Southeast Asian Journal of Economics Vol.11(1), April 2023: 189-216
Received: Jul 28 2022
Revision: Aug 29 2022
Accepted: Dec 16 2022

Do financial and personal characteristics of the household become institutional shields from natural disasters? A closer look at Vietnamese rural areas

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Abstract

To identify whether households' financial and personal characteristics serve as institutional shields from natural disasters, we analyzed more than 2,027 households in rural Vietnam in the VARHS dataset from 2008 to 2016. Results show that households receiving an early warning, household size, and participation in organizations positively impact household income sources in agriculture, while natural disasters and expenditures hurt household income, with varying degrees of influence depending on the income source. Kinh households suffer less damage, especially during natural disasters, and their loss of agricultural income in that year is also less than that of ethnic minority households. The findings suggest that the government needs to pay more attention and give support to ethnic minority households and promote early warning to contribute to mitigating the negative impacts of disasters.

Keywords: agricultural income, natural disasters, farm households, loss, livelihoods.

1. Introduction

Natural disasters are one of the most significant causes of poverty in developing countries. Newman and Tarp (2020) highlighted that unprotective production and weather shocks threaten the agricultural economy in many rural areas because farmers in less developed areas are considered vulnerable, deprived of their low-income sources, and excessively dependent on agriculture (Sarker et al., 2019). Accordingly, major natural disasters often alter agricultural production, such as a hurricane that destroys household property and limits other economic activities (Barnett-Howell & Foltz, 2022). Precipitation can negatively affect agricultural production and household income as well (Newman & Tarp, 2020). Similarly, with limited resources to deal with natural disasters, Vietnam will experience specific impacts of disasters on agricultural activities in rural areas.

In the context of Vietnam's transitioning economy, the gap between agricultural and non-farm income is widening, and rural income inequality is rising (Jaffee et al., 2016). Accordingly, the income consumption or welfare of households are negatively affected by natural disasters and their abilities to cope with risks (Arouri et al., 2015; Hasegawa, 2010; Thomas et al., 2010), with different levels of impact in the short- and long-term (Newman & Tarp, 2020). In general, studies on this topic have two main conclusions: disasters have either a negative impact (in the majority) or no impact on income. The difference in results is explained by different studies using different methods with different data.

However, natural disasters are not always detrimental to household income. In research about household vulnerability under the effect of floods in Nepal, Bista (2020) utilized many econometrics models in which experimental measurements are used to determine household vulnerability in the Sot Khola water basin. The results show that mainstream societies in rural areas have the knowledge, native skills, conservative households, traditional labor force, primitive technology, and more; their acknowledgment of disasters enables

households to prevent economic loss and limit vulnerability. Keerthiratne and Tol (2018), in their research on the impact of disasters on an unequal distribution of income in Sri Lanka, illustrated that the rich suffer more severe damage than the poor. Specifically, if the poor are mainly low-skilled labor or general laborers, they can easily diversify their income resources after natural disasters strike. While the rich may suffer capital loss, natural disasters can open new doors for the less fortunate. However, Carter et al. (2007) provided a different conclusion in their research about natural catastrophes' impacts on properties and recovering ability of households in Ethiopia and Honduras. The authors emphasized that households with lower income are less able to rehabilitate and will recover over a more extended period than those with higher income.

Various studies about the impacts of natural disasters on household income have been undertaken, but their findings are mixed. Previous findings showed that agricultural income was either negatively affected or not affected by disasters, and their long-term effects on income were not discussed thoroughly, especially when happening continuously. Another contradiction is whether natural disasters result in inequality between higher lower-income households. This contradiction may be explained by the fact that previous studies were conducted with different scopes, data sets, and research methods. Furthermore, to better consider poverty, it is not enough to consider only the mechanical increase of income, so this study uses four different sources of income from agricultural activities to provide an overview of the types of income agriculture. The study also analyzes the differences in agricultural income between groups of farmers participating in Farmers' Unions, groups of farmers who are warned about natural disasters or predicted in advance, large-scale households, and more. Thereby, the research results will provide valuable information for policymakers in finding ways to overcome and minimize damage caused by natural disasters.

This article contributes to research on the impact of natural disasters on the agricultural income of rural households in Vietnam. First, the study

uses a large-scale dataset on household access to resources created by the Central Institute for Economic Management in conjunction with three survey partners from 2008 to 2016. Second, it analyzes the impact of natural disasters on agricultural income – a risky source of income in rural Vietnam. Thirdly, regarding the impact of natural disasters on agricultural income, the study has generalized all common sources of agricultural income in rural households in Vietnam, detailed through the four sources. Agriculture income includes crops, forest products, livestock, and fisheries. In addition, the study also analyzes the characteristics of the household (gender, age, ethnicity, educational level of the household head, household size, early warnings, membership in an organization, association, number of cattle, etc., household expenditure, and proportion of the total labor force) affecting this source of income. Compared with previous studies, this study focuses on clarifying the impact of natural disasters on agricultural income and adding more variables on disaster damage by year, assessing the difference in impact on agricultural income between ethnic minority households (who are more pessimistic) and Kinh people when experiencing natural disasters. These variables contribute to portraying the general picture of the impact of natural disasters on rural common agricultural income and new characteristics of rural households in Vietnam in the process of economic development. To that end, the remainder of this paper consists of the following sections. Section 2 discusses the literature review on the effect of natural disasters on household income. Section 3 describes the data and explains research methods and statistical criteria. Section 4 uses model regression to demonstrate the analysis, compares the research in advance, and tests to perform the results. Section 5 is the conclusion and recommendations.

2. Literature review

Researchers have yet to reach a consensus on the definition of a natural disaster, even though their definitions are relatively similar. According to Lindell and Prater (2003), natural disasters occur when a geographic,

meteorological, or hydrographic event overwhelms the affected community. Likewise, Prasad and Francescutti (2017) pinpointed that a natural disaster is the aftermath of a natural hazard that is frequently linked to resource depletion and casualties. Therefore, natural disasters can be interpreted as the dire consequences of natural events which impede the operation of a community or society vulnerable to natural hazards and lead to widespread loss of human life, economic properties, and the environment.

There are many studies on the types of natural disasters in different provinces and countries. For example, Saleem, Mizunoya, Helmut, Moeen, and Ajmal (2020) applied Geographic Information Systems (GIS) to measure income vulnerability for rural households. The authors used the disparity approach (DID), showing statistical significance at the 1% level, as well as calculating the household distance from rivers to see the income vulnerability of households to floods. The results show that the impact of natural disasters in Pakistan has a lasting impact on the income of affected households, but those who live near the river will be more affected. In addition, the empirical analysis shows that after a flood, households tend to move away from agriculture-related activities; thus, their income is reduced.

Alam (2017) assesses the main drivers of vulnerability and livelihood cycles of vulnerable riparian households in Bangladesh. The author used the Intergovernmental Panel on Climate Change (IPCC) approach to vulnerability and developed an approach using the "livelihood vulnerability index" and "climate vulnerability index." The results show that the Livelihood Vulnerability Index and the Climate Vulnerability Index differ between locations, and the high index values of both measures indicate a positive correlation between these two indexes. The main drivers affecting aspects of vulnerability are livelihood strategies and access to food, water, and health facilities. These vulnerable households are also vulnerable because their current low livelihood status leads to a vicious cycle of poverty. Like the above studies, using an empirical vulnerability model derived from the risk-sharing theory, Wongmonta (2019)

assesses the connection between consumption insurance and household vulnerability with household-level panel data from the Socioeconomic Survey (SES) of Thailand during 2005 - 2012. Almost half the sampled households had one or more members working in the agricultural sector (two family members on average). The study suggests that agricultural households appeared to be one of the most vulnerable groups in times of economic difficulty. Moreover, larger households and self-employed heads were emphatically associated with vulnerability, and female-headed households are more vulnerable than male-headed households. Education and household properties also showed a negative relationship with household vulnerability. Such findings had implications for public safety net improvements that shield the most vulnerable populations from uninsured risk exposure.

Anttila-Hughes and Hsiang (2013) suggest that households in the Philippines with low incomes will often experience a higher cumulative loss than high-income households, with losses measured through the total cost of living monetary value of losses accumulated over time since a hurricane occurred. To measure the impact of natural disasters on household income from agriculture, the study uses the framework proposed by Scoones (1998) for sustainable livelihood analysis. The authors also postulate that hurricanes reduce household income in the year following the storm due to the direct physical damage of the storm and disruption of economic activity, contrary to Mendelsohn et al.'s (2012) hypothesis for immediate damage. However, natural disasters do not affect household business inequality (Keerthiratne & Tol, 2018). Households behave as if they have a fixed income, or all households reduce their spending proportionally regardless of their income level in response to disasters. Natural disasters reduce income inequality in both agricultural and non-agricultural regions. The income of wealthier households is mainly from non-agricultural sources such as production and business activities and off-season agricultural activities. Poorer households have a higher share of income from agriculture.

Reducing expenditure is not only a household response but also a re-

sponse to natural disasters of the local government, as shown in the study by Sudsawasd and Puapan (2014). The authors examined the correlation between climate variability and fiscal expenditure by adopting a regression-based measure of discretionary changes in fiscal policy and a standard OLS estimator as the model estimator technique. Regarding the measure of climate variability, the study employed the root mean square errors. Results were unexpected in that only the variability of the cumulative growing degree months for the rainy season and the agricultural year is negatively correlated with economic cycles, as measured by the output gap. Moreover, the Ministry of Agriculture receives smaller budgets and reduces spending when the cumulative growing degree months for the rainy season increase. The research indicates that there may be neglect for climate variability and potential misdirection of budgetary expenditure.

When considering the effect of heavier rainfall and frequent severe floods on the agricultural sector of Laos, Sayavong (2016) found that the agricultural sector, especially rice production, will be severely affected. The instability of agricultural production will affect the Economic Vulnerability Index (EVI), which is one of the criteria to remove Laos from the list of Least Developed Countries (LDCs) (Sayavong, 2016). In another study, Li, Zheng, and Lu (2022) estimated the link between rural households' poverty and natural disasters using the logit model and the 2014 China Family Panel Studies (CFPS) data. The study suggests that farmers with a higher percentage of agricultural earnings are more likely to face poverty, and unexpected catastrophes may cause direct damage to their fixed properties. Furthermore, in areas highly vulnerable to disasters, the effectiveness of scale management in relieving relative poverty may be reduced.

From a different aspect, Devkota, Phuyal, and Shrestha (2021) employed a binary logistic regression model for survey data in Nepal to investigate the differences in income and adaptive capacities to climate change between the poor and non-poor farmers. They showed that while the latter harness var-

ious external adaptation mechanisms to climate change, the former has fewer diverse adapting options within their capacity. As an indication, the poor are more vulnerable than the non-poor. This outcome is similar to the findings of Flaminiano (2021), who adopted a regression discontinuity design to evaluate the impacts of the Pantawid Pamilyang Pilipino Program (CCT) on the goods spending of households exposed to shocks. They found that CCT beneficiaries (facing shocks such as natural disasters) reduced their expenditures on tobacco and alcohol, whereas non-CTT ones spent a larger proportion of their income on such goods.

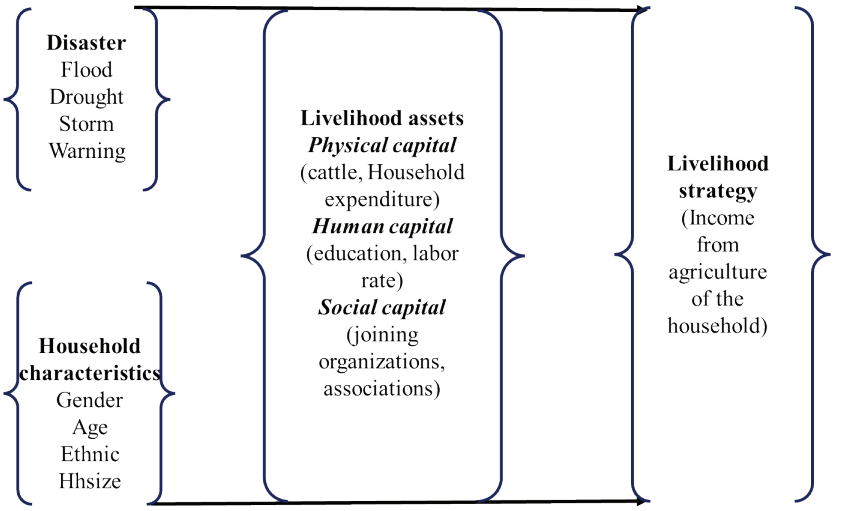
One of the typical scientific studies discussing the adverse effects of natural disasters on agricultural income is that of Hasegawa (2010). Using the Vietnamese household-level datasets of 2002 and 2004 to investigate responses to different risks, he discovered that income and consumption are affected by natural disasters and households' coping ability. For example, an external risk can negatively affect people's lives, especially a natural disaster such as a flood. Similarly, Thomas, Christiaensen, Do, and Trung (2010) used a three-year Vietnam Living Standards Survey dataset (2002, 2004, and 2006) to estimate the impact of natural disasters on household welfare. In addition to showing that the income of households is less affected by natural disasters than the average income, the results showed that disasters have significant short-term impacts. Bui, Dungey, Nguyen, and Pham Bui (2014) also found that natural disasters sharply reduce the per capita income and expenditure of affected households in Vietnam. The average reduction rate dropped from about 4% to 8%, or about 3 million VND, attributed to special scores and test variables. In another study, Newman and Tarp (2020) found that households can achieve short-term income harmonization when exposed to time-related shocks by saving and using a loan account. In the long run, the shocked household will invest less in the household's common and productive assets, thereby negatively influencing the family's welfare for a long time. However, other researchers proposed positive findings regarding the effect of disasters

and natural hazards on household income. In a study on natural disasters, household welfare, and resilience in rural Vietnam (Arouri et al., 2015), the authors used commune-level fixed-effects regression to estimate the impact of natural disasters on the well-being and poverty of rural households in Vietnam, then examined household and community characteristics that can strengthen households' resilience to disaster. The results show that all three types of disasters considered in this study, including storms, floods, and droughts, hurt household income. Households in communes with higher average expenditure and more equitable time distribution are more resilient to disasters.

After reviewing previous studies, the research also applies Birkmann's theoretical framework (Birkmann, 2007), in which vulnerability is measured at various levels to measure the multi-dimensional damage of natural disasters on household welfare. Specifically, with a focus on economic factors, we estimate disasters' impacts on each specific source of agricultural income. Furthermore, the agricultural income of households in the case of natural disasters is affected by individual characteristics, such as ethnicity, gender, age, household education, and household size (Arouri et al., 2015; Bista, 2020; Bui et al., 2014; Gaiha et al., 2007; Karim, 2018; Skoufias et al., 2020), and elements related to economic factors of households, such as early warning, organization membership, the amount of livestock, expenditure, or labor proportion (Bista, 2020).

To measure the impact of disasters on household income, the study uses the sustainable livelihoods analysis framework of Scoones (1998). When applied to rural areas of developing countries, a rural household in this framework is considered the basic decision-making unit (Ellis, 2000).

Figure 1. The theoretical framework of natural disasters impacts on household income



Source: The authors' adaptation from Scoones' model (1998).

The reduced livelihood framework comprises two closely connected components: livelihood background and livelihood strategy in household characteristics (Figure 1). Livelihood assets are classified into different types of capital: physical capital (number of cattle and household expenditure), human capital (education and employment rate), and social capital (joining organizations and associations). These types of capital or assets form the basis on which a household chooses its livelihood strategy as a combination of income-generating activities. This theoretical framework highlights the different factors that shape household livelihoods. A new feature of this theoretical framework is the additional study of the effects of natural disasters on the agricultural income of households.

3. Research data and methods

3.1 Research data

The dataset on access to resources for households in rural Vietnam (VARHS) has been investigated since 2002 by the Central Institute for Economic Management under the Ministry of Planning and Investment (CIEM), the Center for Consulting Agricultural Policy, the Institute of Labor and Social Sciences (ILSSA), and the Economic Research Group (DERG) of the University of Copenhagen, together with Danish International Development Assistance (Danida). The United Nations University's Institute for World Development Economics (UNU-WIDER) began participating in 2010. In which ILSSA performs many tasks related to planning and field investigation, UNU-WIDER works closely with the rest of the research groups in a survey design and data analysis to ensure the VARHS project provides data and related policy research to policymakers and research capacity to be able to exploit the benefits that this data set brings.

To explore geographical differences related to rural access to resources, the survey team classified the provinces into five regional groups, including provinces such as the Red River Delta (former Ha Tay), the North (Lao Cai, Phu Tho, Lai Chau, and Dien Bien), the Central Coast (Nghe An, Quang Nam, and Khanh Hoa), the Central Highlands (Dak Lak, Dak Nong, and Lam Dong), and the plains Mekong River (Mekong Delta) (Long An). The VARHS survey rounds consisted of very detailed interviews conducted under relatively harsh conditions during June and July in rural areas in 12 provinces of Vietnam. The authors approached the dataset through a project funded by UNU-WIDER. This research analyzes the results of 5 rounds of VARHS surveys conducted once every two years to collect detailed information on rural households in 12 Northern, Central, and Southern provinces from 2008 to 2016. The VARHS project surveyed more than 2,000 rural households in 12 Vietnamese provinces, with a total of 10,259 observations after data processing.

Speaking of agricultural income, the Central Institute of Economic Management (CIEM) et al. (2017) emphasized that the earnings of Vietnamese farm households comprise four types: (1) agricultural income (income from agricultural activities such as planting or cattle rearing); (2) income from salaries and paid labor; (3) non-agricultural income (from industrial activities and cottage industries, including such fields as food processing, construction materials, or machining machinery) or trade-in-services activities (sales and collection); and (4) other income (from public benefits and other unusual income). Applying the aforementioned definition in combination with the VARHS database, the research synthesizes the typical agricultural income of a farm household in Vietnam from four primary sources: (1) crops, (2) forestry production, (3) animal husbandry, and (4) fishery.

3.2 Research methods

According to past studies (Birkmann, 2007; Gaiha et al., 2007; Hasegawa, 2010; Bui et al., 2014; Muttarak & Lutz, 2014; Arouri et al., 2015; Patankar & Patwardhan, 2016; Alam, 2017; Zulfikar and STP, 2019; Bista, 2020; Newman & Tarp, 2020; Saleem et al., 2020; Skoufias et al., 2020; Thomas et al., 2010; Kanwal & Sirohi, 2021; Trinh et al., 2021), the regression model based on panel data was used to measure the impact of natural disasters on income sources from agriculture through five models (1)-(5). Accordingly, each dependent variable of these models is a source of income from agriculture, presented in the following form:

$$LnInc_{it} = \beta_0 + \beta_1 nat_{it} + \beta_2 war_{it} + \beta_3 gen_{it} + \beta_4 age_{it} + \beta_5 ethnic_{it} + \beta_6 eduh_{it} + \beta_7 hhsize_{it} + \beta_8 organh_{it} + \beta_9 lncat_{it} + \beta_{10} lnexp_{it} + \beta_{11} pro_{it} + \nu_i + \varepsilon_{it} \quad (1)\text{-}(5)$$

In which, $LnInc_{it}$ are the income sources, respectively, as (1) $LnIn_{it}$ (total income: income from agriculture is measured by aggregating income from a household's agricultural, forestry, fishery, mining, and fishing activities), (2) $LnIn\_Cr_{it}$ (income from crops), (3) $LnIn\_Fp_{it}$ (income from forest

products), (4) $LnIn\_Li_{it}$ (income from livestock), and (5) $LnIn\_Ai_{it}$ (income from aquatic industries).

The study also measures the impact of natural disasters on households by the values of damage at the time of disaster or one year later through three regression equations (6)-(8) with the following form:

$$LnLos_{it} = \beta_0 + \beta_1 nat_{it} + \beta_2 war_{it} + \beta_3 gen_{it} + \beta_4 age_{it} + \beta_5 ethnic_{it} + \beta_6 eduh_{it} + \beta_7 hhsize_{it} + \beta_8 organh_{it} + \beta_9 lncat_{it} + \beta_{10} lnexp_{it} + \beta_{11} pro_{it} + \nu_i + \varepsilon_{it} \quad (6)\text{-}(8)$$

Where $LnLos_{it}$ are the damage values over time, respectively, as (6) $LnLo_{it}$ (total loss: damage value of natural disasters by year), (7) $LnLo\_0_{it}$ (damage in the year of the disaster), and (8) (damage after one year of natural disasters).

To test the difference in the impact of natural disasters on agricultural income by ethnicity of rural households in Vietnam, the study implements a regression model with the interaction variable nat_{it} x $ethnic_{it}$ corresponding to the eight equations. As shown above, the residuals of these estimation models are divided into two parts, ν_i and ε_{it} (in which i and t indicate space and time units, respectively). The component ν_i represents all unobserved variables that differ between subjects spatially only or "panel effects" (either fixed or random). Meanwhile, the component ε_{it} represents unobserved variables that vary between subjects both spatially and temporally, or "the error term."

For panel data, the most popular estimation methods are the pooled ordinary least squares regression model (OLS), the fixed effects model (FEM), and the random effects model (REM). The fixed effects can address outcome bias problems arising from characteristic differences within observations by isolating the influences of time-invariant characteristics from the predictors (Wooldridge, 2009). While FEM represents unobserved characteristics from a fixed number of units, REM assumes units are randomly selected from the much larger population; thus, it better represents spatial error. Regarding panel

data analysis, Gujarati (2021) recommended starting with the Pooled OLS, FEM, and REM models and performing hypothesis testing to find a model that fits the panel data. In this study, the authors will perform regression on all three models and then choose the most suitable one. The variables used in the regression are listed in Appendix 1.

To control estimate problems (including outlying, multicollinearity, and heteroskedasticity), statistical tests must be performed before and after running regression models to ensure unbiased estimates. The first is the test for outliers which is necessary to remove exceptional cases from the analyzed sample data (Bates et al., 2021); in this study, the significance of this test is applied at the 5% level. The VIF method is used to detect multicollinearity, and in the case of VIF > 10, multicollinearity is considered present in the models (Kim, 2019). Finally, the Breusch-Pangant/Cook-Weisberg test is performed to detect heteroskedasticity (Wooldridge, 2009), and in the case of heteroskedasticity, standard errors in models should be robust-modified.

4. Results and discussion

The results have undergone the Wooldridge test, Variance Inflation Factors test, and Modified Wald test to examine the models' autocorrelation, multicollinearity, and heteroskedasticity, respectively. The results show no sign of autocorrelation or multicollinearity; however, heteroskedasticity is detected. Thus, to guarantee the reliability of the estimates, we obtain robust standard errors which address the presence of heteroskedasticity. Tables 1 and 2 also indicate the impacts of natural disasters on the agricultural income of households and the different effects on variables.

The research uses eight regression models for the main dependent variables (agricultural income and the amount of damage) to evaluate the extent to which these variables are affected by the independent ones (Table 1). Accordingly, agricultural income is broken down by source of income, including crops, forestry, livestock, and fishery; the amount of damage is

measured in two different periods, including the current year and the following year, to evaluate the impacts of various factors in detail. To clarify the relationship between natural disasters and ethnicity, the interactive variable $int1_{it}$ $(nat_{it}*ethnic_{it})$ is utilized (Table 2).

Table 1. Regression result of the impacts of natural disasters on agricultural income (model without interactive variables)

MODEL 1 (WITHOUT INTERACTIVE VARIABLES)								
Variables	$LnIn_{it}$	$LnIn\_Cr_{it}$	$LnIn\_Fp_{it}$	$LnIn\_Li_{it}$	$LnIn\_Ai_{it}$	$LnLo_{it}$	$LnLo\_0_{it}$	$LnLo\_1_{it}$
Nat_{it}	-0.701***	-0.330***	-0.00229	-0.908***	-0.634***	0.0516	-0.0278	0.0958*
	(0.0910)	(0.0696)	(0.00890)	(0.115)	(0.0585)	(0.0601)	(0.0386)	(0.0501)
War_{it}	0.301***	0.229***	-0.0154	-0.0197	0.0673	-0.0428	-0.00316	-0.0467
	(0.112)	(0.0763)	(0.00992)	(0.149)	(0.0662)	(0.0378)	(0.0216)	(0.0316)
Gen_{it}	0.320	0.0724	-0.000679	-0.00493	0.0889	1.393***	0.364***	0.960***
	(0.346)	(0.255)	(0.00901)	(0.428)	(0.206)	(0.0716)	(0.0428)	(0.0595)
Age_{it}	-0.00110	-0.0133	-0.000914	-0.00672	-0.00753	0.0142	0.0514	-0.0232
	(0.0131)	(0.0103)	(0.000679)	(0.0156)	(0.00887)	(0.0963)	(0.0547)	(0.0875)
$Ethnic_{it}$	1.003	0.318	-0.00272	0.491	0.324	-0.0346	-0.163	0.145
	(0.842)	(0.450)	(0.00392)	-1.075	(0.449)	(0.261)	(0.157)	(0.243)
$Eduh_{it}$	-0.0310	-0.00930	-0.00244	-0.0248	-0.0234	-0.0687***	-0.00636	-0.0548***
	(0.0311)	(0.0194)	(0.00289)	(0.0441)	(0.0218)	(0.0118)	(0.00565)	(0.0110)
$Hhsize_{it}$	0.495***	0.519***	-0.00104	0.153	0.00973	0.243	-0.337	0.381
	(0.0741)	(0.0572)	(0.00419)	(0.0960)	(0.0473)	(0.654)	(0.365)	(0.525)
$Organh_{it}$	0.388**	0.330***	0.00193	0.331	-0.0789	-0.126***	-0.0199	-0.108***
	(0.178)	(0.128)	(0.0215)	(0.204)	(0.0967)	(0.0254)	(0.0155)	(0.0235)
$Lncat_{it}$	0.0548	-0.0170	0.00197	0.642***	0.0235	0.498***	0.200***	0.289***
	(0.0346)	(0.0239)	(0.00286)	(0.0461)	(0.0206)	(0.116)	(0.0656)	(0.100)
$Lnexp_{it}$	-0.0330**	-0.0167*	0.000305	-0.0568***	-0.0217**	0.0162	-0.00362	0.0109
	(0.0154)	(0.0100)	(0.00128)	(0.0214)	(0.00958)	(0.0231)	(0.0134)	(0.0198)
Pro_{it}	-0.359***	-0.318***	-0.000129	-0.120**	0.0296	-0.00620	-0.00108	-0.000640
	(0.0507)	(0.0392)	(0.00315)	(0.0586)	(0.0291)	(0.0126)	(0.00723)	(0.0110)
Constant	6.894***	7.730***	0.0847	3.523***	0.932	4.385***	0.923*	3.170***
	-1.064	(0.722)	(0.0542)	-1.342	(0.689)	(0.898)	(0.487)	(0.809)

MODEL 1 (WITHOUT INTERACTIVE VARIABLES)								
Variables	$LnIn_{it}$	$LnIn\_Cr_{it}$	$LnIn\_Fp_{it}$	$LnIn\_Li_{it}$	$LnIn\_Ai_{it}$	$LnLo_{it}$	$LnLo\_0_{it}$	$LnLo\_1_{it}$
Observations	**5,530**	**5,530**	**5,530**	**5,530**	**5,530**	**5,530**	**5,530**	**5,530**
No. of IDs	**2,027**	**2,027**	**2,027**	**2,027**	**2,027**	**2,027**	**2,027**	**2,027**
R-squared	**0.048**	**0.051**	**0.001**	**0.103**	**0.046**	**0.100**	**0.027**	**0.067**

Notes: Standard deviation in the brackets; (***) 1% level of confidence, (**) 5% level of confidence, and (*) 10% level of confidence.

Source: The authors.

As illustrated from the models, natural disasters, household education, proportion of labor, early warnings, household size, and expenditure are accepted at the 1% significance level. The regression coefficient of the natural disaster variable has a positive sign regarding the total amount of loss in the following year, while the sign is negative when it comes to the total income, income from livestock, or fishery. This finding means that the impact of natural disasters on income gets more severe when conditions get worse. In addition, regarding the second model (with interactive variables), the coefficients of disasters with the total loss, loss in the current year, and loss in the next year are 218.0%, 66.9%, and 133.6%, respectively. Meanwhile, the first model yielded a result of 9.58% in the year after. This finding can be explained by the destructive power of storms and floods which can destroy crops, cause climate change, and affect the water level, resulting in a great loss of livelihood and income. This finding is similar to that of Chapagain and Raizada (2017), who claim that disasters cause severe damage to the living conditions and food security of farm households in many countries. According to Arouri, Nguyen, and Youssef (2015), three types of disasters (storms, floods, and droughts) hurt income and household expenditure.

Table 2. Regression result of the impacts of natural disasters on agricultural income (model with interactive variables)

MODEL 2 (WITH INTERACTIVE VARIABLES)								
Variable	$LnIn_{it}$	$LnIn\_Cr_{it}$	$LnIn\_Fp_{it}$	$LnIn\_Li_{it}$	$LnIn\_Ai_{it}$	$LnLo_{it}$	$LnLo\_0_{it}$	$LnLo\_1_{it}$
Int_{it}	-0.532***	-0.373***	-0.0240	-0.253	0.652***	-1.022***	-0.396***	-0.487***
	(0.188)	(0.127)	(0.0276)	(0.273)	(0.156)	(0.173)	(0.123)	(0.136)
Nat_{it}	-0.291*	-0.0420	0.0162	-0.713***	-1.136***	2.180***	0.669***	1.336***
	(0.159)	(0.0979)	(0.0275)	(0.248)	(0.147)	(0.163)	(0.118)	(0.126)
War_{it}	0.312***	0.237***	-0.0149	-0.0148	0.0545	0.0342	0.0591	-0.0136
	(0.112)	(0.0762)	(0.00998)	(0.149)	(0.0659)	(0.0958)	(0.0545)	(0.0875)
Gen_{it}	0.314	0.0675	-0.000993	-0.00825	0.0975	-0.0480	-0.168	0.138
	(0.345)	(0.254)	(0.00880)	(0.428)	(0.207)	(0.257)	(0.154)	(0.243)
Age_{it}	-0.000214	-0.0127	-0.000874	-0.00629	-0.00862	-0.0670***	-0.00570	-0.0540***
	(0.0131)	(0.0103)	(0.000652)	(0.0157)	(0.00904)	(0.0118)	(0.00565)	(0.0110)
$Ethnic_{it}$	1.331	0.548	0.0121	0.647	-0.0781	0.873	-0.0931	0.681
	(0.852)	(0.455)	(0.0184)	-1.090	(0.464)	(0.673)	(0.372)	(0.532)
$Eduh_{it}$	-0.0301	-0.00863	-0.00239	-0.0243	-0.0246	-0.124***	-0.0192	-0.107***
	(0.0311)	(0.0193)	(0.00286)	(0.0441)	(0.0215)	(0.0258)	(0.0155)	(0.0237)
$Hhsize_{it}$	0.488***	0.514***	-0.00137	0.149	0.0186	0.0377	-0.0332	0.0892*
	(0.0737)	(0.0569)	(0.00412)	(0.0961)	(0.0470)	(0.0597)	(0.0386)	(0.0501)
$Organh_{it}$	0.377**	0.322**	0.00145	0.326	-0.0658	0.477***	0.192***	0.279***
	(0.178)	(0.128)	(0.0218)	(0.205)	(0.0969)	(0.115)	(0.0649)	(0.0999)
$Lncat_{it}$	0.0582*	-0.0146	0.00213	0.644***	0.0194	0.0227	-0.00109	0.0140
	(0.0346)	(0.0239)	(0.00296)	(0.0460)	(0.0205)	(0.0229)	(0.0133)	(0.0198)
$Lnexp_{it}$	-0.0338**	-0.0173*	0.000268	-0.0571***	-0.0207**	-0.00775	-0.00168	-0.00138
	(0.0154)	(0.0100)	(0.00127)	(0.0214)	(0.00943)	(0.0125)	(0.00724)	(0.0109)
Pro_{it}	-0.350***	-0.312***	0.000252	-0.116**	0.0192	-0.0265	0.00313	-0.0390
	(0.0504)	(0.0389)	(0.00294)	(0.0588)	(0.0288)	(0.0376)	(0.0218)	(0.0317)
Constant	6.570***	7.503***	0.0701	3.370**	1.328*	3.765***	0.683	2.874***
	-1.060	(0.726)	(0.0446)	-1.350	(0.710)	(0.903)	(0.485)	(0.815)
Observations	**5,530**	**5,530**	**5,530**	**5,530**	**5,530**	**5,530**	**5,530**	**5,530**
No. of IDs	**2,027**	**2,027**	**2,027**	**2,027**	**2,027**	**2,027**	**2,027**	**2,027**
R-squared	**0.050**	**0.052**	**0.002**	**0.103**	**0.054**	**0.110**	**0.032**	**0.07**

Note: $int1_{it}$ (nat_{it}*$ethnic_{it}$); Standard deviation in the brackets; (***) 1% level of confidence, (**) 5% level of confidence, and (*) 10% level of confidence.

Source: The authors.

Table 2 shows that the interactive variable of the model, $int1_{it}$ (nat_{it}* $ethnic_{it}$), has a high significance level of 1%, indicating that disasters and ethnicity have a correlation that helps to reduce substantial amounts of loss. Each ethnicity has different ways of adapting to losses caused by disasters, some of which effectively diminish the damage of such natural hazards. It has been recorded that the impact of disasters will be much lower on the Kinh households and households of smaller sizes, with a higher proportion of members in the labor age (Arouri et al., 2015). In other words, the endurance against natural disasters of the above households is better than that of the minority and large-size households, especially those having underage members. Moreover, the research also reveals that a high level of education would minimize the negative effects of natural disasters on income. Therefore, the educational level of the household head and members' ability to work play a vital role in reducing vulnerability and damage, whereas social sources seem to have a smaller impact. Hence, higher school attendance and education should reduce the impacts of natural disasters.

Furthermore, an early warning system can help lessen households' vulnerability through preparation and prevention, as households will have more time to move to a safer place (Bista, 2020). Likewise, an early warning system has enabled households to actively prepare in advance and evacuate immediately if necessary (Shah et al., 2018). However, the coefficient of the early warning variable is relatively low, only between 22% - 32%. Therefore, increasing agricultural income requires careful research and a proper application of early warning systems to reduce losses.

Other factors taken into consideration are expenditure and household size. On the one hand, expenditure has a negative impact on income from crops, fishery, and livestock, although no effect on loss is recorded. It can be explained by the fact that natural disasters can significantly decrease income and household expenditure, thus widening the gap between the rich and poor (Bui et al., 2014). On the other hand, Keerthiratne and Tol (2018) pinpointed

that the rich are more likely to suffer from greater losses than the poor since the latter can diversify their sources of income.

Overall, we have inherited and contributed to overcoming the limitations of previous studies about the impacts of natural disasters on the agricultural income of farm households in Vietnam. Nevertheless, the results of our research could not prevent the following limitations. The research focuses on verifying the relationship between the effects of natural disasters and the agricultural earnings of Vietnamese farm households. Meanwhile, other proxy variables and aspects (such as using alternative hazard prevention to insurance or public benefits) were left unexplored. Due to our limited database, we only conduct research and analysis within a suitable scope.

5. Conclusion and recommendations

Through statistical description and regression result analysis of the data panels, the research shows that early warning and household size and participation in the organization have positive impacts on agricultural income and contribute to diminishing loss caused by the disaster. Among these, household size is the most impactful factor, while participation in the organization and early warning ranks second and third, respectively. On the other hand, disaster, expenditure, and employment share in agriculture have a negative impact on agricultural income. The regression result illustrates that natural disasters have a far greater impact on income than the two other variables.

Based on these findings, several actions should be taken as soon as possible. Disaster prevention is regarded as an indispensable element in national construction and protection, especially for Vietnam, a country heavily affected by natural disasters. However, Vietnam still needs greater improvements to aid people in rural areas, especially where the main occupation is agriculture, to lessen the impact of natural disasters on income. The authors propose some recommendations for the government and households as follows:

Government recommendations

The government declared several mechanisms and policies to promote natural disaster prevention and control, such as the Government Decree regarding the establishment and management of disaster management funds on August 1, 2021. This decree was an elaboration of some articles of the law on natural disaster management and law on amendments to some articles of the law on natural disaster management and law on dikes from July 6, 2021. Approval of the implementation plan of the project "Enhancing community awareness and community-based disaster risk management until 2030" in the province came on June 4, 2021, along with efforts in disaster prevention with good results in 2021, but these policies are not specific in instructing rural households in Vietnam on how to respond to each specific area, livestock, and plants during natural disasters. These reduce disaster prevention programs' effectiveness because they cannot help rural households reduce property damage. Therefore, the research team proposes many recommendations for the government, focusing on three aspects: knowledge, skills, and propaganda. In particular, the government should broaden the public's knowledge about crops and livestock, train the force for disaster prevention and people in rural households, and propagandize disaster prevention.

Household recommendations

The role of people in proactively preventing, responding, and overcoming the consequences of natural disasters is significant in reducing losses and promoting sustainable development. However, the reality is that people still need to gain the knowledge and skills to prevent and respond to some types of natural disasters because, in some locales, education on natural disaster prevention and control is still limited. People are not allowed to participate directly in training courses and learn how to prevent each specific type of disaster, which greatly influences disaster prevention results because the community is an essential factor in showing whether disaster prevention is

effective or not. Therefore, people need to be fully equipped with knowledge, skills, and awareness of prevention and rescue work in natural disasters. Some recommendations for rural households include:

- *Firstly*, households should learn sufficient disaster prevention skills, ensure the requirements according to the motto "4 on-site" (on-site command, on-site forces, on-site supplies and vehicles, and on-site logistics), install monitoring systems, and ensure communication between the sea and land.
- *Secondly*, households should improve their adaptability to natural disasters, such as building safe houses in flood areas or changing the crop and livestock structure to suit the characteristics of natural disasters in each region.
- *Thirdly,* households should raise their awareness of disaster warnings and consequences. Households should participate in programs such as "Community participating in disaster prevention," "Villages are safe from natural disasters" on television stations, "Community connection" on Facebook, and contests such as "Composing new lyrics for folk songs and traditional music about disaster prevention."
- *Lastly,* people should participate in mitigating and overcoming consequences and restoring and stabilizing production and life after natural disasters.

The study has inherited and contributed to overcoming the limitations of previous studies on the impact of natural disasters on agricultural income; however, the study still has some limitations, such as: (1) The dataset's number of observations over time is relatively short (under 30 years); therefore, it is not possible to forecast in the long term; (2) some issues related to natural disasters have not been considered, such as the number of people injured or killed, the mental stress on people after natural disasters, government financial support, and more. In the future, researchers can estimate, using these factors, the effect of natural disasters on agricultural income to enlarge pictures of natural disasters in rural areas.

Acknowledgements

We are grateful for feedback from editors and anonymous reviewers for their valuable comments on earlier versions of this paper. Especially, we would like to thank Duong Tuan Nguyen, College of Management, National Sun Yat-Sen University, Kaohsiung, Taiwan and Nhan Nguyen Thanh, Faculty of Business Administration, Ton Duc Thang University for his reading and providing feedback on this study.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research is funded by Foreign Trade University under research program number NTCS2021-23.

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Appendix

Appendix 1. Variable Definition

Variable	Definition	Expected Sign	Previous research inherited
Dependent variable ($LnInc_{it}$)			
$LnIn_{it}$	Total income: Income from agriculture is measured by aggregating income from a household's agricultural, forestry, fishery, mining, and fishing activities, according to the function ln(x)		Birkmann (2007); Saleem et al. (2020); Alam (2017); Arouri et al. (2015); Bista (2020)
$LnIn\_Cr_{it}$	Income from crops		
$LnIn\_Fp_{it}$	Income from forest products		
$LnIn\_Li_{it}$	Income from livestock		
$LnIn\_Ai_{it}$	Income from aquatic industries		
Dependent variable ($LnLos_{it}$)			
$LnLo_{it}$	Total loss: Damage value of natural disasters by year, calculated by the function ln(x)		Birkmann (2007); Patankar & Patwardhan (2016); Saleem et al. (2020); Bista (2020)
$LnLo\_0_{it}$	Damage in the year of the disaster, calculated by the function ln(x).		
$LnLo\_1_{it}$	Damage after one year of natural disaster, calculated by the function ln(x)		
Independent variables			
Int_{it}	Interaction between natural disasters and ethnic situation		
Nat_{it}	Natural disasters: Dummy variable takes the value of 1 if the household suffers from floods, droughts, storms, and other natural disasters; and 0 for vice versa	+/-	Hasegawa (2010), Thomas et al. (2010), Newman & Tarp (2020), Trinh et al. (2021)
War_{it}	Early warnings	+/-	Bista (2020)

Variable	Definition	Expected Sign	Previous research inherited
Personal characteristics of households			
Gen_{it}	Gender: Dummy variable takes the value 1 if the head of household is male and 0 if female	+/-	Skoufias et al. (2020); Bui et al. (2014); Arouri et al. (2015)
Age_{it}	Age: Equal to the surveyed year minus the year of birth of the household head	+/-	Skoufias et al. (2020); Arouri et al. (2015)
$Ethnic_{it}$	Ethnicity: Dummy variable takes the value 1 if the head of household is Kinh and 0 if ethnicity	+/-	Bui et al. (2014); Gaiha et al. (2007); Arouri et al. (2015)
$Eduh_{it}$	The educational level of the household head: Number of schooling years of household head	-	Muttarak & Lutz (2014); Skoufias et al. (2020); Kanwal and Sirohi (2021)
$Hhsize_{it}$	Household Size: Total number of people in the household	+/-	Skoufias et al. (2020); Bui et al. (2014); Arouri et al. (2015)
Financial characteristics of households			
$Organh_{it}$	Organization	+/-	Bista (2020)
$Lncat_{it}$	Number of cattle	+/-	Kanwal & Sirohi (2021)
$Lnexp_{it}$	Household expenditure	+/-	Saleem et al. (2020)
Pro_{it}	The proportion of the total labor force	+/-	Bista (2020)

Source: The authors