, the lower the adaptive capacity
	2. Households headed by a female		The lower the percentage of female-headed households, the higher the adaptive capacity
	3. Average age of households´ head (only for female)		The older the female-headed household, the higher the adaptive capacity

	4. Household heads having no education	Proportion of families that the head of household did not go to school	Education plays a vital role in helping people be more aware and able to adjust to FF&LS
	5. Household heads who are ethnic minorities		Ethnic minority groups have less adaptive capacity than the ethnic majority group
	6. Poor households	Household who have an income of 700,000 VND (around $30) per person per month.	The wealthier the household, the higher the adaptive capacity
Livelihood Strategies	7. Average diversification index of farming	Calculated by adding together the total number of agricultural livelihood activites plus 1 and dividing by 1, e.g., if a household has three different activities such as cultivating crops, raising livestocks and exploits natural resources then the index will be: 1/(3+1) = 0,25	Livelihood diversification strengthens adaptive capacity
	8. Households experiencing jobless during FF&LS season		Having no job reduces people's capacity to adapt
	9. Households who exploite natural resources during FF&LS		Families who exploit natural resources have less adaptive capacity
	10. Households whose a member working in various community	Percentage of households reporting that at least one family member works outside of the community	Job diversification increases adaptive capacity
	11. Households whose incomes mainly from forestry/agricultural activities		The more diverse the income source, the greater the adaptive capacity
Social Network	12. Households without any help/support during FF&LS		Receiving outside help increases a household´s adaptive capacity
	13. Households who did not provide help to any others		Providing help to other people strengthens adaptive capacity
	14. Household head does not belong to any organization		Information and support from organizations increases adaptive capacity

	15. Households who borrow money for lending to others	The ratio of household borrowing to household lending (until now). E.g. If a household borrowed money but did not lend money, the ratio would be 2:1; if a household lent money but did not borrow money, the ratio would be 1:2	The higher the ratio, the more financial stress and less capacity for adaptation
Health	16. Average distance (house to the nearest health center (or hospital))		The longer the distance, the more vulnerable
	17. Households whose at least one member has a chronic illness		Families with chronic illnesses are more sensitive
	18. Households who do not have an insurance card		Families without an insurance card are more sensitive
	19. Households who are not afforable to pay off the costs of health care	Percentage of households who reported they cannot afford the costs related to health care in case of sickness	The less capability of paying for health-related costs, the more sensitive the household
Food	20. Households experiencing insufficient food produced from their farm		Lack of food increases sensitivity
	21. Households experiencing decreased production of food	Percentage of households who reported decreasing crop yields	Reduced crop yields reflects more sensitivity
	22. Crop diversification index	The inverse of (the total number of crops + 1)	Crop diversification decreases sensitivity
	23. Households not raising livestock		Raising livestock may decrease sensitivity
Water	24. Households experiencing problems to access irrigation water		Limited access to irrigation water increases sensitivity
	25. Households experiencing problems to access potable water		The higher the percentage, the higher the sensitivity
	26. Households using water from a natural resource	Proportion of families reporting that they use water from rivers, lakes, or creeks as their primary water source	Households utilizing natural water resources are more sensitive

Housing	27. Households having no Red book	Proportion of families who reported they have no land certificate (Red book)	Land tenure certificatation helps a family to decrease sensitivity
	28. Households having no toilet facility		Households without a toilet facility are more sensitive
	29. Households without stabilized houses	Percentage of households that have an unsolid house, based on the main material of house´s walls, floor and roof	An unstabilized house increases sensitivity
Hazard impacts	30. Households experiencing house lost or property damage caused by FF&LS	Percentage of households reporting that they lost a part of their house or property due to FF&LS	The higher the percentage, the greater the exposure
	31. Households experiencing agricultural land damage casued by FF&LS		The higher the percentage, the greater the exposure
	32. Households who did not receive FF&LS warnings		The higher the percentage, the greater the exposure
	33. Households whose a member becomes ill or injured due to FF&LS		The higher the percentage, the greater the exposure
	34. Households having a recent death casued by FF&LS		The higher the percentage, the greater the exposure
	35. Mean standard deviation of monthly average precipitation (1980-2015)	Standard deviations from the average monthly precipitation between 1980-2015 was averaged for each commune	

Table A3: Actual minimum and maximum indicator values for An Binh, An Thinh, and Dai Son.

Key components	Indicators	Units	An Binh	An Thinh	Dai Son	Maximum value in 3 villages	Minumum value in 3 villages
Socio-demographic profile	1. Proportion of dependency	Ratio	0.39	0.41	0.44	3.00	0
	2. Households headed by a female	Percent	12.99	8.57	6.16	100.00	0
	3. Average age of households´ head (only for female)	1/#years	0.02	0.02	0.02	0.03	0.011
	4. Household heads having no education	Percent	48.05	27.62	45.21	100.00	0
	5. Household heads who are ethnic minorities	Percent	51.97	38.32	95.89	100.00	0
	6. Poor households	Percent	18.83	16.19	47.95	100.00	0
Livelihood Strategies	7. Average diversification index of farming	1/# livelihoods	0.29	0.29	0.27	1.00	0.250
	8. Households experiencing jobless during FF&LS season	Percent	77.92	80.95	95.21	100.00	0
	9. Households who exploite natural resources during FF&LS	Percent	3.90	2.86	0.68	100.00	0
	10. Households whose a member working in various community	Percent	23.38	27.62	12.33	100.00	0
	11. Households whose incomes mainly from forestry/agricultural activities	Percent	68.18	54.29	56.16	100.00	0
Social Network	12. Households without any help/support during FF&LS	Percent	33.12	30.48	33.56	100.00	0
	13. Households who did not provide help to any others	Percent	14.94	11.43	29.45	100.00	0
	14. Household head does not belong to any organization	Percent	50.65	34.29	56.16	100.00	0
	15. Households who borrow money for lending to others	Ratio	0.89	0.81	0.77	2.00	0.5
Health	16. Average distance (house to the nearest health center (or hospital))	Km	4.78	6.65	14.82	38.00	1.000
	17. Households whose at least one member has a chronic illness	Percent	35.06	21.90	26.03	100.00	0
	18. Households who do not have an insurance card	Percent	15.17	31.89	2.50	100.00	0
	19. Households who are not afforable to pay off the costs of health care	Percent	50.45	70.00	42.86	100.00	0
Food	20. Households experiencing insufficient food produced from their farm	Percent	34.42	47.62	33.56	100.00	0

	21. Households experiencing decreased production of food	Percent	61.69	52.38	56.16	100.00	0
	22. Crop diversification index	1/# crops	0.33	0.33	0.40	1.00	0.167
	23. Households not raising livestock	Percent	22.08	15.24	13.01	100.00	0
Water	24. Households experiencing problems to access irrigation water	Percent	29.87	55.24	32.19	100.00	0
	25. Households experiencing problems to access potable water	Percent	20.78	6.67	8.90	100.00	0
	26. Households using water from a natural resource	Percent	74.03	40.00	87.67	100.00	0
Housing	27. Households having no Red book	Percent	43.60	20.46	16.01	100.00	0
	28. Households having no toilet facility	Percent	10.39	7.62	13.70	100.00	0
	29. Households without stabilized houses	Percent	55.19	68.57	63.01	100.00	0
Hazard impacts	30. Households experiencing house lost or property damage caused by FF&LS	Percent	35.71	38.46	21.92	100.00	0
	31. Households experiencing agricultural land damage casued by FF&LS	Percent	89.61	99.05	96.58	100.00	0
	32. Households who did not receive FF&LS warnings	Percent	11.69	2.86	11.64	100.00	0
	33. Households whose a member becomes ill or injured due to FF&LS	Percent	10.39	2.86	1.37	100.00	0
	34. Households having a recent death casued by FF&LS	Percent	1.95	-	0.68	100.00	0
	35. Mean standard deviation of monthly average precipitation (1980-2015)	Millimeters	126.94	114.39	129.07	380	25.9

Source: Field survey, 2016.

Appendix B

Regarding the function of vulnerability, Fellmann (2012) describes exposure as a relation of the nature and exposed level of a system to nontrivial climate changes. Sensitivity, on the other hand, describes the affection level (either positive or negative) caused by the reaction of human in particular environmental conditions. Meanwhile, adaptive capacity indicates the likelihood to having tools or adaptation approaches to prevent potentially adversed impacts.

There is no specific form of the relationship between vulnerability and these three independent endogenous components. However, it follows that increased expose and sensitivity is positively correlated to vulnerability while increased adaptive capacity has negative impacts on vulnerability (Ford and Smit, 2004). In other words, decreasing the system vulnerability requires weakening the sensitivity and improving the adaptive capacity of the related system (Fig. B1) (Fellmann, 2012).

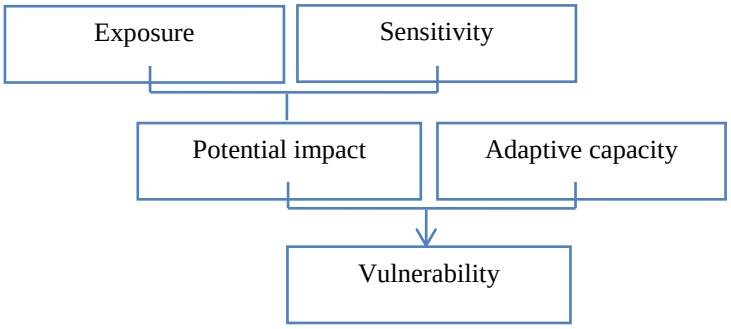

Fig. B1. Vulnerability and its components.

Source: Fellmann (2012).

On the contrary, if the system is less exposed and less sensitive, but has a robust adaptive capacity, it is understood as being less vulnerable (Smit et al., 1999; Smit and Wandel, 2006).

According to Deressa et al. (2009), indicator and econometric approaches are two common analytical methods often employed to assess the levels of household vulnerability to climate change, in which the indicator methods identify main variables that affect vulnerability. In other words, by using multiple techniques (e.g., judgment by experts, analysis of principle component, or correlation analysis with disasters happened in the past) researchers will select key indicators among numerous indicators. This approach, however, is constrained by the researchers´ subjectivity when choosing indicators (Hahn et al,, 2009). Regarding econometric approaches, there are often three principal methods (Hoddinott & Quisumbing, 2003): Vulnerability as Expected Poverty (VEP), Vulnerability as low Expected Utility (VEU) and Vulnerability as uninsured Exposure to Risk (VER). Of these, VEP and VEU are universal to assess individuals' vulnerability, while VER is used to examine loss of welfare because of external shocks. However,

testing different econometric assumptions, such as hypotheses, standard errors and confidence intervals, are highly challenging. In addition, users often use weak or unclear assumptions related to causality which may result in biased indicator selection. As a result, the present study employs an indicator-based vulnerability assessment method, the Household Vulnerability Index (HVI_{FL}), developed by Hahn et al. (2009).

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4. Natural Hazard´s Effect and Farmers´ Perception: Perspectives from Flash Floods and Landslides in Remotely Mountainous Regions of Vietnam

Originally published as: NTT Pham, D Nong, M Garschagen, 2020. Natural Hazard´s Effect and Farmers´ Perception: Perspectives from Flash Floods and Landslides in Remotely Mountainous Regions of Vietnam. Sci. Total Environ. https://doi.org/10.1016/j.scitotenv.2020.142656.

Abstract

Understanding perceptions of indigenous people toward natural disasters is essential in social and environmental research to facilitate further studies in investigating the impacts of the events, as well as in examining the adaptive strategies and having implications for policymakers and relevant institutional bodies. We took this essential feature to study the perceptions of local people toward the two common natural disasters: flash floods and landslides. We selected the case study in three communes (An Binh, An Thinh, and Dai Son) in Van Yen district, Yen Bai province in Vietnam. This is because flash floods and landslides are two frequent natural disasters that highly adversely affect these areas where major poor ethnic minority communities reside. We conducted six Focus Group Discussions (FGDs) and household surveys (405 households) in 2016. The results showed that a decline in productivity, a decrease in income, more hard-working conditions, and an increase in daily expenses were the most observed impacts of these natural disasters in the communes. The analysis also revealed that almost 45% of farmers perceived an increasing trend in the frequency and impacts of flash floods and landslides over the past 15 years. A Multinomial Logit (MNL) model was used to analyze the determinants of farmers´ awareness of flash floods and landslides, which indicated that farmers' perceptions of flash floods and landslides are associated with socio-economic characteristics, such as gender, agricultural experience, ethnic groups, climate information, and household income conditions. We suggested that local governments should pay more attention to strengthen farmers´ awareness to help improve perceptions of local people toward common natural disasters so that they would gain better adaptive capacities and become more sustainable, which are in line with the Sustainable Development Goals.

Keywords: Perception; Flash floods; Landslides; Yen Bai province; Vietnam; Multinomial Logit model.

4.1. Introduction

Natural hazards and extreme weather events triggered by climate change have been threatening agricultural production and food security in many regions around the world (IPCC, 2018). They particularly threaten developing nations, of which a large population heavily relies on agricultural production as primary income sources (Deschenes & Greenstone, 2007; Porter et al., 2014). Agriculture-related households in these regions are becoming increasingly vulnerable due to low adaptive capacities and high exposures to natural disasters (Adger, 2003; Kates, 2000). In addition, being the foremost sustainable source of food and mainly depending on environmental conditions, agriculture is widely recognized to be one of the most affected sectors to climatic hazards in various ways (Das, 2005; Kurukulasuriya & Mendelsohn, 2006). For instance, increasing global warming causes decreased crop yields, increased livestock deaths, outbreak of insect pests, and diseases due to heat stress. Changes in precipitation, on the other hand, lead to increased frequency of droughts and floods, shift in crop growing season, and increase soil erosion resulting from intense rainfall and floods. Besides, increased sea-level causes loss of arable lands and salinization of irrigation water, particularly in the Pacific islands and Southeast Asian countries (FAO, 2015; Mendelsohn, 2008; World Bank, 2017). In such contexts, adaptation measures should be considered thoroughly to increase the resilience and adaptive capacity, to reduce the vulnerability at the farm level, and to secure rural livelihoods (Adger et al., 2009; Gbetibouo, 2009).

Yet, it is important to pinpoint that before individuals respond to climate variability, they in advance need to be aware of changes in the environment that would affect their production activities, livelihoods, and daily activities (Adger et al., 2009; Hasan & Kumar, 2019). Natural hazards not only affect social aspects, but also significantly impact environmental issues, such as soil erosion, landscape, land-use change, and related emissions. Hence, perceptions of local people towards natural hazards are essential to protect and improve the environment and people's social features. That is, people's perceptions will direct their adaptation actions on how they change their cropping patterns, crop variegation, crop management, and soil and plant protection. These actions have impacts on land-use change, landscape, soil quality, carbon release, and many other environmental features. People's living behaviors (changing living habits, moving to other places, or finding non-agricultural and forest-related jobs) against natural hazards due to their perceptions also affect the environment nearby because their impacts on natural resources will change. Consequently, perceptions can be considered to be the root of adaptation strategies, and the decision to undertake adaptation measures is strongly influenced by cognitive factors (Adger & Vincent, 2005; Grothmann & Patt, 2005). As a result, no

appropriate adaptation or maladaptation to moderate the escalating adverse impacts of natural hazards might be resulted from misconceptions about climate trends and variability, as well as induced risks.

Against this background, various studies have used different methods to study farmers´ cognitive processes subject to changes in environmental conditions. In particular, the determinants have been examined across different contexts and regions, for example, in Austria (Mitter et al., 2019), in Australia (Agho et al., 2010), in Bangladesh (Hasan & Kumar, 2019; Hasan & Kumar, 2020), in Pakistan (Abid et al., 2019), in Zimbabwe (Zamasiya et al., 2017), in Thailand and Vietnam (Cullen & Anderson, 2016; Le Dang et al., 2014; Waibel et al., 2018), in China (Pan, 2016); in South Africa (Gandure et al., 2013; Gbetibouo, 2009), in Ethiopia (Deressa, 2009), in Slovenia (Santoro et al., 2019), and in Germany and Zimbabwe (Grothmann & Patt, 2005). By conducting a case study in Punjab-Pakistan, Abid et al. (2019) suggested that local farmers' perception of climate variations is influenced by not only internal but also environmental factors, such as education, land holdings, ownership, cooperation, and geographical location. There is evidence, documented from a case study of an ethnic community in Himalaya, suggesting that gender and age are primary aspects in order to grasp how the local farmers acknowledged their attitudes subject to changes of climate (Scharma et al., 2020). Another exploration, carried out in Nigeria to investigate the climate variability perception among different economic sectors accross the maize-poultry value chaine, advocated that poultry and maize farmers are more likely to perceive changes in climate than feed millers and maize merchants (Liverpool-Tasie et al., 2020). Additionally, a cross-European analysis, deducted by Poortinga et al. (2019), has added political factors in understanding households' perception of changes in climatic events. These studies, however, only focused on understanding people´s perceptions of climate-related events in general, not focusing on particular events caused by climate variabilities, such as flash floods and landslides. These specific natural hazards have been major problems in mountainous regions, particularly in steeply mountainous and highly deforested areas (MONRE, 2017). These natural disasters often happen intensively and quickly destroy agricultural production fields, houses, roads, public facilities, keeping people in these remote areas more isolated to receive external help (Marconi et al., 2011). People in such situations usually experience food shortages, lack of healthcare, and salvage in many days or weeks. Also, many households obviously lose their houses and production fields permanently after flash floods and landslides happened (Pham et al., 2019). Hence, understanding farmers' perceptions of flash floods and landslides obviously becomes one important aspect in environmental research with signficant implications for many highly moutainous areas around the world.

The present analysis applies a quantitative approach to investigate not only how rural farmers in the Northern Mountainous Regions of Vietnam perceive changes in the frequency and impacts of flash floods and landslides but also which socio-economic variables at the household level might potentially explain individual perception process. In addition, by means of focus group discussions (FGDs) and in-depth interviews, this study identifies the major impacts of such natural hazards on the households' livelihoods. In view of the existing literature related to farmers' perception to climate change, which assumed that farmers' demographic profile, farmland characteristics, social networks, institutional attributes, and locational dimension might be highly relevant in understanding individuals' perception, this study further considers additional factors concerning the salient features of the research areas (ethnicity of the households' head and household conditions). Additionally, the topic of rural farmers' perception to such natural hazards (flash floods and landslides) has not yet received adequate attention and investigation globally. The knowledge on this aspect is still limited, as there is scarce empirical research underlying the drivers influencing farmers´ perception of such flash floods and landslides.

The primary objective of this study is, therefore, to fill the gap in the existing literature on exploring variables potentially impacting how rural farmers perceive changes in flash floods and landslides by using the Multinominal Logit model. In other words, this objective has twofold.

- First, we select the base case (or the worst case) that some farmers are not aware of any changes in the frequency and impacts of flash floods and landslides. Then we examine how different factors (explanatory variables) affect other farmers' perceptions that make them select the other options ('increased', 'decreased', or 'remained unchanged') relative to the base case. This would help us explain why local people have some brainstorming about the things happened around them rather than do not know anything so that relevant stakeholders will be able to help improve their perceptions by focusing on enriching the most influenced factors.
- Second, we investigate how factors drive farmers' perception in particular choice categories ('increased', 'decreased', 'remained unchanged', or 'do not know') so that we can understand the dominant factors in each option. Consequently, it would help promote their perceptions by focusing Government`s implementation on these dominant factors, which would result in better directions for future policy strategies to help achieve sustainable development in the society.

We further attempt to draw out to what extent rural farmers have been affected by such natural hazards. Our case study is carried out in one of the most remotely and highly mountainous regions (Van Yen district, Yen Bai province in Vietnam), where many indigenous people reside (Do et al., 2013).

According to the income level statistics, people living in this area have been regarded as extremely poor residents under the Program 135 announced by the Vietnamese Government9, and their livelihoods mainly rely on agricultural production and forest collection. Local people also have low education levels and poor production facilities. Public infrastructures are also not well developed in the region. Yet, flash floods and landslides frequently happen intensively in the area, causing major livelihood problems on these indigenous residents.

The present study is useful in many different aspects, mainly reflecting how indigenous people perceive particular natural hazards frequently happening in their living areas so that local and state governments, as well as non-profit organizations, are able to help to improve their perceptions on how important to understand correctly and comprehensively the impacts of these natural hazards. It is to help not only people living in the study areas but also to assist residents in many other similarly geographic and socio-economic regions. The findings are also useful for designing appropriate policy measures to support farmers in selecting adaptation methods and become more resilient facing future natural hazards. In addition, to our knowledge, the research is the first attempt using econometric models to explore awareness of people regarding flash floods and landslides in Vietnam. Such investigations have significant contributions to elaborate further farmers' adaptive behaviors and protection motivation to climate variability and natural hazards at both national and local levels. Such findings may not only help policymakers have a holistic view of the impact of these disasters on people's livelihood activities but also assist them in identifying factors that need the interventions and supports from local authorities in raising people's awareness. Thus, the findings of our study add to the growing literature on understanding individual cognition and further becoming helpful for designing effective development programs not only in the study areas but also in other regions with similar socio-economic and climate conditions.

The paper is structured in four sections. The material and methods of the research are presented in Section 2. We further discuss the main findings and results in Section 3. The conclusions and potential policy implications are finally provided in Section 4.

[9] http://csdl.ubdt.gov.vn/noidung/vanbandt/SiteAssets/Lists/UBDTVanBanDen/EditForm/yenbai.pdf

4.2. Material and Methods

4.2.1 Study area and household survey

This study was conducted in Van Yen district situated in the North of Yen Bai province in Vietnam (Fig. 1). The province is located between the Northwest – Northeast and Midlands North of the country, which is characterized by rugged mountains rising from East to West and from South to North. Two main rivers are flowing through the province: The Red River and the Chay River (Marconi et al., 2011). In addition, Yen Bai has about 200 canals, small streams, large lakes, and swamps. The province's economy depends mainly on agriculture and forestry, with 79.4% of the labor force working in these sectors. In total, agricultural land makes up nearly 16% of the province's area, while 69% of the land area is classified as forest land (CARE, 2013).

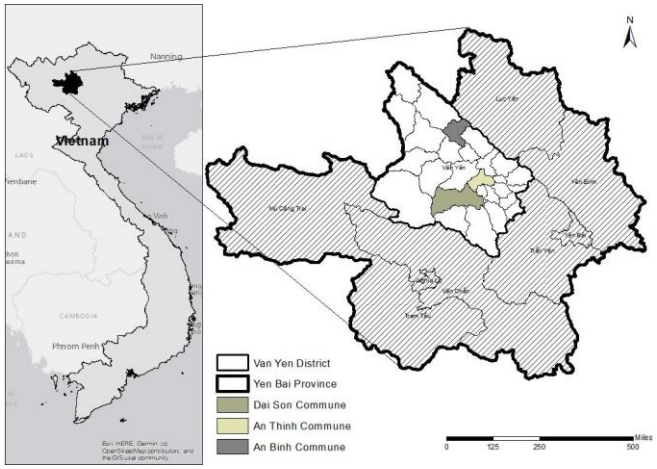

Fig. 4.1. Map of the study areas.

The areas covered by this study include three communes, namely An Binh, An Thinh, and Dai Son in Van Yen district. The district´s terrain is very diverse, with low valley locked between steep mountains. These three communes were selected since they are particularly characterized by (1) geographical zones; (2) flash flood and landslide situations; (3) economic patterns; and (4) ethnic minority groups. Also, the selection of these sites was carried out with the supports from officials in different organizations, such as the Department of Irrigation and Flood Control, the Agricultural Department, and the Statistical Department in Vietnam, as well as local leaders in these communes.

In the selected areas (Table 1), An Binh commune is located in the Northeast of the district. This commune is home to 4142 residents belonging to 'Kinh' (the only one major ethnic group among 54 ethnic groups in Vietnam) and 'Dao' groups. An Binh was established in 1979 when the Government called on people to live and work in the commune (most of them were from Ha Nam (a delta province near Hanoi capital), and only a few were from Lao Cai – another mountainous province nearby). An

Thinh is situated in the middle of the district. The commune has 9000 inhabitants, and most of them belong to 'Tay, Dao, and Kinh' groups. Most of the 'Kinh' people in An Thinh are Catholic. The commune was established in 1980, with 57 households moved from Thac Ba lake (another region in the province). The total population in Dai Son is 3249 people, and they belong to four main ethnic groups: 'Dao' (73,5%), 'Tay, H´Mong, and Kinh'. Dai Son lies nearby An Thinh commune and has 2500 ha cinnamon. There is one cinnamon oil extracting company in Dai Son commune. All these three communes are classified as extremely disadvantaged and poor communes and supported by Program 135 from 2016 to 2020 (Pham et al., 2020).

Table 4.1: Key characteristics of study areas.

Category	An Binh	An Thinh	Dai Son
Total area (km^2)	36.14	26.37	83.75
Location	Middle land	Low land	Highland
Number of villages	8	18	8
Major Crops	Cassava	Rice	Cinnamon
Total population (person)	4142	9000	3249
Population density (person/km^2)	115	274	28
Minority ethnic groups	Dao	Tay, Dao	Dao

Source: Authors' field survey in 2016.

The study used primary data collected from a household survey divided into two stages. In the first period between September and November 2015, we conducted in-depth interviews and focus group discussions in order to figure out the study background and also to determine the specific research areas in Van Yen district. In-depth interviews were undertaken with officials of the Agriculture Department, Departments of Irrigation and Flood Control, Meteorological Center, Statistical Departments in Yen Bai province, and chairmans in surveyed communes. The main focus covered in in-depth interviews were (1) livelihood activities, (2) weather conditions, (3) the situation of flash floods and landslides in recent 15 years, (4) main causes resulting in the occurrence of these natural disasters, and (5) which regions and who are strongly exposed to these natural hazards. In addition, three FGDs were uptaken with local farmers who are in different ranges of age and gender. Each FGD required the participant of a commune's official (a vice chairman of the commune or staff of the local agriculture department) since their presence helps people to be more open-mind in providing/sharing information, as well as to assist interviewers to verify the provided information. These FGDs contain information about agriculture-related production activities of farmers. Such information includes (i)

crop calendar, (ii) challenges of farming activities, (iii) impacts of weather/climate and other factors (e.g., market price and institutional changes) on households' livelihoods, (iv) timeline and magnitude/scale of historical natural hazards, (v) types of natural hazards that local people have been experienced, and (vi) what kinds of measures they have been applying.

Meanwhile, a pre-test of the questionnaire was implemented with five households in each commune. After the pilot survey had been carried out, the questionnaire was revised for the formal household survey in the next fieldwork taken place from February to April 2016. In the second phase of data collection, we interviewed a total of 405 households in the selected communes. The sample structure is presented in Table 2. In addition, the respondents in each commune were selected randomly from the list of households whose livelihoods and production activities impacted by flash floods and landslides, which were reported by local officers. The study does not choose respondents based on the ratio of the total population since the whole region and communes include both groups of people who have experienced and not experienced flash floods and landslides. In other words, the selection of surveyed samples in this study was based on the real affected magnitude of households in the research areas. In contrast, people who did not experience flash floods and landslides would not indicate reasonably or correctly the awareness toward these natural hazards; hence, they are not entirely suitable to answer the research questions and help achieve the research objectives. The collected data encompassed a wide range of variables, including eight sections: (1) household profile and housing, (2) general information about plots and land use, (3) crop production of the household, (4) irrigation, (5) livestock and aquaculture, (6) market, extension, (7) assets/savings/loans/income, (8) the perception regarding the frequency and impacts of flash floods and landslides on agricultural production and their livelihoods, as well as information related to adaptation responses, and social capital (see Annex).

Table 4.2: List of selected villages and samples.

Commune	Village	Samples
An Binh	Khe Trang	50
	Khe Ly	40
	Khe Rong	29
	Hoa Nam	12
	Cau Cao	22
	Total samples in An Binh	153
An Thinh	Goc Nu	37
	Khe Cat	27
	Lang Cau	13
	Cua Ngoi	29
	Total samples in An Thinh	106
Dai Son	Thon 1	45
	Thon 2	31
	Thon 3	34
	Thon 4	36
	Total samples in Dai Son	146
	Sum of the totals	405

The data collected from 405 sample households were entered into a computer following the Excel format and encoded into numeric structures. The input data were then thoroughly examined several times to check whether the existence of erroneous values appeared due to data input mistakes by using the Data Analysis and Statistical Software (STATA) version 14. Descriptive statistics and regression analysis are also critical approaches in this research. The descriptive statistics, including mean, standard deviation, frequency, and percentage, were used to present an overview of field study findings in terms of households´ characteristics, effects of flash floods and landslides on households' livelihoods, and farmers' perception to changes in the frequency and impacts of these natural hazards. The analysis was quantified by employing non-parametric tests, including Kruskal Wallis, Pearson's Chi-squared, and Fisher´s Exact tests. Then, the regression analysis (multinomial logit regression) was applied to investigate the determinants of households' perception of flash floods and landslides.

4.2.2 Empirical model

In general, to analyze the perception of farmers on changes in climatic events, the descriptive method is often used. However, with the goal is to pinpoint the factors determining the perception of farmers; different methods were used in the literature. For example, Tran et al. (2015) identified the awareness

of small-scale farmers subject to climate change and variability in Vietnam by separating them into two groups: Poor and non-poor farmers; then listed the percentage of farmers for each change in climatic indicators based on the following four categories: 'increased', 'decreased', 'no change', and 'do not know'. The farmers´ perceptions were tested by using the Chi-square index to see whether observations between poor and non-poor farmers are statistically significant and are in line with historical climatic data. This method is relatively simple because it does not explicitly indicate the factors affecting small-scale farmers´ perceptions. By classifying farmers based on their farming experience, Maddison (2006) used years of farming experience as a criterion to find out how farmers perceived changes in climate, such as temperature, precipitation, and drought. Afterward, Maddison applied a probit regression method to examine whether the farmers´ perception is sensitive to other factors mostly related to their socio-economic characteristics. The probit or logit regression method was also applied in other studies (Amadou et al., 2015; Gbetibouo, 2009). This method, on the other hand, is limited once the perception of respondents is not a binary outcome. In such a situation, the Multinomial Logit (MNL) model, an extension of logistic regression, is more advanced as it is able to explore potential relationships between the different levels of farmers´ perception and a set of household attributes (Debela et al., 2015). Consequently, the MNL model is used to analyze the determinants of farmers´ perception to flash floods and landslides in the research areas. This model is amongst the most frequently used nominal regression models and has been applied in a number of studies to identify factors affecting farmers´ perception of climate change (Debela et al., 2015; Rosaine, 2014). The MNL model considers the relationship between a nominal dependent variable and a set of independent variables that either binary or continuous variables.

To describe the MNL model, let P denote a random variable or a multinomial observation taking the values $\{1, 2, \dots, i\ (i = 405)\}$ for I (a positive integer) and let x denote a set of explanatory variables. In this case, P denotes the perception options of farmers, m stands for four categories: 'increased', 'decreased', 'no change', and 'do not know', and x includes different households´ attributes. The MNL model can be written as:

$$Pr_{(P_i\ = m|x_i)} = \frac{\exp(x_i \beta m|b)}{\sum_{I=1}^{i} \exp(x_i \beta i|b)} \qquad (1)$$

Where b is a base case, which is also referred to as the comparison group. Suppose that we have four outcomes and fix the model with the alternative fourth as the base category, then the equation (1) can be written as:

$$Pr_{(}\ P_i = m|x_i) = \frac{\exp(x_i \beta m|4)}{\sum_{I=1}^{i} \exp(x_i \beta i|4)} \quad (2)$$

In the MNL model, under which the latent variables depend on covariate values that change across individuals but not across alternatives, an assumption of independent and identically distributed alternatives known as the Independence of Irrelevant Alternatives (IIA) are required (Young et al., 2009). More specifically, it denotes that the probability of perceiving a specific change on flash floods and landslides by a given respondent needs to be independent from the probability of perceiving other changes during these events. From the estimated parameters of the MNL model, the relative higher or lower probabilities compared to the base case are computed by using the exponential function. The following marginal effects are also derived from the MNL estimates to interpret the effects of independent variables on the probabilities (Wooldridge, 2010).

$$\frac{\partial \mathrm{P_i}}{\partial \mathrm{x_k}} = \mathrm{P_i}\left(\beta_{\mathrm{ik}} = \sum_{\mathrm{i=1}}^{\mathrm{i-1}} \mathrm{P_i}\beta_{\mathrm{ik}}\right)$$

The dependent variable (P) in this research includes four categories of farmers´ perception of flash floods and landslides. That is, they perceive that the frequency and impact of flash floods and landslides in the past 15 years (from 2000 to 2015) (1) 'did not change', (2) 'increased', (3) 'decreased' and (4) 'do not know' about it. The explanatory variables (k = 1, 2, …, 12) include a set of twelve farmers´ socio-economic characteristics as described in Section 2.1. It is supposed that the perception model is a function of possible independent variables: (i) the agricultural experience of household head, (ii) male (gender), (iii) ethnic minority group (ethnicity), (iv) levels of education, (v) contact with extension services, (vi) farm size, (vii) distance to market, (viii) farm income, (ix) non-farm income, (x) poor household group (household status), (xi) climate information, and (xii) agro-ecological zone. Then, the perception model can be written as:

$$P_i = \alpha_0 + \sum \beta_j x_{ij} + u_i$$

Where:

i stands for surveyed households (i = 1, 2, 3, …, 405);

α_0 stands for the constant term or intercept;

β_j is the parameters to be estimated;

x_{ij} stands for j farmers´ socio-economic characteristics; and

u_i is the error terms.

The MNL uses the method of Simulated Maximum Likelihood (SML) to estimate the contribution of explanatory variables to farmers´ perception in each category: 'did not change', 'increased', 'decreased' and 'do not know'. The last category 'do not know' was used as the base case. Furthermore, since the estimated coefficients of the MNL model offer only the direction of the effect of the explanatory variables on the dependent variable, the marginal effects (MEs) of the MNL were also reported to know how the response variable affected by a unit change in an independent variable. The model was run by using STATA version 14 (statistical software).

4.2.3 Choice of explanatory variables and hypotheses to be tested

To explore factors influencing farmers´ cognition to changes in frequency and impacts of flash floods and landslides, this study assumes that the perception process is affected by different exogenous variables listed in Table 3. These variables are divided into internal factors (i.e., gender, experience of household head in agriculture, ethnicity, education level, household condition, farm size, farm and non-farm income) and external factors (i.e., contact with extension services, distance to market, climate information, agro-ecological zone), which are specified based on the review of the literature (for example, see Semenza et al., 2007; Deressa et al., 2009; Gbetibouo, 2009; Below et al., 2012; Roco et al., 2015; Debela et al., 2015, Waibel et al., 2018; Zamasiya et al., 2017; Hasan & Kumar., 2019), expert interviews, and own observations during the field study.

Table 4.3: Predictor variables of the perception model.

Variables	Type	Modalities	Expected sign
Internal factors			
Experience in agriculture (years)	C	None	+
Male (gender)	D	1 = male; 0 = female	+
Ethnic minority group (ethnicity)	D	1 = Ethnic minority groups; 0 = 'Kinh' majority group	+
Level of education (degree)	C	1: Illiteracy; 2: Primary school; 3: Secondary school; 4: High school and higher	+
Poor household (household condition)	D	1 = poor household; 0 = non-poor household	+
Farm size (ha)	C	None	+
Farm income (million VND)	C	None	+
Non-farm income (million VND)	C	None	+
External factors			
Contact with extension services	D	0 = No; 1 = Yes	+
Distance to market (km)	C	None	-
Information on climate	D	0 = No; 1 = Yes	+
Agro-ecological zone			
An Binh	D	1 = the farm in An Binh and 0 = otherwise	±
An Thinh	D	1 = the farm in An Thinh and 0 = otherwise	±
Dai Son	D	1 = the farm in Dai Son and 0 = otherwise	±

Note: D: Discontinuous variables; C: Continuous variables

(1) Internal factors:

- Gender (male is defined as a subject '= 1'): With evidence from Uganda, Ghana, and Bangladesh, it is indicated by Jost et al. (2015) that men appear to be more dominant in receiving information on weather alerts and extension services. In general, rural women in mountainous regions are often responsible for childcare, collection of firewood and water – these tasks were described as *light* works – considered to be the main reason leading women to have less access to climate information. Accordingly, it is expected that women are less likely to perceive changes in the frequency and impacts of past flash floods and landslides. Often, they may think the impacts are just similar to the impacts of heavy rains without thinking of more serious events like flash floods and landslides.
- Agricultural experience: Experience in agriculture is determined by the time period (measured in years) that the households´ heads have been working in their agricultural farms. Such experience

becomes important, as they would be familiar with the environment and changes in the working conditions over time that may help farmers predict changes in climate events. It is also evident from the works conducted by Hansen et al. (2004), Gbetibouo (2009), and Silvestri et al. (2012) that farmers with more experience are more likely to perceive temperature changes. Hence, the study hypothesizes that the higher experience of farmers, the higher perception of the frequency and impacts of flash floods and landslides they experience.

- Ethnicity (ethnic minority group is selected as a subject '= 1'): As pointed out by Pham et al. (2010) and Pham et al. (2019), these minority groups often live in remote areas and villages less endowed with infrastructure. Besides, their livelihood activities are greatly dependent on agriculture, which is often heavily affected by flash floods and landslides. These people may, therefore, highly pay attention to the changes of these natural disasters. Hence, this study hypothesizes that if the head of the household belongs to any ethnic minority group, it will be likely to increase the probability of perceiving changes in the frequency and impacts of flash floods and landslides.
- The education level of the household head: Educated farmers would have more capacity to access and understand disseminated information (Marx et al., 2007; Weber, 2010). It is often observed that educated farmers are more likely to notice changes in climate (Gbetibouo, 2009; Huda, 2013). The research, hence, assumes that a higher level of education will positively correlate with perceiving changes in the frequency and impacts of flash floods and landslides.
- Household condition (poor household is defined as a subject '= 1'): This variable identifies household income characteristics: poor and non-poor households, as classified by the Ministry of Labor and Social Affairs of Vietnam. Since the research sites in this study are rural areas, a poor rural household is defined with a monthly income equal to or below 700,000 VND (around $30). It is often observed in the study regions that while wealthier farmers often reside in favorable locations, poor households typically live in remote areas where flash floods and landslides occur frequently. This may lead to the possibility that the poor will be more interested in updating the changes of these natural disasters than the non-poor. Likewise, the present research hypothesizes that there is a positive relationship between poor household and farmers´ cognition about the variations of flash floods and landslides.
- Farm size: A farmer with a large scale farm usually needs to invest more inputs in agricultural production, leading to higher opportunity costs. Hence, they would pay more attention to climate matters, such as rainfall, temperature, flood, drought, etc. It is subsequently assumed in this study that farm size would be positively associated with the perception of farmers toward changes in the frequency and impacts of flash floods and landslides that happened in the region.

- Farm and non-farm income: The influence of farm and non-farm income on the farmers´ awareness on this matter is assumed to be different. Households with more farm activities are hypothesized to be more aware of changes in the frequency and impacts of flash floods and landslides since their livelihoods greatly rely on agriculture. While households with the main income from non-farm activities might not highly pay their attention to climate factors. Thus, farmers with higher farm income are expected to be more likely to perceive changes in the frequency and impacts of flash floods and landslides; meanwhile, an opposite trend is assumed in the case of non-farm income.

(2) External factors

- Availability of extension services[10]: With the aim of promoting agricultural productivity, increasing food security, and improving rural livelihoods, agricultural extension services facilitate farmers' access to knowledge, information, and technologies. Thus, this research hypothesizes that contact with extension services increases the likelihood of perceiving changes in the frequency and impacts of flash floods and landslides.
- Distance to market: Maddison (2006) identified that the market serves as a resource of interchanging information with other farmers. The negative relationship between distance to market and perception of flash floods and landslides is thus hypothesized.
- Climate information: According to Deressa et al. (2009), Maddison (2006), and Nhemachena & Hassan (2008), precise information on climate may help people to uptake the right decision to adapt to changes in climate. It is therefore assumed that access to information on weather and climate will increase the likelihood of observing changes in the events of flash floods and landslides.
- Agro-ecological zone: The characteristics of agro-ecological zones would be significantly different from one to the others. We thus hypothesized that the agro-ecological zone would have a mixed effect on the farmer´s awareness of changes in the frequency and impacts of flash floods and landslides.

4.3. Results and discussions

4.3.1 Farmers´ characteristics

The socio-economic characteristics of surveyed respondents are shown in Table 4. Our household survey results indicated that, on average, the household heads have 26.77 (± 11.93) years of experience

[10] There are some services provided by extension officials (called extension services), such as transfering information and knowledge in organizing and managing agricultural production (seedling, breeding, preventing pests, updating market price and so on), as well as training farmers with new varieties.

in agriculture, which is determined by the period that a household head started working in agricultural fields. In addition, most of the interviewed households are headed by men (about 90% of the total respondents), and 65% of them belong to ethnic minority groups, for example, 'Dao' (Black Dao and White Dao), 'Tay', and 'Hoa'. Approximately 29% of surveyed households are documented in the poor household list. Generally, the education levels of the respondents are low in the research area. Remarkably, there are approximately 42% of illiterate household heads in the whole sample. The average landholding size is 62.35 'Sao'11 (equivalent to 2.32 ha) per household. Besides, family income includes farm and non-farm income, of which farm income was the primary earning source of most surveyed farmers.

The connection between farmers and extension staffs in the research area has not been really focused, indicating by rare visits of the extension officials to households in the last 12 months. Only about 24% of the respondents reported the visitings of officials. In addition, the average distance to the closest commune market was 3.73 km.

Table 4.4: The details of the explanatory variables used in the perception model.

Variables	Type	Mean	Std.D	Min	Max
Internal factors					
Experience in agriculture (years)	C	26.77	11.93	1	66
Male (gender)	D	0.90	0.30	0	1
Ethnic minority group (ethnicity)	D	1.75	0.64	1	3
Poor household (Household condition)	D	116	28.64	0	1
Level of education (degree)	C	1.83	1.33	0	8
Farm size (ha)	C	2.32	2.52	0.012	25.21
Farm income (million VND)	C	55.99	80.55	0	
Non-farm income (million VND)	C	35.06	42.62	0	
External factors					
Contact with extension services (0/1)	D	0.24	0.43	0	1
Distance to market (km)	C	3.74	2.68	0.1	35
Information on climate (0/1)	D	0.91	0.29	0	1

[11] A measurement of agricultural land in Vietnam.

4.3.2 Effects of flash floods and landslides on the livelihood of farmers in the research areas

The severity of natural hazards often results in complex and substantial impacts on the agricultural sectors, especially on marginalized rural population groups (Funk et al., 2020; Singh et al., 2020). Interviewed farmers were asked *In which aspects and to what extend your family's livelihoods have been affected by flash floods and landslides.* With respect to this issue, a number of interviewees, accounting for 95 % of the surveyed farmers, disclosed their rigorous experience in adverse impacts of flash floods and landslides over the past 15 years (Table 5). In particular, it is reported by 93% of all respondents that one of the most observed impacts of these climate-induced hazards is admitted as a critical reason for crop failure and reductions in productivity, which in the long run could lead to food insecurity. Local farmers, in addition, have pointed out the uncertainty in their incomes as an inevitable consequence of such hazards due to reduced output levels, owning by heavy dependence of their incomes on agriculture. Subsequently, there are a majority of surveyed households (97%) claimed decreases in their household incomes in recent years. It is due to the fact that farm income has a major share of the total family income compared to non-farm incomes.

Table 4.5: Effects of flash floods and landslides on farmers in the research areas.

	An Binh	An Thinh	Dai Son	Average	P-value
No effect	1.3%	2.86%	9.59%	4.69%	0.002
Reduce productivity	96.1%	97.09%	86.30%	92.80%	0.001
Lost livestock, aquaculture	33.77%	27.88%	21.23%	27.72%	0.053
Cause diseases in people	37.66%	56.73%	27.40%	38.86%	0.000
Cause diseases in livestock, poultry	50.65%	74.04%	23.97%	47.03%	0.000
Lost land	31.82%	18.27%	43.84%	32.67%	0.000
Reduce income	94.81%	99.04%	96.58%	96.53%	0.210
Cause injury, death	2.6%	2.88%	1.37%	2.23%	0.758
Damage housing, assets	35.71%	38.46%	21.23%	31.19%	0.005
Increase daily expenses	42.21%	53.85%	95.21%	64.36%	0.000
More hardly working conditions	82.47%	79.81%	97.95%	87.38%	0.000

P-values are provided according to Pearson´s chi-squared and Fisher´s exact tests.

Source: Authors' field survey in 2016.

In addition, the local community also declared that they are confronting more obstructive and challenging working conditions (87%) under intensive pressures of flash floods and landslides. For example, since landslides often cause fields to be buried by rocks and soils, and people could not

afford to hire machines due to budget constraints, they had to carry out/clear rocks and stones all by themselves. As such, more labor is required for farming activities than usual. It was recounted by Mr. Truong Van Minh, residing in Khe Khe group – Khe Trang village, An Binh commune, that cinnamon and cassava were grown on 3 ha hilly land heritaged from his parents. However, a catastrophic landslide in 1998 compelled pronounced damages to his cultivated land. The whole cinnamon trees were devastated, leading to a loss of approximately 90 million VND (about US $3,900). In addition, around 0.5 ha of cultivated land has been inoperative afterwards.

The surveyed results also reveal miscellaneous uncertainties translated by flash floods and landslides, such as increased daily expenses (informed by 64% of respondents), causing diseases in livestock and poultry (47%), people (39%), and losing land (33%). On average, there are approximately 5% of total respondent households stating that they were not affected by the negative impacts of flash floods and landslides, in which most of them were living in Dai Son commune. Respondent households in the research areas commonly noted that flash floods and landslides have severe effects on the scale of productive land (stated by 32% of interviewees), that is already restricted due to the steep terrain and inhabitants' pressures since many fields or forest areas had been uncultivated due to buried rocks and soil. Flash floods and landslides are estimated to normally cause damages to infrastructure and limit access to the market. Also, due to these natural hazards, mud, stones, and rocks are often accumulated in the fields that generate even worse and long-term damage than single disasters, such as floods and drought. In this situation, farmers need to invest more labor forces to recover their agricultural land. In many cases, land is no longer suitable for future cultivation. Another story was shared by a household headed woman, Mrs. Ly Thi Lin in ‘Five’ group – Khe Rong village, An Binh commune, that in 2008 her house was swept away due to one of the most striking flash floods she had been witnessed in 40 years in the commune. Due to the event, her house was totally destructed, and all crops in two ‘Sao’ (approximately 0.072 ha) of agricultural land were wiped, costing equivalent to around 100 million VND (approximately US$4,350). Her family was then moved to the current house according to the commune’s support policy.

4.3.3 Farmer´s perception of flash floods and landslides

Farmers were asked to give their observations regarding changes in the frequency and impacts of flash floods and landslides based on their experiences over the past 15 years in their living areas during the focus group discussions and household surveys. Then, farmers´ perceptions of flash floods and landslides in terms of the frequent changes consist of four categories. That is, they perceive that the frequency and impacts of flash floods and landslides over the past 15 years (from 2000 to 2015) (1)

'did not change', (2) 'increased', (3) 'decreased' and (4) 'do not know'. Almost all respondents perceive changes in the frequency and impacts of flash floods (97%) and landslides (93%). It is noticeable that the annual occurrence of flash floods and landslides has been estimated to increase in the past 15 years (from 2000 to 2015) by most of the respondents on average. It is also denoted that local individuals are facing difficulties in predicting/estimating flash floods and landslides due to unstable and abnormal alterations over the past years. For example, in the past, flash floods often occurred from May to August, yet, in recent years, the local community might witness such event in October or in February, as mentioned by Mr. Lich in An Thinh commune. Although changes of these climate-induced hazards have been aware of throughout the research areas, the farmers´ perception of each of these events is profoundly different between Dai Son and the other two communes. While most of the respondents in Dai Son perceived an increased trend of flash floods and landslides (85.62% and 77.40%, correspondingly), a majority of farmers in An Binh and An Thinh communes observed the decreased trend of these weather events (ranges from roughly 40% to 50%). In addition, farmers in Dai Son commune are seen to be more likely to be aware of the changes in flash flood and landslide events. The likely reason might be that Dai Son's community has been exposed and hit more frequently by flash floods and landslides; hence, local people may be more noticed to such events. Also, livelihood activities of respondents in Dai Son have significantly relied on agriculture that is strongly influenced by weather factors and conditions, so they might pay more attention to changes in these natural hazards in order to minimize the negative impacts of flash floods and landslides. About 16% and 20% of total respondent households noticed that there had been no change in the annual frequency and impacts of flash floods and landslides over the last 15 years. They perceive that they have been affected the same over the years in terms of both health conditions as well as physical damages (such as crop failure, damaged houses, and destroyed cultivation fields), and the frequency of such hazards is similar over time. Statistical results, according to the Kruskal-Wallis test, show that perceiving changes in the frequency and impacts of flash floods and landslides is significantly different among the three communes ($P<0.01$).

Table 4.6: Farmer´s perception of flash floods and landslides.

		An Binh	An Thinh	Dai Son	Average	P-value
Flash flood	Did not change	22.08%	19.05%	8.22%	16.30%	0.0001
	Increased	25.97%	30.48%	85.62%	48.64%	
	Decreased	46.10%	49.52%	5.48%	32.35%	
	Do not know	5.84%	0.99%	0.68%	2.72%	
Landslide	Did not change	23.38%	27.62%	10.96%	20%	0.0001
	Increased	27.27%	13.33%	77.40%	41.73%	
	Decreased	40.26%	48.57%	10.27%	31.60%	
	Do not know	9.09%	10.48%	1.37%	6.67%	

P-value is provided according to Kruskal-Wallis test.

Source: Authors' field survey in 2016.

4.3.4 Factors determining the local community's attitudes: Results from the Multinomial Logit regressions

The influences of each households' socio-economic variable on how farmers' awareness of changes in flash floods and landslides are presented in Table 7 and Table 8, derived from Multinomial Logit regressions. The models were tested for multicollinearity by using the variance inflation factor (VIF). In addition, the validity of the independence of the irrelevant alternatives (IIA) assumptions was examined for both the models by using both the Hausman tests and the Small – Hsiao tests. Model test results are provided in Appendix A, which indicate that the Multinomial Logit models are significant ($P<0.01$) and relevant in detecting the farmers' perspectives. The estimated correlations from Table 7 and Table 8 allow us to understand whether predictor factors have a positive or inverse connection with people's attitudes. Besides, marginal effects are also applied in order to further inspect the variation in the probability of a particular choice in the perception of changes in the frequency and impacts of flash floods subject to a unit change in the independent variables. Results of the marginal effects are presented in Table B1 and Table B2 in Appendix B.

Among the 12 independent variables categorizing as internal and external factors hypothesized in the perception models, seven variables were found as significant predictors (at different levels including $P<0.1$, $P<0.05$, and $P<0.01$) influencing the ways local people noticed changes of flash floods and

landslides. These significant explanatory elements consist of (1) agricultural experience, (2) male (gender), (3) ethnic minority group (ethnicity), (4) poor household (household condition), (5) distance to market, (6) information on climate, and (7) agri-ecological zone. On the other hand, the empirical results also specified that education level, farm size, farm income, non-farm income, and contact to extension services are statistically non-significant (greater than 10% confidence level) to farmers' cognitive to these climate-induced hazards in the surveyed regions. Detailed explanations of the regression's results are discussed below.

Table 4.7: Determinants of MNL model for farmers´ perception of flash floods (estimated coefficients and relative risk ratios (RRR)).

Variables	Perception					
	Did not change		Increased		Decreased	
	Coefficient (RRR)	P>|z|	Coefficient (RRR)	P>|z|	Coefficient (RRR)	P>|z|
Internal factors						
Experience in agriculture	0.079 (1.082)*	0.056	0.077 (1.080)*	0.062	0.102 (1.107)**	0.013
Male (gender)	1.701 (5.479)*	0.079	1.224 (3.401)	0.190	1.684 (5.387)*	0.075
Ethnic minority group (ethnicity)	2.290 (9.875)	0.107	2.705 (14.954)*	0.056	2.435 (11.416)*	0.085
Poor household (household condition)	0.124 (1.132)	0.890	-0.327 (0.721)	0.715	-0.246 (0.782)	0.784
Education level	-0.071 (0.931)	0.859	-0.193 (0.824)	0.623	-0.092 (0.912)	0.818
Farmsize in ha	0.373 (1.452)	0.351	0.381 (1.464)	0.337	0.495 (1.640)	0.213
Farm income	0.018 (1.018)	0.476	0.021 (1.021)	0.402	0.020 (1.020)	0.421
Non-farm income	-0.014 (0.986)	0.142	-0.015 (0.985)	0.118	-0.014 (0.986)	0.147
External factors						
Contact extension services	0.627 (1.872)	0.487	0.766 (2.151)	0.393	0.292 (1.339)	0.746
Distance to market	-0.159 (0.853)*	0.098	-0.179 (0.836)*	0.071	-0.142 (0.868)	0.138
Climate information	0.714 (2.042)	0.416	1.506 (4.509)*	0.090	2.181 (8.855)**	0.023
An Thinh	1.321 (3.747)	0.299	1.578 (4.845)	0.213	1.382 (3.983)	0.273
Dai Son	1.622 (5.063)	0.245	4.173 (64.909)***	0.002	0.367 (1.443)	0.797
Constant	-2.491 (0.082)	0.188	-2.540 (0.079)	0.172	-3.976 (0.019)**	0.041

Note: The base case: 'do not know' whether there were changes in the frequency and impacts of flash floods.

Numbers in parentheses are risk relative ratios, which are in the exponential form of the values outside the parentheses.

*, **, *** significant at 10%, 5% and 1%, respectively.

LR chi-square (39) = 202.06 Prob > chi-square = 0.0000

Log likelihood = -347.794 Pseudo R^2 = 0.2251

Source: Authors' own estimation.

Table 4.8: Determinants of MNL model for farmers´ perception of landslides (estimated coefficients and relative risk ratios (RRR)).

Variables	Perception					
	Did not change		Increased		Decreased	
	Coefficient (RRR)	P>|z|	Coefficient (RRR)	P>|z|	Coefficient (RRR)	P>|z|
Internal factors						
Experience in agriculture	0.018 (1.018)	0.423	0.014 (1.014)	0.524	0.039 (1.040)*	0.073
Male (gender)	2.000 (7.389)**	0.016	0.428 (1.534)	0.547	1.187 (3.277)	0.103
Ethnic minority group (ethnicity)	1.389 (4.011)**	0.033	2.010 (7.463)***	0.003	1.910 (6.753)***	0.003
Poor household (household condition)	1.403 (4.067)**	0.037	0.734 (2.083)	0.273	0.800 (2.226)	0.236
Education level	0.249 (1.283)	0.279	-0.022 (0.978)	0.922	0.025 (1.025)	0.912
Farmsize in ha	-0.105 (0.900)	0.372	-0.128 (0.879)	0.192	-0.053 (0.948)	0.590
Farm income	-0.003 (0.997)	0.485	0.002 (1.002)	0.595	0.001 (1.001)	0.798
Non-farm income	-0.007 (0.993)	0.259	-0.007 (0.993)	0.258	-0.002 (0.998)	0.747
External factors						
Contact extension services	0.369 (1.446)	0.500	0.316 (1.372)	0.562	-0.240 (0.787)	0.658
Distance to market	-0.036 (0.965)	0.665	0.023 (1.023)	0.771	0.063 (1.065)	0.413
Climate information	0.685 (1.986)	0.311	1.967 (7.149)***	0.006	3.545 (34.640)***	0.000
An Thinh	-0.442 (0.643)	0.439	-1.380 (0.252)**	0.020	-0.733 (0.480)	0.179
Dai Son	1.126 (3.083)	0.245	3.761 (42.991)***	0.000	0.995 (2.705)	0.304
Constant	-2.181 (0.113)	0.119	-1.778 (0.169)	0.184	-4.493 (0.011)***	0.005

Note: The base case: 'do not know' whether there were changes in the frequency and impact of landslides.

Numbers in parentheses are risk relative ratios, which are in the exponential form of the values outside the parentheses.

*, **, *** significant at 10%, 5% and 1%, respectively.

LR chi-square(39) = 207.90 Prob > chi-square = 0.0000

Log likelihood = -392.81622 Pseudo R^2 = 0.2093

Source: Authors' own estimation.

4.3.4.1 Internal factors

a. Experience in agriculture

Experience in agriculture may be considered as a proxy of farmers' age. In both models, the agricultural experience is positively related to all farmers' attitudes to changes in the frequency and impacts of flash floods and landslides. The regression results show statistically significant associations between experience in agriculture and people' perception of flash flood events in all cases ($P<0.05$ and $P<0.1$) (Table 7); and only in the case local farmers perceived landslide events 'decreased' ($P<0.1$) (Table 8). Hence, it indicates that more experience in agriculture of the household head would bring them a higher probability not only in recognizing changes in the frequency and impacts of flash floods but also in noticing a decreasing trend of landslides. In addition, risk relative ratios' results (Table 7) show that one more year working in agriculture would lead to a higher probability of perceiving the 'did not change', 'increased', and 'decreased' in the frequency and impacts of flash flood events relative to the 'do not know' option by 8.20%, 8.00%, and 10.7%, correspondingly. Besides, a one-year increase in the farming experience is associated with a higher probability of 4.0% in observing the 'decreased' in the frequency and impacts of landslides compared to the 'do not know option' (Table 8). The research findings are in line with the statements given by (Cullen & Anderson., 2016; Liverpool-Tasie et al., 2020), who concluded that rural farmers' observation might be shaped by well-being experiences in livelihood activities of the households. It is further noted that senior farmers, who had a long time devoted to practices in agriculture, would have more knowledge related to climate-induced disasters, leading to their cognitive acumen (Ahmad & Afzal, 2020; Ayal & Leal Filho, 2017; Funatsu et al., 2019; Khan et al., 2020).

b. Male (gender)

As hypothesized, the coefficients of gender variable are positive, which depict that male-headed households had better awareness about changes in the frequency and impacts of flash floods and landslides. The estimated correlations disclose that being a male significantly increases the probability of farmers in perceiving 'did not change' and 'decreased' of flash floods at a 10% significance level, and in recognizing changes of landslide 'did not change' at a 5% significance level. The relative risk ratios from both models display that the probability for male in perceiving the 'did not change' and 'decreased' in the frequency and impacts of flash floods relative to the 'do not know' option is about 4.5 times (= 5.479-1) and four times (= 5.387-1), respectively, higher than for female while it is six times (= 7.389-1) higher for a man than for a woman in the probability of perceiving the 'did not change' option compared to the 'do not know' choice for landslide events. In addition, the values of

marginal effects given in Table B2 (Appendix) show a 16.1 percentage point higher in the probability of a man in noticing the 'did not change' option of landslides compared to a woman. The probable explanation might be that women in the surveyed areas usually take responsibility for children caring and household activities, thus causing them to have less access and connection to information and outside resources than men. Hence, they are not as sensitive as men in realizing changes in such climate-induced disasters. This result is also in accordance with empirical findings from (Ahmad & Afzal, 2020; Huda, 2013; Sharma et al., 2020; Tesfahunegn et al., 2016), who reported that male is more likely to perceive climate stimuli. Likewise, it might be concluded that gender is likely to determine local farmers' attitudes to flash floods and landslides.

c. Ethnic minority group (ethnicity)

Ethnicity presented as a proxy for smallholder farmer's characteristics in remote and mountainous regions of Vietnam. The regression results disclose that the ethnic minority group has a significantly positive correlation with individuals' cognitive of changes in the frequency and impacts of flash floods and landslides. Results of risk relative ratios, besides, provide that the probability of the ethnic minority group in perceiving changes of these natural disasters is much higher than the 'Kinh' people. For example, it is 14 times higher in the probability of the ethnic minority group in noticing changes in flash floods and landslides compared to the 'Kinh' majority group. Marginal effect calculations further point out that being ethnic minority groups would result in a lower probability of 6.2 percentage points than the 'Kinh' people in not perceiving of landslides (Table B2 in Appendix). This finding suggests that ethnic minority groups such as 'Tay', 'Dao' in the study communities tend to be not likely to misperceive changes of flash floods and landslides compared to the 'Kinh' people. It is derived from the fact that ethnic minority groups often live in upland and marginal areas making them become more exposed to the effects of flash floods and landslides. In addition, they often rely their livelihoods more on agricultural and forestry activities, which are climate-driven, than the 'Kinh' people; hence, people in these areas are more likely to observe and notice changes of these natural hazards.

d. Poor household (household condition)

The poor household variable shows a mixed effect on farmers' perception to flash floods and landslides. It has exhibited a negative relation to the farmers' awareness of changes in the frequency and impacts of flash floods (except for the 'did not change' option); however, the coefficients are not significant. On the other hand, the estimated coefficients are positively correlated with the perception of landslides in all cases, yet only significant in perceiving the 'did not change' option at a 5%

significance level. It is further given additional information by the risk relative ratio calculation that a non-poor household might have a less three times (=4.067-1) in the likelihood of perceiving 'did not change' relative to 'do not know' option in changes of landslides. Furthermore, results from the marginal effects suggest that being a poor household results in a higher probability of 12.2 percentage points in perceiving 'did not change' of landslides compared to the non-poor household (Table B2 in Appendix). The result is also supported by previous studies (Ayal & Leal Filho, 2017), which concluded that poorer-farmer might be in a better position to have a sensation of climate variability. The positive and significant correlation can be explained by the fact that most poor households are located in Dai Son commune that is the most vulnerable area in the research site and is heavily affected by landslides (Pham et al., 2020). Furthermore, the local community excessively relies on agriculture, which is under increasing pressure led by negative impacts of landslides, as a primary source of income. Subsequently, we reach a conclusion that farmers who are the poor might be well aware of the effects as well as changes of landslides.

4.3.4.2. External factors

a. Distance to market

As expected, negative estimated coefficients are found between the distance to market variable with farmers' perception of flash floods and landslides in almost all categories (except for the cases of perceiving 'increased' and 'decreased' of landslides). The finding demonstrates that households with favorable distance to market are more likely to enhance the probability of noticing changes in flash floods and landslides. This is attributed by the fact that the market is considered to be a useful information channel for local farmers (Pham et al., 2019). However, the estimated correlation is statistically significant in only the case of perceiving 'did not change' ($P<0.1$) and 'increased' ($P<0.1$) for farmers´ perception related to flash floods. The results of relative risk ratios imply that one kilometer further in the distance to market will result in a lesser probability of perceiving the 'did not change' option and 'increased' option relative to the 'do not know' option for flash flood events by about 0.8%. Indeed, a similar finding was documented with a case study in Bangladesh by (Hasan & Kumar, 2019), who denoted that the more the distance to market, the fewer farmers´ perception of climate stimuli.

b. Climate information

Findings indicate that climate information has a positive relationship with the perception of flash floods and landslides in all categories, which indicates that receiving and keeping weather information updated could bring farmers a precise and sharper cognition regarding upcoming weather irregularities

as well as flash floods and landslides. The regression estimates display that information on climate has a statistically significant positive association with farmers' perception in noticing changes of flash floods at a 10% significance level and of landslides at a 5% significance level. Results of relative risk ratios further point out how different in noticing changes of such natural hazards if farmers are able to access climate information. For example, the probability of noticing the 'decreased' relative to the 'do not know' option in the frequency and impacts of flash floods is about eight times (= 8.855-1) higher for people who get climate information compared to those have no information. A similar statement was reported by (Khan et al., 2020; Roco et al., 2015). It is noted that local communities can access information on weather conditions through different types of social media such as radio, television, or via the village's meeting. It is plausible that available access to weather information might increase individuals' awareness since the more availability and timeliness of climate information, the more farmers' perception of such natural disasters.

c. Agro-ecological zone

The regression results, presented in Table 7 and Table 8 with the estimated coefficient at 1% and 5% significance levels, support the research hypothesis that household location is a pertinent predictor that needs to be investigated in order to comprehend how flash floods and landslides are recognized in the surveyed sites. The results are consistent with previous studies (Khan et al., 2020; Roco et al., 2015), which demonstrated that farmers' awareness often varies across different agro-ecological zones; the present study has shown that local differences have two directions (either positive or negative) significantly impacting people's perception. It is worthy noting that the agro-ecological zone has a positive relationship with farmers' perception of all categories in An Binh and An Thinh, while a negative sign is reported in Dai Son. However, the estimated correlation is positively significant in only the case of noticing 'increased' in the frequency and impacts of both flash floods and landslides in Dai Son commune ($P<0.01$) and negatively significant in the case of noticing 'increased' in changes of landslides in An Thinh commune ($P<0.05$). Such correlations reveal that farmers in An Thinh are less likely to perceive increased changes in landslides, while farmers from Dai Son are more likely to notice increased changes in both these natural hazards. These findings are derived from the fact that An Thinh is located in a flat terrain with more developed infrastructure, where people experience less occurrence of landslides than in the past; thus, the community in these areas might have less notice of an increasing trend in landslides. On the other hand, smallholder farmers in Dai Son (the most hilly and remote area with poor road and facility quality among three researched communes) had been more exposed and undergone impressive influences of flash floods and landslides. Consequently, the

inhabitant in Dai Son is more sensitive to the 'increased' observation of landslides; or in other words, their perception is more proactive regarding these climate-induced hazards.

4.4. Conclusion

Flash floods and landslides are severe natural disasters in many highly mountainous regions around the world, particularly in areas where strong deforestation occurs. In Vietnam, these events mainly happen in the Northern mountainous regions, one of the country´s most impoverished communities. The impacts of flash floods and landslides in this region are pressing issues causing major socio-economic problems, which are even expected to be more severe in the remote areas due to high levels of poverty, poor adaptive capacities and infrastructure, inadequate access to healthcare facilities and technologies, and high dependence on natural resources. Such remote areas challenge the achievements of poverty reduction and require sustainable strategies and assistance to adapt to climate change. However, empirical research on how farmers perceive changes in such climate-induced natural disasters still remains limited in the region.

The study aims to explore to what extent the livelihoods of rural farmers in one of the poorest provinces in the Northern region of Vietnam are affected by flash floods and landslides. Besides, since understanding the perception of local people on natural hazards is significant to advise effective supporting policies in the process of promoting the implementation of adaptation measures, we, therefore, sought to determine the factors influencing farmers´ perception of these natural hazards. The study reveals that an overwhelming majority of farmers recognized the changes in flash floods and landslides and expressed the negative impacts of flash floods and landslides on their livelihood activities. The most recorded damages in the study area include reducing productivity, decreasing income, more hard-working conditions, increasing daily expenses, causing disease in livestock, poultry, and people, and losing land. These consequences subsequently lead to increasing households´ sensitivity and decreasing their adaptive capacity to recover or overcome adverse sequences of natural hazards.

Results from the MNL models suggested that local farmers´ perceptions are shaped by both internal (i.e., experience in agriculture, male (gender), ethnic minority group (ethnicity), and poor household (household condition)) and external factors (i.e., distance to market, climate information, and agri-ecological zone). The study's findings are firmly in line with recent studies (Ahmad & Afzal, 2020; Ayal & Leal Filho, 2017; Funatsu et al., 2019; Khan et al., 2020), emphasizing the influence of farmers' socio-economic, psychological, and geographic characteristics on the perception process of smallholder farmers subject to climate variability. Specifically, we found evidence that having one

more year experience in agriculture would increase the probabilities (8.2%, 8.0%, and 10.7%) of perceiving the 'did not change', 'increased', and 'decreased' options in the frequency and impacts of flash floods compared to the 'do not know' option. Furthermore, a higher probability of 4.0% in recognizing the 'decreased' phenomenon in the frequency and impacts of landslides relative to the 'do not know' option are recorded. In addition, the research detected that being a male would significantly increase households' perception. For example, the probability for a man in perceiving the 'did not change' compared to the 'do not know' option in the frequency and impacts of flash floods and landslides is 4.5 times and 6 times higher than for a woman, respectively.

Interestingly, belonging to an ethnic minority group and being a poor household were witnessed to be significantly and positively associated with the perception of changes in the frequency and impacts of flash floods and landslides, as it is characterized by the socio-economic aspects in the study areas that those people in such areas rely more on agriculture and forest rather than the major group (the 'Kinh' people). The regression results pointed out that the probabilities of smallholder farmers in the ethnic minority groups in noticing the 'increased' and 'decreased' relative to the 'do not know' option in the changes of flash floods and landslides are more or equal 10 times and around 6 times higher than the 'Kinh' majority group, correspondingly. While the way individuals perceived changes of these climate-induced events is significantly and negatively related to the distance to market, it is found to be positively associated with the level of information on climate local farmers may receive. For instance, the likelihood of perceiving the 'did not change' and 'increased' option compared to the choice of 'do not know' in the frequency and impacts of flash floods would be reduced 0.8% for those who live far away from the market one more kilometer. Also, receiving climate information would increase at least 3.5 times in the probability of perceiving changes in both flash flood and landslide events. Meanwhile, level of education, availability of extension services, farm size, farm and non-farm income are found to be insignificantly correlated with the awareness of rural households on flash floods and landslides.

From policy and development strategy perspectives, the findings in this study indicate several important implications to improve the awareness of local people.

- First, building farmers´ capacity should be a priority. To do so, the local Government should encourage farmers to participate in social organizations and join vocational training to keep updating new information, as well as fostering their learning process.
- Second, the awareness of people living in different communes are diverse, and their understanding might not be entirely correct, the local Government should have more officials

to deliver climate information adequately and frequently, or they can increase the contact with local people using different means. Local Government would also need to improve the effectiveness of the extension agency.

- Third, there are still major gaps in understanding the frequency and impacts of flash floods and landslides between different groups of people, such as between male and female, between experienced people and less experienced fellows, and between ethnic groups. Hence, special programs targeting specific groups of people are needed to improve their awareness and balance the overall understanding of people in the region.

This study was, however, constrained/limited by selecting explanatory factors in the perception models as it only covered several aspects affecting people's perceptions to changes of flash floods and landslides. More specific factors related to economic, political, and social changes may also affect their understanding; however, through the survey, FGDs, and discussions with local officials, we realized that these factors had not changed dramatically recently. Hence, these factors might not significantly affect the results of this study. However, it is still acknowledged as limitations at this stage, and we expect to include in future work not only individual household features but also specific economic, political, and social changes in order to improve the estimations.

Appendix A

The perception model´s results are shown in Table 7 (for the perception of flash floods) and Table 8 (for the perception of landslides). The Ordinary Least Square model was fitted, and the model was tested for multicollinearity using the variance inflation factor (VIF). The means of VIF for all variables in both models are 1.31 (range from 1.04 to 1.70), which is less than 10, indicating that multicollinearity is not a problem in these models. These models, in addition, were run and tested for the validity of the independence of the irrelevant alternatives (IIA) assumptions by using both the Hausman tests and the Small – Hsiao tests. Both tests failed to reject the null hypothesis of independence of the flash flood and landslide perception choices, presenting that the MNL specification is appropriate to model farmers´ perception of changes in the frequency and impacts of flash floods and landslides. Furthermore, the Multinomial Logit Regression models are highly significant at 1 percent level (perception model of flash floods: LR chi-square (39) = 202.06; Log-likelihood = -347.79407; P > chi-square = 0.0000; Pseudo R^2 = 0.2251 and perception model of landslides: LR chi-square (39) = 207.90; Log-likelihood = -392.81622; P > chi-square = 0.0000; Pseudo R^2 = 0.2093), suggesting that these models have strongly explanatory powers.

Appendix B

Table B1: Marginal effects from the MNL of perception on flash floods.

Variables	Perception							
	Did not change		Increased		Decreased		Do not know	
	Coefficient	P>|z|	Coefficient	P>|z|	Coefficient	P>|z|	Coefficient	P>|z|
Internal factors								
Experience in agriculture	-0.001	0.652	-0.004	0.153	0.005**	0.024	-0.000	0.359
Male (gender)	0.084	0.461	-0.107	0.280	0.065	0.380	-0.006	0.496
Ethnic minority group (ethnicity)	-0.047	0.386	0.083	0.304	-0.031	0.616	-0.005	0.382
Poor household (Household condition)	0.067	0.258	-0.060	0.460	-0.008	0.905	0.001	0.826
Education level	0.013	0.521	-0.027	0.358	0.014	0.577	0.000	0.710
Farmsize in ha	-0.007	0.629	-0.015	0.291	0.022**	0.029	-0.001	0.473
Farm income	-0.001	0.357	0.000*	0.351	-0.000*	0.995	-0.000	0.367
Non-farm income	-0.000	0.974	-0.000	0.760	0.001	0.766	0.000	0.380
External factors								
Contact extension services	0.000	0.994	0.081	0.248	-0.080	0.125	-0.001	0.559
Distance to market	-0.001	0.899	-0.008	0.582	0.006	0.562	0.000	0.366
Information on weather	-0.179*	0.072	0.039	0.732	0.146**	0.039	-0.006	0.489
An Thinh	-0.028	0.592	0.056	0.468	-0.025	0.658	-0.003	0.433
Dai Son	-0.166***	0.000	0.635***	0.000	-0.464***	0.000	-0.005	0.356

Note: *, **, *** are significant at 10%, 5% and 1% levels, respectively.

Source: Authors' own estimation.

Table B2: Marginal effects from the MNL of perception on landslides.

Variables	Perception							
	Did not change		Increased		Decreased		Do not know	
	Coefficient	P>|z|	Coefficient	P>|z|	Coefficient	P>|z|	Coefficient	P>|z|
Internal factors								
Experience in agriculture	-0.001	0.664	-0.004	0.201	0.005**	0.024	-0.001	0.279
Male (gender)	0.161***	0.001	-0.207**	0.038	0.093	0.228	-0.047	0.329
Ethnic minority group (ethnicity)	-0.078	0.169	0.102	0.254	0.038	0.595	-0.062**	0.010
Poor household (Household condition)	0.122*	0.061	-0.066	0.390	-0.026	0.704	-0.030	0.110
Education level	0.042*	0.059	-0.032	0.278	-0.008	0.765	-0.002	0.805
Farmsize in ha	-0.002	0.880	-0.014	0.290	0.013	0.264	0.004	0.280
Farm income	-0.001	0.119	0.001	0.184	0.000	0.758	-0.000	0.876
Non-farm income	-0.000	0.488	-0.001	0.321	0.001	0.108	0.000	0.343
External factors								
Contact extension services	0.046	0.413	0.071	0.327	-0.110*	0.047	-0.006	0.730
Distance to market	-0.012	0.211	0.001	0.964	0.012	0.246	-0.001	0.749
Information on weather	-0.287**	0.005	0.127	0.188	0.294***	0.000	-0.134*	0.091
An Thinh	0.103	0.124	-0.195**	0.015	0.047	0.472	0.045	0.164
Dai Son	-0.205***	0.000	0.599***	0.000	-0.322***	0.000	-0.073***	0.002

Note: *, **, *** are significant at 10%, 5% and 1% levels, respectively.

Source: Authors' own estimation.

Acknowledgments

We are very grateful to the Vietnam International Education Cooperation Department and the United Nations University in Bonn, Germany for financing the research. We would like to thank Professor Jakob Rhyner for his supports and guidance, Mrs. Trinh Hao and Mrs. Dao Chiem for helping with data collection, and also thank all interviewees for participating in the survey.

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5. Farmers´ Decisions to Adapt to Flash Floods and Landslides in the Northern Mountainous Regions of Vietnam

Originally published as: NTT Pham, D Nong, M Garschagen, 2019. Farmers' decisions to adapt to flash floods and landslides in the Northern Mountainous Regions of Vietnam. J. Environ. Manag. https://doi.org/10.1016/j.jenvman.2019.109672.

Abstract

Understanding household´s decision making in agricultural production to natural hazards is significant for policymakers and extension organizations in supporting farmers to optimize adaptive strategies, there are, however, still limited empirical researches that emphasize the determinants affecting the choice of measures in the process of adaptation. This paper explores the decision-making process of rural households in adapting to flash floods and landslides (FF&LS) by conducting a household survey on 405 purposively selected households in Yen Bai province, one of the poorest mountainous regions in Vietnam. Based on the multi-portfolio framework, the study assumes that farmers have multiple choice of adaptation strategies simultaneously and these adaptation measures are correlative. Multivariate Probit models were used to figure out the household decision making process in adapting to FF&LS. Survey results showed that changing cropping patterns, crop variegation, diversifying types of crop varieties, as well as managing and implementing crop protection (soil and plant) are the primary adaptation measures applied by local farmers. Furthermore, lack of money, inadequate support from local government, shortage of machinery and technical equipment, as well as insufficient knowledge about FF&LS were listed as major constraints in the study area. The MVP analysis indicated that all farmers´ perception, socio-economic, farming features, and institutional conditions strongly influence the farmers' adaptation decisions regarding FF&LS. Future policies may therefore need to consider these major contributing factors with appropriate interventions to facilitate suitable adaptations for local farmers.

Keywords: Adaptation; Flash floods and landslides; Yen Bai province; Vietnam; Livelihood strategy; Multivariate Probit Model.

5.1. Introduction

People´s livelihoods in developing countries are often profoundly affected by natural hazards and extreme weather variability. However, they often recover slowly following hazard events because of a low adaptive capacity resulting from low income and undeveloped infrastructure. Enhancing farmers´ adaptive capacity to natural hazards in agriculture in order to ensure food security is increasingly attracting the attention of scholars. Among different types of natural

disasters, flash floods and landslides (FF&LS) are considered to be the most frequent destructive hazards resulting in high mortality and significant economic losses in both agriculture and urban infrastructure (Salvati et al., 2018). They are also typical events in mountainous areas (Jonkman, 2005). In this regard, adaptation measures are considered one of the most appropriate approaches to reducing rural households´ vulnerability and strengthening their livelihoods in face of the impacts of FF&LS. The IPCC (2001), for example, indicated that the policy decisions on adaption play a crucial role in reducing vulnerability to climate change by improving the self-abilities of rural communities to adjust to climate change, to reduce potential damages, as well as to deal with adverse consequences.

There have also been various multidisciplinary studies carried out to examine the implications of farmers' adaptations to climate variability (Le Dang et al., 2014; Trinh et al., 2018). Adger and Vincent (2005), Below et al. (2012) and Smit and Wandel (2006), for example, found that to clarify the problematic sources of the vulnerability of individuals and to develop suitable adaptation plans, it is necessarily required to improve understanding and approaches of the adaptation processes of farmers. The IPCC (2001) also defined adaptation as changes in natural and human systems to react to realistic and anticipated climatic stimuli or their consequences, which would eventually limit damage or take advantage of beneficial opportunities. In addition, adaptation can be classified as either planned adaptation or as autonomous adaptation. In the agricultural sector, the most common adaptation measures to climate varieties are the use of water or drought-tolerant crop varieties and livestock breeds, modern irrigation systems, crop variegation, integrated farming systems, as well as adjusting cropping calendars (Bradshaw et al., 2004; Deressa et al., 2009; Kurukulasuriya & Mendelsohn, 2006; Nhemachena & Hassan, 2008).

In this context, there are several studies that have been conducted which examine the impact of natural hazards or climate changes, such as droughts, floods and salinity intrusion, on the livelihood of rural households in Vietnam (Kam et al., 2012; McElwee et al., 2010; McKinley et al., 2016; Pham, 2011; UN-VietNam, 2014). These studies used either qualitative or quantitative methods to identify the critical drivers of farmers´ responses to climate change. For example, running a binary logit model and multivariate probit model to examine the determinants of farmers´ adaptive practice to climate change in agricultural production in the Central region of Vietnam, Trinh et al. (2018) pointed out that attendance in climate change training courses and farm size were among the most significant factors in explaining the farmers´ adaptation behavior to changes of climate. However, this study has not yet considered several factors that would influence adaptation, such as farmers´ perceptions of climate change

and also the socio-economic and farming features (ethnicity, households´ wealthy, land ownership, etc.). There are limited knowledge and understanding on how farmers give their priorities and their willingness/propensity in adaptation process to natural disasters. In addition, no empirical research is available that emphasizes the determinants affecting the choice of measures in the process of adaptation to FF&LS in the mountainous context. Also, there is growing awareness of the need for field-based studies to accurately comprehend the adaptation responses to changes in climate at the local level in order to provide useful information for policy making and strengthening households´ adaptation.

Against this background, our primary objective is to identify the main factors that influence the decisions of rural farmers in terms of adaptation to natural disasters, particularly FF&LS. We select our case study in several communes in the remotely mountainous areas in the Northern Mountainous Regions in Vietnam, as these areas usually experience major FF&LS annually. It is noted that FF&LS are two events that usually take place simultaneously in this area. There is no perception by local people that these two events are separated. Therefore, when referring to the adaptation to either FF&LS, people in the study area are always aware that their adaptation measures are for both FF&LS. In other words, these two disasters can be considered to be a single event in the study area. Our hypotheses are that farmers´ adaptive behavior in the region might be determined by their cognition of FF&LS, socio-economic characteristics, farming features, and institutional conditions. We consequently aim at modeling the farmers´ adaptation process by using a Multivariate Probit model. We also assume that farmers have multiple portfolios of adaptation strategies at the same time and these adaptation measures are correlative.

This study is not only important academically but also contains significantly practical implications, as studies of the adaptation strategies of rural farmers subject to FF&LS are scarce, particularly for highly remote mountainous areas. More importantly, the Vietnamese government specifies that study area is an extremely poor region. Most people in the province belong to minority ethnic groups with low incomes, poor education, a lack of clothes, food, clean water and healthcare services, and undeveloped infrastructure. They also mainly rely on farming and forestry for food and livelihoods, which are highly vulnerable to natural hazards. Hence, the findings of this study provide sound references for the governments in Vietnam to understand local households' difficulties and behaviors in order to develop appropriate policies to help them recover quickly and sustainably from future natural hazards. In addition, the method and findings in this study are also appropriate references for other studies or government bodies facing similar economic, social and geographical contexts.

The paper is structured as follows: Section 2 presents how data was collected and the empirical model used. The analyzed results as well as comprehensive discussion are presented in Section 3 whilst the conclusions and policy implications are discussed in Section 4.

5.2. Materials and Methods

5.2.1 Study zone and household survey

Vietnam with its natural conditions and location is one of the countries most frequently and strongly influenced by various kinds of natural hazards, such as flash floods, tornadoes, landslides, tropical storms, and drought (IPCC, 2001; Marconi et al., 2011; World Bank, 2011). Average yearly precipitation in most parts of Vietnam ranges from 1400 mm to 2400 mm. The distribution of rainfall, however, is uneven throughout the year and across regions, with roughly 80 – 90% of the precipitation concentrated in the rainy season, frequently leading of FF&LS (Chaudhry & Ruysschaert, 2008). According to MONRE (2009), over the past 50 years, the average annual temperature has increased by 0.5 Celsius degree; annual precipitation has decreased in the North and increased in the South; and the sea level has risen about 20 cm. Moreover, it is expected that by the end of the 21st Century, the average temperature in Vietnam would increase by 2.3 Celsius degrees; total annual rainfall and precipitation in the rainy season (May – October) would increase whereas dry season´s rainfall (November – April) would decrease; and the sea level may rise about 75 cm compared to the period 1980-99.

Among natural disasters, FF&LS have been particularly threatening to the life and productivity of people who live in remote rural areas, especially in the Northern Mountainous Regions where natural resources are significant sources of livelihood for most people. It is estimated that in ten years (from 2006 to 2016), there were a massive number of FF&LS events happened in the mountainous regions of Vietnam (MONRE, 2017), which resulted in crop losses and destruction of housing and property. In addition, strong FF&LS, with their extremely destructive characteristics, have trapped many rural households in a cycle of poverty (Marconi et al., 2011). In comparison with other areas in the Northern Mountainous Regions, Yen Bai province, which experienced an exceptionally huge number of deaths and injuries, was one of the most devastated areas. In addition, the affected areas in this province often become unreachable for weeks to months because of damaged roads. For example, according to the People´s Committee of Yen Bai (2006), economic losses due to natural disasters were estimated to be between 10 and 50 billion VND per year, equivalent to $0.43–$2.2 million. In 2005, the province experienced five noticeable FF&LS events which caused the deaths of 50 people. Also, the volume of soil eroded was estimated at about 75,000 m^3, while 2,607 ha of seasonal paddy and vegetables fields were flooded, most of which were destroyed (1,200 ha and 1,055

ha respectively). Recently in 2017, there were three consecutive events of FF&LS in Yen Bai province that caused 16 deaths, 16 injuries, and washed away 50 houses.

The Vietnamese government consequently considered it a priority to resolve the issues in the region by implementing various policies and supportive programs in order to reduce poverty and achieve sustainable development. For example, the government set up natural disaster prevention and control committees at different provincial, district and communal levels. In addition, the government also provides in-kind and financial supports to households that suffered severely from natural hazards in order to recover from adverse impacts. For instance, Yen Bai province provided 10 million VND/person (or $430/person) for households who lost family members, and 25 million VND (or $1,090) and 15 kg of rice/person/month for a two-month period for families whose houses were swept away or completely collapsed.

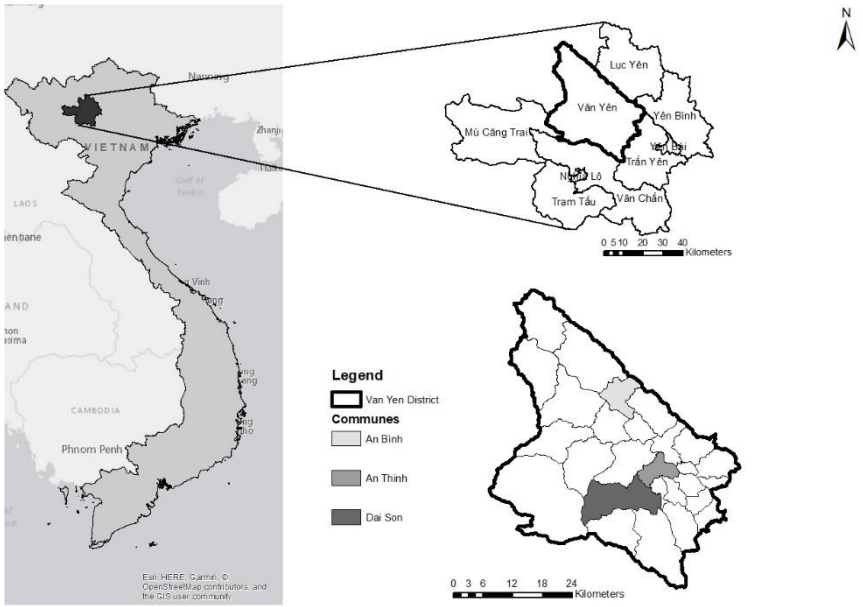

Figure 5.1. Map of the study areas.

The research took place in Van Yen district, Yen Bai province, one of the poorest provinces in the Northern Mountainous Regions of Vietnam (World Bank, 2012). Yen Bai´s per capita GDP in 2017 was estimated at $1,306.08 compared to the national average of $2,389 (GSO, 2017). The district covers 1,391.54 km^2 and comprises of three economic regions: the rice intensification (13 communes), fruit crop (6 communes) and cinnamon areas (8 communes). Among the 26 communes and one town in the district, the study area was made up of three purposively selected communes that are An Binh, An Thinh, and Dai Son (see Figure 1). The selection of these communes was based on preliminary interviews with key informants, such as officials from the Departments of Irrigation and Flood Control, the Agricultural Department and the Statistical Department as well as local leaders in these communes. Each commune is

characterized by a typical crop, for instance, in An Binh this is cassava production whereas in An Thinh and Dai Son it is rice and cinnamon respectively. Primary data were collected by conducting a household survey in two stages. The first stage was implemented from September to November 2015 and the second stage from February to April 2016. During the first stage, in-depth interviews and focus group discussions were carried out in order to capture the research context. At the same time, a pre-test of the questionnaire was also conducted with five households in each commune. After the pre-survey had been carried out, the questionnaire was then revised and a well-structured questionnaire was prepared for the formal household survey. The questionnaire was prepared in English and translated into Vietnamese later because the language used in the survey was Vietnamese.

In the second stage, the survey team included three experienced interviewers based at Thai Nguyen University, Vietnam. Initially three days were spent explaining the primary purpose and objectives of the study. The respondents were chosen based on the impact level of FF&LS on their livelihoods and production activities, which were reported by local officers. Furthermore, only the responses of the household head or main laborer of the household were recorded since they are not only decision makers but also often have better memory related to issues of production activities in their households. The samples included 154 households in An Binh, 105 households in An Thinh and 146 households in Dai Son making a total sample size of 405. The data was collected under nine broad headings, including: (1) household profile: age, education level, ethnicity, household condition, (2) land use: farm size, land ownership, (3) crop production: planted crops, crop varieties, using of plant protection products, fertilizers and pesticides, crop yields, crop prices, (4) irrigation: source of irrigation water, sufficiency of irrigation sources, irrigation fee, (5) livestock and aquaculture: types of livestock, aquaculture, number of livestock currently owned, (6) market, extension, assets/savings/loans/income: distance to market, difficulties in agricultural productions, extension services, household durable goods, credit availability, sources of income, (7) the perception of climate variability: farmers´ perception of rainfall, drought, temperature, flash flood, landslide, (8) adaptation decisions: impacts of FF&LS to agricultural production, adaptation responses, difficulties in adaptation, and (9) social capital: sources of assistance during and after FF&LS. Particularly, the dependent variable was collected by asking the respondents whether they have noticed any changes of FF&LS, what have been the impacts of FF&LS on their agricultural production, and what practices they had taken to adapt to FF&LS. It took approximately 1 to 1.5 hours to interview each respondent.

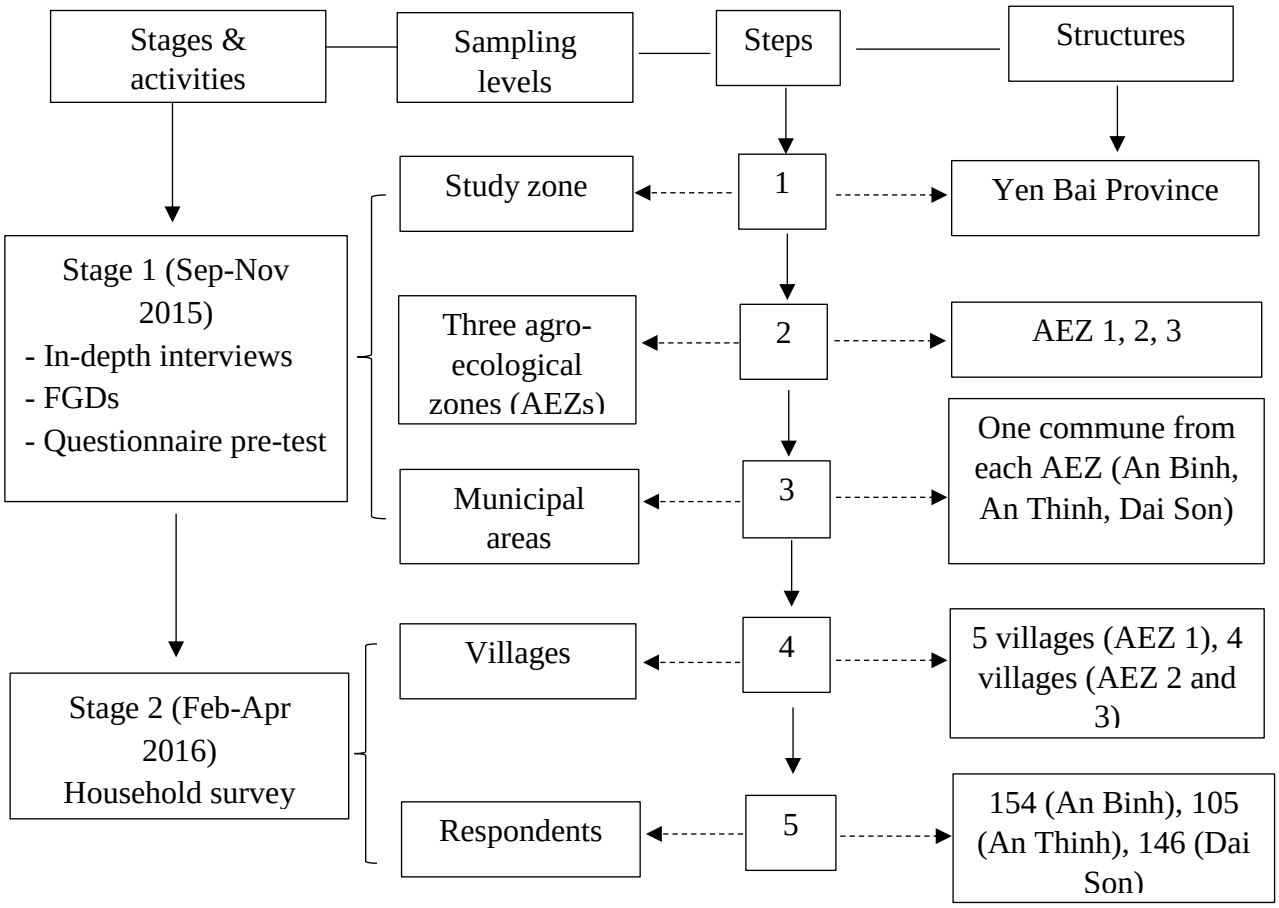

Figure 5.2. Sampling procedure in the study areas.

Note: FGD refers to Focus Group Discussion; AEZ stands for agro-ecological zones.

5.2.2 Theoretical background

In recent years, the discourse of adaptation has attracted attention of researcher and experts in climate change since changes in climate are considered one of the crucial elements that threaten food security and livelihoods. To date, there are a number of different bodies on the adaptation assessment of climate change. Fundamentally, the technology adoption framework and the utility maximization framework are often applied to analyze adoption decisions (Norris & Batie, 1987) and to model farmers´ adaptation to climate change (Waibel et al., 2018). These approaches indicate that an individual will adopt a technology if he/she perceives that the adoption will bring him/her higher utility or net profit. Theoretically, a combination of portfolios is preferable since it results in higher benefit. However, as pointed out by Dhakal (2016), there is always a link between one decision and others in the individual decision-making process in the case of multiple options. Therefore, it will be meaningful to consider the multi-portfolio decision approach in explaining the joint decision problem. In this study, we follow this approach to figure out the determinants affecting decisions of households in adapting to FF&LS.

The socio-economic, demographic, and structural factors have been preoccupated of many researchers in understanding the determinants of household adaptation to new technologies (e.g., irrigation technology) (Koundouri et al., 2006). Among these factors, risk has been recognized as a key element affecting the adoption level of individuals (Jensen, 1982; Just & Zilberman, 1983). In addition, based on an assumption of farmers´ risk aversion, the results by Koundouri et al. (2006) and Saha et al. (1994) indicated that risk and incomplete information play a significant role in farmers´ decisions. It is the fact that risks in practice and the availability of information sources have a direct impact on perceptions of individuals in making adaptive decisions. It is also important to point out that adoption of new technologies is frequently driven by economic profits whereas adaptations to climate change are considered as responses to reduce risks and to minimize potential losses. Both of these adoptions are directly influenced by perception of actual or expected changes. Hence, it is indispensable to link perception of farmers in an adoption model in the context of climate change or natural hazards (Grothmann & Patt, 2005; David Maddison, 2006). In addition, adoption decisions of farmers are assumed to be influenced by land availability (farm size and tenure arrangements), access to credit, and other constraints, such as risk/uncertainty (weather variations), human capital, supply constraints (the availability of complementary inputs) (Feder et al., 1985). In doing so, in this study we aim at modeling the farmers´ adaptations by considering farmers´ perception, socio-economic characteristics, farming features, and institutional conditions as exogenous variables in explaining how farmers adapt or not adapt to natural disasters (i.e., flash floods and landslides).

Most of the households in the research areas have adopted more than one strategy as responses to FF&LS. In fact, however, not all strategies followed by farmers relate directly to FF&LS. There may be some other push or pull factors unrelated to FL&LS which may have driven the farmers to adopt to practices. For example, changing cropping pattern from cassava to cinnamon or acacia could be affected by market factors (increasing price of cinnamon) and by imitation process (the farmers imitate their neighbor in selecting adaptation measures). In other words, this adaptation might be driven by economic profit rather than the impacts of FF&LS. However, these factors might not be significant in the study areas, as the prices of agricultural commodities do not change considerably so that farmers would change their cropping pattern. In addition, cultivating cassava by households in the study areas in the past is one of the key causes leading to increasing risks of landslides in the region. Also, the research areas are severely prone to FF&LS. Therefore, this study assumes that farmers´ adaptation by not only changing cropping pattern but also other practices are driven by FF&LS.

5.2.3 Empirical model

Analytical approaches are often used to analyze adaptation decisions in general and decision-making processes for adaptation to climate change in particular. Of these, the Multinomial Logit (MNL) or the Multinomial Probit (MNP) models are broadly used. In these models, the estimation of the explanatory variables effects on a multi-choice dependent variable is carried out, regardless the need of knowing the order of response categories. The application of both MNL and MNP to explore determinants of farmer adaptation choices due to unfavorable changes in climate has been carried out by many scholars (for example, see Deressa, 2009; Gbetibouo, 2009; Kurukulasuriya & Mendelsohn, 2006; Nhemachena & Hassan, 2008). The main advantages of the MNL are: (1) the simplicity in computation of choice probabilities (Tse, 2006), and (2) the possibility of analyzing decisions across multiple groups, enabling the determination of choice probabilities for different categories (Wooldridge, 2008). Both the MNL and MNP models represent the potential outcomes that indicate adaptation decisions as one joint decision. This means that the issues in explaining how explanatory variables affect the original separated adaptation choices are likely to be found in multinomial replications of a multivariate choice system (Nhemachena & Hassan, 2008). As farmers´ adaptation choices are either substitutive or supplementary of one another, the goal of modeling adaptation strategies to FF&LS in the study is to isolate the effects of exogenous variables on each of the adaptation measures. In such situations, a Seemingly Unrelated Regression (SUR) model is introduced. This model assumes that farmers' responses to FF&LS includes all different adaptation choices. Thus, there might be a correlation between the decision to undertake one given strategy and the adaptation of another option.

Accordingly, in order to overcome the aforementioned issues and to determine the factors influencing farmers´ strategies of particular adaptation measures, the Multivariate Probit regression model (MVP) is employed. The MVP model examines simultaneously the influence of the set of independent variables on each of the different adaptation choices whereas allowing the error terms of unobserved factors to be correlated without constrains (Golob and Regan, 2002; Lin et al., 2005). Such a method has been using widely. For example, Nhemachena and Hassan (2008) employed the MVP model to identify the adaptation schemes to climate variation in farm-level households in Southern Africa. Similar studies were also conducted in the rural Mid-Hills of Nepal (Piya et al., 2013), in Northern Ethiopia (Feleke et al., 2016), and in Northern Benin (Yegbemey et al., 2013). In addition, Piya et al. (2013) highlighted that the MVP model presents one major advantage compared to the MNL model by relaxing the assumption of Independence of the Irrelevant Alternatives (IIA), which is often unrealistic in

numerous cases. The MVP model used in this research is characterized by a set of n binary dependent variables $\mathbf{A_i}$ and contained a set of household characteristics, as shown in (1):

$$\mathbf{A_i} = \boldsymbol{\beta_0} + \sum_{\mathbf{j}} \boldsymbol{\delta_j z_{ij}} + \mathbf{k_i} \quad (1)$$

Where:

$\boldsymbol{\beta_0}, \mathbf{k_i}$ are the intercept and error terms, respectively; $\boldsymbol{\delta_j}$ are the estimated parameters; $\mathbf{z_{ij}}$ stands for j farmers´ perceptions of FF&LS, socio-economic characteristics, farm characteristics, and institutional conditions.

In this research, the adaptation behavior of farmers to FF&LS was modelled by using discrete dependent variables with multiple choices. The farmers were asked to indicate whether they had adapted by means of the following methods:

- Adjusting planting time
- Changing cropping pattern
- Use of different crop varieties
- Farming diversification
- Changing in land use purposes
- Selling properties
- Receiving external supports (the local government/friends/relatives)
- Borrowing financial resources
- Migration
- Income from off-farm jobs
- Using more plant protection products, i.e. chemicals and fertilizers
- Adoption of mulching for soil moisture conservation

Once examining the frequency of aforementioned adaptation measures based on the survey reports, the adaptation strategies are finally categorized into five different groups: changes in cropping pattern, use of different crop varieties, crop variegation, crop management and protection (including soil and plant), and others.

In fact, this research only considers the case of whether a household takes adaptation strategies or not, without considering the intensity/degree of the applications. Since the farmers are only able to provide their opinion about whether or not they implemented these measures without knowing how much or to what degrees they applied these measures. Hence, it is more appropriate to use the binary scale for variables.

Farmers in the research area often choose multiple strategies as a way to adapt to FF&LS rather than relying on a single practice. Therefore, in this study, the MVP model includes five simultaneous models. Each adaptation decision of farmers is a discrete choice form, in which 1 denotes farmers who adopt the practice and 0 if otherwise. Hence, for each adaptation decision, the MVP is specified as follow:

$$\mathbf{A_{ni}} = \begin{cases} 1 \text{ if } \mathbf{A_{ni}} = \boldsymbol{\beta_n} + \sum_{\mathbf{j}} \boldsymbol{\delta_{nj}} \mathbf{z_{ij}} + \mathbf{k_{ni}} > 0 \\ 0 \text{ otherwise} \end{cases} \quad (2)$$

Where:

n is the number of observations (n = 405);

i is the number of adaptation options (i = 5);

β stands for the constant term;

δ is the estimated parameters; and

$\mathbf{k_n}$ are the error terms having multivariate normal distribution.

The MVP model uses the method of Simulated Maximum Likelihood (SML) to estimate the contribution of explanatory variables (household attributes) to farmers´ adaptation decisions.

5.2.4 Selection of explanatory variables and tested hypotheses

The farmers´ decisions to undertake particular adaptation strategies is influenced by numerous exogenous elements. Based on the review of relevant literature on adaptation studies, theoretical behavioral hypotheses, observations during the fieldwork, and data availability, a set of exogenous variables in the model were identified. In this study, the foundational assumption was that adaptation can be influenced by (1) farmers' perceptions of FF&LS, (2) socio-economic characteristics (i.e., age of the leader, ethnicity, literacy, household condition (poor or non-poor household), farm and non-farm income, market availability), (3) farm characteristics (land ownership, farm size), and (4) institutional conditions (irrigation system access, extension service connection, and credit availability). The considered explanatory variables, as well as their expected influences are illustrated in Table 1.

Table 5.1: Descriptions of explanatory variables in the adaptation model.

Variables	Type	Modalities	Expected sign
Farmers´ perceptions			
Perceptions of FF&LS	D	0 = No; 1 = Yes	+
Socio-economic characteristics			
Age (years)	C	_	±
Level of education (degree)	C	_	+
(1: Illiteracy; 2: Primary school; 3: Secondary school; 4: High school and higher)			
Ethnicity	D	0 = No; 1 = Yes	-
Household condition (Poor household)	D	0 = No; 1 = Yes	-
Farm income (log)	C	_	+
Non-farm income (log)	C	_	+
Market availability (km)	C	_	-
Farm characteristics			
Land ownership	D	0 = No; 1 = Yes	+
Farm size (ha)	C	_	±
Institutional conditions			
Irrigation	D	0 = No; 1 = Yes	+
Extension service connection	D	0 = No; 1 = Yes	+
Credit availability	D	0 = No; 1 = Yes	+

Note: D: Discontinuous variables; C: Continuous variables.

(1) Farmers´ perceptions of FF&LS

The perception of farmers is considered an essential precondition to adapt to natural hazards (D Maddison, 2006) as people will have higher chances of undertaking adaptation options if they are aware of changes in climatic conditions. The study, therefore, assumes that the probability of adopting adaptation strategies will be higher if farmers perceive and are aware of FF&LS.

(2) Socio-economic characteristics

- The age of the leader is somewhat linked with the level of farming experience. Studies by Anim (1999), Bekele and Drake (2003), Thacher et al. (1996), and Zhang and Flick (2001) revealed that age does not influence farmers' decisions to take part in reforestation investment, or soil and water management activities. On the other hand, it was found that age of the household head has a negatively significant relationship with the farmers´ decisions to adapt (Anley et al., 2009; Burton et al., 1999; Dolisca et al., 2006; Featherstone & Goodwin, 1993; Gould et al., 1989; Lapar and Pandey, 1999). Bayard et al. (2007), however, indicated that age was significantly and positively related to the adaptation of conservation measures. The present study, therefore, expects that the age of the household head has both positive and negative effects on adaptation practices.

- The literacy influences farmers' access to proper information and promotes the implementation of upgraded technologies in farming practices. According to Adesina and Baidu-Forson (1995), Daberkow and McBride (2003), and Deressa (2009), high levels of education among household heads increases the probability of taking up adaptation measures and adopting new technologies. Furthermore, farmers possessing better academic level are more likely to uptake adaptation choices to climate change (D Maddison, 2006). Hence, this study hypothesized that educated farmers are more probably to adapt to FF&LS.

- Ethnicity of the household head has an effect on adaptation. For instance, it is emphasized by CARE (2013) that Vietnam's ethnic minorities in the Northern mountainous areas are significantly poorer than Vietnam's ethnic majority (the 'Kinh' people). In addition, although there are significant differences in terms of socio-economic characteristics among the 53 ethnic minority groups in Vietnam, a Vietnamese person belonging to an ethnic minority is usually born into poorer conditions rather than a person born into a 'Kinh' family within the same region. Following this statement, ethnic minorities are expected to be less likely to invest in adaptation measures to FF&LS since they are normally poorer than the 'Kinh' people, and often live in remote areas and villages where are less endowed with good infrastructure (Pham et al., 2010).

- Household condition (poor or non-poor household) is another factor affecting adaptation. Based on income criteria, the Vietnamese government defines a poor rural household as one which only has an income equal to or below 700,000 VND (around $30) per person per month. A benchmark of 900,000 VND (around $39) per person per month applies to urban areas. In general, the livelihood resources and options of the poor to respond are typically narrower and more climate-sensitive than the non-poor (African Development Bank

et al., 2003; Hallegatte et al., 2016). This means that higher-income households have a greater ability to carry out adaptation options to climate stimuli. Consequently, this study hypothesizes that wealthier households are more probably to adapt to FF&LS.

- Farm income and non-farm income indicate the diversity of income sources. In general, households with diversified income sources are less vulnerable and more likely to quickly recover from natural hazard-induced shocks than people that subsist on a single source of income. In addition, high income from either farm or non-farm activities is representative of a household's wealth. Shiferaw and Holden (2006) stated that higher-income households are in a better position to adopt new farming technologies. Hence, it is expected that higher income farmers have a higher probability of using adaptation measures to FF&LS.

- Market availability indicates how far farmers can reach places where people come to sell their homemade products and buy necessary commodities. Since markets can be considered to be places for information exchange among farmers, Maddison (2006) pointed out that proximity to markets is one of the significant factors of adaptation. Moreover, with favorable distances to the market, farmers have higher chances to trade products with others by selling their farming products, and buying merchandises, such as fertilizers, new crop varieties, and irrigation facilities as well as to sell their farming products. Thus, it is hypothesized that less the market availability, the less adaptable farmers are to FF&LS.

(3) Farming characteristics

- Land ownership is often represented by a certificate that proves the legal ownership rights of households to the land that they are using. With these rights, farmers can mortgage their land to banks, credit institutions or other farmers in order to borrow money so that they can have additional financial sources to use for production or purchasing new farming technology such as threshers, harvesters, winnowing machines, selective breeding, pesticides, chemical fertilizers, and insecticides. Accordingly, land ownership is assumed to be positively correlated with decision making processes of farmers to adapt to FF&LS.

- In the research areas, farm size is one of the criteria characterized for a households´ wealth. Farm size has been suggested as not an essential factor behind motivating adaptation measures (Anim, 1999). However, it was highlighted that farmers with larger farms are more likely to construct embankments and improved cut-off drains (Anley et al., 2009; Okoye, 1998) while small farms are correlated with soil conservation investment decisions (Nyangena, 2008). Hence, this study assumes that farm size has either a positive or negative effect on undertaking adaptation to FF&LS.

(4) Institutional conditions

- Access to irrigation systems plays a crucial role in agriculture to maintain productivity and production levels so that farmers can earn constant revenues and reduce the risk of food insecurity. An adequate irrigation system allows farmers to increase the number of crops harvested in a year. It is therefore expected that access to irrigation systems is positively related to the uptake of adaptation measures to FF&LS.
- It is well-known that extension services deliver a significant source of information on agricultural production practices and a changing climate. Evidence from various studies (e.g., Adesina & Baidu-Forson, 1995; Maddison, 2006; Nhemachena & Hassan, 2008) indicates that access to extension services increases the likelihood of adopting adaptation measures to climate change. Hence, contact with agricultural extension services is hypothesized to be positively correlated with adaptation choices to FF&LS.
- Increasing the possibilities of access to credits helps farmers to strengthen their farming practices in response to changing climatic conditions. Deressa (2009) showed that access to credit has a significant positive impact on the likelihood of choosing adaptation strategies. Hence, here it is expected that credit availability has positive influences to adaptation options to FF&LS.

5.3. Results and Discussion

5.3.1 Farmers´ characteristics

Table 2 presents the characteristics of respondents in the research areas. It includes information in terms of farmers´ perceptions towards FF&LS, their socio-economic characteristics, farming features, and institutional conditions. The results indicated that nearly half of respondents realized the increasing trend of FF&LS over the past 15 years. In addition, on average, the age of the household heads in the study area was 46.70 (± 10.83) years old with 65% belonging to ethnic minority communities such as Dao, Tay, and Hoa. The level of education, however, was low with 42% of household heads lacking even primary school education. The poor households occupied approximately 29% of the total samples. Most of the households in the study regions listed agriculture as the major income generating activity; hence, farm income contributed to the majority share of their total income. Moreover, the average distance to the nearest market was 3.73 km.

In Vietnam, in order to prove the legal ownership of land, the landowner must have a land certificate called the Red Book. It was observed that 27.5% of the land in the surveyed area was without the Red Book. On average, the farm size was 2.31 ha, and the majority of these lands

can access irrigation systems (64%). On the contrary, only about one-fourth of farmers were in extension service connection while a relatively higher proportion of respondents reported credit availability (64%).

Table 5.2: The details of explanatory variables used in the adaptation model.

Variables	Type	Frequency/Mean	Percentage/Standard deviation
Perceive increasing flash floods	D	199	49.14
Perceive increasing landslides	D	171	42.22
Socio-economic characteristics			
Age (years)	C	46.70	11.6
Level of education (degree)	C	1.99	0.99
Ethnicity	D	260	64.20
Household condition (Poor household)	D	116	28.64
Farm income (million VND)	C	55.99	80.55
Non-farm income (million VND)	C	35.06	42.62
Market availability (km)	C	3.73	2.68
Farm characteristics			
Land ownership	D	293	72.35
Farm size (ha)	C	2.31	2.52
Institutional conditions			
Access to irrigation	D	261	64.44
Extension service connection	D	98	24.20
Credit availability	D	259	63.95

Note: Frequency and Percentage in case of qualitative (dummy) variables; Mean and Standard deviation in case of quantitative (continuous) variables.

5.3.2 Farmers' adaptation strategies to FF&LS and constraints

5.3.2.1 Farmers´ responses to FF&LS

As aforementioned, FF&LS usually happen at the same time in the study area and local people perceive that these two disasters are actually only one disaster. We consequently assume that adaptation practices implemented by households are always for both FF&LS together. In the research regions, various strategies were applied by farmers in order to adapt to and get rid of the negative impacts of FF&LS. The strategies include two main categories: 1) internal farming activities, such as adjusting sowing/planting times, changing cropping and livestock pattern and varieties, diversifying farming, changing land use, selling land/livestock/asset, and 2) external supports, such as assistance from government/relatives or friends, and borrowing financial resources. The adaptation strategies are grouped into five classification depending on the frequency they are used in practices (see Table 3).

Table 5.3: Household adaptation practices in the research regions.

Adaptation practices	Proportion of households used (%)
Changing cropping patterns	37.04
Crop variegation	51.36
Use of different crop varieties	81.23
Crop management and protection (soil and plant)	86.91
Other adaptations	69.88

In the research area, the local farmers use changing cropping patterns as a common adaptation strategy (amounted for 37.04% of the total respondents). For instance, farmers plants acacia and cinnamon on the hills instead of growing cassava to avoid landslides since cassava cultivation was considered to be one of the main reasons resulting in land erosion, thereby increasing the risk of landslides. Another practical advantage of this adaptation strategy is increases in household incomes. Diversifying crops was also another strategy adopted by over half of the respondents (51.36%). In the past, farmers produced rice in two seasons annually; hence, land sometimes are free without planting any trees. Later, during the leisure time after harvesting rice, farmers started growing maize to prevent soil erosion caused by heavy rain. In hilly terrain, cassava was intercropped with cinnamon during the early stages of cinnamon growth. This method increased coverage and reduces water flow to limit soil erosion and leaching, thereby helping farmers keep soil fertility and improve economic value per the same

area unit. In addition, another method that 81% of the respondents widely adopted was short duration and flood tolerant crop varieties. In order to encourage the use of tolerant varieties, local authorities also reduced their price. Furthermore, almost 87% had adopted soil management and plant protection strategies. This is because FF&LS also cause soil degradation and outbreaks of crop pests; hence, to improve soil fertility and limit damages caused by pests, farmers used more protection means for plants like pesticides, fertilizers, as well as adopted mulching technique on their lands. Farmers who had fields adjacent to streams adopted many soil conservation activities, such as construction of embankments, weaving stone baskets and planting bamboo trees to prevent damage from landslides.

5.3.2.2 Challenges for controlling adverse impacts of FF&LS

The terms of *limits* and *barriers* are mostly used interchangeably by researchers in the field of adaptation to climate change (Moser and Ekstrom, 2010). Barriers refer to the interfered conditions, factors or obstacles that weaken the efficiency of adaptation strategies. To overcome the barriers, both individual efforts and social exertion such as cognitive changes, creative management, changing of prioritization, institutions, use of land and resources, etc., should be taken into account. Several barriers to adaptation in agriculture have been reported, such as inadequate information on climate and climate impacts, lack of adaptive capacity, inefficiency extension, institutional inertia, cultural acceptability, and financial constraints (e.g., access to credit, inadequate fertile land, infrastructure, lack of functioning markets, and insurance systems) (IPCC, 2014). Limits, on the other hand, are the conditions or factors making climate change adaptation less effective and difficult to overcome (Adger et al., 2007). The present study, therefore, pinpoints significant barriers to adaptation processes comprising physical and ecological limits, technological limits, financial restrictions, informational and cognitive barriers, and social and cultural barriers.

According to the farmers, the barriers experienced in adapting to FF&LS are: a lack of production means and family labor forces, a limitation of knowledge about FF&LS, difficulties in accessing recent weather information, insufficient or limited support from local government, social and cultural barriers, and limited awareness.

It is noted that inadequate financial resources are claimed as a major constraint to farmers in implementing adaptation strategies (73% of total respondents as shown in Table 4). Bryan et al. (2009) also stated that a lack of adequate credit facilities causing financial barriers was one of the most critical hindrances that obstructs the implementation of appropriate climate adaptation choices. People in the research area did not have adequate money to purchase farm inputs, such as hybrid seeds, fertilizers, pesticides, and farm implements. House repair and

clearing rocks in the field or on the hills were also not carried out in time due to budget constraints. About 64% of the total interviewed households stated that they do not have machinery and equipment to support them in agricultural production, for example, tractors and ploughs. Therefore, they often had to hire these machines. As a result, in these three communes, there are numerous fallow fields and hills because people have no money or machinery to overcome the impacts of FF&LS.

As indicated by Antwi-agyei et al. (2013), access to appropriate climatic information is a useful tool that can be used to improve the implementation of adaptation measures by households. Inappropriate climate information could be critical for food security (Antwi-agyei et al., 2013) and decreases successful implementation of adaptation technologies or limits adequate adaptation to climate change (Adger et al., 2009). The results from the household survey pointed out that a limitation of general knowledge about FF&LS and inadequate weather information was perceived as barriers for adaptation in the three communes (52% and 37% of respondents, respectively).

Inadequate support from local government bodies was another constraint suggested by 43% of the respondents. Davies (1996) defined institution as the social links which connect stakeholders to reach various capital sources with the means of enforcing power could determine the sources of information in which they pass on the route to positive or negative adaptation. Institutions not only play an essential role in improving the capacity of local municipalities to cope with climate variability (Agrawal and Perrin, 2008), but also are a key to eliminating obstacles to climate adaptation (Biesbroek et al., 2013). To facilitate scientific applications in farming activities that include the implementation of innovative farming methods, extension officers are considered to be the connecting link between the scientific community and farmers. However, the results from field surveys indicated that extension activities in these communes were not efficient because of two main reasons. The first reason is that most of the extension officers are young and do not have much work experience. The other reason is that they do not have a high responsibility in their job (they did not go directly to farmers' homes to disseminate knowledge). Most interviewed households answered that there was no visit of extension staff to their home in the last year (in 2015). Besides, the local government also provided financial support for households who are vulnerable to landslides to move to safer places. However, each household received only around 15 million VND (around $650) which was not enough to pay the total costs of moving. As a result, despite recognizing their dangerous situations some households remained put and imperiled their lives due to financial constraints.

Culture is an essential element to understanding the causes and meaning behind people's responses to climate change. Furthermore, different cultural groups will act differently to the severe impacts of climate change, even within the same geographical region (Adger et al., 2013). The survey results indicated that 61% of respondents are from minority ethnic groups, and 40% of them did not even go to school; social and cultural barriers are therefore considered to be one of their constraints in adopting adaptation strategies to deal with the adverse impacts of FF&LS. About 36% of interviewed households reported a shortage of labor in their family, and 19% of them did not know what to do to cope with these weather-related events.

Table 5.4: Farmers' difficulties in coping with and preventing FF&LS.

	An Binh	An Thinh	Dai Son	Average	P-value
	(1)	(2)	(3)	(4)	(5)
Lack of weather information	40.91%	36.19%	34.25%	37.28%	0.473
Lack of money	77.92%	58.10%	79.45%	73.33%	0.000
Lack of local government supports	40.26%	48.57%	40.41%	42.47%	0.339
Social and cultural barriers	16.23%	9.52%	45.21%	24.94%	0.000
Lack of knowledge about FF&LS	47.40%	46.67%	58.90%	51.36%	0.074
Lack of machinery and technical equipment	53.90%	46.67%	86.99%	63.95%	0.000
Shortage of labor in family	37.91%	23.81%	42.77%	35.89%	0.008
Do not know what to do	16.23%	28.57%	13.70%	18.52%	0.007

P-value calculated from Pearson´s chi-squared test

Source: Our field survey, 2016.

5.3.3.3 Multivariate Probit adaptation models

Heteroscedasticity and multicollinearity are two common problems occurring in econometric analysis with cross-sectional data. Multicollinearity possibly diminishes the accuracy of the estimated parameters. The Variance Inflation Factor (VIF), therefore, needs to be defined and used to unveil the possible multicollinearity among the independent variables (Hair et al., 2014). The means of VIF for all variables in both models are 1.24 (range from 1.02 to 1.50) (less than 10) indicating that multicollinearity is not a problem in these models. Also, we estimated a robust variance estimator based on a variable list of equation-level scores and a covariance matrix to solve the possibilities of heteroscedasticity in these models. The adaptation models´ results show that:

1) The Multivariate Probit Model is highly significant (Wald chi2 (65) = 157.66; Log likelihood = -1039.4316; P > chi2 = 0.000 for the flash flood adaptation model (in the case of including farmers' perceptions of flash floods) and Wald chi2 (65) = 160.38; Log likelihood = -1037.4472; P > chi2 = 0.000 for the landslide adaptation model (in the case of including farmers' perceptions of flash floods).

2) The Chi-square results of Likelihood ratio test are statistically significant at 1% (Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0; chi2(10) = 49.61; Prob > chi2 = 0.000 for the flash flood adaptation model and the likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0; chi2(10) = 50.25; Prob > chi2 = 0.000 for the landslide adaptation model) implying the correlation of the equations in the models. Such results also indicate that the adaptation models used in this study have a strong explanatory power.

Table 5.5: Covariance of the error terms.

Rho	Flash flood adaptation model			Landslide adaptation model		
	Coefficient	Std. Err	P>z	Coefficient	Std. Err	P>z
rho21	0.247***	0.078	0.002	0.246***	0.078	0.002
rho31	0.133	0.093	0.150	0.131**	0.092	0.155
rho41	-0.295***	0.098	0.003	-0.302**	0.098	0.002
rho51	0.256***	0.080	0.001	0.267***	0.080	0.001
rho32	0.082	0.092	0.373	0.084	0.092	0.362
rho42	-0.106	0.105	0.314	-0.102	0.105	0.331
rho52	0.145*	0.080	0.069	0.134**	0.081	0.097
rho43	0.233**	0.110	0.034	0.221**	0.110	0.045
rho53	0.097	0.089	0.274	0.095	0.089	0.287
rho54	-0.039	0.095	0.686	-0.047	0.094	0.615

Likelihood ratio test of: rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0.

Note: *; **; *** indicate significance at 10%, 5% and 1%, respectively.

The results from the Multivariate Probit Regression models (Table 6 and table 7) indicate that (1) farmers´ perceptions of flash floods, (2) farmers´ perceptions of landslides, (3) age of the leader, (4) literacy, (5) ethnicity, (6) household condition, (7) land ownership, (8) farm size, (9) irrigation, (10) extension service connection, (11) market availability, and (12) farm income are

the main factors influencing in farmers´ adaptation decisions. Some of these variables are significant at different significance levels for one adaptation measure (e.g., (3), (4), (6), (7), (10), (11), or more than one adaptation choices (e.g., (1), (2), (5), (8), (9), (12)), whereas some (e.g., non-farm income, access to credit) are not statistically significant.

Farmers´ perceptions

Farmers´ perceptions of FF&LS are found to be negative and significant correlated to changing crop patterns but positive and significant relationships in the cases of diversifying crops, soil management and plant protection. As a consequence, farmers who observe increasing trends of FF&LS are more likely to adapt by means of crop variegation, crop management and protection (soil and plant), while, unexpectedly, farmers who do not notice increasing trends are more likely to adapt by changing cropping patterns. The reasoning behind this is that changes in cropping patterns, for example, from cassava to cinnamon or acacia, may not come from the perception of increased likelihood resulting in FF&LS; but actually derives from the economic benefits of other crops.

Table 5.6: Multivariate probit model of determinants of farmers´ adaptation choices (including perception on flash floods).

Explanatory variables	Changing in crop pattern		Crop variegation		Changing in crop varieties		Crop management and protection (soil and plant)		Others	
	Coefficient	*P>z*	*Coefficient*	*P>z*	*Coefficient*	*P>z*	*Coefficient*	*P>z*	*Coefficient*	*P>z*
Flash flood perception	-0.34**(0.14)	0.018	0.24*(0.14)	0.078	0.04(0.16)	0.821	0.83***(0.19)	0.000	0.08(0.14)	0.564
Socio-economic characteristics										
Age of the leader	0.10(0.15)	0.516	-0.39***(0.15)	0.009	0.14(0.17)	0.415	-0.01(0.19)	0.976	-0.03(0.15)	0.827
Education	-0.16**(0.08)	0.047	-0.01(0.08)	0.852	0.02(0.09)	0.861	0.10(0.10)	0.354	-0.06(0.08)	0.458
Ethnicity	-0.35**(0.16)	0.036	0.20(0.16)	0.233	-0.42**(0.19)	0.038	0.24(0.21)	0.254	-0.12(0.17)	0.445
Household condition	-0.30*(0.17)	0.071	0.09(0.16)	0.573	0.14(0.18)	0.441	-0.19(0.21)	0.362	0.04(0.16)	0.790
Farm income	0.13*(0.07)	0.055	0.25***(0.07)	0.000	0.13*(0.07)	0.080	-0.03(0.09)	0.711	-0.03(0.06)	0.595
Non-farm income	0.04(0.04)	0.376	0.01(0.04)	0.849	0.05(0.05)	0.289	0.04(0.05)	0.404	-0.02(0.04)	0.659
Market availability	0.00(0.03)	0.989	-0.10***(0.03)	0.006	0.02(0.03)	0.497	-0.00(0.03)	0.897	0.03(0.03)	0.292
Farming characteristics										
Land ownership	0.07(0.17)	0.658	0.39**(0.17)	0.020	0.00(0.19)	0.982	0.01(0.21)	0.953	0.05(0.17)	0.756
Farm size	-0.06*(0.03)	0.059	0.02(0.03)	0.470	-0.01(0.03)	0.822	0.08*(0.06)	0.085	-0.03(0.03)	0.344
Institutional conditions										
Irrigation	0.29**(0.14)	0.044	0.17(0.14)	0.221	-0.07(0.16)	0.674	0.13(0.18)	0.461	0.30**(0.14)	0.035
Extension service connection	-0.05(0.15)	0.748	-0.29*(0.15)	0.062	-0.19(0.17)	0.256	-0.30(0.19)	0.112	-0.17(0.15)	0.274
Access to credit	-0.13(0.14)	0.378	-0.12(0.43)	0.414	0.15(0.18)	0.335	0.27(0.18)	0.135	0.13(0.14)	0.364
Constant	-0.87(1.29)	0.500	1.98(1.27)	0.119	-0.58(1.40)	0.683	0.25(1.62)	0.878	0.75(1.27)	0.553
Model summary						/atrho	Coef.	Std.E	P>z	
Log likelihood = -1043.9229						/atrho21	0.252***	0.083	0.002	
Wald chi2 (65) = 151.78						/atrho31	0.133	0.094	0.155	
Prob > chi2 = 0.000						/atrho41	-0.304***	0.107	0.004	
						/atrho51	0.262***	0.085	0.002	
						/atrho32	0.082	0.092	0.375	
						/atrho42	-0.106	0.106	0.317	
						/atrho52	0.146*	0.081	0.073	
						/atrho43	0.237**	0.116	0.041	
						/atrho53	0.097	0.089	0.277	
						/atrho54	-0.039	0.096	0.686	

Note: The values in the brackets are Standard Errors; *, **, *** are significant at 10%, 5% and 1%, respectively.

Table 5.7: Multivariate probit model of determinants of farmers´ adaptation choices (including perception on landslides).

Explanatory variables	Changing in crop pattern		Crop variegation		Changing in crop varieties		Soil management and plant protection		Others	
	Coefficient	*P>z*	*Coefficient*	*P>z*	*Coefficient*	*P>z*	*Coefficient*	*P>z*	*Coefficient*	*P>z*
Landslide perception	-0.39***(0.14)	0.006	0.27*(0.14)	0.054	0.01(0.16)	0.898	0.76***(0.21)	0.000	0.20(0.14)	0.147
Socio-economic characteristics										
Age of the leader	0.11(0.15)	0.460	-0.42***(0.15)	0.006	0.13(0.17)	0.421	-0.05(0.18)	0.794	-0.04(0.15)	0.809
Education	-0.16*(0.08)	0.050	-0.01(0.08)	0.855	0.02(0.09)	0.868	0.08(0.10)	0.354	-0.05(0.08)	0.470
Ethnicity	-0.34**(0.16)	0.043	0.19(0.17)	0.237	-0.41**(0.20)	0.040	0.22(0.21)	0.299	-0.17(0.17)	0.358
Household condition	-0.29*(0.16)	0.080	0.07(0.16)	0.599	0.13(0.18)	0.438	-0.16(0.21)	0.394	0.02(0.16)	0.881
Farm income	0.13*(0.07)	0.066	0.27***(0.07)	0.000	0.14*(0.07)	0.078	-0.03(0.09)	0.891	-0.02(0.07)	0.554
Non-farm income	0.03(0.04)	0.431	0.01(0.04)	0.799	0.05(0.05)	0.281	0.05(0.05)	0.367	-0.02(0.04)	0.711
Market availability	0.00(0.03)	0.947	-0.10***(0.04)	0.004	0.03(0.03)	0.504	-0.01(0.03)	0.733	0.04(0.03)	0.241
Farming characteristics										
Land ownership	0.05(0.17)	0.785	0.43**(0.17)	0.014	0.02(0.19)	0.995	0.09(0.21)	0.748	0.08(0.17)	0.735
Farm size	-0.06*(0.03)	0.076	0.01(0.03)	0.506	-0.01(0.03)	0.822	0.10(0.06)	0.146	-0.04(0.03)	0.315
Institutional conditions										
Irrigation	0.30**(0.14)	0.042	0.18(0.14)	0.240	-0.06(0.16)	0.671	0.11(0.18)	0.451	0.30**(0.14)	0.041
Extension service connection	-0.05(0.15)	0.744	-0.29*(0.15)	0.056	-0.20(0.17)	0.254	-0.30*(0.19)	0.095	-0.18(0.15)	0.263
Access to credit	-0.11(0.17)	0.434	-0.12(0.17)	0.348	0.15(0.18)	0.336	0.20(0.21)	0.209	0.12(0.17)	0.407
Constant	-1.24(1.23)	0.456	2.66*(1.24)	0.095	-0.41(1.35)	0.693	0.56(1.53)	0.707	0.85(1.21)	0.548
Model summary						/atrho	Coef.	Std.E	P>z	
Log likelihood = -1042.8049						/atrho21	0.251***	0.083	0.003	
Wald chi2 (65) = 152.86						/atrho31	0.132**	0.094	0.160	
Prob > chi2 = 0.000						/atrho41	-0.311**	0.108	0.004	
						/atrho51	0.273***	0.086	0.001	
						/atrho32	0.085	0.093	0.364	
						/atrho42	-0.102	0.106	0.335	
						/atrho52	0.134**	0.082	0.101	
						/atrho43	0.225*	0.116	0.052	
						/atrho53	0.095	0.090	0.290	
						/atrho54	-0.048	0.095	0.616	

Note: The values in the brackets are Standard Errors; *, **, *** are significant at 10%, 5% and 1%, respectively.

Socio-economic characteristics

The age of the household head which characterizes for farmers´ experience has a negative relationship with the likelihood of choosing crop variegation, crop management and protection (soil and plant), and other strategies, as reactions to FF&LS. Furthermore, the relationship between the age of the household head and adaptation choices is only statistically significant in the case of selecting crop variegation ($P<0.01$). The correlation, however, is positive but non-significant with changing crop patterns and changing crop varieties ($P>0.1$). The result indicates that old household heads are less likely to diversify their farming, change their soil management, plant protection measures, and other strategies. The reason behind this fact is that most old household heads are illiterate and belong to the 'Dao' people; they therefore still cultivate as they have done in the past, as well as not implementing other adaptation responses, such as migration, borrowing money or finding off-farm jobs, etc. The level of education is negatively and significantly ($P<0.05$) correlated with farmers´ decisions to change cropping patterns. The direction of influence, however, is found to be positive but non-significant with changing crop varieties, soil management and plant protection. It means that less educated farmers tend to change the different types of crop models, as they often cannot decide by themselves which crops are suitable for their household resources (e.g., labor force, land, finance, etc.); they just follow their neighbors in selecting plants.

Ethnicity has mixed effects on farmers´ adaptation choices to FF&LS. It correlated negatively and significantly with changes in cropping patterns and crop varieties at a 5% significance level. Nevertheless, belonging to an ethnic minority is positively and non-significantly correlated with crop variegation, crop management and protection (soil and plant) ($P>0.1$). The negative sign on changing cropping patterns and crop varieties indicates that farmers belonging to the 'Kinh' majority group would choose these adaptation measures as reactions to FF&LS. On the other hand, minority groups are more likely to adapt by means of crop variegation, crop management and protection (soil and plant). Household condition is negatively and significantly associated with changing cropping patterns ($P<0.1$). The correlation of household condition, however, is positive but non-significant with the rest of the adaptation choices, except soil management and plant protection (negative relationship). This result also highlights that household condition only determines farmers´ decisions to adopt different cropping pattern strategies. Indeed, wealthier households commonly own more land and financial capital that facilitates their adaptation choices in terms of changing crop models.

Farm income, as hypothesized, has a positive relationship with the likelihood of choosing to change cropping pattern, crop variegation, and changing crop varieties at 10%, 1%, and 10% significance levels, respectively. Wealthier households have the financial resources to invest in

new crop varieties, which are usually more expensive than the old varieties; they are also able to use more labor and spend more money diversifying farming. The results from the MVP models, in contrast, indicated that farmers´ choices of adaptation strategies could not be explained by non-farm income (P>0.1). The household survey indicated that between two groups (poor and non-poor households), the poor households have a larger share of non-farm income in the total household income. This is because the poor often have more dependent members and less farmland compared to non-poor households. As a result, they must earn income from non-farming activities, such as collecting and selling cinnamon for traders, and peeling cinnamon bark. In addition, in most of the cases, the poor are less educated than the non-poor households, they therefore just imitate others in selecting adaptation choices. These may be the main reasons why non-farming income does not affect decision making processes to adapt to FF&LS.

The market availability is negatively and significantly (P<0.05) correlated with changes in crop variegation. In other words, the closer the market is, the more favorable it will be for farmers to diversify crops since market access could help farmers buy fertilizer, pesticides, and get more information on agricultural activities.

Farming characteristics

As expected, land ownership has a positive correlation with all adaptation measures. However, the relationship is only significant in the case of crop variegation (P<0.05). It indicates the fact that if farmers have full legal rights to their land, they are more likely to diversify their farming system. On other words, to motivate farmer to actively invest in agriculture, government needs to secure their property rights (Kokoye et al., 2013). Farm size is positively and significantly (at 10% significance level) related to the adoption of soil management and plant protection in the perception model on flash floods. Indeed, farmers with large scale farm land are more likely to have more capital and resources, making it easier for them to adapt to FF&LS through practices such as applying more protection means for plant like pesticides, fertilizers, as well as adopted mulching technique on their lands or making embankments, weaving stone baskets and planting bamboo trees along the fields. However, farm size unexpectedly negatively determines the adoption of changing cropping patterns in both models. As extracted from the survey data, the visible reason is that households with a large farm size already grew cinnamon or acacia in the past and they are unlikely to change, while those with a small farm size normally planted cassava or maize on the hilly land and now have changed to cinnamon. This result indicates that families with a smaller farm size are likely to adapt to FF&LS by means of this practice.

Institutional conditions

Irrigation has a positive and significant relationship to the likelihood of choosing to change cropping patterns ($P<0.05$) and other strategies ($P<0.05$) as adaptation measures to FF&LS. It means that irrigated farms are more likely to change cropping pattern or find off-farm jobs, borrow money, or migrate, etc. The positive correlation between irrigation and other strategies can be clarified by the fact that although farmers in the research areas can access irrigation, most of them indicate that irrigation water is not sufficient for their fields, especially in winter (dry season).

Not as hypothesized, contact with extension services has a negative correlation with all adaptation strategies. In addition, the influence is only significant with crop variegation, crop management and protection (soil and plant) at a 10% significance level. This means that farmers who have access to extension services are more likely to not take adaptation options as reactions to FF&LS. The negative sign can be clarified by the fact that although extension officials give advice on crop variegation and other farming activities, farmers still make their own decisions. Local farmers think most of the extension officers are young and have less experience in agriculture; hence, farmers would not always follow their guidelines. Finally, the results from the MVP models shows that access to credit does not determine farmers´ adaptation choices to FF&LS. In fact, to support and encourage poor households in fostering agricultural production, the local authority has a policy for the poor to get loans from the 'Social Banks' with a low interest rate (i.e., 6.6%/year) and with a long loan term (10 years). However, most interviewed households are afraid of borrowing money from the banks for their own business. Instead, they borrowed money from the 'Social Banks' under the support policy of the local government and lent that money to someone else (often to wealthier households or their relatives). In addition, many poor households borrowed money from the government's supporting programs for the poor to spend on other activities, such as buying a motorbike, food, and alcohol, not on cattle or production equipment. As a result, the government´s supporting policy was not used for the right purpose and leads to an increasing income gap in the research areas.

5.4. Conclusions and policy implications

Using a data set of a household survey in Van Yen district, Yen Bai province in the Northern Mountainous Regions in Vietnam, this study shed light on how farmers have been adapted to FF&LS and identified challenges of adaptation. Furthermore, this study also analyzed the key factors that influence farmers' adaptation choices to FF&LS. The study was carried out to help the Vietnamese governments have a better understanding of farmers' behavior and reactions when selecting adaptation strategies to FF&LS, thereby helping them to develop appropriate supporting policies. This is highly important for this region in Vietnam because this area is considered one of

the poorest regions in the country with a majority of the population belonging to minority ethnic groups. They tend to have low levels of education whilst also lack proper clothing, food, clean water, and healthcare services, and live far away from centers of towns. In addition, their main incomes rely on agricultural and forestry activities; hence, they are highly vulnerable to FF&LS, which frequently occur in the region. Hence, the findings would be good references for policymakers to develop suitable policies to help poor people recover quickly and sustainably from future natural hazard impacts. The results of our case study demonstrate that the MVP model is an appropriate method to explore the complexity of adaptation processes and is replicable to similar physio-geographic areas and smallholder farmers, with the refinement of variables suited to the locality.

The most common adaptation strategies reported include changes in cropping patterns, crop variegation, altering crop varieties, crop management, and protection methods (soil and plant). Technological limitations and financial restrictions, as well as institutional restraints and cognitive barriers should not be disregarded in investigating the adaptive behavior of farmers as they are reported to be amongst the most significant barriers to adaptation. The key drivers of farmers´ decisions to implement adaptation strategies are determined by using the MVP model. In the model, the dependent variable is households´ adaptation choices that include five adaptation options, and the exogenous variables contain household attributes.

The results of the analysis indicated that the perception of farmers to FF&LS and households´ characteristics, such as belonging to an ethnic minority, the literacy, the household condition, farm income, and market availability, have significant impacts on adaptation strategy preference of farmers. In this regard, our findings call for policies that enhance better knowledge for local farmers through investment in education systems, such as opening free literacy classes, organizing training courses for technology transfers on sustainable land use cultivation and for improving farmers´ awareness on sustainable land use. Information on the weather should be provided to farmers on time. Also, supplying agricultural production inputs with reasonable prices and selling-product-assistance can be considered to be promising solutions in improving people´s income, thereby supporting them to adapt to and overcome the adverse impacts of FF&LS. Upgrading infrastructure, such as roads, should be taken into account to encourage farmers to adapt to FF&LS.

In addition, this study disclosed that some of the farming characteristics including land ownership and farm size also significantly affect farmers´ decision making processes. Since the willingness of farmers to invest in the farming system will be enhanced if they have ownership of their land, creating favorable conditions for people to legalize their land ownership should be considered by policymakers. Institutional factors represented by irrigation system and extension service

connection influence farmers´ adaptation choices. Feasible directions for future policies are upgrading irrigation systems and improving the quality of extension officers. To do so, the local government should organize training courses (i.e., cultivation techniques, breeding techniques) to enhance the capacity of commune extensionists. Besides, the extension officers need to communicate more often with local farmers to create a good relationship resulting in increasing trust from them. Since the scope of this paper is to examine how policymakers can facilitate the adaptation process at a household level, future analysis needs to properly answer the question over which adaptations are economically viable and most effective at increasing farmers´ resilience.

Appendix

Table A1: Typical flash floods and landslides in the mountainous provinces of Vietnam

No.	Type of hazard	Year	Place	Results
1	Flash flood	15/07/2000	Sapa, Lao Cai	20 dead and 25 injured people
2	Flash flood	03/10/2000	Nam Coong village, Nam Cuoi commune, Sin Ho district, Lai Chau	39 dead and 18 injured people
3	Flash flood	16/08/2002	Bac Quang and Xin Man districts, Ha Giang	25 dead and 17 injured people
4	Flash flood	20/09/2002	Huong Son, Huong Khe, and Vu Quang districts, Ha Tinh	53 dead and lost, and 111 injured people
5	Flash flood	2004	Du Tien, Du Gia communes, Yen Minh district, Ha Giang	45 dead people
6	Landslide	2004	Lao Cai	22 dead and lost, 16 injured people
7	Flash flood	28/09/2005	Van Chan district, Yen Bai	50 dead and lost people
8	Flood, flash flood, landslide	2008	Lao Cai and Yen Bai	120 dead and lost people
9	Landslide	2009	Pac Nam commune, Bac Kan	13 dead and five injured people
10	Flash flood	9/2011	Thanh Hoa, Nghe An	Six dead people
11	Landslide	07/09/2012	Mu Cang Chai district, Yen Bai	Eight dead people
12	Flash flood	05/09/2013	Ban Khoang commune, Sapa district, Lao Cai	11 dead and lost, 16 injured people
13	Flash flood and landslide	08/2017	Mu Cang Chai, Yen Bai	14 dead and missing, nine injured people 29 washed away houses, and 25 damaged or destroyed houses
14	Landslide	09/2017	Tram Tau, Yen Bai	Two dead and seven injured people
15	Flash flood and landslide	04/08/2017	Muong La district, Son La	Ten killed, six missing and four injured people. 258 damaged houses

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6. Conclusions and directions for future researches

This chapter presents the significant findings of the research, draws conclusions from outcomes, and provides some recommendations to policymakers and future research. The conclusions are based on the major empirical findings from the survey results and econometric analyses. Furthermore, the specific policy recommendations relevant to the different stakeholders in order to reduce farmers´vulnerability, improve their perception, as well as facilitate their adaptation process to flash floods and landslides are also highlighted in this chapter. The chapter will be ended by providing suggestions for both policymakers and future researchers.

6.1 Conclusions

This study focuses on the analysis of the relationship between vulnerability, perception, and adaptation of rural farmers to flash floods and landslides at the household level in Van Yen district, Yen Bai province. Initially, based on the data from a survey of 405 households in 3 communes: An Binh, An Thinh, and Dai Son, the research presented the five livelihood assets, including human capital, natural capital, physical capital, financial capital, and social capital. The vulnerability level of households under the impacts of flash floods and landslides was employed by applying the HVI_{FLd} and a substitute approach (HVI_{FLd} – IPCC) in combination with in-depth qualitative data. In addition, the undesirable impacts of these natural disasters on the household's livelihoods were also identified in order to point out the difficulties of farmers in adapting to such climate-related events. The present study, lastly, figures out the driving forces stimulating the farmers´ perception of and adaptation to flash floods and landslides.

6.1.1 What are the key households' features/characteristics?

In terms of human capital, men are mostly found to be the head of households and be responsible for up taking adoption of technologies. Up to 18% of the respondents are uneducated, and roughly 62% of interviewers belong to ethnic minority groups such as Dao, Tay, and Hoa. It was found that 4,29 persons are the average family size in each household, and 3,03 of them are in the working-age (between 15 to 65 years old). The household´s head, on average, has 27 years' experience in agriculture.

Regarding social capital, Youth's Union, Women's Union, and Farmer's Union are recorded as crucial organizations that over half of interviewers took part in. However, the present research indicated a high proportion of farmers (almost 77%) have no contact with extension officials in the last year. The cohesive relationship and mutual support of the community are witnessed in the research regions. This is shown by the percentage of people (81% of respondents) who willing to

help their neighbors during difficult times with such kinds of assistance as metal support, in-kind aid (rice, seeds, livestock, and exchanging working days), and financial help (cash).

Concerning natural capital, the most common crops are rice, maize, and cassava. The agriculture is characterized by the small and scattered farm with the average farm size of 62,5 Sao per household. Most of the lands are attained through heritage from parents or are given by the State. About 27,5% of the respondents´ land has no land certificate (Red book). Agricultural land and hilly land are two main types of farmland. Typically, agricultural land is located nearby the house, and it is easy to access while the hilly land is vice versa. Agriculture is subordinate on not only weather conditions but also the irrigation system. It is indicated that roughly 37% of agricultural land having a problem in accessing to irrigation water.

In respect of financial capital, only few respondents have savings (7% of total interviewees). Furthermore, about 36% of the respondents are found having barriers in accessing to credit. People in the research areas raise livestock such as pig, chicken, cow, and sheep in small-scale, mainly serve for family demand. Physical capital in the study areas showed that although almost all of the households have access to electricity, most of them still use firewood as a primary source of cooking and even heating in the winter. Limited internet access, un-treatment water sources, precarious housing, and difficult access to the hospital are existing problems in the regions.

6.1.2 Who and which area are more vulnerable and exposed to flash floods and landslides?

By applying the HVI_{FLd} and a substitute approach (HVI_{FLd} – IPCC) in combination with in-depth qualitative data, the present study assessed rural household´s vulnerability to flash floods and landslides in three agro-ecological areas in Van Yen district. The results indicate the main determinants influencing the farmers' capacity to adapt to FF&LS. In addition, the research's findings pinpoint who are likely to be more sensitive and are more exposed to these natural hazards. Such weather-related events led to a wide range of losses and damages such as losing in housing or property, damaging in agricultural land, getting injury/illness or even death of households´ members, and declining in crop yield. The overall indices demonstrate that rural farmers residing in Dai Son commune, a highland region characterized by cinnamon growing, are the most vulnerable to the impacts of flash floods and landslides, despite this commune being the least exposed to these natural disasters. Ethnicity, diversified sources of income, organization membership, health insurance, food security, land tenure document, water resources, and locational dimensions are considered the main factors affecting the vulnerability of farmers under the impacts of flash floods and landslides.

6.1.3 To what extent flash floods and landslides affected households' livelihoods? And what are the main determinants of farmers' perception?

The research's findings reflect how indigenous people recognize and perceive changes in the frequency and impacts of flash floods and landslides. Results disclose that there is an overwhelming majority of farmers who had noticed the changes in frequency and impacts of flash floods and landslides, and stated the adverse impacts of flash floods and landslides on their livelihood activities. Reducing productivity, decreasing income, more hard-working conditions, increasing daily expenses, causing disease in livestock, poultry, and people, and losing land are recorded as the most unfavorable influences of flash floods and landslides to rural households in the study areas. Using a Multinomial Logit model to examine the drivers of peoples´ perceptions of flash floods and landslides, the analysis' results reveal that not only internal factors (i.e., experience in agriculture, male (gender), ethnic minority group (ethnicity), and poor household (household condition)) but also external factors (i.e., distance to market, climate information, and agri-ecological zone) strongly influence how farmers perceive changes in the frequency and impacts of flash floods and landslides.

6.1.4 How have farmers been adapted to flash floods and landslides? What are the foremost challenges of adaptation and key factors affecting farmers' decision-making process?

Upon recognizing changes in flash floods and landslides, local farmers uptake multiple portfolios of adaptation strategies. The research found that only few farmers (3% of the respondent) did nothing to respond to these natural hazards; most of them are located in An Binh. The most recorded adaptation measures are changes in cropping patterns, crop variegation, altering crop varieties, crop management, and protection methods (soil and plant). In addition, technological limitations and financial restrictions, as well as institutional restraints and cognitive barriers are significant impediments hindering the effectiveness of adaptation strategies. By applying the Multivariate Probit model, the factors affecting the farmers´ choices as responses to flash floods and landslides are analyzed. The adaptation model proposes that the perception of farmers to flash floods and landslides, ethnic minority groups, farm income, and farm size are the most important factors deciding specific adaptation choices. Besides, the level of education, household status, irrigation, and distance to market also influence farmers´ decisions to adapt to flash floods and landslides.

6.2 Recommendations

6.2.1 Policy recommendations

Based on the findings of this study, we derived a number of suggestions to policymakers in order to reduce households' vulnerability, enhance farmers' awareness, and strengthen households' adaptation to flash floods and landslides as follow:

Promoting farmers´literacy and organizing vocational training courses: The local government should stress on improving farmers´ knowledge through opening literacy classes, establishing training courses for technology transfers on sustainable land use cultivation and for improving the farmers´awareness on sustainable land use. Furthermore, offering vocational training courses is also needed, for example, training people to make handicrafts from the cinnamon tree - one of the staple trees in these areas.

Supporting and strengthening agricultural extension services: Extension services play an essential role in achieving agricultural sustainability. And to some extent, information and knowledge transferred by extension officials have a great influence on the decision-making process of farmers in changing their farming systems, applying new technologies, or in choosing new varieties of crops and livestock. Yet, the extension services in the research areas are remaining insufficient. As a result, it is a prerequisite to promote the extension services through strengthening the extension system and improving the qualification of extension officers. The extension services must be enhanced in terms of quantity as well by hiring extra staff with priority given to native people who know better about the local perspective than non-local people. With precise received information, farmers might make better decisions on adaptation to flash floods and landslides.

Facilitating and simplifying access to the credit system: Limited access to credit is considered one of the most difficulties for farmers to promote and expand agricultural production, as well as strengthen households´ livelihoods. It is on record that ethnic minorities in the Northern Mountainous Regions of Vietnam have less access to overall rural credit than Kinh people, and the credit amounts are usually limited. Against this background, the credit system should be less complicated by making the loan procedures simpler, and the repayment time should be in the longer term. However, the provision of credit needs to pay more attention to the purposes of credit use and the seasonality of farming production.

Paving the way for people to have land right certificate: The willingness of farmers to invest in the farming system will be enhanced if they have ownership of their land. Owning the certificate of land also helping people in the research areas can access credit sources by using the land

certificate as a kind of collateral asset. In doing so, to support farmers' decision to adapt to flash floods and landslides, the local government should create favorable conditions for people to legalize their land ownership. In addition, since land fragmentation also should be considered as a problem encumbering farmers to get the land certificate, it is necessary to encourage exchanging agricultural plots between households in order to reduce fragmentation.

Beside all aforementioned policy recommendations, improving the quality of drinking water sources, enhancing the irrigation systems, supplying agricultural production inputs with reasonable prices, and providing the local weather forecast should also be considered to enhance local farmers' capacity in order to overcome the adverse impacts of flash floods and landslides on the livelihood of people in the research areas.

6.2.2 Recommendations for future researches

- This study focuses on the impacts of flash floods and landslides on farmers in mountainous areas. Further researches should be directed towards the assessment of the impacts of other natural hazards such as drought, flood, and salinity instruction on the livelihoods of households in other regions.

- This research examines the rural farmers' livelihoods and investigates the aspects affecting households' vulnerability to flash floods and landslides. Future studies should consider to analyze which livelihoods are suitable and able to support local people to reduce their vulnerability to such natural hazards.

- The present research analyses key determinants influencing farmers' adaptation decisions. Future analyses should consider the assessment of which adaptations bring higher economic efficiency to contribute to improving farmers' resilience toward future natural disasters.

- Future studies may also consider to analyze the farmer's adaptation in a more comprehensive perspective comprising of changes in the institutional, environmental, and economic situation. Furthermore, the data should be gathered at different times (panel data), which can help the researchers make a comparison and have a comprehensive look at the study areas.

7. Summary

7.1 Summary in English

Background of the research

Natural hazards are considered as the most critical challenges that human being is facing nowadays. Vietnam, situated in South East Asia and dominated by the agricultural sector, is heavily influenced by various types of natural disasters such as floods, flash floods, storms, drought, landslides, and earthquakes. Characterized by a high rate of poverty, marginalization, and limited access to information, production means and resources, the Northern Mountainous Regions are being one of the most prone areas to weather-related events in the country. The regions comprise multiple ethnic minority groups who have deficient levels of education, low income, and poor housing systems. Also, local people strongly depend on agriculture as a major source of income and for daily food demands. As a result, they are highly vulnerable to the impacts of flash floods and landslides that frequently happen in the region. The region has dropped behind other regions in terms of economic development. Against this backdrop, studies should be undertaken in order to provide good references for policymakers to develop appropriate policies that may help people in such regions recover quickly and sustainably from such climate-related events.

The study aims to investigate the households´ vulnerability and to evaluate how farmers have perceived and adapted to flash floods and landslides in Van Yen district, Yen Bai province. The specific objectives of the study are (i) To figure out the households' resources/households' socio-economic characteristics; (ii) To explore rural households' livelihoods and to disclose the factors affecting their vulnerability to flash floods and landslides; (iii) To draw out to what extent local people have been affected by flash floods and landslides; as well as to examine main determinants influencing how rural farmers perceive changes on such natural hazards; (iv) To pinpoint how farmers have been adapted to flash floods and landslides, to expose impediments during the adaptive implementation process, and to evaluate key drivers impacting farmer´s adaptation responses to flash floods and landslides. The findings should support policymakers and local managements to identify the most vulnerable regions, and the driving forces influencing local farmers´ perception and adaptation to flash floods and landslides. Subsequently, necessary measures will be implemented towards sustainable livelihoods for farmers in the context of flash floods and landslides.

Material and methods

Both primary and secondary data were considered in the study. The primary data were collected by using key informal interviews, focus group discussions, and face to face interviews with 405 farmers through the structured questionnaire in An Binh, An Thinh, and Dai Son commune, Van Yen district. The secondary data, including monthly temperature and rainfall information, were gathered from the National Hydrometeorological Center. The data collected from 405 sample households were entered into a computer using MS – Excel by encoding into numeric structures. The inputted data, after that, were strictly examined again to check whether the existence of erroneous values occurred due to data entering mistakes by using Data Analysis and Statistical Software (STATA) version 14. Descriptive statistics, correlation analysis, and regression analysis are three critical analyses in the research. The descriptive statistics including mean, standard deviation, frequency, percentage were used to present an overview of field study findings in terms of household´s resource conditions (human capital, natural capital, physical capital, financial capital, and social capital), farmers perception to changes in climate and their adaptations to flash floods and landslides. The analysis was quantified by using both non-parametric and parametric tests through mean differences. One-way ANOVA analysis is used in case the dependent variables are normally distributed and non-parametric methods such as Willcoxon Mann-Whitney-U test, Kruskal Wallis test, Perason´s Chi-squared, and Fisher´s Exact test are applied for non normally distributed dependent variables. Descriptive statistical tools were combined with a composite index to assess the vulnerability level of farmers regarding flash floods and landslides. Then, regression analyses (multinomial logit regression and multivariate probit regression) were applied to investigate the determinants of households' perception of and their choices in adaptation practices to flash floods and landslides. The regression models were run by using STATA software.

Major findings

The survey results reveal that the research areas are dominated by male-headed households. People in the regions mainly belong to ethnic minority groups, which are characterized by a low level of education, a high dependency rate, and great reliance on agriculture. Joining in local organizations of farmers and providing supports (either in-kind or spiritual assistance) to each other have been witnessed throughout three surveyed communes. Yet, the linkage between farmers and extension officials still remains a concerning issue that local authorities should pay more attention to because of its inefficiency. Livelihoods of households are associated with small-scale farming, and farm income has typically resulted from the cultivation of rice, maize, cassava, and cinnamon. However, having land without tenure certificates, obstacles in assessing

credit, and ineffective operation of irrigation systems are also recorded as key reasons leading to people 's hesitation in making investment decisions on their farming system. Most households are able to access to electricity while approaching to the Internet has not been popular yet in the research areas. Using natural water sources for daily life demands without considering any treatment measures and consuming firewood as a principal source of cooking are additional issues affecting to health-related problems in the regions.

Most of the respondents in the research areas observed an increase in the frequency and impacts of flash floods and landslides over 15 recent years. As indicated by a majority of local households, declining crop yields and income, increasing daily expenses, escalating the severity of the working condition, and increasing disease outbreak for livestock and poultry are unavoidable harassments translated by flash floods and landslides. The majority of respondents did respond to these natural hazards by means of applying adaptation measures on their agricultural activities. Among all responses, changes in cropping patterns, crop diversification, altering crop varieties, crop management, and protection methods (soil and plant) are the most common practices implemented by local farmers to adapt to flash floods and landslides. Famers also confirmed obstacles hindering their incentives in uptaking adaptation practices, such as a lack of production means and family labor forces, a limitation of knowledge about flash floods and landslides, difficulties in accessing updated climate information, insufficient or limited support from local government, social and cultural barriers, and limited awareness.

The Household Vulnerability Index pointed out that farmers in Dai Son commune are more vulnerable than those in An Binh and An Thinh communes subject to the impacts of flash floods and landslides, which identified by the Social Network, Socio-Demographic Profile, and Wate component. The regression results from MNL models disclose that experience in agriculture, gender, ethnic minority group, poor household, distance to market, climate information, and agro-ecological zone have strong influences on the farmers´ perception of flash floods and landslides. In addition, the adaptation models reveal that farmers´ perceptions on flash floods and landslides in accordance with socio-economic, farming features, and institutional conditions, such as ethnic minority group, the literacy, the household condition, farm income, market availability, land ownership, and farm size, have significant influences on farmers' preference in selecting adaptation measures regarding flash floods and landslides.

Policy recommendations

Based on the empirical findings, this research provides some suggestions for identifying policy interventions that may help to reduce the household´s vulnerability and to promote local farmers in adaptation process towards flash floods and landslides, such as:

- Promoting farmers´ literacy and organizing vocational training courses;
- Strengthening the agricultural extension services;
- Facilitating and simplifying the applying process of the credit system;
- Paving the way for people to have the land right certificate.

The other recommendations, for example, improving the quality of drinking water sources, enhancing the irrigation systems, supplying agricultural production inputs with reasonable prices, and providing the local weather forecast, should also be stressed and received more attention from local authorities.

Areas for further research

Follow up studies may address how other natural hazards such as drought, flood, and salinity instruction impact on the livelihood of rural households in other regions at a larger scale (regional and national level). Further studies should also consider to analyze the farmer's adaptation in a complete context comprising of changes in the institutional, environmental, and economic situation. Furthermore, the data should be gathered at a different time (panel data), that can help the researchers make a comparison and have a comprehensive look at the study areas.

7.2 Zusammenfassung

Hintergrund der Forschung

Naturgefahren gelten als die kritischsten Herausforderungen, denen sich der Mensch heutzutage gegenübersteht. Vietnam liegt in Südostasien und wird vom Agrarsektor dominiert. Es ist stark von verschiedenen Arten von Naturkatastrophen wie Überschwemmungen, Sturzfluten, Stürmen, Dürre, Erdrutschen und Erdbeben beeinflusst. Die nördlichen Gebirgsregionen zeichnen sich durch eine hohe Armutsrate, Marginalisierung aus und haben eingeschränkten Zugang zu Informationen, Produktionsmitteln und Ressourcen. Diese Regionen sind eines der am stärksten von Wetterereignissen betroffenen Gebieten im Land. Die Regionen umfassen mehrere ethnische Minderheiten mit einem schlechten Bildungsniveau, niedrigen Einkommen und schlechten Wohnsystemen. Auch die lokale Bevölkerung ist stark von der Landwirtschaft als Haupteinnahmequelle und für den täglichen Nahrungsbedarf abhängig. Infolgedessen sind sie sehr anfällig für die Auswirkungen von Sturzfluten und Erdrutschen, die in der Region häufig auftreten. Diese Region ist in Bezug auf die wirtschaftliche Entwicklung hinter andere Regionen zurückgefallen. Vor diesem Hintergrund sollten Studien durchgeführt werden, um den politischen Entscheidungsträgern gute Referenzen für die Entwicklung geeigneter Strategien zu liefern, die

den Menschen in solchen Regionen helfen können, sich schnell und nachhaltig von solchen klimabezogenen Ereignissen zu erholen.

Die Studie zielt darauf ab, die Verwundbarkeit der Haushalte zu untersuchen und zu bewerten, wie Landwirte Sturzfluten und Erdrutsche in dem Bezirk Van Yen in der Provinz Yen Bai wahrgenommen und angepasst haben. Die spezifischen Ziele der Studie sind (i) Ermittlung der Ressourcen/sozioökonomischen Merkmale der Haushalte; (ii) Untersuchung der Lebensgrundlagen ländlicher Haushalte und Offenlegung der Faktoren, die ihre Anfälligkeit für Sturzfluten und Erdrutsche beeinflussen; (iii) Ermittlung, inwieweit die Menschen vor Ort von Sturzfluten und Erdrutschen betroffen sind; sowie die Hauptdeterminanten zu untersuchen, die Einfluss darauf haben, wie Landwirte Veränderungen in Bezug auf solche Naturgefahren wahrnehmen, (iv) um genau zu bestimmen, wie Landwirte an Sturzfluten und Erdrutsche angepasst werden, um Hindernisse während des adaptiven Umsetzungsprozesses aufzudecken und um die wichtigsten Faktoren zu bewerten, die sich auf die Anpassungsreaktionen der Landwirte auf Sturzfluten und Erdrutsche auswirken. Die Ergebnisse sollten politische Entscheidungsträger und lokale Führungskräfte bei der Ermittlung der am stärksten gefährdeten Regionen und der treibenden Kräfte unterstützen, die die Wahrnehmung und Anpassung der lokalen Landwirte an Sturzfluten und Erdrutsche beeinflussen. Anschließend werden die notwendigen Maßnahmen zur nachhaltigen Existenzsicherung der Landwirte im Zusammenhang mit Sturzfluten und Erdrutschen umgesetzt.

Material und Methoden

In der Studie wurden sowohl Primär- als auch Sekundärdaten berücksichtigt. Die Primärdaten wurden mithilfe von informellen Schlüsselinterviews, Fokusgruppendiskussionen und persönlichen Interviews mit 405 Landwirten über den strukturierten Fragebogen in den Gemeinden An Binh, An Thinh und Dai Son, Distrikt Van Yen, gesammelt. Die sekundären Daten, einschließlich monatlicher Temperatur- und Niederschlagsinformationen, wurden vom Nationalen Hydrometeorologischen Zentrum gesammelt. Die aus 405 Stichprobenhaushalten gesammelten Daten wurden mit MS-Excel durch Codierung in numerische Strukturen in einen Computer eingegeben. Die eingegebenen Daten wurden danach erneut streng geprüft, um herauszufinden, ob fehlerhafte Werte aufgrund von Dateneingabefehlern unter Verwendung der Datenanalyse- und Statistiksoftware (STATA) Version 14 enthalten sind. Beschreibende Statistiken, Korrelationsanalysen und Regressionsanalysen sind drei kritische Punkte Analysen in der Forschung. Die deskriptiven Statistiken, einschließlich Mittelwert, Standardabweichung, Häufigkeit und Prozentsatz, wurden verwendet, um einen Überblick über die Ergebnisse der Feldstudie in Bezug auf die Ressourcenbedingungen der Haushalte (Humankapital, Naturkapital,

Sachkapital, Finanzkapital und Sozialkapital) und die Wahrnehmung der Landwirte zu geben zu Klimaveränderungen und deren Anpassung an Sturzfluten und Erdrutsche. Die Analyse wurde unter Verwendung sowohl nicht parametrischer als auch parametrischer Tests durch mittlere Differenzen quantifiziert. Eine Einweg-ANOVA-Analyse wird verwendet, wenn die abhängige Variablen normalverteilt sind und nichtparametrische Methoden wie der Willcoxon-Mann-Whitney-U-Test, der Kruskal-Wallis-Test, der Perason-Chi-Quadrat-Test und der Fisher-Exakt-Test angewendet werden angewendet, wenn die abhängige Variablen nicht normalverteilte sind. Deskriptive statistische Instrumente wurden mit einem zusammengesetzten Index kombiniert, um die Anfälligkeit der Landwirte für Sturzfluten und Erdrutsche zu bewerten. Anschließend wurden Regressionsanalysen (multinomiale Logit-Regression und multivariate Probit-Regression) angewendet, um die Determinanten der Wahrnehmung der Haushalte und ihre Wahlmöglichkeiten bei Anpassungspraktiken an Sturzfluten und Erdrutsche zu untersuchen. Die Regressionsmodelle wurden unter Verwendung der STATA-Software ausgeführt.

Wichtigsten Ergebnisse

Die Umfrageergebnisse zeigen, dass die Forschungsgebiete von Haushalten mit männlichem Kopf dominiert sind. Die Menschen in den Regionen gehören hauptsächlich ethnischen Minderheiten an, die sich durch ein niedriges Bildungsniveau, eine hohe Abhängigkeitsrate und eine starke Abhängigkeit von der Landwirtschaft auszeichnen. In drei befragten Gemeinden wurde beobachtet, wie sie sich lokalen Organisationen von Landwirten angeschlossen haben und sich gegenseitig unterstützten (entweder in Form von Sachleistungen oder geistlicher Unterstützung). Die Verbindung zwischen Landwirten und Erweiterungsbeamten bleibt jedoch ein besorgniserregendes Thema, dem die lokalen Behörden aufgrund ihrer Ineffizienz mehr Aufmerksamkeit schenken sollten. Der Lebensunterhalt der Haushalte ist mit kleinbäuerlicher Landwirtschaft verbunden, und das landwirtschaftliche Einkommen resultiert typischerweise aus dem Anbau von Reis, Mais, Maniok und Zimt. Grundstücke ohne Nutzungsbescheinigungen, Hindernisse bei der Bewertung von Krediten und ein ineffektiver Betrieb von Bewässerungssystemen werden jedoch auch als Hauptgründe dafür angeführt, dass die Menschen zögern, Investitionsentscheidungen für ihr landwirtschaftliches System zu treffen. Die meisten Haushalte haben Zugang zu Elektrizität, während die Annäherung an das Internet in den Forschungsbereichen noch nicht beliebt ist. Die Nutzung natürlicher Wasserquellen für den täglichen Lebensbedarf ohne Berücksichtigung von Behandlungsmaßnahmen und der Verbrauch von Brennholz als Hauptkochquelle sind weitere Probleme, die sich auf gesundheitliche Probleme in den Regionen auswirken.

Die meisten Befragten in den Forschungsgebieten beobachteten in den letzten 15 Jahren einen Anstieg der Häufigkeit und der Auswirkungen von Sturzfluten und Erdrutschen. Wie die Mehrheit der lokalen Haushalte angibt, sind sinkende Ernteerträge und Einkommen, steigende tägliche Ausgaben, eskalierende Schwere der Arbeitsbedingungen und zunehmender Krankheitsausbruch bei Nutztieren und Geflügel unvermeidbare Belästigungen, die durch Sturzfluten und Erdrutsche verursacht werden. Die Mehrheit der Befragten reagierte auf diese Naturgefahren mit Anpassungsmaßnahmen für ihre landwirtschaftlichen Aktivitäten. Unter allen Antworten sind Änderungen der Anbaumuster, die Diversifizierung von Kulturpflanzen, die Veränderung der Pflanzensorten, des Pflanzenmanagements und der Schutzmethoden (Boden und Pflanze) die am häufigsten von lokalen Landwirten angewandten Praktiken zur Anpassung an Sturzfluten und Erdrutsche. Die Famers bestätigten auch Hindernisse, die ihre Anreize für die Übernahme von Anpassungspraktiken behinderten, wie z. B. ein Mangel an Produktionsmitteln und Arbeitskräften in der Familie, eine Einschränkung des Wissens über Sturzfluten und Erdrutsche, Schwierigkeiten beim Zugang zu aktualisierten Klimainformationen, unzureichende oder begrenzte Unterstützung durch die lokale Regierung, soziale und kulturelle Barrieren und begrenztes Bewusstsein.

Der Household Vulnerability Index wies darauf hin, dass Landwirte in der Gemeinde Dai Son anfälliger sind als in den Gemeinden An Binh und An Thinh. Diese sind von den Auswirkungen der Sturzfluten und Erdrutschen ausgesetzt und wurden durch das soziale Netzwerk, das soziodemografische Profil und die Wate-Komponente ermittelt. Die Regressionsergebnisse von MNL-Modellen zeigen, dass Erfahrungen in den Bereichen Landwirtschaft, Geschlecht, ethnische Minderheit, armer Haushalt, Entfernung zum Markt, Klimainformationen und agroökologische Zone einen starken Einfluss auf die Wahrnehmung der Landwirte auf Sturzfluten und Erdrutschen haben. Darüber hinaus zeigen die Anpassungsmodelle, dass die Wahrnehmung der Landwirte in Bezug auf Sturzfluten und Erdrutsche in Übereinstimmung mit sozioökonomischen, landwirtschaftlichen Merkmalen und institutionellen Bedingungen wie ethnischen Minderheiten, Alphabetisierung, Haushaltsbedingungen, landwirtschaftlichem Einkommen, Marktverfügbarkeit und Land erfolgt Eigentum und Betriebsgröße haben einen erheblichen Einfluss auf die Präferenz der Landwirte bei der Auswahl von Anpassungsmaßnahmen in Bezug auf Sturzfluten und Erdrutsche.

Richtlinien empfehlungen

Basierend auf den empirischen Ergebnissen liefert diese Studie einige Vorschläge zur Ermittlung politischer Interventionen, die dazu beitragen können, die Anfälligkeit des Haushalts zu verringern und die lokalen Landwirte im Anpassungsprozess an Sturzfluten und Erdrutsche zu fördern, sowie:

- Förderung der Alphabetisierung der Landwirte und Organisation von Berufsbildungskursen;

- Stärkung der landwirtschaftlichen Beratungsdienste;

- Erleichterung und Vereinfachung des Antragsverfahrens für das Kreditsystem;

- Wegbereiter für Menschen mit dem Landrechtszertifikat.

Die anderen Empfehlungen, zum Beispiel die Verbesserung der Qualität der Trinkwasserquellen, die Verbesserung der Bewässerungssysteme, die Versorgung der landwirtschaftlichen Produktion mit angemessenen Preisen und die Bereitstellung der lokalen Wettervorhersage, sollten ebenfalls betont und von den lokalen Behörden stärker berücksichtigt werden.

Bereiche für weitere Forschung

In Folgestudien kann untersucht werden, wie sich andere Naturgefahren wie Dürre, Überschwemmungen und Salzgehalt auf den Lebensunterhalt ländlicher Haushalte in anderen Regionen in größerem Umfang (auf regionaler und nationaler Ebene) auswirken. Weitere Studien sollten auch in Betracht ziehen, die Anpassung des Landwirts in einem vollständigen Kontext zu analysieren, der Änderungen in der institutionellen, ökologischen und wirtschaftlichen Situation umfasst. Darüber hinaus sollten die Daten zu einem anderen Zeitpunkt gesammelt werden (Paneldaten), damit die Forscher einen Vergleich anstellen und einen umfassenden Blick auf die Untersuchungsgebiete werfen können.