

Vulnerability and Adaptation of Coastal Livelihoods to the Impacts of Climate Change: A Case Study in Coastal Districts of Nam Dinh, Vietnam

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Abstract

Communities in coastal areas tend to be dependent on climate sensitive resources for their livelihoods which make them vulnerable to the impacts of climate change. Livelihood adaptation plays a vital role in mitigating vulnerabilities, increasing resilience, and achieving sustainable income and food security in the long term. Drawing on quantitative data from a case study in three coastal districts of Nam Dinh province in Vietnam, this paper investigates vulnerability and adaptation of coastal livelihoods to the impacts of climate change at a household level. Findings suggest that (i) climate change has positive effects on livelihood assets, especially natural and physical capital; (ii) the more livelihood assets are affected by climate change, the more livelihood strategies are affected; (iii) the more livelihood strategies are affected by climate change, the more livelihood outcomes are affected, and (iv) households are implementing passive adaptation activities on their livelihoods rather than active ones to counter the impacts of climate change. It is recommended that in order to help households successfully adapt to the impacts of climate change, it is necessary for the government to support households to improve their livelihood assets, especially natural and physical capital, and to enhance institutions and policies on climate change adaptation at national and local levels.

Keywords: Adaptation, climate change, coastal area, livelihoods, vulnerability.

1. Introduction

Sustainable livelihoods have been a topic of interest in the debate on development, poverty reduction, and environmental management in both theoretical and practical perspectives. Integrating sustainable livelihood frameworks with climate change, it is realized that climate change is a key factor causing vulnerability of livelihoods, because climate change does impact livelihood assets and that the impacted livelihood assets will affect livelihood strategies, which in turn will affect the livelihood outcomes. The impacts of climate change on livelihoods will affect the viability of livelihoods unless effective adaptation measures are taken to protect and improve existing livelihoods.

Coastal areas are one of the most vulnerable places due to the impacts of climate change. Communities in coastal areas tend to be dependent on near shore habitats which make them climate sensitive resource users. The vulnerabilities of those who live in coastal areas and the need to build their capacity to adapt to such climatic fluctuations are among the most important challenges in adapting to climate change. Local people in coastal communities are constantly adjusting their livelihoods depending on their capacity, particularly access to livelihood assets. Livelihood adaptation to climate change plays a vital role in mitigating vulnerabilities, increasing resilience, and achieving sustainable income and food security in the long term.

The threats of climate change, such as sea level rise, storm, flooding, and saltwater intrusion are really serious for Vietnam because it is a country with a long coastline and two low-lying deltas located near the sea. While

Vietnam's coastal economy is fast developing, coastal areas are increasingly threatened by the most challenging impacts of climate change. Key economic sectors that would experience direct impacts and reduced productivity in coastal region include fisheries (especially aquaculture), agriculture, manufacturing industries and transport (Jeremy Caraw-Reid, 2008). Around 58% of coastal livelihoods in Vietnam are based on agriculture, fisheries and aquaculture - and these are the livelihoods that are most dependent on climate and water resources (Peter Chaudhry and Greet Ruyschaert, 2007).

Nam Dinh is a coastal province located at the south of the Red River Delta of Vietnam. Nam Dinh's economic structure is characterized by a high share of agriculture-forestry-fishery sector in GDP (33% in 2001-2011) and this sector is highly sensitive to changes in the climate. In addition, the share of labor force involved in the agriculture-forestry-fishery sector of Nam Dinh is the largest in the coastal Red River Delta, both in terms of the number (618,714 people in 2011) and proportion (65% in 2011). This labor force comprises approximately 34% of the province's population (Nam Dinh Statistics Department, 2011). Therefore, mitigating vulnerabilities and building household-level adaptive livelihood strategies plays a vital role in order to achieve sustainable income and food security in the long term for the coastal districts of Nam Dinh province in the context of climate change.

This paper aims to investigate vulnerability and adaptation of coastal livelihoods to the impacts of climate change at the household level through a case study in three coastal districts of Nam Dinh, Vietnam. It is expected that findings

from this research will make a contribution to practical adaptation initiatives in the context of climate change for coastal areas in particular and for Vietnam in general.

2. Theoretical framework

2.1. Sustainable livelihood frameworks and climate change

2.1.1. Sustainable livelihoods

Several definitions of livelihood have been made in the literature, notably the definition of Chamber and Conway (1992), Scoones (1998) and DFID (2001). Chamber and Conway's (1992, p.6) definition of a livelihood was that it "comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term". Drawing on Chamber and Conway (1992), Scoones (1998, p.5) who defined a livelihood as that which "comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural base". In 2001, the UK Department for International Development (DFID) launched a concept of livelihood as a guidance for their own assistance activities in which a livelihood "comprises the capabilities, assets and activities required for a means of living". This concept is basically similar to the concept of live-

lihood developed by Chambers and Conway (1992) and Scoones (1998).

2.1.2. Sustainable livelihood frameworks

In the literature, several sustainable livelihood frameworks have been developed, notably Sustainable Rural Livelihoods Framework of Scoones (1998), Sustainable Livelihoods Framework of DFID (2001), and Sustainable Coastal Livelihoods Framework of IMM (2004). In general, sustainable livelihood frameworks analyze the interaction between five components affecting livelihoods, including (i) livelihood assets; (ii) livelihood strategies, (iii) livelihood outcomes; (iv) institutions and policies at different levels; and (v) external context. The main idea of the framework is that within a certain institutional and political context, a household uses their own existing livelihood assets (including human, natural, financial, physical, and social capitals) to implement livelihood strategies (such as agriculture, fisheries, aquaculture, tourism, diversification of livelihoods, and migration, etc...) in order to achieve sustainable livelihood outcomes (such as job creation, income improvement, risk and vulnerability mitigation, food security improvement, sustainable use of natural resources...) under the impact of external context (shocks, trends, and seasonality). Specifically, analysis of the sustainable livelihood frameworks helps answer the question: Which livelihood assets, livelihood strategies, institutions and policies are critical to achieve sustainable livelihoods for different groups.

2.1.3. Integrating sustainable livelihood frameworks and climate change

Climate change means a change of climate which is attributed directly or indirectly to hu-

man activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (United Nations, 1992). MONRE (2008) defines climate change as “the change of the climate compared to its medium state and/or climate fluctuations maintained over a long period of time, usually a number of decades or longer” (MONRE, 2008, p.6).

Integrating sustainable livelihood frameworks with climate change, it is realized that climate change is a key factor related to the vulnerability of livelihoods. First of all, climate change does affect livelihood assets, especially natural capital (such as land, water, and fisheries resources) and physical capital (such as roads, irrigation systems, and power network) which are sensitive to climate change. When the livelihood assets are vulnerable to the impact of climate change, livelihood strategies will be affected, which in turn will affect livelihood outcomes. In the context that climate change is increasingly complex in the future, livelihoods should be not only sustainable, but also adaptive in order to reduce vulnerability caused by climate change. Therefore, integrating sustainable livelihood frameworks with climate change will help build sustainable and adaptive livelihoods in the context of climate change.

2.2. Vulnerability of coastal livelihoods to the impacts of climate change

2.2.1. Vulnerability

Vulnerability is often discussed in relation to natural hazards and the ability of individuals or social groups to cope with these hazards (Armitage, D. and Plummer, R., 2010). Smit and Wandel (2006) stated that vulnerability

involves the extent to which individuals and communities are susceptible to conditions and situations that indirectly or directly affect their well-being and prospects for sustainability.

Recently, vulnerability has been applied to global climatic change and its impacts. Vulnerability is defined as “the degree to which a system (natural, economic, social) may be vulnerable to climate change, or might not be adaptive to the negative impacts of climate change” (MONRE, 2008, p.6). Human vulnerability to the impacts of climate change depends on 4 factors: (i) nature and magnitude of climate change impacts; (ii) the extent to which human activities are dependent on natural resources and ecosystem services; (iii) the extent to which these resources and services are sensitive to climate change; and (iv) human capacity to adapt to changes in these resources and services (Armitage, D. and Plummer, R., 2010; USAID, 2009).

2.2.2. Vulnerability of coastal livelihoods to the impact of climate change

Climate change creates damages to natural resources sensitive to the climate such as land and water resources. In addition, climate change does affect physical assets such as infrastructure. The impacted assets by climate change will have impacts on the selection of livelihood strategies and expected livelihood outcomes at the household level. In general, climate change will affect such coastal livelihoods such as agriculture and fisheries. When the current livelihoods are more vulnerable to the impact of climate change, households will attempt to carry out adaptation activities. The implementation of adaptation activities depends largely on the capacity to adapt to

the impacts of climate change on livelihoods. Therefore, capacity building for coastal communities that are affected by climate change will help them successfully adapt to the impact of climate change.

2.3. Adaptation of coastal livelihoods to the impacts of climate change

2.3.1. Adaptive capacity and adaptation to climate change

Adaptive capacity can be studied from different perspectives, including natural science, social science, and environment and resource studies. Adaptive capacity is nowadays often considered in the context of environmental changes and linked to environmental governance. In this domain, adaptive capacity is generally referred to as the capability of a social-ecological system to be robust to disturbance and to adapt to actual or anticipated changes (whether exogenous or endogenous) (Armitage, D. and Plummer, R, 2010, p.6).

More recently, adaptive capacity is looked at in the context of global climate change. The capacity to adapt to climate change is defined in many different ways. IPCC defined adaptive capacity as “the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences” (IPCC, 2007, p.869). According to MONRE, adaptive capacity is “the adjustment of the natural or human system to the changing condition or environment, to take advantage of the opportunities of, or to reduce vulnerabilities from actual or potential variation and/or change in the climate” (MONRE, 2008, p.6). USAID said that “adaptive capacity refers to the ability of society to

plan for and respond to change in a way that makes it better equipped to manage its exposure and sensitivity to climate” (USAID, 2009, p.36). Thus, it is realized that consistent throughout the literature is the notion that the capacity to adapt to climate change reflects the ability of a system or society in regulating or responding to climate change in order to achieve three objectives: (i) reduce vulnerability caused by climate change; (ii) reduce damage that may occur; and (iii) take advantage of new opportunities brought by climate change.

Adaptive capacity can be discussed at multiple scales and aspects of environmental change. For climate change, adaptive capacity is often examined at a specific scale, such as household level or community level, and in relationship to a specific climate impact. Adaptive capacity is context-specific and varies from community to community, among social groups and individuals, and over time (Smit and Wandel, 2006, p.287).

Adaptations are manifestations of adaptive capacity, and they represent ways of reducing vulnerability (IPCC, 2007; Smit and Wandel, 2006, p.286). The ability to undertake adaptations can be influenced by such factors as management ability, access to financial, technological and information resources, infrastructure, the institutional environment within which adaptation occurs, political influence, kinship network, etc. (Smit and Wandel, 2006, p.287-288).

There are many forms (technological, behavioral, financial, institutional, and informational) and levels (individual, household, community, group, sector, region, and country) of adaptations. Generally, the adaptation activities are divided into the following levels (Smith

and Wandel, 2006; Henny Osbahr et al., 2008; ADB, 2009 and USAID, 2009):

Based on the time to implement adaptation activities:

- Anticipatory adaptation: is the adaptation which is performed before the impacts of climate change to proactively prevent damage that may occur.

- Reactive adaptation: is the adaptation which is performed after the impacts of climate change to reduce damages.

Based on policy considerations when adaptation activities are implemented:

- Passive adaptation: is the adaptation which is conducted spontaneously (mainly by the private sector) to deal with actual impacts of climate change without policy intervention. Passive adaptation usually consists of temporary adjustments and usually takes place in the short term.

- Active adaptation: is the adaptation which is planned with careful consideration of public policies to adapt to anticipated climate change impacts. Active adaptation therefore consists of strategic adjustments to address the risks associated with climate change in a way that meets the goals of society and usually takes place in the long term.

Based on the implementers of adaptation activities:

- Private adaptation: is the adaptation which is done by individuals, households, and businesses.

- Public adaptation: is the adaptation which is carried out by government agencies at all levels.

2.3.2. Adaptation of coastal livelihoods to

the impact of climate change

According to Chambers and Conway (1992), a livelihood is sustainable which can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, provide sustainable livelihood opportunities for the next generation; and contributes net benefits to other livelihoods at the local and global levels and in the short and long term (Chamber and Conway, 1992, p.6). Therefore, the ability of a livelihood to be able to cope with and recover from stresses and shocks is central to the definition of sustainable livelihoods. In this discipline, those who are unable to cope with (temporary adjustment in the face of change) or adapt to (longer term shifts in livelihood strategies) are inevitably vulnerable and unlikely to achieve sustainable livelihoods.

When livelihoods are vulnerable to climate change impacts, households tend to adjust their livelihood strategies depending on their capacity to adapt. Household livelihood adaptation to climate change can be divided into two levels. The first one is a passive adaptation - in which temporary adjustments in livelihood strategies are made in the short term. The second one is active adaptation - in which planned and strategic adjustments in livelihood strategies are made in the long term with the support of government policies at local/national levels.

Capacity building for households on climate change adaptation is considered to be central to climate change adaptation policies. However, in addition to efforts made by households themselves, external support in the form of flood control, infrastructure development, improvement in access to credit and markets also plays an important role in enhancing the capacity to

adapt to climate change impacts. Regarding the climate change context, livelihood adaptation strategies comprise: (i) local actions taken by households themselves, (ii) supporting activities and subsidies planned by the government, and (iii) support from other organizations that are beyond the control or capabilities of local communities (IUCN, SEI, IISD, 2003).

3. Literature review and hypothesis development

3.1. Literature review

Studies about livelihoods at the household level in the context of climate change have been reviewed from two aspects: (i) impacts of climate change on coastal areas in the world and in Vietnam; and (ii) vulnerability and adaptation practices of households to the impacts of climate change in the world and in Vietnam. These studies have been done by WB (2007), UNDP (2008), Jeremy Carew-Reid (2008), ADB (2009), USAID (2009), MONRE, DFID and UNDP (2010), Oxfam (2011), Tran Tho Dat and Vu Thi Hoai Thu (2012), etc.

It can be seen that previous studies on coastal livelihoods in the context of climate change mainly focused on the following main issues: (i) analysis of the rural and coastal livelihood characteristics; (ii) changes in the climate in the past, and at the present as well as forecasts of future trends in coastal areas; (iii) identification of vulnerable groups to the impacts of climate change in coastal areas; (iv) assessment of household awareness about the impacts of climate change on the lives and livelihoods of the household members; (v) analysis of current livelihood adaptation practices of coastal households to counter the impacts of climate change; and (vi) proposals for livelihood adap-

tation initiatives in coastal areas.

Main findings from these studies include: (i) climate change is currently affecting and will continue to impact the lives of coastal households; (ii) women, the elderly, and children are the groups most vulnerable to the impacts of climate change; (iii) the livelihoods most affected by climate change in coastal areas are agriculture (including rice farming and livestock husbandry) and fisheries (including fishing and aquaculture); (iv) livelihoods are differently vulnerable to the impacts of climate change, thus adaptive strategies for different livelihood groups should be designed in a flexible way; and (v) some adaptive livelihood strategies in agriculture and fisheries as well as government policies to support households to improve their adaptive capacity have been proposed for coastal communities.

For Nam Dinh province, although there have been studies on household livelihoods in the context of climate change, such issues as vulnerability and adaptive capacity of different livelihoods to the impacts of climate change have not been addressed in a comprehensive manner to provide a basis for the development of sustainable and adaptive livelihoods for coastal districts of Nam Dinh province.

3.2. Hypothesis development

This paper aims to investigate vulnerability and adaptation of coastal livelihoods to the impacts of climate change at the household level through a case study in three coastal districts of Nam Dinh, Vietnam. Specifically, the paper seeks answers to the following research questions:

(i). How does climate change affect livelihood assets?

(ii). How do impacted livelihood assets affect livelihood strategies?

(iii). How do impacted livelihood strategies affect livelihood outcomes?

(iv). How do households adapt to risks associated with impacts of climate change on their livelihoods? And,

(v). What are government policies to support households in coastal districts of Nam Dinh province to adapt to climate change?

Research hypotheses are stated as follows:

(i). The more frequently climate change happens, the more livelihood assets are affected (positive relationship).

(ii). The more livelihood assets are affected by climate change, the more livelihood strategies are affected (positive relationship).

(iii). The more livelihood strategies are affected by climate change, the more livelihood outcomes are affected (positive relationship).

(iv). When livelihood strategies are vulnerable to climate change impacts, households tend to adjust their livelihood strategies depending on their capacity to adapt. Household adaptation can be divided into 2 levels: active adaptation and passive adaptation.

(v). To enhance household capacity to adapt to climate change impacts, it is necessary for the government to support households to help them move from passive adaptation to active adaptation.

4. Methodology

4.1. Data collection

4.1.1. Reasons for selection of Nam Dinh province as a case study

Firstly, according to a study by Jeremy

Carew-Reid (2008), Nam Dinh is one of the most affected provinces by climate change in the coastal Red River Delta, particularly in terms of land and the number of affected people.

Secondly, the economic structure of Nam Dinh is represented by a high proportion of the agriculture, forestry, and fisheries sector (accounting for an average of 33% of GDP in 2001-2011). This sector is very sensitive to climate change impacts.

Thirdly, the proportion of laborers working in agriculture, forestry, and fisheries of Nam Dinh province is the largest in four coastal provinces in the Red River Delta (accounting for 68.3% in the period of 2005-2011).

Fourth, for three coastal districts of Nam Dinh province, the agriculture, forestry, and fisheries sector plays an important role in the district's economic development as 77% of the labor force evolving in this sector makes a contribution of 60% to GDP. However, this sector is most vulnerable to the impacts of climate change.

Fifth, Xuan Thuy National Park (Giao Thuy district), which has an area of 15,000 hectares located in connection between the Red River and the sea, is of high biodiversity that many households depend on for a means of living. However, this is also an area highly sensitive to the impact of climate change.

4.1.2. Data collection method

A household survey was conducted in three coastal districts of Nam Dinh province, including Giao Thuy, Hai Hau, and Nghia Hung in December 2012. In each district, two or three coastal communes were selected based

Table 1: Statistic summary of the household survey in Nam Dinh

No	Information	Measurement
1	<i>Variations on climate change:</i> - Drought - Storm - Increased temperature - Sea level rise - Saltwater intrusion	Variations are measured by the frequency that climate change happens with the degrees as follows: never occurs = 1 seldom occurs = 2 moderate occurs = 3 regular occurs = 4 very often occurs = 5
2	<i>Livelihood assets affected by climate change:</i> - Rice cultivation land - Livestock breeding facilities - Aquaculture land - Fishing gear - Salt production land - Road - Irrigation system - Family health - Access to bank loans - Access to information	Impacts are measured as follows: no impact = 1 little impact = 2 medium impact = 3 large impact = 4 very large impact = 5
3	<i>Livelihoods strategies affected by climate change</i> - Rice cultivation - Livestock breeding - Salt production - Aquaculture practices - Fishing	Impacts are measured as follows: no impact = 1 little impact = 2 medium impact = 3 large impact = 4 very large impact = 5
4	<i>Livelihood outcomes affected by climate change</i> - Income from rice cultivation - Income from livestock breeding - Income from salt production - Income from aquaculture practices - Income from fishing	Impacts are measured as follows: no impact = 1 little impact = 2 medium impact = 3 large impact = 4 very large impact = 5
5	<i>Livelihoods adaptation</i> - Rice cultivation - Livestock breeding - Salt production - Aquaculture practices - Fishing	Alternative adaptation practices made by households to counter the impacts of climate change on their livelihoods

Source: Household survey in Nam Dinh in 2012

on two criteria: (i) they are agricultural communes whose main livelihoods are agriculture (rice cultivation, livestock breeding, and salt production) and fisheries (fishing and aquaculture), and (ii) they are suffering from serious climate change impacts that increasingly

Table 2: Model specifications for livelihood's vulnerability

No	Independent variables	Dependent variables
1. <i>Impacts of climate change on livelihood assets</i>		
	- Drought - Storm - Increased temperature - Sea level rise - Saltwater intrusion	- Rice cultivation land - Livestock breeding facilities - Aquaculture land - Fishing gear - Salt production land - Road - Irrigation system - Family health - Access to bank loans - Access to information
2. <i>Impacts of livelihood assets on livelihood strategies</i>		
Model 1	- Rice cultivation land - Road - Irrigation system - Health - Access to bank loans - Access to information	Rice cultivation
Model 2	- Livestock breeding facilities - Road - Irrigation system - Health - Access to bank loans - Access to information	Livestock breeding
Model 3	- Salt production land - Road - Irrigation system - Health - Access to bank loans - Access to information	Salt production
Model 4	- Aquaculture land - Road - Irrigation system - Health - Access to bank loans - Access to information	Aquaculture practices
Model 5	- Fishing facilities - Road - Irrigation system - Health - Access to bank loans - Access to information	Fishing
3. <i>Impacts of livelihood strategies on livelihood outcomes</i>		
Model 1	Rice cultivation	Income from rice cultivation
Model 2	Livestock breeding	Income from livestock breeding
Model 3	Salt production	Income from salt production
Model 4	Aquaculture practices	Income from aquaculture
Model 5	Fishing	Income from fishing

affect agriculture and fisheries. Based on the above criteria, 7 communes were selected for the survey: Giao Xuan and Giao Thien (Giao Thuy district); Hai Dong and Hai Ly (Hai Hau district); Nghia Thang, Nghia Phuc, and Nam Dien (Nghia Hung district).

Information was collected from two main groups of informants: (i) commune leaders and officials working in the agriculture and fisheries sectors and (ii) local households representing 5 main groups of livelihoods that are seriously affected by climate change (rice cultivation, livestock breeding, salt production, fishing, and aquaculture). These informants were asked about variability in the climate (including drought, storm, increased temperature, sea level rise, and saltwater intrusion) in their communes over the past few years; impacts of climate change on their livelihoods (including livelihood assets, livelihood strategies, and livelihood outcomes); and adaptation practices to counter risks associated with climate change on their livelihoods.

A questionnaire was designed to collect quantitative information at the household level. Total number of surveyed households was 385, in which 298 households have their main livelihoods as agriculture and 87 households have their main livelihoods as fisheries. However, after elimination of incomplete or duplicate information on the questionnaires, the number of valid questionnaires was 286.

4.2. Model specifications

4.2.1. Analytical framework for livelihood vulnerability

Using data collected from the household survey in three coastal districts of Nam Dinh province, OLS method is applied to estimate (i)

impacts of climate change on livelihood assets, (ii) impacts of livelihood assets on livelihood strategies, and (iii) impacts of livelihood strategies on livelihood outcomes.

4.2.2. Analytical framework for livelihood's adaptation

Using the analytical framework of adaptive capacity, which is divided into two levels: passive adaptation, and active adaptation and data from the household survey in three coastal districts of Nam Dinh province, adaptation practices to the impact of climate change of different livelihoods groups at household level were statistically analyzed.

5. Results and discussions

5.1. Household's perceptions on vulnerabilities of their livelihoods to the impacts of climate change

Interviewed households clearly felt changes in the climate in recent years. Local people said that storms occurred the most often (compared to other weather phenomena) with increasing intensity and unpredictable tendency. Extreme climate events such as increases in frequency and intensity of drought and cold events, more intense storms, hurricanes and typhoons, and reduced rainfall were deeply observed by interviewed households. Seawater intrusion was an urgent issue that local people in Nghia Phuc and Nam Dien communes (Nghia Hung district) and Giao Thien (Giao Thuy district) felt very deeply. High tide has changed dramatically in recent years and Giao Thien people clearly felt this phenomenon. Variations in the climate impacted household livelihoods in seven surveyed communes.

5.1.1. Impacts of climate change on the live-

Table 3: Impacts of climate change on livelihood assets at coastal communes in Nam Dinh province

	Cultivation land	Livestock breeding facilities	Aquacultu re land	Fishing gear	Salt production land	Road	Irrigation system	Human health	Access to bank loans	Access to information
Drought	0.200** [0.098]	-0.035 [0.089]	0.307*** [0.111]	0.244 [0.081]	-0.140* [0.076]	0.122 [0.039]	0.122 [0.044]	0.108** [0.047]	0.134 [0.049]	0.237 [0.051]
Storm	0.320*** [0.091]	0.240*** [0.083]	0.14** [0.103]	-0.023 [0.075]	0.021** [0.071]	0.049** [0.036]	0.096** [0.041]	0.150*** [0.043]	-0.065 [0.045]	-0.062 [0.047]
Increased temperature	0.139 [0.101]	0.344 [0.092]	0.353*** [0.115]	0.045 [0.084]	0.174** [0.079]	0.068 [0.041]	-0.061 [0.046]	0.074** [0.048]	0.131 [0.051]	0.139 [0.053]
Sea level rise	0.164* [0.095]	0.037 [0.086]	0.250** [0.108]	-0.139 [0.079]	0.171** [0.074]	0.126*** [0.038]	0.023 [0.043]	-0.059 [0.045]	0.156 [0.047]	0.105 [0.050]
Salt water intrusion	0.286*** [0.094]	0.025 [0.085]	-0.052 [0.106]	-0.228 [0.078]	-0.024 [0.073]	0.229 [0.038]	0.336 [0.042]	0.268 [0.045]	0.096 [0.047]	0.084 [0.049]
Year	0.009 [0.027]	0.027 [0.025]	-0.003 [0.031]	0.031 [0.023]	-0.012 [0.021]	0.046*** [0.011]	0.049*** [0.012]	0.040*** [0.013]	0.029** [0.014]	0.022 [0.014]
Constant	-17.29 [54.880]	-54.27 [50.013]	5.631 [62.279]	-61.025 [45.506]	25.125 [42.741]	92.014*** [22.077]	96.840*** [24.699]	79.741*** [26.107]	-56.534** [27.442]	-43.526 [28.720]
No of observations	572	572	572	572	572	572	572	572	572	572
R-squared	0.15	0.11	0.04	0.04	0.03	0.43	0.35	0.3	0.23	0.24

Standard errors in brackets, * significant at 10%, ** significant at 5%, *** significant at 1%

Source: Data processed by STATA software from household survey in Nam Dinh in 2012

lihood assets

The impacts of climate change on livelihood assets are shown in Table 3 with the following main points:

- The more frequently drought happens, the more rice cultivation land and family health are affected due to lack of water. The more aquaculture land is affected due to changes in the water environment temperature, the less salt production land is affected due to the faster evaporation of seawater (with statistical significance at 5% and 10%).

- The more storms happen, the more frequently rice cultivation land, livestock breeding facilities, salt production land, road, and irrigation systems are affected due to flooding; and human health is more affected due to increase in diseases (with statistical significance at 5% and 10%).

- The more frequently increased temperatures occur, the more aquaculture land and family health are affected due to changes in the water environment temperature and increase in disease respectively, and the less salt production land is affected due to faster evaporation of seawater (with statistical significance at 5% and 10%).

- Sea level rise happens more frequently, rice cultivation land, salt production land, and roads are more affected due to flooding whereas aquaculture land is more affected due to salinization (with statistical significance at 5% and 10%).

- The more frequently saltwater intrusion occurs, the more rice cultivation land is affected (due to salinization) with statistical significance at 1%.

In short, it can be seen from Table 3 that the more frequently climate change happens, the more livelihood assets are affected. Specifically, storm, drought, and saltwater intrusion have positive effects on natural capital (cultivation land, aquaculture land, and salt production land) and physical capital (road and irrigation systems). These are livelihood assets that are very sensitive to climate change. In addition, storm, drought, and increased temperature have positive effects on human capital (health). Financial capital (access to bank loans) and social capital (access to information) are less affected by climate change.

Based on values of R^2 from the estimation results, it is observed that R^2 values range from 0,04 to 0,43 which are quite low. This can be explained that in addition to 5 variables representing climate change considered in this study, there are other factors affecting the livelihood assets that have not been addressed in the study.

5.1.2. Impacts of livelihood assets on livelihoods strategies

Data in Table 4 show that the more livelihood assets are affected by climate change, the more livelihood strategies are affected. In particular, the impacted livelihood assets (rice cultivation land, livestock breeding facilities, fishing facilities, aquaculture land, and salt production land) have positive effects on the respective livelihood strategies (rice cultivation, livestock breeding, fishing, aquaculture practices and salt production) with statistical significance at 5% and 10%. In addition, physical capital (irrigation system) has a positive effect on rice cultivation; social capital (access to information) has a positive effect on fishing; financial capital (access to bank loans) has a

Table 4: Impacts of livelihood assets on livelihoods strategies at coastal communes in Nam Dinh province

	Rice cultivation	Livestock breeding	Fishing	Aquaculture	Salt production
Road	-0.016 [0.039]	0.054 [0.045]	0.037 [0.028]	-0.066 [0.032]	0.011 [0.025]
Irrigation system	0.001* [0.039]	0.049 [0.045]	-0.028 [0.028]	0.026 [0.031]	0.037 [0.025]
Human health	-0.026 [0.035]	-0.079 [0.040]	-0.031 [0.024]	0.012 [0.028]	-0.024 [0.022]
Access to bank loans	0.042 [0.038]	0.112** [0.044]	0.065** [0.027]	0.112*** [0.031]	-0.031 [0.024]
Access to information	-0.068 [0.036]	-0.021 [0.041]	0.038* [0.025]	-0.041 [0.029]	0.025 [0.023]
Cultivation land	0.932*** [0.013]				
Livestock breeding facilities		0.884*** [0.017]			
Fishing gear			1.020*** [0.011]		
Aquaculture land				0.892*** [0.009]	
Salt production land					0.838*** [0.011]
Constant	0.271*** [0.093]	-0.062 [0.106]	0.065 [0.067]	-0.055 [0.074]	-0.064 [0.059]
Observations	286	286	286	286	286
R-squared	0.91	0.85	0.94	0.95	0.92

Standard errors in brackets, * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Data processed by STATA software from household survey in Nam Dinh in 2012

positive effect on livestock breeding, fishing and aquaculture with a statistical significance at the 5% and 10% levels.

Based on values of R^2 from the estimation results, it can be seen that R^2 values range from 0.85 to 0.95 which are very high. This means that the impacted livelihood assets do affect livelihoods strategies.

5.1.3. Impacts of livelihood strategies on livelihood outcomes

The impacted livelihood strategies and livelihood outcomes have a positive relationship with statistical significance at 1%. It means that the more livelihood strategies are affected by climate change, the more livelihood outcomes are affected. Based on values of R^2 from the

Table 5: Impacts of livelihood strategies on livelihood outcomes at coastal communes in Nam Dinh province

	Income from rice cultivation	Income from livestock breeding	Income from fishing	Income from aquaculture	Income from salt production
Rice cultivation	0.981*** [0.012]				
Livestock breeding		0.936*** [0.014]			
Fishing			0.973*** [0.006]		
Aquaculture				0.999*** [0.008]	
Salt production					0.938*** [0.012]
Constant	0.098*** [0.036]	0.127*** [0.038]	0.004 [0.009]	0.024 [0.015]	0.016 [0.014]
Observations	286	286	286	286	286
R-squared	0.92	0.89	0.98	0.97	0.91

Standard errors in brackets, * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Data processed by STATA software from household survey in Nam Dinh in 2012

estimation results, it is realized that R^2 values range from 0.85 to 0.95 which are quite high. This means that the impacted livelihood strategies do affect livelihood outcomes.

5.2. Household's livelihood adaptation practices to counter the impacts of climate change

Adaptation to climate change is a long-lasting and ongoing process in communities affected by climate risks. When livelihood strategies are vulnerable to climate change impacts, households tend to adjust their livelihood strategies depending on their capacity to adapt. In this process, experiences and best practices are accumulated and shared between households and communities affected.

5.2.1. Adaptation for rice cultivation

Local households in three coastal districts in Nam Dinh province are adjusting rice cultivation practices to cope with flooding, saltwater intrusion, and other extreme weather events. The choices of different adaptation measures for rice cultivation are shown in Table 6.

To counter the impact of extreme weather events, households tend to schedule times for rice cultivation, develop appropriate crop planning, implement appropriate cultivation techniques suitable in the context of climate change, utilize rice varieties able to withstand the harsh environmental conditions, strengthen the agricultural irrigation system, and learn experiences from their neighbors and other local communes.

To deal with flooding, households have tried to invest in new rice varieties with higher

Table 6: Adaptation for rice cultivation at coastal communes in Nam Dinh province

Unit: %

Adaptation options	Hai Dong	Hai Ly	Nam Dien	Nghia Thang	Giao Thien	Giao Xuan
To counter the impact of extreme weather events						
Scheduling times for rice cultivation	93	77	79	35	64	75
Developing appropriate crop planning	90	60	26	42	76	63
Implementing appropriate cultivation techniques in the context of climate change	90	66	61	27	14	53
Utilizing rice varieties able to withstand the harsh environmental conditions	86	63	55	65	0	25
Strengthening agricultural irrigation system	69	63	58	23	36	43
Learning experiences from their neighbors and other local communes	72	63	68	27	96	75
Looking for non-agricultural jobs locally	34	43	50	8	0	8
Mobilizing capital from banks, friends and relatives to invest in new business	14	0	53	15	0	10
Migrating to other areas for new employment opportunities	0	3	53	4	0	5
Planning for risk management	17	31	53	27	0	20
To counter the impact of flooding						
Investing in new varieties with higher yields in the existing cultivated landed	69	49	87	69	86	80
Investment in labor	41	11	39	19	38	15
Investment in fertilizer	62	49	68	27	18	13
Learning experiences from their neighbors and other local communes	83	74	68	31	98	73
Mobilizing capital from banks, friends and relatives to invest in new business	31	11	42	19	2	8
Looking for non-agricultural jobs locally	45	63	63	31	0	5
Migrating to other areas for new employment opportunities	0	6	42	0	0	3
Planning for risk management	28	40	53	31	6	13
To counter the impact of seawater intrusion						
Reducing salinity by flushing saline land	34	31	58	69	16	35
Transferring rice cultivation land into aquaculture land for aquaculture practices	48	46	53	23	20	13
Cultivating salt tolerant varieties	69	37	68	46	76	55
Cleaning channels to remove saltwater from rice fields	86	49	58	27	54	45
Learning experiences from their neighbors and other local communes	76	49	68	23	100	75
Looking for non-agricultural jobs locally	34	51	58	15	0	8
Mobilizing capital from banks, friends and relatives to invest in new business	14	6	63	12	0	5
Migrating to other areas for new employment opportunities	0	14	58	0	0	3
Planning for risk management	28	54	47	19	2	15

Source: Household survey in three coastal districts of Nam Dinh, 2012

Table 7: Adaptation for livestock husbandry at coastal communes in Nam Dinh province*Unit: %*

Adaptation options	Hai Dong	Hai Ly	Nam Dien	Nghia Thang	Giao Thien	Giao Xuan
Increasing investment in food and disease prevention	63	42	86	60	87	66
Changing livestock breeding techniques	81	46	29	55	93	68
Reducing livestock breeding size	47	34	57	5	0	8
Learning experiences from their neighbors and other local communes	59	26	57	15	93	37
Looking for non-agricultural jobs locally	47	42	61	20	9	5
Mobilizing capital from banks, friends and relatives to invest in new business	13	10	75	20	0	11
Migrating to other areas for new employment opportunities	0	0	46	0	0	3
Planning for risk management	13	26	68	35	4	21

Source: Household survey in three coastal districts of Nam Dinh, 2012

yields in the existing cultivated land, intensify their culture of existing cultivated land through investment in fertilizer, and learn experiences from their neighbors and other local communes.

Cleaning channels to remove saltwater from rice fields, cultivating salt tolerant rice varieties, transferring rice cultivation land into aquaculture land for aquaculture practices, reducing salinity by flushing the saline land, and learning experiences from their neighbors and other local communes are the choices of most households to address the impact of salt water intrusion.

5.2.2. Adaptation for livestock husbandry

Households have adjusted livestock husbandry to adapt to the changing weather conditions. It is reported that households have changed livestock breeding techniques, increased investment in food and disease preven-

tion, reduced livestock breeding size, learned experiences from their neighbors and other local communes, and looked for non-agricultural jobs locally.

5.2.3. Adaptation for salt production

Salt production is highly sensitive to the climate conditions and can be done only on sunny days. Because of the high dependence on weather conditions, farmers tend to look for non-agricultural jobs locally in addition to scheduling times for salt production to avoid the rainy season. Many households mobilize capital from banks, friends and relatives to invest in new businesses as an adaptation.

5.2.4. Adaptation for fishing

Fishing depends largely on the abundance of aquatic resources. Climate change tends to make changes in the stocks of aquatic resources, which requires fishermen to adjust their fishing practices. Investing in education for

Table 8: Adaptation for salt production at coastal communes in Nam Dinh province*Unit: %*

Adaptation options	Hai Dong	Hai Ly	Nghia Phuc
Scheduling times for salt production to avoid rainy season	31	67	57
Repairing salt fields with higher boundaries to avoid flooding	8	53	49
Looking for non-agricultural jobs locally	77	60	40
Mobilizing capital from banks, friends and relatives to invest in new business	54	53	33
Migrating to other areas for new employment opportunities	38	13	3
Planning for risk management	42	40	40

Source: Household survey in three coastal districts of Nam Dinh, 2012

children with a hope of new opportunities for alternative livelihoods for the next generation is a new choice for most households in order to reduce their dependence on increasingly degraded marine resources. In addition, scheduling times for fishing activities during the year to avoid fishing in the rainy season, and looking for non-agricultural jobs locally are also the choices of many households in coastal communes in Nam Dinh province.

5.2.5. Adaptation for aquaculture practices

Households in coastal communes in Nam Dinh province have taken some measures to adapt to the impacts of climate change on their aquaculture practices. Households have changed aquatic species, aquaculture techniques and diversification of aquatic species. Learning experiences from their neighbors and other local communes is also the choice of a large number of households.

5.2.6. Assessments of household adaptation practices to the impacts of climate change on

Table 9: Adaptation for fishing at coastal communes in Nam Dinh province*Unit: %*

Adaptation options	Hai Dong	Hai Ly	Nam Dien	Nghia Thang	Giao Xuan
Scheduling times for fishing activities during the year to avoid fishing in the rainy season	60	52	25	44	100
Investing in fishing gear (fishing boats and nets)	40	0	75	67	11
Investing in education for the next generation with new opportunities for alternative livelihoods	80	0	25	11	17
Looking for non-agricultural jobs locally	60	22	75	11	0
Mobilizing capital from banks, friends and relatives to invest in new business	0	35	25	11	0
Migrating to other areas for new employment opportunities	0	0	75	0	0
Planning for risk management	40	30	25	11	28

Source: Household survey in three coastal districts of Nam Dinh, 2012

Table 10: Adaptation for aquaculture practices at coastal communes in Nam Dinh province*Unit: %*

Adaptation options	Hai Dong	Hai Ly	Nam Dien	Nghia Thang	Giao Thien	Giao Xuan
Diluting salinity concentration in the water to reduce the salinity	32	30	25	0	0	9
Repairing aquaculture ponds with higher dykes and sewers	37	40	79	44	0	9
Changing aquatic species, aquaculture techniques as well as diversification of aquatic species	58	60	43	78	90	73
Stopping or reducing the scale of aquaculture farming	26	30	54	22	0	9
Learning experiences from their neighbors and other local communes	63	60	61	33	100	64
Looking for non-agricultural jobs locally	16	20	57	0	0	5
Mobilizing capital from banks, friends and relatives to invest in new business	16	20	46	0	0	5
Migrating to other areas for new employment opportunities	0	0	57	0	0	5
Planning for risk management	33	44	34	0	0	18

Source: Household survey in three coastal districts of Nam Dinh, 2012

their livelihoods in three coastal districts of Nam Dinh province

To implement livelihood strategies in the context of the increasing intensity and frequency of natural disasters caused by climate change, local people in seven coastal communes of Nam Dinh province have continuously adjusted their livelihoods accordingly to their capacity and resources. First of all, they are implementing adaptation practices on their existing livelihoods to mitigate damage caused by climate change. In addition, local people are also trying to take advantage of new opportunities brought by climate change, such as transferring rice cultivation land into aquaculture land for aquaculture practices, changing aquatic species, aquaculture techniques as well

as diversification of aquatic species which contributes to the transformation of the production structure at local area or looking for non-agricultural jobs to reduce their dependence on the increasingly risky agricultural sector.

To successfully adapt to climate change impacts, vulnerable communities need to be innovative and creative in their livelihood strategies. In this discipline, they can be effective agents for innovations that lead to efficient adaptation practices to climate change. However, findings from the household survey in three coastal districts of Nam Dinh province showed that households are implementing passive adaptation activities on their livelihoods rather than active ones to counter the impacts of climate change because of the following reasons.

Firstly, the adaptation measures are mainly drawn from local experiences and this has contributed positively in reducing the vulnerability of livelihoods. For example, people have scheduled carefully the seasonal calendar for their livelihood activities in order to minimize potential damage caused by climate risks, or they have considered times for planting, harvest, and fishing, or have restructured crops suitable for weather and soil conditions. In addition, local people have applied traditional methods of natural disaster forecasting through radio and other media means. When signs of storms occur, they will reinforce dykes, and prepare boats, and household properties.

Secondly, social asset (through social relationships and networks within the community) plays a very important role in the adaptation activities through sharing of knowledge and best practices between communes affected by climate change. Most households learn experiences from local neighbors to implement adaptation measures for rice cultivation, livestock husbandry, fishing, and aquaculture. Besides, they also have multiple ways to support each other in protecting ships, boats, and household properties.

Thirdly, the number of households that selected mobilizing capital from banks, friends and relatives to invest in new business as an adaptation measure is quite small. This is due to the fact that formulation of adaptive livelihood strategies and livelihood diversification depend heavily on the accumulation and diversification of household livelihood assets. In fact, coastal households are poor ones with limited livelihood assets, especially financial and human capital.

- Financial capital has always played an important role in creating a safe and stable livelihood to counter the impact of changing external environment. The poor have very similar characteristics in terms of quality of housing, access to land, physical assets, reserves, and indebtedness (such as bank loans). This shows that households in a certain socio-economic group can implement relatively similar livelihood strategies and differ only in size and investment costs, especially for agricultural activities. For other livelihood strategies such as fishing and aquaculture, only those with sufficient capital can invest in these strategies. Therefore, it is quite difficult for the poor to adjust their livelihood strategies if that requires large expenses (for example investment in new varieties or switching from agriculture to aquaculture). Although households can borrow money from friends or banks to restore their livelihoods and damaged properties, lack of a sustainable financial resource is a major obstacle to the implementation of planned adaptation practices.

- Human capital, in the forms of knowledge, experience, and skills that households utilize to implement livelihood strategies, is a determinant of household livelihood adaptation strategies. Even if households have financial capital, they are not always able to switch from agricultural production to aquaculture because this requires households to be educated in aquaculture skills. Thus, these households could not switch careers to adapt to the new climatic conditions without support of retraining.

- Major livelihood strategies in coastal areas such as rice cultivation, salt production, fishing, and aquaculture are largely dependent on access to natural resources, especially water.

Sustainable management of, and improvement in, access to water resources in the coastal areas therefore play an essential role for livelihood adaptation. In addition, local infrastructure, especially sea dikes, irrigation and drainage system, ... also has a great impact on household livelihoods. However, these factors are beyond the control of households in local areas.

6. Conclusions and policy implications

Building sustainable and adaptive livelihoods is an urgent need for Vietnam in general and for coastal areas in particular to help households effectively adapt to climate change. Livelihood adaptation is key to mitigate vulnerabilities and increase resilience to climate change impacts which requires improvement in adaptive capacity and implementation of appropriate actions for those areas sensitive to climate change.

Livelihood assets play a central role to household livelihoods as they determine the choice of livelihood strategies and then affect livelihood outcomes. Findings from a case study in Nam Dinh province show that climate change affects the livelihood assets and thereby changing livelihood strategies and livelihood outcomes of households. Therefore, at the household level, government policy to strengthen households' livelihood assets plays a vital role in helping families move from passive adaptation to active one. The supports aiming at improving the livelihood assets include:

- Natural capital: Enhancing natural resource management, especially ecosystem system based management.

- Physical capital: Improving local infrastructure (roads, electricity, and water supply) to withstand climate change impacts.

- Financial capital: Ensuring access to credit programs, insurance services and other finan-

cial services.

- Human capital: Training skills to help people switch careers; enhancing emergency assistance programs; and implementing social protection policies and disaster risk management.

- Social capital: Enhancing the exchange of local information and communication on climate change adaptation.

In addition, the adaptive capacity of a local community is closely related to economic capacity and strong leadership of local government. Although each country, each community or household vulnerable to climate change has its own way to respond and mitigate possible impacts, an action plan with careful consideration of public policies needs to be made at all levels to establish planned and strategic adaptation. Government must play a vital role in creating enabling policy, financial and legal frameworks, capturing and sharing experience, and raising public awareness on climate change. Thus, at the national/local level, institutions and policies on climate change adaptation should be enhanced, including:

- Capacity building on climate change adaptation: mainstreaming climate change adaptation into development planning at national/local levels, and implementing community-based adaptation initiatives at the community level.

- Strengthening adaptation practices for sectors that are most affected by climate change: including agriculture (increasing investment in agricultural infrastructure, strengthening technical assistance for agricultural extension system, and enhancing transfer of scientific and technical initiatives) and fisheries (building fisheries information system, strengthening community based marine resource management, and improving management of aquaculture practices with more environmental regulations).

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