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Natural Disaster, Information Technology, and Agriculture Production in Vietnam: Evidence from Panel Data Analysis

Khai Cong Dinh
School of Government, College of Economics, Law, and Government, University of Economics Ho Chi Minh City, 72407 Ho Chi Minh City, Vietnam
Research Group Public Governance and Developmental Issues, University of Economics Ho Chi Minh City, 72407 Ho Chi Minh City, Vietnam
Email: khai@ueh.edu.vn

Thanh Quang Ngo*
School of Government, College of Economics, Law, and Government, University of Economics Ho Chi Minh City, 72407 Ho Chi Minh City, Vietnam
Research Group Public Governance and Developmental Issues, University of Economics Ho Chi Minh City, 72407 Ho Chi Minh City, Vietnam
Email: thanhnq@ueh.edu.vn

Corresponding Author: *Thanh Quang Ngo**

Agriculture is among the most susceptible industries to natural calamities. Technology is crucial to agricultural output. While agricultural machinery directly impacts agricultural output by increasing yield and quality, information technology may influence coping mechanisms for responding to natural disasters and so increase agricultural productivity. This paper examines (1) the degree to which agriculture production in Vietnam is impacted by natural disasters such as floods, drought, typhoons, and landslides, (2) how coping strategies mitigate the negative effects of natural disasters, and (3) how information technology influences the selection of coping strategies in response to a natural disaster. Our primary premise is that natural catastrophes have a detrimental influence on agricultural production and that coping mechanisms might somewhat mitigate these negative effects. In addition, information technology can facilitate the selection of coping measures for natural disasters.

Key words: Agriculture production, information technology, natural disasters, panel data analysis, Vietnam.

1. INTRODUCTION

Agriculture is one of the most vulnerable industries to natural disasters due to its intrinsic sensitivity to climate conditions. According to Sivakumar (2005), a natural disaster devastates neighboring living beings. There are two types of natural disasters: hydro-meteorological and geophysical (Sivakumar, 2005), with the former including landslides, droughts, extreme temperatures, heatwaves, floods, tropical cyclones, windstorms, and others (insect infestation and waves/surges) and the latter including earthquakes and volcanic eruptions (IFRC/RCS, 2003).

Natural catastrophes have much more devastating effects on agriculture-dependent nations, particularly developing nations. Due to the effects of natural disasters like floods, drought, typhoons, and landslides, agricultural output is declining significantly. According to (The food and Agriculture Organization (FAO, 2017), for climate-related disasters such as floods, droughts, and tropical storms, 25% of all damage and losses occur in the agriculture sector. Agriculture is the sector most affected by droughts, accounting for approximately 84% of the average of all economic impacts. In addition, Asia is the region most affected by production losses, with crop and livestock production losses of USD 28 billion, or 40% of overall losses, followed by Africa with USD 26 billion. The prospect of food and drink scarcity would pose a global hazard, jeopardizing the livelihoods of 2.5 billion people worldwide who rely on agriculture for a living.

Technology is crucial to agricultural output. The adoption of information technology (such as telephones, televisions, computers, and the internet) has increased rapidly over the period studied by Kaila (2015). In contrast, agricultural machinery (in various types related to agricultural activities) has changed only marginally. While agricultural machinery directly impacts agricultural output by increasing yield and quality, information technology may influence coping mechanisms for responding to natural disasters and so increase agricultural productivity.

In this context, the use of information technology will bring a flood, drought, seawater intrusion, storm, landslide, and flash flood digital models; natural disaster warning/monitoring systems from satellites or on-site gauges processed via IoT, big data in early detection of natural disasters to prevent and minimize damage caused by natural disasters (Zevenbergen et al., 2014). In addition, with the aid of information technology, the farmer can have a plan for wisely utilizing their land. In addition, they can predict future weather conditions to select appropriate coping methods and reconstruct adaptable plants and animals to mitigate the negative consequences of natural disasters (Lundin, 2011; Mukherji, 2014; Ponce, 2013). Notably, the Vietnam General Directorate of Natural Disaster Prevention and Control has recently implemented various communication forms and social networks (such as Facebook and YouTube) to communicate with users. This makes people aware of weather developments and can initiate prompt responses.

Vietnam, an agriculture-based nation in Southeast Asia with a maritime border and a landscape characterized by a long coastline, experiences numerous storms annually. In all regions of the nation in 2020, natural disasters emerged as convoluted, fierce, and unexpected. According to the annual statistics of the Vietnamese government, there have been over 458 natural disasters since the beginning of the year (13 storms in the East Sea, 263 vortexes, cyclones, 101 flash floods, landslides, 82 earthquakes, droughts, severe seawater intrusion, riverbank, and coastal erosion). Vietnam is one of the most susceptible nations in the region due to its vulnerability to natural catastrophes. In-depth research on this topic can aid policymakers in developing more suitable remedies for the Vietnam scenario.

This paper examines (1) the degree to which agriculture production in Vietnam is impacted by natural disasters such as floods, drought, typhoons, and landslides, (2) how coping strategies mitigate the negative effects of natural disasters, and (3) how information technology influences the selection of coping strategies in response to a natural disaster. Our primary premise is that natural catastrophes have a detrimental influence on agricultural production and that coping mechanisms might somewhat mitigate these negative effects. In addition, information technology can facilitate the selection of coping measures for natural disasters. While many empirical studies have been conducted on the effects of natural disasters at the national, regional, community, household, and individual levels, as well as the sector and crop levels, such as Blaikie et al. (2014), Loayza et al. (2012), Kaplan (2010), Ludwig et al. (2007), De Haen et al. (2007), Sawada (2007), Alderman, Ho This is primarily due to a lack of pertinent information.

The study focuses on the effects of natural catastrophes on agricultural productivity, coping mechanisms, and the use of information technology in Vietnam for several reasons (World Bank, 2009). Second, agricultural output has been vital to Vietnam's rural and economic development. Due to the limited potential for extending arable land to improve output (due to fast industrialization and urbanization), the risk of food insecurity and agricultural growth in Vietnam could be exacerbated by natural disasters and deteriorating agricultural productivity. The third source of our data is the Vietnamese Access to Resources Household Survey (VARHS), conducted in five two-year surveys between 2008 and 2016. It contains in-depth information on agricultural production at the farm level, the many forms of natural catastrophes, their occurrence times, their severity levels, and information technology. They enable an analysis of natural disasters, information technology, and agricultural productivity at the farm level.

The study's findings can provide policymakers with valuable information about the negative effects of natural catastrophes on farm productivity, coping mechanisms, and the role of information technology in Vietnam. The government should have strong and effective policies and initiatives to mitigate the negative effects of natural catastrophes if they lead to a decline in agricultural productivity. In addition, a national framework for combating natural disasters should promote and tailor more effective coping mechanisms with information technology to deal with the negative repercussions of a natural disaster.

The study is anticipated to contribute to the literature on environmental and development economics. Secondly, it offers empirical data on the effects of natural disasters and coping techniques and the function of information technology in agriculture production, on which the empirical literature is quiet. It differentiates between present and inter-temporal impacts and between incidence and severity effects.

The organization of the study is as follows: Section 2 gives a detailed literature analysis, Section 3 explains data and methodology, Section 3 presents empirical results, and Section 4 closes and raises implications.

2. LITERATURE REVIEW

2.1 Information Technology and Vietnamese Agriculture Sector

Agriculture is recognized as a significant economic growth industry in Vietnam. Surprisingly, rapid industrialization growth damaged the country's agricultural sector in terms of GDP and employment. Yet, agriculture remains a vital component of the economy due to its competitive advantage over countries in comparable locations (Fernández-Pastor et al., 2016). Since the 1990s, Vietnam has maintained its position as one of the major exporters of "rice, coffee, pepper, and cashew nuts." In addition, production and exports of fruits and vegetables, rubber, and cassava rose; the export of vegetables and fruits exceeded that of rice. It is mentioned that the Vietnamese government's efforts contributed to the country's effective advancement in agricultural production technologies. Diverse agricultural practices are developed and disseminated to cultivate distinct rice varieties and essential commodities (Mammo, 2015). The Vietnamese government is likewise interested in encouraging innovative agricultural production practices. Private corporations also strive to invest in the European agricultural system to develop high-tech goods. However, the government's legislative structure regulating agricultural production techniques is murky. But, the government is now targeting these businesses to provide adequate support for the transition to high-tech agriculture (Msengezi et al., 2018).

Regrettably, high-tech GHG investments cannot deliver quality returns on their own. Hence, production management must be enhanced further to enhance quality and add value by "regulation of water input, sunlight exposure, and growing speeds" (Sadiq et al., 2023b). This specialized agricultural strategy necessitates in-depth knowledge of all aspects with the potential to affect yield. However, it is regrettable that enterprises involved in high-tech agriculture in Vietnam tend to have inadequate knowledge of production factors, techniques, and markets (Sakata, 2019). ICT application in agriculture is crucial, and ICT use in agricultural production has become prevalent, particularly in the European market. This is because it helps meet retail industry leaders' quality and safety standards. Also, it aids in resolving key problems such as labor shortages. This prompted us to examine the relationship between technology and agricultural productivity, which could benefit the Vietnamese agricultural sector (Chien et al., 2021; Wolfert et al., 2017).

2.2 Natural Disaster and Agricultural Production

Climate complexity and natural catastrophes are thought to impact crop output considerably. It not only harms agricultural output but also influences cropping decisions. In Vietnam, disaster-related agricultural losses are caused by floods and severe storms, which damage crops and the infrastructure and irrigation system. Complicating the problem are the accompanying agricultural diseases, which ultimately negatively influence crop output. Since 2000, it is estimated that the country has lost about 10 million tonnes of rice due to floods and storms. Also, the tragedy resulted in the flooding of around 120,00km2 of rice fields (UNDP, 2015). Due to the difficulties in estimating the crop production damage induced by a natural hazard, the claims also show that the stated loss statistics may understate the actual damage. It is also believed that natural disasters indirectly affect agricultural output due to agricultural behavior changes. For example, if summer crop sowing is delayed due to rainfall, the crops become more susceptible to flooding in the fall. It is also believed that the effects of natural disasters and climate change vary by region. Several studies have also calculated the agricultural impact of natural disasters (Moslehpour et al., 2022). For example, Loayza et al. (2009) found that droughts and storms harm agriculture.

Nonetheless, research indicates that floods have a favorable impact. Similarly, Sivakumar (2005) suggested that the major effect of natural disasters on agriculture is negative. According to another study, the unfavorable effects of natural disasters suggest a lack of agricultural self-sufficiency, particularly in nations with low income, poverty, and hunger (Israel et al., 2012; Trinh et al., 2021). Fragments of earlier research, particularly in Vietnamese, confirm that climate change and natural catastrophes harm agricultural production. It is believed that by 2050, due to natural disasters and climate complications, rice output may become sluggish and, in some circumstances, decrease by between 2 and 7 million tonnes. There is little doubt, according to studies, that natural disasters and climate change represent a significant threat to the nation, even impeding its socioeconomic progress (Sadiq et al., 2023a). Moreover, persistent temperature fluctuations, unexpected weather patterns, and frequent natural disasters harm industries, regions, and people's lives, particularly in rural areas (IPCC, 2014).

Owing to the severity of the threat posed by natural disasters, the government of Vietnam has enacted several national measures to enhance adaptability and draw attention to the issue. Nonetheless, the difficulties remain unresolved due to corruption and a lack of community coordination (Chein et al., 2022; UNDP, 2015). Literature also indicates that the Vietnamese government has not yet developed a viable strategy to address the issue of climate change on a national scale. Therefore, it is essential to monitor the relationship so that appropriate policy measures can be implemented to deal with the situation. (Huang et al., 2022)

The study also demonstrates that natural disasters and climatic complexity harm crop yield. The effect, however, is heterogeneous, as it varies by geography and crop situation. For example, in the Central Highlands and North-West, rice is one of the most vulnerable crops to natural calamities (Spencer & Polachek, 2015).

3. DATA AND METHODS

3.1 Data

The data are from the 2008, 2010, 2012, 2014, and 2016 Vietnamese Access to Resources Household Survey (VARHS). Farms are asked to name specific natural disasters to collect information regarding natural disasters. In the 2008 and 2010 surveys, natural disasters were collected in a generic sense; however, from 2012 to 2016, floods, droughts, and typhoons were recorded specifically.

The questionnaire also gives information regarding natural catastrophes' frequency (current and previous year), intensity, and persistence (completely recovered, partially recovered, and still suffering severely).

The questionnaire includes the coping techniques employed by households in response to each (specific) natural disaster, as well as estimates of the losses experienced by farms as a result of (specific) natural disasters, expressed in Vietnamese dong terms (Vietnam Dong, VND).

Coping strategies include: (1) "Household (HH) did nothing to cope with shock(s)"; (2) "HH reduced consumption to cope with shock(s)"; (3) "HH sold assets to cope with shock(s)"; (4) "HH used savings to cope with shock(s)"; (5) "HH got assistance from relatives to cope with shock(s)"; (6) "HH got assistance from the government to cope with shock(s)"; (7) "HH borrowed money to cope with shock(s)"; and (8) "HH got insurance payment to cope with shock(s)."

The VARHS section on information technology contains information on technology. The technology of information includes telephones, televisions, and satellites. The areas of agricultural land, crop agriculture, livestock, forestry, aquaculture, and agricultural services provide data on agricultural production.

3.2 Empirical Approach

Our empirical investigation focuses on the extent to which natural disaster affects farm-level agriculture productivity and the extent to which farms manage to cope with the negative effects of natural disaster, particularly the role of information technology in mitigating the negative effects of natural disasters within the framework of the traditional Cobb-Douglas production function as illustrated by Te'o (1997). We employ three phases of empirical research to investigate these topics.

3.3 Impact of Natural Disasters on Agriculture Production

Secondly, we investigate the effects of natural disasters on agricultural production at the farm level. Under specific conditions, the relationship between natural disasters and the depletion of farm produce can be determined using a panel fixed-effects technique. Using a fixed-effects model that adjusts for time-invariant farm heterogeneity, we leverage the panel dimension of our data. Time-varying farm characteristics are also included as control variables. The most important explanatory factors are natural catastrophes' frequency, severity, and duration. A fixed-effects estimate technique will eliminate any time-invariant unobserved heterogeneity while including control variables for inputs will capture any remaining time-varying heterogeneity.

The whole farm-level fixed effects model is given by (Model 1):

$$Y_{it} = (\alpha_1 LAB_{it} + \alpha_2 LAND_{it} + \alpha_3 CAP_{it} + \alpha_4 SHOCK\_REC_{it}) + \beta \sum_1^3 NAT_{it}^j + \delta \sum_1^3 LOSS_{it}^j + \phi \sum_1^3 NATLOSS_{it}^j + \tau t + ui + \varepsilon_{it} \quad (1)$$

Where: Y_{it} is agriculture production measured by the output values per hectare.

LAB_{it}, $LAND_{it}$, and CAP_{it} represent a vector of farm production inputs such as labor (total of HH working numbers), land (arable land), and capital (valuable assets), respectively.

$SHOCK\_REC_{it}$ denotes (1) shocks apart from natural disasters, namely: Biological shocks, demographic and social shocks, and economic shocks, and (2) the recoveries from shocks of all kinds.

NAT^j_{it} (j=1,2) are dummy variables indicating natural disasters occurred in the survey year (t) and one year ago (t-1), respectively. If the current natural disaster negatively affected agriculture output, we would expect the coefficients on this term to be negative and statistically significant (the current occurrence effect). If the past natural disaster resulted in a loss in agriculture output, we would expect the coefficients on these terms to be negative and statistically significant (the inter-temporal occurrence effect).

$LOSS^j_{it}$ (j=1,3) are variables indicating total loss from a natural disaster that occurred in the survey year (t) and one year ago (t-1), respectively.

$NATLOSS^j_{it}$ (j=1,3) is the interaction between natural disasters and total loss from natural disasters that occurred in survey year (t) and one year ago (t-1), respectively. Suppose natural disasters are severe, resulting in a loss in agriculture output. In that case, we expect the coefficient on these interaction terms to be negative and statistically significant (the current and inter-temporal severity effects, respectively).

τ_t represents time dummies, u_i is a farm-specific fixed effect, and ε_{it} is the farm random error term. We assume that regional differences, which control for agriculture productivity variations across regions, are subsumed within the farm fixed effect while the time dummies control for technological changes over time. Model (1) controls for (1) other shocks apart from natural shocks and (2) shock recovery from natural disasters and other shocks.

We explore Model (1) into two models: (1) Model (1.1) with natural disasters in general (General Model), (2) Model (1.2) with specific natural disasters (namely: floods, droughts, and typhoons) (Specific Model). In each group of the models, we estimate models with natural disasters (Panel A), models with natural disasters and losses (Panel B), and models with interactions between natural disasters and their losses (Panel C).

3.4 Impacts of Natural Disasters and Coping Strategies on Agriculture Production

In the second phase of our research, we investigate how coping mechanisms can mitigate the decline in agricultural output. We consider the following eight categories of coping strategies: Adaptation techniques include: (1) "Household did nothing to cope with shock(s);" (2) "Household reduced consumption to cope with shock(s);" (3) "Household sold assets to cope with shock(s);" (4) "Household used savings to cope with shock(s);" (5) "Household received help from relatives to cope with shock(s);" (6) "Household received help from the government to cope with shock(s);" (7) Household borrowed money to cope with shock(s);

A specified model is as follows (Model 2):

$$Y_{it} = (\alpha_1 LAB_{it} + \alpha_2 LAND_{it} + \alpha_3 CAP_{it} + \alpha_4 SHOCK\_REC_{it}) + \beta \sum_1^3 NAT_{it}^j + \delta \sum_1^3 LOSS_{it}^j + \phi \sum_1^3 NATLOSS_{it}^j + \chi \sum_1^7 COP_{it}^j + \gamma \sum_1^7 COPNAT_{it}^j + \tau t + ui + \varepsilon_{it} \quad (2)$$

Where: COP^j_{it} (j=1 - 8) are dummy variables indicating seven specific coping strategies conducted in the survey year (t) and one year ago (t-1), respectively. $COPNAT^j_{it}$ (j=1 - 8) are the interactions between natural disasters and seven specific coping strategies in survey year (t) and one year ago (t-1), respectively. Assume coping mechanisms aid in mitigating the loss of agricultural production caused by a natural disaster. In this situation, we anticipate that the coefficients of these interaction terms will be positive and statistically significant (the positive current and inter-temporal coping-occurrence effects). If not, negative coefficients (the adverse current and inter-temporal coping-occurrence effects) are statistically significant.

Model (2) is separated into two models: (1) Model (2.1) with natural disasters in general and (2) Model (2.2) with specific natural catastrophes (namely: floods, droughts, and typhoons). In each Model category, we estimate models with coping strategies (Panel A) and models with natural catastrophe and coping strategy interactions (Panel B).

3.5 The Impacts of Natural Disasters, Coping Strategies, and Information Technology on Agricultural Production

In the third step of our research, we consider how information technology can facilitate coping mechanisms and, consequently, lessen farm productivity depletion. Four information technology proxies are considered: telephones, televisions, computers, and the internet. The following describes a specific model (Model 3):

Table 1: Statistical Description, 2008-2016

	Mean	SD.	Within SD.	Between SD.
Agriculture productivity (Value per hectare)	2.24	3.18	2.12	2.36
Land (arable land) (ln)	0.45	0.46	0.43	0.15
Labor (total of HH working numbers)	2.75	1.53	1.27	0.85
Assets values (ln)	7.02	1.93	1.26	1.45
IT				
Telephones	0.74	0.44	0.26	0.35
Televisions	0.94	0.24	0.16	0.18
Sattelite	0.33	0.47	0.27	0.39
Natural shocks				
Natural disaster (t)	0.13	0.34	0.17	0.29
Floods (t)	0.01	0.12	0.05	0.10
Droughts (t)	0.03	0.16	0.07	0.14
Typhoons (t)	0.02	0.14	0.06	0.13
Natural disaster (t-1)	0.05	0.22	0.10	0.20
Flood (t-1)	0.00	0.07	0.03	0.06
Drought (t-1)	0.01	0.11	0.05	0.10
Typhoon (t-1)	0.01	0.07	0.03	0.06
Shock recovery				
Natural disaster (t)	0.20	0.58	0.30	0.50
Floods (t)	0.02	0.20	0.09	0.17
Droughts (t)	0.05	0.31	0.14	0.27
Typhoons (t)	0.03	0.23	0.11	0.21
Natural disaster (t-1)	0.08	0.35	0.17	0.31
Flood (t-1)	0.01	0.11	0.05	0.09
Drought (t-1)	0.02	0.20	0.09	0.18
Typhoon (t-1)	0.01	0.11	0.05	0.10
Losses from shocks ('000 VND)				
Natural disaster (t)	502.94	4384.71	2030.06	3886.66
Floods (t)	64.38	3131.99	1400.26	2801.68
Droughts (t)	104.28	1660.23	741.20	1485.66
Typhoons (t)	87.14	1476.52	658.45	1321.64
Natural disaster (t-1)	239.50	2745.62	1243.25	2448.13
Flood (t-1)	20.38	785.98	352.30	702.64
Drought (t-1)	40.09	1064.28	475.11	952.39
Typhoon (t-1)	18.70	526.47	234.89	471.18
Other shocks				
Biological shocks (t)	0.17	0.38	0.21	0.31
Demographic and social shocks (t)	0.05	0.21	0.10	0.19
Economic shocks (t)	0.08	0.28	0.14	0.24
Biological shocks (t-1)	0.03	0.17	0.08	0.15
Demographic and social shocks (t-1)	0.06	0.23	0.10	0.21
Economic shocks (t-1)	0.01	0.11	0.05	0.10
Coping strategies				
Cope 1: "HH did nothing to cope with shock(s)."	0.19	0.39	0.20	0.33
Cope 2 "HH reduced consumption to cope with shock(s)."	0.21	0.41	0.21	0.35
Cope 3 "HH sold assets to cope with shock(s)."	0.03	0.17	0.08	0.15
Cope 7 "HH used savings to cope with shock(s)."	0.06	0.24	0.11	0.21
Cope 8 "HH got assistance from relatives to cope with shock(s)."	0.05	0.21	0.10	0.18
Cope 9 "HH got assistance from the government to cope with shock(s)."	0.01	0.11	0.05	0.10
Cope 10 "HH borrowed money to cope with shock(s)."	0.04	0.19	0.09	0.17
Cope 11: "HH got insurance payment to cope with shock(s)."	0.01	0.12	0.05	0.11
Coping strategies to natural disasters				
cope1_natural_s0	0.13	0.34	0.17	0.29
cope1_natural_s1	0.04	0.20	0.09	0.17
cope1_drought_s0	0.01	0.11	0.05	0.10
cope1_typhoon_s0	0.01	0.11	0.05	0.10
cope2_natural_s0	0.14	0.34	0.17	0.30
cope2_ natural_s1	0.06	0.23	0.11	0.20
cope2_flood_s0	0.01	0.10	0.05	0.09
cope2_drought_s0	0.01	0.12	0.06	0.10
cope2_typhoon_s0	0.01	0.10	0.05	0.09
cope3_natural_s0	0.02	0.14	0.06	0.12
cope3_natural_s1	0.01	0.11	0.05	0.10
cope7_natural_s0	0.03	0.18	0.09	0.16
cope7_natural_s1	0.02	0.12	0.06	0.11
cope8_natural_s0	0.01	0.12	0.05	0.10
cope10_natural_s0	0.02	0.14	0.06	0.12

Notes: Coping strategies to natural disasters: cope1_natural_s0: # "HH did nothing to cope with shock(s)"; cope1_natural_s1: # "HH did nothing to cope with shock(s)"; cope1_drought_s0: # "HH did nothing to cope with shock(s)"; cope1_typhoon_s0: # "HH did nothing to cope with shock(s)"; cope2_natural_s0: # "HH reduced consumption to cope with shock(s)"; cope2_natural_s1: # "HH reduced consumption to cope with shock(s)"; cope2_flood_s0: 3 "HH reduced consumption to cope with shock(s)"; cope2_drought_s0: # "HH reduced consumption to cope with shock(s)"; cope2_typhoon_s0: # "HH reduced consumption to cope with shock(s)"; cope3_natural_s0: # "HH sold assets to cope with shock(s)";

cope3_natural_s1: # "HH sold assets to cope with shock(s)"; cope7_natural_s0: # "HH used savings to cope with shock(s)"; cope7_natural_s1: # "HH used savings to cope with shock(s)"; cope8_natural_s0: # "HH got assistance from relatives to cope with shock(s)"; cope10_natural_s0: # "HH borrowed money to cope with shock(s)".

$$Y_{it} = (\alpha_1 LAB_{it} + \alpha_2 LAND_{it} + \alpha_3 CAP_{it} + \alpha_4 SHOCK\_REC_{it}) + \beta \sum_1^3 NAT_{it}^j + \delta \sum_1^3 LOSS_{it}^j + + \phi \Sigma_1^3 NATLOSS_{it}^j + \chi \Sigma_1^7 COP_{it}^j + \gamma \Sigma_1^7 COPNAT_{it}^j + \varphi \Sigma_1^7 ITECH_{it}^j + \kappa \Sigma_1^7 COPITECH_{it}^j + \tau t + ui + \varepsilon_{it} \quad (3)$$

Where: $ITECH^j_{it}$ (j=1 - 3) are dummy variables indicating four proxies of information technology conducted in survey year (t) and one year ago (t-1), respectively. $COPITECH^j_{it}$ (j=1 - 8) are the interactions between four proxies of information technology and seven specific coping strategies in survey year (t) and one year ago (t-1), respectively. If information technology helps to ease the coping strategies, we expect the coefficients on these interaction terms to be positive and statistically significant; if not, the coefficients can be negative and statistically significant. We explore Model (3) into two models: (1) Model (3.1) with natural disasters in general, and (2) Model (3.2) with specific natural disasters (namely: floods, droughts, and typhoons). In each group of the models, we estimate models with IT (Panel A) and models with the interactions between coping strategies and information technology (Panel B).

1. EMPIRICAL RESULTS

1.1 Statistical Description

Table 1 presents a statistical description of the variables from 2008 to 2016. Overall, the substantial within-household variation over time supports using a fixed-effects model specification (Table 1).

3.6 Estimation Results

3.6.1 Impact of Natural Disasters on Agriculture Production

Table 2 displays empirical data from (1) Model (1.1) with natural disasters in general (General Model) and (2) Model (1.2) with specific natural disasters (namely, floods, droughts, and typhoons) (Specific Model). Models with natural disasters (Panel A), models with natural disasters and losses (Panel B), and models with interactions between natural disasters and their losses (Panel C) are estimated for each model group (Panel C).

Model 1.1's Panel A demonstrates that biological shocks with full recovery positively influence agricultural productivity, whereas natural disasters still suffering have a positive effect on agriculture production. A possible reason is that the losses are small or insignificant. The coefficients of losses from natural disasters in Panel B of Model 1.1 are minimal, suggesting that the losses may be small and insignificant. In addition, when losses are included, natural disasters in the past have proven to harm agricultural production.

When losses from each type of natural catastrophe are evaluated, Panel C of Model 1.1 verifies the consequences of natural disasters illustrated in Panels A and B. Natural disasters, in general, may conceal their effects on agricultural productivity, as different forms of natural disasters may have varying effects on agricultural production. Model 1.2 presents the precise effects of specific natural disasters in Panel A by independently considering floods, droughts, and typhoons. Complete recovery from floods and droughts has a positive effect on agricultural production.

Panel B of Model 1.2 demonstrates that once losses from specific natural disasters have been compensated for, specific natural disasters with partial recovery from the shocks continue to harm agricultural productivity.

3.6.2 Impacts of Natural Disasters and Coping Strategies on Agriculture Production

The results of (1) Model (2.1) with natural disasters in general and (2) Model (2.2) with specific natural disasters is presented in Table 3. (Namely: floods, droughts, and typhoons). In each Model group, we estimate models with coping strategies (Panel A) and models with natural catastrophe and coping strategy interactions (Panel B) (Panel B). Panel A of model 1.1 demonstrates that certain coping strategies, notably "borrowing money to cope with natural shocks" and "selling assets to cope with natural shocks," have beneficial impacts. However, agricultural productivity may decline once a household decides to limit consumption in response to a natural disaster. As coping methods are implemented in reaction to natural disasters, as shown in Panel B of Model 2.1, "households choosing to cut consumption to cope with natural shock(s)" or "households selling assets to cope with shocks" become statistically significant. In contrast, "households that did nothing to cope with natural shock(s)" or "households that borrowed money to cope with natural shock(s)" may experience a decrease in agricultural output, and the burdens of borrowing might harm agricultural output.

In Model 2.2, specific natural disasters are considered. Panel A of Model 2.2 reveals that "HH lowered consumption to cope with the flood(s)" can result in a decrease in agricultural output, but "HH did nothing to cope with drought (s)" can increase agricultural output. The effects are confirmed when flood and drought coping methods are used (Panel B of Model 2.2).

3.6.3 Impacts of Natural Disasters, Coping Strategies and Information Technology on Agricultural Production

The empirical results of (1) Model (3.1) with natural disasters in general and (2) Model (3.2) with particular natural disasters is presented in Table 4. (Namely: floods, droughts, and typhoons). In each model group, we estimate models with IT (Panel A) and models with interactions between coping techniques and IT (Panel B) (Panel B).

Table 2: Impact of natural disasters on agriculture production, 2008-2016

	Model 1.1			Model 1.2	
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Panel A	Panel B	Panel C	Panel A	Panel B
Land (arable land) (ln)	0.725***	0.727***	0.746***	0.714***	0.696***
	(0.148)	(0.148)	(0.148)	(0.148)	(0.148)
Labor (total of HH working numbers)	-0.078	-0.078	-0.077	-0.073	-0.076
	(0.072)	(0.073)	(0.072)	(0.072)	(0.072)
Labor (total of HH working numbers), squared	0.009	0.009	0.010	0.009	0.010
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Assets values (ln)	0.515***	0.513***	0.516***	0.516***	0.514***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
re1_floodR2				1.021**	
				(0.489)	
re0_droughtR2				0.565**	
				(0.259)	
re0_droughtR3				-0.769***	-1.341***
				(0.222)	(0.282)
re0_droughtR4				1.056***	
				(0.386)	
re1_droughtR2				0.568*	
				(0.304)	
re1_typhoonR2				-0.707*	
				(0.419)	
re1_typhoonR3				1.432**	2.300***
				(0.630)	(0.703)
re1_typhoonR4				-4.199***	
				(1.451)	
re0_private2	0.307**	0.304**	0.299**	0.336**	0.344**
	(0.137)	(0.137)	(0.137)	(0.137)	(0.137)
re0_economicA2	0.339**	0.334**	0.339**	0.362**	0.368**
	(0.167)	(0.167)	(0.167)	(0.167)	(0.166)
re0_economicA4	0.583***	0.589***	0.605***	0.591***	0.622***
	(0.196)	(0.196)	(0.196)	(0.195)	(0.196)
re1_economicA2	0.924***	0.906***	0.958***	0.972***	0.633*
	(0.297)	(0.297)	(0.297)	(0.297)	(0.345)
year_3	-0.469***	-0.462***	-0.496***	-0.482***	-0.473***
	(0.059)	(0.059)	(0.059)	(0.059)	(0.059)
year_4	-0.463***	-0.455***	-0.487***	-0.483***	-0.472***
	(0.062)	(0.062)	(0.062)	(0.062)	(0.062)
re0_natural14	0.485**	0.467**	0.489**		
	(0.209)	(0.217)	(0.209)		
re1_natural14	-0.639	-0.785*	-0.629		
	(0.396)	(0.409)	(0.396)		
re0_natural22	0.386***	0.378***	0.469***		
	(0.090)	(0.090)	(0.094)		
naturalloss_s0		0.004			

Table 2: Continued

		(0.011)			
naturalloss_s1		0.023			
		(0.016)			
llosts0_nat2			-0.050***		
			(0.017)		
re1_droughtR3					-1.356***
					(0.461)
re1_droughtR4					-1.193*
					(0.711)
re1_economicA4					-0.883*
					(0.523)
llosts0_drought					0.095***
					(0.029)
llosts1_flood					0.088*
					(0.049)
llosts1_drought					0.162***
					(0.046)
llosts1_typhoon					-0.153***
					(0.052)
llosts1_eco					0.111*
					(0.060)
Constant	-1.584***	-1.587***	-1.590***	-1.559***	-1.539***
	(0.154)	(0.154)	(0.154)	(0.154)	(0.154)
Observations	10,655	10,655	10,655	10,655	10,655
R-squared	0.118	0.118	0.119	0.120	0.121
Number of HH	2,131	2,131	2,131	2,131	2,131
F statistic	87.38	75.88	81.83	64.48	58.52
F for u_i=0	2.831	2.803	2.837	2.857	2.856
Log-likelihood	-22557	-22556	-22552	-22543	-22538
R-squared within Model	0.118	0.118	0.119	0.120	0.121
R-squared between Model	0.309	0.312	0.309	0.293	0.290
R-squared overall Model	0.204	0.206	0.205	0.199	0.198

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3: Impacts of natural disasters and coping strategies on agriculture production, 2008-2016

	Model 2.1		Model 2.2	
	(1)	(2)	(3)	(4)
VARIABLES	Panel A	Panel B	Panel A	Panel B
Land (arable land) (ln)	0.731***	0.741***	0.701***	0.693***
	(0.148)	(0.148)	(0.148)	(0.148)
Labor (total of HH working numbers)	-0.064	-0.072	-0.072	-0.072
	(0.072)	(0.072)	(0.072)	(0.072)
Labor (total of HH working numbers), squared	0.008	0.009	0.009	0.009
	(0.010)	(0.010)	(0.010)	(0.010)
Assets values (ln)	0.514***	0.513***	0.514***	0.514***
	(0.017)	(0.017)	(0.017)	(0.017)
re0_natural14	0.517**	0.454**		
	(0.210)	(0.209)		
re1_natural14	-0.658*	-0.559		
	(0.395)	(0.413)		
re0_natural22	0.509***	0.482***		
	(0.096)	(0.094)		
re0_private2	0.290**	0.291**	0.337**	0.344**
	(0.137)	(0.137)	(0.137)	(0.137)
re0_economicA4	0.623***	0.607***	0.580***	0.576***
	(0.196)	(0.195)	(0.195)	(0.195)
llosts0_nat2	-0.045***	-0.049***		
	(0.017)	(0.017)		
llosts1_eco	0.106*	0.157***		0.094
	(0.059)	(0.051)		(0.059)
cope1_natural_s1		0.389**		
		(0.188)		
cope2_natural_s1		-0.370**		
		(0.171)		
cope7_natural_s1	0.541***	1.043***		
	(0.198)	(0.322)		
INT_cope1_natural_s1		-0.595**		
		(0.257)		
INT_cope2_natural_s1		0.573**		
		(0.227)		
INT_cope3_natural_s0		0.699**		
		(0.297)		
INT_cope3_natural_s1		0.760**		
		(0.334)		
INT_cope7_natural_s1		-0.906**		
		(0.421)		
year_3	-0.489***	-0.484***	-0.488***	-0.483***
	(0.059)	(0.059)	(0.059)	(0.059)
year_4	-0.488***	-0.476***	-0.484***	-0.481***
	(0.062)	(0.062)	(0.062)	(0.062)
re1_economicA2	0.630*		0.944***	0.665*
	(0.344)		(0.296)	(0.344)

Table 3: Continued

cope2_natural_s0	-0.198**			
	(0.079)			
cope3_natural_s0	0.475***			
	(0.184)			
re0_droughtR3			-1.200***	-1.202***
			(0.244)	(0.244)
re1_droughtR3			-1.346***	-1.348***
			(0.461)	(0.461)
re1_droughtR4			-1.140	-1.156
			(0.711)	(0.711)
re1_typhoonR3			2.324***	2.321***
			(0.703)	(0.703)
re0_economicA2			0.349**	0.349**
			(0.166)	(0.166)
llosts1_flood			0.084*	0.083*
			(0.049)	(0.049)
llosts1_drought			0.164***	0.165***
			(0.046)	(0.046)
llosts1_typhoon			-0.149***	-0.149***
			(0.052)	(0.052)
floodloss_s0			0.122**	0.122**
			(0.050)	(0.050)
cope1_drought_s0			1.063***	
			(0.237)	
cope2_flood_s0			-0.971**	
			(0.407)	
INT_cope1_drought_s0				1.065***
				(0.237)
INT_cope2_flood_s0				-0.976**
				(0.407)
Constant	-1.584***	-1.591***	-1.547***	-1.540***
	(0.154)	(0.154)	(0.154)	(0.154)
Observations	10,655	10,655	10,655	10,655
R-squared	0.121	0.122	0.122	0.122
Number of HH	2,131	2,131	2,131	2,131
F statistic	68.56	56.09	59.11	56.43
F for u_i=0	2.821	2.831	2.865	2.865
Log-likelihood	-22541	-22534	-22531	-22530
R-squared within Model	0.121	0.122	0.122	0.122
R-squared between Model	0.305	0.313	0.289	0.288
R-squared overall Model	0.205	0.209	0.198	0.197

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Panel A of Model 3.1 describes the additional effects of information technology on phones, television, and satellites. We discover the negative effects of television on agricultural production, which may indicate that television programs do not successfully assist farmers in enhancing their agricultural knowledge and practices. Panel B1 of Model 3.1 demonstrates the impact of digital technologies on coping with natural disasters. It is demonstrated that mobile phones have a big and positive effect on agricultural production when they prevent farmers from responding to natural calamities. Farmers who continue to reduce their consumption in response to natural disasters may experience reduced production. Regarding television viewing, "HH reduced consumption to cope with shocks" leads to declining agricultural output. Agriculture production can grow for the scenarios "HH did nothing to cope with shocks" and "HH borrowed money to cope with shocks." Using satellites yields results that are comparable to those obtained through the use of mobile phones.

In short, the results indicate that information technology has few effects on various coping techniques. Its effects are limited in providing farmers with the knowledge to deal with natural disasters and reduce consumption in response to natural shocks (s).

Table 4: Impacts of Natural Disasters, Coping Strategies and Information Technology on Agricultural Production, 2008-2016

	Model 3.1				Model 3.2		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Panel A	Panel B1	Panel B2	Panel B3	Panel A	Panel B1	Panel B2
Land (arable land) (ln)	0.694***	0.691***	0.696***	0.712***	0.665***	0.665***	0.666***
	(0.146)	(0.146)	(0.146)	(0.146)	(0.146)	(0.146)	(0.146)
Labor (total of HH working numbers)	-0.085	-0.084	-0.082	-0.090	-0.087	-0.084	-0.087
	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)
Labor (total of HH working numbers), squared	0.010	0.009	0.009	0.011	0.010	0.009	0.010
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Assets values (ln)	0.675***	0.673***	0.677***	0.677***	0.676***	0.677***	0.677***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
re0_natural14	0.424**	0.386*	0.430**	0.417**			
	(0.206)	(0.210)	(0.206)	(0.206)			
re0_natural22	0.434***	0.428***	0.482***	0.455***			
	(0.093)	(0.100)	(0.095)	(0.093)			
re0_private2	0.245*	0.254*	0.250*	0.252*	0.286**	0.287**	0.284**
	(0.135)	(0.135)	(0.135)	(0.135)	(0.135)	(0.135)	(0.135)
re0_economicA2		0.292*			0.311*	0.317*	0.311*
		(0.164)			(0.164)	(0.164)	(0.164)
re0_economicA4	0.531***	0.556***	0.553***	0.558***	0.523***	0.517***	0.523***
	(0.193)	(0.193)	(0.193)	(0.193)	(0.193)	(0.193)	(0.193)
llosts0_nat2	-0.068***	-0.065***	-0.064***	-0.066***			
	(0.017)	(0.017)	(0.017)	(0.017)			
llosts1_eco	0.153***	0.155***	0.156***	0.154***			
	(0.050)	(0.050)	(0.050)	(0.050)			
cope7_natural_s1	0.460**	0.775***		0.925***			
	(0.198)	(0.299)		(0.302)			
INT_cope1_natural_s1	-0.650***	-0.567***	-0.679***	-0.442**			
	(0.246)	(0.213)	(0.240)	(0.186)			
INT_cope2_natural_s1	0.270*	0.343**	0.661***	0.524***			
	(0.147)	(0.151)	(0.215)	(0.165)			
INT_cope3_natural_s0		0.939***	0.991***	0.919***			
		(0.290)	(0.291)	(0.289)			
INT_cope7_natural_s1		-0.560	-0.584	-0.687*			
		(0.396)	(0.391)	(0.397)			
phone_	0.010	0.002	-0.002	-0.003	0.036	0.032	0.037
	(0.065)	(0.068)	(0.065)	(0.065)	(0.064)	(0.064)	(0.064)
tv_	-2.337***	-2.341***	-2.325***	-2.343***	-2.325***	-2.324***	-2.341***
	(0.146)	(0.146)	(0.147)	(0.146)	(0.146)	(0.146)	(0.146)
satel_	0.044	0.042	0.043	0.105*	0.047	0.045	0.048
	(0.057)	(0.057)	(0.057)	(0.061)	(0.057)	(0.057)	(0.057)
P_cope1_natural_s0		0.191**					
		(0.095)					
P_cope1_natural_s1		0.374**					
		(0.191)					
P_cope2_natural_s0		-0.293***					
		(0.093)					
year_3	-0.611***	-0.607***	-0.610***	-0.608***	-0.610***	-0.609***	-0.611***
	(0.059)	(0.059)	(0.059)	(0.059)	(0.059)	(0.059)	(0.059)
year_4	-0.602***	-0.600***	-0.611***	-0.612***	-0.613***	-0.610***	-0.612***
	(0.063)	(0.063)	(0.063)	(0.063)	(0.063)	(0.063)	(0.063)
cope1_natural_s1	0.391**						

Table 2: Continued

	(0.182)						
T_cope1_natural_s1			0.432**				
			(0.183)				
T_cope2_natural_s0			-0.186**				
			(0.082)				
T_cope2_natural_s1			-0.373**				
			(0.168)				
T_cope7_natural_s1			0.865***				
			(0.308)				
S_cope1_natural_s1				0.512**			
				(0.217)			
S_cope2_natural_s0				-0.304**			
				(0.129)			
S_cope2_natural_s1				-0.661***			
				(0.207)			
re0_droughtR3					-0.953***	-0.870***	-0.943***
					(0.241)	(0.237)	(0.242)
re1_droughtR3					-1.207***	-1.207***	-1.208***
					(0.437)	(0.437)	(0.437)
re1_typhoonR3					2.316***	2.316***	2.301***
					(0.693)	(0.693)	(0.693)
re1_economicA2					0.908***	0.906***	0.905***
					(0.292)	(0.292)	(0.292)
llosts1_flood					0.095*	0.095**	0.095*
					(0.048)	(0.048)	(0.048)
llosts1_drought					0.155***	0.155***	0.155***
					(0.042)	(0.042)	(0.042)
llosts1_typhoon					-0.136***	-0.136***	-0.136***
					(0.051)	(0.051)	(0.051)
floodloss_s0					0.122**	0.103**	0.122**
					(0.049)	(0.044)	(0.049)
cope1_drought_s0					1.101***		
					(0.234)		
cope2_flood_s0					-0.943**		-0.943**
					(0.401)		(0.401)
P_cope1_drought_s0						1.112***	
						(0.252)	
P_cope2_flood_s0						-0.886**	
						(0.390)	
T_cope1_drought_s0							1.097***
							(0.240)
Constant	-0.444***	-0.424**	-0.449***	-0.456***	-0.444***	-0.453***	-0.436**
	(0.171)	(0.171)	(0.171)	(0.171)	(0.171)	(0.171)	(0.171)
Observations	10,655	10,655	10,655	10,655	10,655	10,655	10,655
R-squared	0.145	0.148	0.147	0.148	0.147	0.147	0.147
Number of HH	2,131	2,131	2,131	2,131	2,131	2,131	2,131
F statistic	76.14	61.65	63.90	64.36	66.79	66.63	66.72
F for u_i=0	2.782	2.781	2.780	2.790	2.806	2.802	2.804
Log-likelihood	-22388	-22370	-22375	-22370	-22376	-22377	-22376
R-squared within Model	0.145	0.148	0.147	0.148	0.147	0.147	0.147
R-squared between Model	0.371	0.363	0.360	0.364	0.349	0.350	0.350
R-squared overall Model	0.240	0.238	0.237	0.240	0.232	0.232	0.232

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4. CONCLUSIONS AND IMPLICATION

Agriculture is among the most susceptible industries to natural calamities. Technology is crucial to agricultural output. While agricultural machinery directly impacts agricultural output by increasing yield and quality, information technology may influence coping mechanisms for responding to natural disasters and so increase agricultural productivity. This paper examines (1) the degree to which agriculture production in Vietnam is impacted by natural disasters such as floods, drought, typhoons, and landslides, (2) how coping strategies mitigate the negative effects of natural disasters, and (3) how information technology influences the selection of coping strategies in response to a natural disaster. Our primary premise is that natural catastrophes have a detrimental influence on agricultural production and that coping mechanisms might somewhat mitigate these negative effects. In addition, information technology can facilitate the selection of coping measures for natural disasters.

The findings suggest that ICT applications in Vietnam's agricultural sector are still in their infancy. Few companies tried to provide services such as giving weather and production-related data. In addition, several companies have created experimental farms that enable production systems to run efficiently through ICT. It demonstrates that information technology can improve the efficiency and effectiveness of agricultural methods.

There is a continued demand for precision agriculture due to the increasing interest of urban customers in eco-friendly products and international presence. Also, the export potential for agricultural products is expanding due to the country's participation in the free trade agreements. International integration provides the nation with a competitive advantage in ICT applications. Additionally, participation in ICT may be advantageous for the nation, particularly for those who have changed to new commodities, such as corporate farms and farmers. Based on the data, it is also possible to suggest that IT applications have the potential to increase production efficiency and reduce water consumption and labor-related problems.

In addition, government-generated ICT-related laws and programs assist business farm operations. Yet, when it comes to traditional methods, they may become less useful and relevant, hence limiting the benefits for common farmers. This obstacle could provide difficulty for the government in establishing IT-related software and manufacturing processes. Hence, the government should remember that applications must be inexpensive and user-friendly. In this way, regular farmers can also receive benefits, and the labor shortage issue in the agriculture sector, which poses a threat to the nation if not resolved promptly, can be resolved.

Additionally, IT dissemination among regular farmers may lower the production risk at the macro level. Consequently, the country's potential lies in developing network platforms where information is accessible and useful to everybody. Yet, the situation of data ownership may get problematic. Hence it is recommended to establish data protection measures.

In short, the results indicate that information technology has few effects on various coping techniques. Its effects are limited in providing farmers with the knowledge to deal with natural disasters and reduce consumption in response to natural shocks (s).

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