

Adaptive livelihood strategies among small-scale fishing households to climate change-related stressors in Central Coast Vietnam

Phuong T.A. Huynh

University of Sciences, Hue University, Hue, Vietnam, and

Ngoan D. Le, Sen T.H. Le and Thang N. Tran

University of Agriculture and Forestry, Hue University, Hue, Vietnam

Abstract

Purpose – This paper aims to examine adaptive livelihood strategies used by small-scale fishing households in the two coastal communities in Central Vietnam under the context of climate change-related stressors.

Design/methodology/approach – Field data were collected through mixed quantitative and qualitative methods including a review of secondary data, key-informant interviews, group discussions and household surveys with 300 sampled fishing households. The qualitative data support the analysis and discussion of quantitative data.

Findings – The results showed local households' perception of the presence and influence of multiple climate and climate stressors on their fishery-based livelihoods in terms of employment and income in many ways. The affected households exerted to develop a diversity of adaptation methods within and out of fishing to sustain their livelihoods and cover a deficit in household income. The household socio-demographic characteristics particularly education, labour force, fishing equipment and social support played significant importance in characterising the categories of adaptation strategies among the survey households. The role of local governments in creating an enabling environment for local-level adaptation, as well as protecting marine and coastal ecosystems was rather limited despite their recognized importance.

Originality/value – The paper provides an empirical case of how small-scale fishing households in coastal communities in Central Vietnam are adapting to climate-related stressors. It suggests policy should promote livelihood diversification opportunities and address household-level constraints for adaptation. Fisheries management plan is urgently needed to control illegal fishing activities for sustainable use of coastal and marine fishery resources and the appropriate mechanism is important to stretch local governments' resources for better supporting local-level adaptation.

Keywords Climate change, Coastal livelihood, Local level adaptation, Small-scale fisheries

Paper type Research paper



1. Introduction

Climate change is globally happening and already causing a wide range of impacts on human and natural systems (Mooney *et al.*, 2009; Noble *et al.*, 2014). The impacts of climate change will be most strong in developing countries where millions of people are substantially dependent on natural ecosystems for livelihoods and well-beings (Béné, 2006; Adger *et al.*, 2003; Allison *et al.*, 2009; Purcell and Pomeroy, 2015; Weatherdon *et al.*, 2016). Fisheries are considered as one of the most vulnerable sectors (Béné, 2006; Kosamu, 2015) because climate change will directly and indirectly affect coastal and marine ecosystem and fisheries via multiple pathways (Badjeck *et al.*, 2010; Daw *et al.*, 2012). Particularly, the warmer temperature can directly raise the metabolism of marine and coastal fish species and even be fatal to some types of species resulting in negatively impacting on fish productivity, abundance and distribution to the variation or decline in fish catch and processing (Brander, 2010; Barange *et al.*, 2014). Because of their great dependence on fish resources for food security, employment and income coastal communities and fishing households become much more vulnerable (Boon and Ahenka, 2013; Barange *et al.*, 2014; Brander *et al.*, 2017; Hanich *et al.*, 2018; Muringai *et al.*, 2019). Climate change impacts also challenge contemporary fisheries management in many countries (Poulain *et al.*, 2018).

Vietnam is considered one of the most affected countries by climate change with the perceived and expected variations in all climate variables (IPCC, 2007). It was reported that temperature will rise up 1.7°C–2.7°C and sea level will rise at about 73 cm by the year 2100; total rainfall will likely increase toward fluctuation; and extreme weather events are likely to be more severe (Tran *et al.*, 2016). With a long coastline of 3,260 km running from the North to the Southwest, coastal regions as the home to about 20% of the total national population living in around 1,000 coastal communities are most vulnerable to climate change in Vietnam (Pomeroy *et al.*, 2009; Teh *et al.*, 2014). Small-scale coastal and marine fisheries, which provide employment, livelihoods and income for millions of coastal people and contribute to the national economy in Vietnam, have been already confronting a wide range of difficulties and challenges such as overfishing (Pomeroy *et al.*, 2009), weak management (Dao and Pham, 2003); and user conflicts over fishing in coastal areas (Boonstra and Bach Dang, 2010). Climate change is likely to exacerbate other stressors with increasingly negative outcomes for coastal livelihoods (Cinner *et al.*, 2012; Tran *et al.*, 2016; Pampeng and Ahmad, 2017).

In the context of increasing uncertainties with respect to climate change impacts on natural and social systems (Adger, 2006), adaptation will be essential at all levels to help affected or threatened communities or groups protect themselves and sustain their livelihoods (Cinner *et al.*, 2012; Noble *et al.*, 2014). Adaptation measures were worldwide found to be diverse and different from context to context, from countries to countries (Huynh and Resurreccion, 2014; Wang *et al.*, 2016; Mulyasari *et al.*, 2018). Poulain *et al.* (2018) stressed that adaptation responses in developing countries often target small-scale and coastal fisheries and fishing communities whilst adaptation in developed countries often focused on industrial and large-scale fishing and aquaculture operations. Therefore, for the developing countries, understanding how the communities or groups are adapting to the impacts of climate change at the local level is necessary to guide future adaptation strategies to best support for threatened communities and groups (IPCC, 2007; Žurovec and Vedeld, 2019).

In the context of Vietnam, despite the visibility of policies, laws and strategies in climate change adaptation at the national level, a large extent of adaptation was evidently found at the local level (Huynh and Resurreccion, 2014; Boonstra and Hanh, 2015; Tran *et al.*, 2014; Le *et al.*, 2018; Nguyen *et al.*, 2018; Van *et al.*, 2015; Shrestha *et al.*, 2016; Huynh and Stringer, 2018; Trinh *et al.*, 2018). The results of most existing studies highlighted the vulnerability of

natural resource dependent livelihoods and the diversity and complexity of adaptation strategies to the impacts of climate change at local and household levels. For the importance of small-scale fisheries and local-level adaptation measures in Vietnam, it needs much more empirical evidences to inform local to national efforts and coastal management strategies that can encourage and support adaptation for effective responses to climate change. This paper is a further attempt to contribute to growing knowledge of local level adaptation to climate change and to provide important empirical evidences for more effective policies and management strategies to best support threatened communities and households living in coastal regions. It adopts the livelihood approach to understand various dimensions of households' livelihoods and their pursuit of adaptation strategies in the context of climate change-related stressors. The objectives of the study were to explore key stressors threatening local fishing-based livelihoods, investigate the diversity of adaptive strategies used by affected fishing households and discuss the importance of household socio-demographic characteristics and the efforts of local governments in local-level adaptation.

The paper is structured as follows: Section 1 provides an introduction; Section 2 reviews the literature. The methodology is presented in Section 3. Section 4 presents the results and discussion, followed by conclusions in Section 5.

2. Literature review

Climate adaptation is widely defined as “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects” (IPCC, 2007), which includes actions to moderate, avoid harm or exploit beneficial opportunities (Noble *et al.*, 2014). In this sense, adaptation is widely recognized as promising ways to enhance the adaptive capacity of a system in alleviating or minimizing the vulnerability to climate change impacts (Wang *et al.*, 2016; Abdul-Razak and Kruse, 2017). It was much argued that adaptation takes many shapes and forms depending on the particular context of a community, region or country (UNFCCC, 2019). It is not a homogeneous process and is affected by various factors (Blythe *et al.*, 2014) and often is undertaken at the local level (Brugger and Crimmins, 2015; Poulain *et al.*, 2018). For its importance, IPCC (2007) placed local knowledge of adaptation at the centre of discussion for formulating adaptation strategies to protect people and communities.

Livelihoods are conventionally defined as “the capabilities, assets and activities required for a means of living” (Chambers and Conway, 1992, p. 6). A livelihood strategy basically refers to a chosen combination of assets and activities that generate income for an individual or a household through a set of economic actions to achieve livelihood outcomes (Ellis, 1998; Serrat, 2017). For adaptation, livelihoods refer to the choices and actions that people take to earn a living, meet their consumption needs, cope with uncertainty and respond to new opportunities (de Haan and Zoomers, 2005; Blythe *et al.*, 2014). Livelihood has been increasingly used as a conceptual and analytical framework in enhancing the understanding of livelihood strategies particularly at the micro or local level (Allison and Ellis, 2001; Holvoet and Allison, 2008). This approach emphasizes on the link between household assets (focusing on what households have rather than what they do not have), the activities in which households can engage with a given asset profile and mediating processes that govern access to assets and to alternative activities (Moser, 1998).

In climate change adaptation analysis, livelihood framework is often applied to understand how different the households and communities in the first place are affected and adapt to the changes related to their livelihoods, and how livelihood strategies can help build adaptive capacity to enable affected households and communities to better adapt to the

changes (Allison and Ellis, 2001; Holvoet and Allison, 2008; Reed *et al.*, 2013), particularly in developing countries where national scale adaptation remain limited (Blythe *et al.*, 2014).

Recently, an increasing body of studies have adopted livelihood framework in examining the adaptive strategies of fishing households and communities particularly in developing countries (Iwasaki *et al.*, 2009; Zamroni and Yamao, 2014; Mulyasari *et al.*, 2018; Musinguzi *et al.*, 2016; Amevenku *et al.*, 2019; Hoang *et al.*, 2020). The key insights from these studies included as follows:

- Fishers have adopted to the impacts of climate change in various ways to sustain their livelihoods (Musinguzi *et al.*, 2016; Hoang *et al.*, 2020); and
- The households' attributes often play the determining roles in characterising their adaptive strategies (Cinner *et al.*, 2009; Abdul-Razak and Kruse, 2017; Mulyasari *et al.*, 2018; Amevenku *et al.*, 2019).

Meanwhile, local governments were difficult in exerting their critical role in local-level adaptation and protect coastal ecosystems (Deri and Alam, 2008). The findings of these studies strongly stressed that adaptation is location-specific and influenced by local and household conditions, therefore, local specific knowledge of how threatened or affected households are adapting to the changes is needed for adaptation strategies and natural resource management. Most of these studies applied a mixed methods approach including both quantitative and qualitative methods (Blythe *et al.*, 2014; Musinguzi *et al.*, 2016). This kind of approach is argued to be most relevant in developing a deeper and more holistic understanding of adaptive strategies at the local level (Iwasaki *et al.*, 2009; Bennett *et al.*, 2016; Campos *et al.*, 2016).

2. Methodology

2.1 Study areas

Lying along 1,400 km length of the coastline, the Central Coast is a vulnerable region to annual climate-related events including increased storms, surges and flooding as compared to any other coastal areas in Vietnam (McElwee, 2017). This region has been and continues to be among the most affected regions to climate-related changes and sea level rise in the future (Tran *et al.*, 2016).

Phu Dien and Quang Cong – two coastal communities located in Thua Thien Hue province – among the most climate change-affected regions in the Central Coast Vietnam (Ngoan, 2019) were selected for field data collection of this study. The two communities (Figure 1) shared similar ecological and socio-economic features of a coastal community. Being located in a shallow water marine, these communities are traditionally exposed to coastal natural hazards and ranked as poor communities within the region. With a natural area of 13.95 km², the Phu Dien community has 11,042 populations in 3,359 households whilst Quang Cong has 6,729 populations in 1,696 households in 2018. About more than 60% of the total local households in the two communities are fisher folk and a number of other households engage in fisheries-related activities for pretty extra income. This percentage of local fisher folk has been changing year by year due to different reasons including household separation or geographic development.

Coastal and marine fishing in the two communities takes place in in-shore or off-shore waters as open access resource within 20 nautical miles lasting within 6–8 months annually. A typical fishing household is often characterised as self-employed where male labours work on gear and catch fish using non-mechanized or small mechanized fishing boats as individually or small groups (mostly family labour force) whilst female labours are responsible for other fishing-related activities such as fish drying and processing, fish sauce

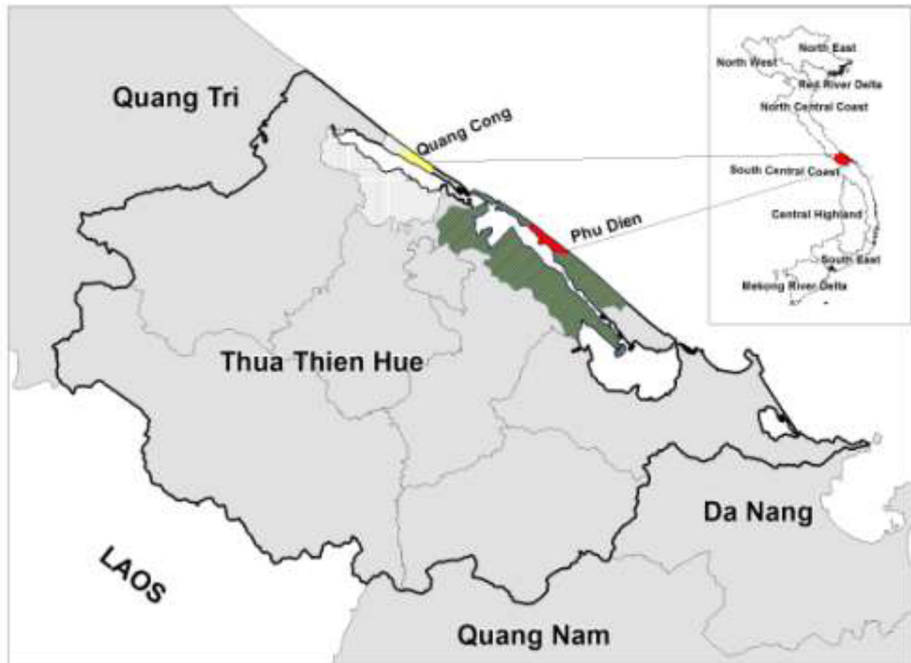


Figure 1.
Map of the study
areas in Central Coast
Vietnam

making, marketing, net making or mending. Fishery-based livelihoods as traditional livelihood system plays the vital importance for these households as important sources of employment and income, as well as a cultural tradition of the communities.

2.2 Data collection and analysis

This study incorporated a number of quantitative and qualitative research methods in data collection and analysis with the purpose of providing a better understanding of the research topic. The field work was conducted at the research sites from mid-2018 to early 2020. Firstly, a review of secondary data was organized to get the information related to ecological, socio-economic characteristics of local communities, local livelihood systems, environment-related conditions sourced mostly from local government documents. The information from this source of data helped the authors to get an overall understanding of local context for the design of other methods such as group discussions, key-informant interviews and household surveys.

The group discussions were concurrently conducted with the key-informant's interviews at the research sites. One group discussion was conducted in each community with the attendance of 12 adult members represented from local fishing households in each discussion. The attendees with different age and gender were selected based on the available fishing household list and the recommendation from local village heads. The group discussions were carried out in the late afternoon at community houses following with different steps based on prepared guidelines to collect the data related to the fishing livelihood system, livelihood stressors and key adaptation methods at the community level. During the group discussion, the attendees often talked and discussed with the researchers

about the topics, the researchers took notes and used visual tools such as mapping for gathering the data. The information from the group discussion was used for designing household survey and case evidence in the paper where appropriate. The interviews with key informants were carried out with the head and one fisherman with about 40 years of fishing experience in each community. Each interview lasted about 45 min with some guideline questions and each question was asked at a time. The questions focussed on the cultural, social and economic importance of the traditional livelihood system, pressing issues for fishing at the locality, institutional support for fishing households and management measures for protecting fishing households, as well as promoting the sustainability of natural resources at the localities for now and future. The responses were noted on the written notes for each question and key information was checked with the interviewees after the whole interview.

The household surveys with questionnaire as the key quantitative research method in this study were conducted at the last phase of the study. The fishing households in the two selected communities are the target population for the survey. Firstly, the list of local fishing households was collected from the village heads in each community. On the basis of the formula suggested by Scheaffer *et al.* (2011) and the practice in the research sites, using the simple random sampling technique, the final sample for the survey consisted of 300 households for the two communities, occupying around 20% of total fishing households of the two communities at the study time. The survey was conducted face-to-face with the adult member at each sample's house. In very few cases, selected households were not able to participate in the survey, nearby households were chosen as replacements to make sure the sample size. The questionnaire was designed to obtain household-level information to accomplish the research objectives. The questions included closed-ended, opened-ended and multiple-choice to gather information about demographic characteristics of the samples, their own perceptions of climate change and other stressors, vulnerability, livelihood adaptation methods and desires for livelihoods.

The survey data were then inputted using Excel 2016. The analysis tools including descriptive statistics were firstly applied to present the socio-demographic characteristics, livelihood stressors and livelihood adaptation methods among the survey samples. To understand the role of household characteristics and local environment in characterising livelihood adaptation methods among the sampled households, the steps of analysis were conducted. Firstly, adaptation methods used by the samples were grouped into three categories including fishing diversification, fishing and non-fishing diversification and non-fishing diversification. Secondly, descriptive statistics were applied to present basic features of each categorized group based on the socio-demographic characteristics of the sampled households. Finally, the Kruskal–Wallis test was applied to determine if there are statistically significant differences on the selected variables between the three adaptation categories (Table 3). We then discussed the results from the quantitative data in combination with relevant qualitative data collected from the key-informant interviews and group discussions in constructing local adaptive strategies among the fishing households. The notes from the interviews and group discussions were proceeded based on the keywords and phrases to categorize recurring themes and relevant opinions for the purpose of the study.

The use of the mixed research methods within this study faced some difficulties. It took time and resources to plan the study and select appropriate quantitative and qualitative methods for best addressing the research objectives and to gather the data with the participation of various stakeholders at the research sites. The process of analysis also required more time commitment and research expertise of the authors in integrating both

types of data to present and interpret the results. Despite that, this approach helped provide more specific and comprehensive insights about the local-level adaptation.

3. Results and discussions

3.1 Perceptions of multiple stressors affecting fishery-based livelihoods among fishing households

Fishing activities in the study areas are generally conducted in inland, short or near shore waters. Local fishers used traditional fishing gears (lines, traps and nets), mechanized or non-mechanized fishing boats within the limited fishing area (5–10 sea miles). The secondary data revealed fish catch ranging within 3,000–4,000 tons per year per community. Fish products were used for many purposes including home consumption, direct sale and making fish sauce, fish dry processing. Fishery-based livelihoods are the main sources of income for local fishing households. The heads of the communities strongly confirmed two vital roles of local fishery-based livelihoods including contributing to the household and local economies and protecting national boundary security.

The data from the group discussions revealed that local households perceived multiple factors affecting and threatening their fishery-based livelihoods over the past decades. The descriptive analysis of the survey data showed the stressors, in order of importance, including declining fluctuations in fish abundance and distribution, variation and change in climate variables, pollution of marine and coastal environment, difficult output market for fish products and fishing area conflict at the different perception of the sampled households (Figure 2).

The first perceived stressor was the fluctuation in fish abundance and distribution in the sea. Even some local fish species were confirmed to disappear or become rare. The fish resource fluctuation was reported to lead to a noticeable decrease in a local fish catch over past years, critically threatening local households' income:

“Most members of local fishing households are traditionally involved in fisheries for their household income and employment. Local men are responsible for fishing, local women work in fish marketing, fish sauce processing and fish net making. Now, fish catch is decreasingly fluctuating year by year, local fishing households loose these main sources of income over time.” (Head of community, key-informant interview, 2019).

The second perceived stressor severely affecting local fishing activities included the variation and change in climate variables (Figure 2). In the group discussions, local respondents stressed that temperature was clearly hotter and hotter, rainfall became more fluctuated toward decreasing, storms happened unpredictably and severely than ever. These changes

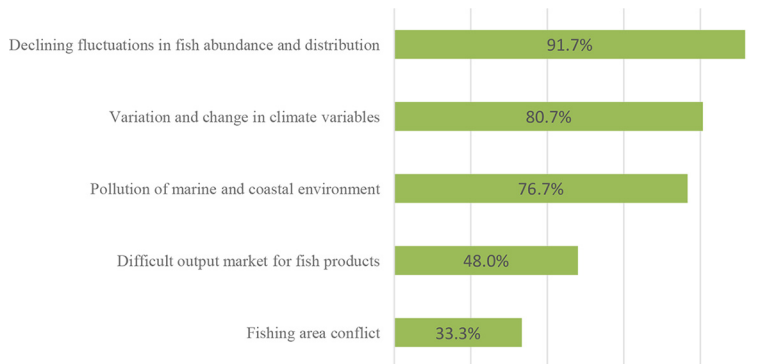


Figure 2.
Livelihood stressors being experienced by fishing households in the research communities over past years

were perceived to affect fishing-related livelihoods in different ways. For instance, due to hot temperature, local fishers could not go for fishing for a longer time than usual or they had to go for fishing at the early or late time of the day. The unpredicted presence of storm when fishers were boat fishing out in the water was really harmful for fishing equipment and labours. Local respondents stated that the change in climate variables was among the key causes of the decrease in fish abundance at the sea.

The pollution of marine and coastal environment was also a significant stressor to local fishing activities. Local respondents blamed for some industrial companies located in other regions to cause marine pollution resulting in a cumulative decrease in their fish catch, particularly in recent years:

“Over past decades, we have caught less and less fish year by year, since 2018 fish resources have been even more decreased due to marine environmental pollution.” (56-year-old fisher, group discussion, 2019).

These stressors not only severely affected actual fishing activities but also brought accumulative impacts on other fishery-related livelihoods at the research sites in varied ways, particularly to the employment and income of local female labours:

“Local women are mainly responsible for fish net mending, fish sauce making and fish drying processing. Many of us now have to abandon some activities like fish sauce making or fish drying because of lack of fresh fish materials. As a result, our employment and income are severely losing.” (40-year-old woman, group discussion, 2019).

These results showed that people in the study areas well perceived the visibility of non-climate and climate stressors and their impacts on local fishery-based livelihoods in complicated ways. This is in line with the findings from the current studies that climate change in intricate interaction with other stressors are threatening coastal and marine small-scale fisheries in developing countries (Iwasaki *et al.*, 2009; Freduah *et al.*, 2017; Malakar *et al.*, 2018). In each context, the stressors are differentiated and the experience of threatened communities and households are distinct (Table 1).

3.2 Adaptive livelihood strategies among fishing households

In total, 91% of the sampled households in the survey reported to conduct at least one adaptation method to respond to the impacts of the climate and non-climate stressors on their fishery-based livelihoods over past years. In total, 67% of the samples chose to diversify into fishing, in order of priority, including buying more fishing gears, improving current fishing boats, changing fishing time and practice, building higher power mechanized fishing boats or joining informal fishing groups (Table 2).

The critical points emerged from the field data that despite perceived stressors on fishery-based livelihoods, local households decided to keep fishing through a number of adaptation methods. However, not many local households (24.3%) intensified in fishing like investing in higher power mechanized fishing boats for maximizing fish catch because they experienced the feeling of uncertainty in such a risky context. Most of the households tended to develop low-cost adaptation methods such as buying more fishing gears, particularly fishing nets. During the field visit, it was observed that local fishing households used small mesh size fishing nets which could catch all kinds of fish species (of all sizes) and electricity in fishing. They perceived the harmful impacts of using such kinds of fishing methods on fish resources but it could help maximize fish catch to meet their household purposes.

In total, 56% of the sampled households developed adaptation methods outside fishing, in order of priority, including seasonal migration for paid work, local-based paid work,

Variables	Description	Mean (min-max)	Std. dev.
<i>Age of household head</i>	Age of the heads of household	52.4 (25–65)	8.6348
<i>Education of household head</i>	Educational attainment obtained by the household head (1. Illiterate; 2. Primary school; 3. Secondary school; 4. High school; 5. Higher education)	2.28 (1–5)	0.9511
<i>Age of spouse</i>	Age of the spouse of household head	50.73 (24–65)	9.1986
<i>Education of spouse</i>	Educational attainment obtained by the spouse	2.14 (1–5)	0.7086
<i>Household size</i>	Number of total members as recognized by the household	4.66 (2–9)	1.3823
<i>Active labour</i>	Number of individuals 15–60 years of age as recognized as active labour by the household	2.62 (1–7)	1.1993
<i>Fishing experience</i>	The years the adult household members involved in fishing	33.00 (10–55)	10.3412
<i>Fishing equipment^a</i>	Aggregate index of fisheries-related equipment a household possesses	2.28 (1–5)	0.9511
<i>Social and organizational support^b</i>	Aggregate index of support sources a household can get	3.35 (0–4)	0.8465
<i>Perception of climate change^c</i>	Aggregate index of understanding of climate change from different sources	1.31 (0–3)	0.9499

Table 1. Socio-demographic characteristics of the sampled fishing households in the research sites

Notes ^aCalculated as the sum of scores (yes:1, no:0) based on 5 variables: mechanized boat, non-mechanized boat, guffa, fishing nets, and squid fishing light. Index ranges between 0 and 5. ^bCalculated as the sum of scores (yes:1, no:0) based on 4 variables: support from relatives, from community member, from local fishing formal group, and from local government. Index ranges between 0 and 4. ^cCalculated as the sum of scores (yes:1, no:0) based on 3 variables: getting information from television or newspaper; from local government through meetings and training; from community members. Index ranges between 0 and 3

Adaptive strategies	Number of local respondents (n = 300)	Respectively percentage (%)
<i>Adaptive responses within fishing</i>	202	67.3
- Buying more fishing gears	150	74.3
- Improving current fishing boats	132	65.3
- Changing fishing time practice	52	25.7
- Building high power fishing boats	49	24.3
- Joining informal fishing groups	24	11.9
<i>Adaptive responses in non-fishing activities</i>	168	56.0
- Seasonal migration for paid work	83	49.4
- Local-based paid work	38	22.6
- Small-scale agricultural production (crop cultivation, poultry raising)	31	18.5
- Local-based petty trading	22	13.1
- Permanent migration for paid work	17	10.1
<i>No clear adaptive responses</i>	27	9.0

Table 2. Diversity of adaptive strategies used by the sampled fishing households in the research sites over the past five years

small-scale agricultural production, petty trading and permanent migration (Table 2). It is noted from the data that engaging paid work in the informal sector was common non-fishing diversification activities among the fishing households, especially seasonal paid work outside the local:

“We preferred going out for paid work when we can allocate our time with fishing. This is good because we can both keep fishing and earn extra income from other works. In fact, we want to engage in non-fishing activities at the local but there are hardly any opportunities for us.” (45-year-old fisher, group discussion, 2019).

Some households sent their labours for permanent migration for employment if they could allocate the others for fishing at home. Not many the samples invested in agricultural production because they hardly had agricultural land. Those who had small garden land or small plot of agricultural land tried to diversify their crop cultivation and poultry raising, partly for home consumption and partly for pretty extra income. In fact, the non-fishing diversification activities available to local households in this study are low-paid and uncertain because they largely depend on social demand and climate.

The findings of this study are somehow in line with Mulyasari *et al.* (2018) in Bengkulu province in Indonesia where marine capture fishermen developed a wide range of fishing-related adaptation strategies to climate change within and out of fishing; including changing fishing ground, adjusting fishing time, diversifying fishing gear and diversification of economic activities. In another case of Chilika lagoon in India, fishing communities developed different adaptation strategies such as the development of hydrological interventions, participatory micro-watershed management to sustain fish resources and provided loan finance from banks to fishing people for buying more fishing gears and investing in children's education in the context of to climate variability and extreme events (Iwasaki *et al.*, 2009). However, fishers in coastal Mozambique (Blythe *et al.*, 2014) decided to intensify their fishing effort through shifting from fishing in the shallow waters along the beach with seine nets to fishing in the open ocean with gill nets.

The results strongly support the ideas that diversification in both fishing and non-fishing activities is a common adaptative strategy among small-scale fishing households in response to livelihood stressors (Holvoet and Allison, 2008; Daw *et al.*, 2012; Kasperski and Holland, 2013; Blythe *et al.*, 2014; Islam *et al.*, 2014). It also points out the fact that non-fishing diversification is often just an addition rather than a substitution for fishing (Martin *et al.*, 2013).

3.3 Determinants of adaptive livelihood strategies among fishing households

The decision of livelihood strategies largely depends on the context and conditions of each household, particularly what they have to conduct activities for livelihood outcomes (Allison and Ellis, 2001). In this study, the authors considered the socio-demographic characteristics of households as the selected variables to examining the differences in adaptive livelihood strategies among the fishing households. The survey data revealed that about 35.5% of the sampled households decided to develop their adaptation strategies both in fishing and non-fishing activities whilst the others either diversify within fishing (38.5%) or non-fishing diversification (25.6%) (Table 3). The results of the Kruskal–Wallis test revealed the statistically significant effects of some variables including educational attainment of household head, the number of active labours, fishing equipment and social and organizational support ($p < 0.001$ – $p < 0.05$) in distinguishing the categories of adaptive livelihood strategies among the samples (Table 3).

Table 3.
Categories of
adaptive livelihood
strategies used by
the sampled fishing
households in the
research sites

Variables	Fishing diversification (<i>n</i> = 105)		Fishing and non-fishing diversification (<i>n</i> = 97)		Non-fishing diversification (<i>n</i> = 71)	
	Mean (min-max)	Std. dev.	Mean (min-max)	Std. dev.	Mean (min-max)	Std. dev.
<i>Age of household head</i>	50.5 (25-65)	9.1506	50.5 (26-65)	8.5611	54.4 (42-65)	6.4062
<i>Education of household head**</i>	2.26 (1-4)	0.7342	2.50 (1-4)	0.7233	2.3 (1-4)	0.6137
<i>Age of spouse</i>	49.2 (25-65)	9.4780	48.5 (24-65)	9.2861	52.6 (35-65)	7.4444
<i>Education of spouse</i>	2.1 (1-4)	0.6783	2.2 (1-5)	0.7777	2.1 (1-4)	0.6823
<i>Household size</i>	4.80 (2-8)	0.8218	4.75 (2-9)	1.3542	4.66 (2-9)	1.4730
<i>Active labour*</i>	2.50 (2-5)	0.8218	2.70 (2-5)	0.8799	2.76 (2-5)	0.9778
<i>Fishing experience</i>	31.3 (10-55)	10.6454	31.1 (10-50)	9.7980	34.2 (15-52)	9.1250
<i>Fishing equipment**</i>	2.5 (1-5)	0.9107	2.6 (1-5)	0.8347	1.9 (1-4)	0.8831
<i>Social and organizational support*</i>	3.25 (1-4)	0.7389	3.50 (2-4)	0.6103	3.37 (0-4)	1.0421
<i>Perception of climate change</i>	1.2 (0-3)	0.9315	1.3 (0-3)	0.9001	1.3 (0-3)	1.0134

Notes *Indicating significant differences of means using Kruskal-Wallis test between the three household adaptation categories: **p* < 0.05; ***p* < 0.01; ****p* < 0.001

As a whole, the mean of the educational attainment of the household heads involved in the survey is at 2.28, ranging between primary and secondary school levels (Table 1). The results of the Kruskal–Wallis test demonstrated the statistically significant difference of the means of educational attainment among the male members between the three adaptation categories ($p < 0.01$), where those engaged in fishing and non-fishing diversification got the highest level of education (2.50), whereas those engaged in fishing only got a lowest mean of education (2.26) (Table 3). The data from the group discussions supported this fact that those with lower educational level tended to confine themselves into only fishing diversification as the case:

“When I finished my primary school, I started to go for fishing with my father and stopped studying since then. Now I want to travel for wage work but most of the companies often recruit those with at least primary school level. So, fishing is the only thing I can do at this time” (a 30-year-old fisher, group discussion, 2019).

In the study on adaptation responses to livelihood stressors in coastal Mozambique, Blythe *et al.* (2014) also found that lower literacy rates limited the access of local people to wage work in urban areas, thereby confining them to fishery-based adaptation strategies.

The size of family labour force significantly marked the differences among the three adaptation categories at statistical significance ($p < 0.05$) (Table 3). On average, a household had 2.62 active labours (Table 1), in which those engaging in both fishing and non-fishing diversification and those engaged in non-fishing diversification only tended to have higher mean, standing at 2.70 and 2.76, respectively. With more active labours, the fishing households could have more choices in developing livelihood strategies either within or out of fishing:

“At this time, we have four labours. Last year, we decided to send our 18-year-old daughter to Ho Chi Minh city for working at a company, while my husband, our oldest son and me still keep involving in fishing and fish sauce making.” (a 45-year-old woman, group discussion, 2019).

For a fishing household, fishing equipment such as fishing boats and gears serves the principle material assets for livelihood outcome. On average, a fishing household in the research sites possessed 2.28 types of fishing equipment (Table 1), where those involved in non-fishing diversification had a lower mean of this variable than those in the other categories (Table 3). The results of Kruskal–Wallis test showed a significant difference among three adaptation categories ($p < 0.01$) (Table 3). The field data revealed that having more fishing equipment was both a reason and an incentive for a household to diversify within fishing despite their perception of increasing risks related to climate-related changes:

“We seem have no better choice than just keeping in fishing because what we are having on hand are fishing boats and nets.” (50-year-old fisher, group discussion, 2019).

Social and organizational support also characterised the differences among the three adaptation categories in this study at a significant level ($p < 0.05$) (Table 3). The households diversified livelihood strategies both within and out of fishing got the highest mean of social and organizational support (3.50) as compared to those engaged out of fishing (3.37) or within fishing only (3.25) (Table 3). Among the support sources, local responses confirmed the relatives and community members played the first and most importance for a household in different ways particularly in the critical time:

“Community members and relatives helped us a lot particularly during the time of stress or risks. We can borrow some small money from them or they can help to sell fish for us. Our community is really good.” (50-year-old woman, group discussion, 2019).

The heads of the communities reported that their local governments organized some training for local households to enhance their climate change knowledge, informed some job opportunities and supported those in need in financial access, however, they confessed that their efforts were not enough to meet the demand of local fishing households. The head of the Phu Dien community expressed as follows:

“As our responsibility, we want to support local households especially fishers to diversify their income sources in this increasing environmental and climate change impacts. So far, we collaborated with some international and local organizations to implement a variety of training courses to support local fishing households to alternative livelihoods. However, with limited natural resources except sea water for fishing and lack of market demand and output, it is an extreme challenge for us.” (Key-informant interview, 2018).

The head of the Quang Cong community shared that local governments were fully aware of their critical role in supporting local fishing households specially in the context of climate change, however, they were indeed facing a number of challenges such as lack of legal framework, tools and guidelines, limited human and financial resources.

The results showed that household assets play a vital role in determining what strategies a household are likely to develop to sustain their livelihood and income. This are similar to [Musinguzi *et al.* \(2016\)](#), who found that the demographic characteristics of the fishers including age, education, fishing experience, technology, social groups determined the likelihood of livelihood diversification among fishers. The paper strongly argued adaptation is not a homogeneous process but different from household to household. The development of adaptation methods are largely influenced by a variety of factors ([Nielsen and Reenberg, 2010](#); [Blythe *et al.*, 2014](#)), in which household assets, particularly what a household has on hand play a vital role in adaptive livelihood strategies used by the households ([Islam *et al.*, 2014](#); [Amevenku *et al.*, 2019](#)). [Porter *et al.* \(2015\)](#) argued the important role of local government in climate change adaptation but local authorities face substantial difficulties in implementing adaptation plans due to budget cut and a lack of political support from the central government. In this study, despite their efforts, local governments in the two communities face challenges and constraints in creating an enabling environment for local fishing households to better adapt to the livelihood stressors.

5. Conclusions

This paper provides an empirical case of how small-scale fishing households in coastal communities in Central Vietnam are adapting to non-climate and climate stressors through a livelihood approach. The results revealed that the variation and change in climate variables in interaction with the non-climate factors were perceived to affect and threaten local fishery-based livelihoods in complicated ways. The survey households autonomously developed a bundle of adaptation methods within and out of fishing mainly based on their available assets and limited livelihood opportunities. Despite the impacts of multiple stressors on fishing activities, local households decided to develop adaptative strategies in fishing. More critically, they conducted illegal fishing activities including using electricity or destructive forms of fishing gears to catch fish. In non-fishing activities, local households are largely reliant on wage employment in the informal sector with irregular, uncertain and low income meanwhile local-based livelihood diversification opportunities are very limited. The results of the study showed the significant influence of household’s socio-demographic characteristics including education, labour force, fishing equipment and social support in characterising the categories of adaptation strategies among the sampled households. Despite a perceived important role,

the local government faced the constraints and challenges in creating an enabling environment for local-level adaptation.

The study suggests that policy should provide livelihood diversification opportunities so that fishing households can diversify their income sources rather than heavily relying on fishing-based livelihoods in such a context of multiple risks. Because socio-demographic characteristics of a household (what a household has) play a vital role in marking adaptive livelihood strategies among households, efforts are needed to promote the positive attributes and address the constraints like providing awareness and vocational skills.

The study then strongly stressed that current adaptive livelihood strategies used by local fishing households can have uncertain consequences, even exacerbating the households' sensitivity to climate change. Particularly, using destructive forms of fishing gears like small mesh size fishing nets to catch fish can seriously harm the ecosystem. A Fisheries management plan is urgently needed to protect fishery resources and sustain the marine ecosystem's capacity to contribute to coastal livelihoods for the long-term (Smít and Wandel, 2006; Musinguzi *et al.*, 2016). Local governments can play a very important role in promoting and facilitating local-level adaptation, appropriate mechanisms need to be diversified to stretch local governments' resources.

The impacts of climate change in association with other socio-economic and environment stressors will be likely to increase in the future (IPCC, 2007), it urgently requires proper adaptation planning and effective management strategies to best support threatened communities and households, as well as to promote the sustainability of marine and coastal ecosystems (Thomas *et al.*, 2019). The local specific knowledge of vulnerability and adaptation is critically needed, therefore, more studies should be conducted to predict the trend line of climate-related risks at the micro level and the complexity and challenges of local-level adaptation in different contexts to guide policies and management efforts to best build the resilience of affected households and communities, as well as of natural ecosystem.

References

- Abdul-Razak, M. and Kruse, S. (2017), "The adaptive capacity of smallholder farmers to climate change in the Northern region of Ghana", *Climate Risk Management*, Vol. 17, pp. 104-122.
- Adger, W.N. (2006), "Vulnerability", *Global Environmental Change*, Vol. 16 No. 3, pp. 268-281.
- Adger, W.N., ; Huq, S., ; Brown, K., ; Conway, D. and Hulme, M. (2003), "Adaptation to climate change in the developing world", *Progress in Development Studies*, Vol. 3 No. 3, pp. 179-195.
- Allison, E.H. and Ellis, F. (2001), "The livelihoods approach and management of small-scale fisheries", *Marine Policy*, Vol. 25 No. 5, pp. 377-388.
- Allison, E.H., ; Perry, A.L., ; Badjeck, M., Adger, W.N., ; Brown, K., Conway, D., Halls, A.S., Pilling, G.M., Reynolds, J.D., Andrew, N.L. and Dulvy, N.K. (2009), "Vulnerability of national economies to the impacts of climate change on fisheries", *Fish and Fisheries*, Vol. 10 No. 2, pp. 173-196.
- Amevenku, F.K.Y., Asravor, R.K. and Kuwormu, J.K.M. (2019), "Determinants of livelihood strategies of fishing households in the Volta basin, Ghana", *Cogent Economics and Finance*, Vol. 7 No. 1, doi: [10.1080/23322039.2019.1595291](https://doi.org/10.1080/23322039.2019.1595291).
- Badjeck, M., Allison, E.H., Halls, A.S. and Dulvy, N.K. (2010), "Impacts of climate variability and change on fishery-based livelihoods", *Marine Policy*, Vol. 34 No. 3, pp. 375-383.
- Barange, M., Merino, G., Blanchard, J.L., Scholtens, J., Harle, J., Allison, E.H., Allen, J.I., Holt, J. and Jennings, S. (2014), "Impacts of climate change on marine ecosystem production in societies dependent on fisheries", *Nature Climate Change*, Vol. 4 No. 3, pp. 211-216.

- Béné, C. (2006), "Small-scale fisheries: assessing their contribution to rural livelihoods in developing countries", Working paper, FAO Fisheries Circular. No. 1008, FAO, Rome, p. 46.
- Bennett, N.J., Blythe, J., Tyler, S. and Ban, N.C. (2016), "Communities and change in the anthropocene: understanding social-ecological vulnerability and planning adaptations to multiple interacting exposures", *Regional Environmental Change*, Vol. 16 No. 4, pp. 907-926.
- Blythe, J.L., Murray, G. and Flaherty, M. (2014), "Strengthening threatened communities through adaptation: insights from coastal Mozambique", *Ecology and Society*, Vol. 19 No. 2, available at: <http://dx.doi.org/10.5751/ES-06408-190206>
- Boon, E. and Ahenka, A. (2013), "Assessing climate change impacts on ecosystem services and livelihoods in Ghana: case study of communities around Sui Forest Reserve", *Journal of Ecosystem and Ecography*, Vol. 03 No. 02, pp. 1-8.
- Boonstra, W.J. and Bach Dang, N. (2010), "A history of breaking laws - social dynamics of non-compliance in Vietnamese Marine Fisheries", *Marine Policy*, Vol. 34 No. 6, pp. 1261-1267.
- Boonstra, W.J. and Hanh, T.T.H. (2015), "Adaptation to climate change as social-ecological trap: a case study of fishing and aquaculture in the tam giang lagoon, vietnam", *Environment, Development and Sustainability*, Vol. 17 No. 6, pp. 1-18.
- Brander, K. (2010), "Impacts of climate change on fisheries", *Journal of Marine Systems*, Vol. 79 Nos 3/4, pp. 389-402.
- Brander, K., Cochrane, K., Barange, M. and Soto, D. (2017), "Climate change implications for fisheries and aquaculture", in Phillips, B.F. and Pérez-Ramírez, M. (Eds), *Climate Change Impacts on Fisheries and Aquaculture: A Global Analysis*, John Wiley and Sons Ltd, pp. 45-62.
- Brugger, J. and Crimmins, M. (2015), "Designing institutions to support local-level climate change adaptation: Insights from a case study of the U.S. cooperative extension system", *Weather, Climate, and Society*, Vol. 7 No. 1, pp. 18-38.
- Campos, I.S., Alves, F.M., Dinis, J., Truninger, M., Vizinho, A. and Penha-Lopes, G. (2016), "Climate adaptation, transitions, and socially innovative action-research approaches", *Ecology and Society*, Vol. 21 No. 1, Art 13.
- Chambers, R. and Conway, G.R. (1992), "Sustainable rural livelihoods: practical concepts for the 21st century", Working paper 296, Institute of Development Studies, p. 33.
- Cinner, J.E., Daw, T. and McClanahan, T.R. (2009), "Socioeconomic factors that affect artisanal fishers' readiness to exit a declining fishery", *Conservation Biology*, Vol. 23 No. 1, pp. 124-130.
- Cinner, J.E., McClanahan, T.R., Graham, N.A.J., Daw, T.M., Maina, J., Stead, S.M., Wamukota, A., Brown, K. and Bodin, Ö (2012), "Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries", *Global Environmental Change*, Vol. 22 No. 1, pp. 12-20.
- Dao, M.S. and Pham, T. (2003), "Management of coastal fisheries in Vietnam", in Silvestre, G., Garces, L., Stobutzki, I., Ahmed, M., Valmonte-Santos, R.A., Luna, C., Lachica-Alino, L., Munro, P., Christensen, V. and Pauly, D. (Eds), *Assessment, Management and Future Directions for Coastal Fisheries in Asian Countries, World Fish Center Conference Proceedings*, pp. 57-968.
- Daw, T.M., Cinner, J.E., McClanahan, T.R., Brown, K., Stead, S.M., Graham, N.A.J. and Maina, J. (2012), "To fish or not to fish: factors at multiple scales affecting artisanal fishers' readiness to exit a declining fishery", *PLoS ONE*, Vol. 7 No. 2, p. e31460.
- de Haan, L. and Zoomers, A. (2005), "Exploring the frontier of livelihoods research", *Development and Change*, Vol. 36 No. 1, pp. 27-47.
- Deri, A. and Alam, M. (2008), "Local governments and climate change", discussion paper, Commonwealth Secretariat, London, p. 8.
- Ellis, F. (1998), "Household strategies and rural livelihood diversification", *Journal of Development Studies*, Vol. 35 No. 1, pp. 1-38.

- Hanich, Q., Wabnitz, C.C.C., Ota, Y., Amos, M., Donato-Hunt, C. and Hunt, A. (2018), "Small-scale fisheries under climate change in the Pacific Islands region", *Marine Policy*, Vol. 88, pp. 279-284.
- Holvoet, K. and Allison, E.H. (2008), "Livelihood diversification in coastal and inland fishing communities: misconceptions, evidence and implications for fisheries management", working paper, Sustainable Fisheries Livelihoods Programme (SFLP), FAO/DFID, Rome.
- Hoang, H.D., Momtaz, S. and Schreider, M. (2020), "Assessing the vulnerability of small-scale fisheries communities in the estuarine areas of Central Vietnam in the context of increasing climate risks", *Ocean and Coastal Management*, Vol. 196, p. 105302.
- Huynh, L.T.M. and Stringer, L.C. (2018), "Multi-scale assessment of social vulnerability to climate change: an empirical study in Coastal Vietnam", *Climate Risk Management*, Vol. 20, pp. 165-180.
- Huynh, P.T.A. and Resurreccion, B.P. (2014), "Women's differentiated vulnerability and adaptations to climate-related agricultural water scarcity in rural Central Vietnam", *Climate and Development*, Vol. 6 No. 3, pp. 226-237.
- IPCC (2007), "Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change", in Parry, M., Canziani, O., Palutikof, J., Linder, P. and Hanson, C. (Eds), *Climate Change 2007*, Cambridge University Press, Cambridge, IPCC
- Islam, M., Sallu, S., Hubacek, K. and Paavola, J. (2014), "Limits and barriers to adaptation to climate variability and change in Bangladeshi coastal fishing communities", *Marine Policy*, Vol. 43, pp. 208-216.
- Iwasaki, S., Razafindrabe, B.H.N. and Shaw, R. (2009), "Fishery livelihoods and adaptation to climate change: a case study of Chilika Lagoon, India", *Mitigation and Adaptation Strategies for Global Change*, Vol. 14 No. 4, pp. 339-355.
- Kasperski, S. and Holland, D.S. (2013), "Income diversification and risk for fishermen", *Proceedings of the National Academy of Sciences of Sciences*, Vol. 110 No. 6, pp. 2076-2081.
- Kosamu, I.B.M. (2015), "Conditions for sustainability of small-scale fisheries in developing countries", *Fisheries Research*, Vol. 161, pp. 365-373.
- Freduah, G., Fidelman, P. and Smith, T.F. (2017), "The impacts of environmental and socio-economic stressors on small scale fisheries and livelihoods of fishers in Ghana", *Applied Geography*, Vol. 89, pp. 1-11.
- Le, T.H.P., Biesbroek, G.H., Sen, T.H.L. and Wals, A.E.J. (2018), "Understanding smallholder farmers' capacity to respond to climate change in a coastal community in Central Vietnam", *Climate and Development*, Vol. 10 No. 8, pp. 701-716.
- Malakar, K., Mishra, T. and Patwardhan, A. (2018), "Perceptions of multi-stresses impacting livelihoods of marine fishermen", *Marine Policy*, Vol. 97, pp. 18-26.
- Martin, S.M., Lorenzen, K. and Bunnefeld, N. (2013), "Fishing farmers: fishing, livelihood diversification and poverty in rural Laos", *Human Ecology*, Vol. 41 No. 5, pp. 737-747.
- McElwee, P. (2017), "Vietnam's urgent task: adapting to climate change", *Current History*, Vol. 116 No. 791, pp. 223-229.
- Mooney, H., Larigauderi, A., Cesario, M., Elmquist, T., Hoegh-Guldberg, O., Lavorel, S., Mace, M.G., Palmer, M., Scholes, R. and Yahara, T. (2009), "Biodiversity, climate change, and ecosystem services", *Current Opinion in Environmental Sustainability*, Vol. 1 No. 1, pp. 46-54.
- Moser, C.O.N. (1998), "The asset vulnerability framework: reassessing urban poverty reduction strategies", *World Development*, Vol. 26 No. 1, pp. 1-19.
- Mulyasari, G., Irham, Waluyati, L.R. and Suryantini, A. (2018), "Perceptions and local adaptation strategies to climate change of marine capture fishermen in Bengkulu Province, Indonesia", *IOP Conference Series: Earth and Environmental Science*, IOP Publishing Ltd., pp. 1-7.

- Muringai, R.T., Naidoo, D., Mafongoya, P. and Sibanda, M. (2019), "Small-scale fishers' perceptions of climate change and its consequences on fisheries: the case of Sanyathi Fshing Basin, Lake Kariba, Zimbabwe", *Transactions of the Royal Society of South Africa*, Vol. 74 No. 3, pp. 248-257.
- Musinguzi, L., Efitre, J., Odongkara, K., Ogutu-Ohwayo, R., Muyodi, F., Natugonza, V., Olokutum, M., Namboowa, S. and Naigaga, S. (2016), "Fishers' perceptions of climate change, impacts on their livelihoods and adaptation strategies in environmental change hotspots: a case of lake wamala, Uganda", *Environment, Development and Sustainability*, Vol. 18 No. 4, pp. 1255-1273.
- Nielsen, J.Ø. and Reenberg, A. (2010), "Cultural barriers to climate change adaptation: a case from Northern Burkina Faso", *Global Environmental Change*, Vol. 20 No. 1, pp. 142-152.
- Ngoan, L.D. (2019), "Effects of climate change in aquaculture: Case study in Thua Thien Hue Province, Vietnam", *Biomedical Journal of Scientific and Technical Research*, Vol. 10 No. 1, pp. 7551-7552.
- Nguyen, A.T., Vu, A.D., Dang, G.T.H., Hoang, H.A. and Hens, L. (2018), "How do local communities adapt to climate changes along heavily damaged coasts? A stakeholder delphi study in Ky anh (Central vietnam)", *Environment, Development and Sustainability*, Vol. 20 No. 2, pp. 749-767.
- Noble, I.R., Huq, S., Anokhin, Y.A., Carmin, J., Goudou, D., Lansigan, F.P., Osman-Elasha, B. and Villamizar, A. (2014), "Adaptation needs and options", in Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y. O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R. and Whitet, L.L. (Eds), *Climate Change 2014: Impacts, Adaptation, and Vulnerability*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, pp. 833-868.
- Panpeng, J. and Ahmad, M.M. (2017), "Vulnerability of fishing communities from sea-level change: a study of laemsing district in chanthaburi province, Thailand", *Sustainability (Switzerland)*, Vol. 9 No. 8, pp. 1-19.
- Pomeroy, R., Nguyen, K.A.T. and Thong, H.X. (2009), "Small-scale marine fisheries policy in Vietnam", *Marine Policy*, Vol. 33 No. 2, pp. 419-428.
- Porter, J., Demiritt, D. and Dessai, S. (2015), "The right stuff? informing adaptation to climate change in Bristish Local Government", *Global Environmental Change*, Vol. 35 No. 1, pp. 411-422.
- Poulain, F., Himes-Cornell, A. and Shelton, C. (2018), "Methods and tools for climate change adaption in fisheries and aquaculture", in Barange, M., Bahri, T., Beveridge, M.C.M., Cochrane, K.L., Funge-Smith, M. and Poulain, F. (Eds), *Impacts of Climate Change on Fisheries and Aquaculture: Synthesis of Current Knowledge, Adaptation and Mitigation Options*, Food and Agriculture Organization of the United Nations, Rome, pp. 535-566.
- Purcell, S.W. and Pomeroy, R.S. (2015), "Driving small-scale fisheries in developing countries", *Frontiers in Marine Science*, Vol. 2 No. 44, pp. 1-7.
- Scheaffer, R.L., Mendenhall, W., Ott, A.L. and Gerow, K.G. (2011), *Elementary Survey Sampling*, Cengage Learning, p. 452.
- Serrat, O. (2017), "The sustainable livelihoods approach", in Serrat, O. (Ed.), *Knowledge Solutions: Tools, Methods, and Approaches to Drive Organizational Performance*, Springer, pp. 21-26.
- Shrestha, S., Deb, P. and Bui, T.T.T. (2016), "Adaptation strategies for rice cultivation under climate change in Central Vietnam", *Mitigation and Adaptation Strategies for Global Change*, Vol. 21 No. 1, pp. 15-37.
- Smit, B. and Wandel, J. (2006), "Adaptation, adaptive capacity and vulnerability", *Global Environmental Change*, Vol. 16 No. 3, pp. 282-292.

- Reed, M.S., Podesta, G., Fazey, I., Geeson, N., Hessel, R., Hubacek, K., Letson, D., Nainggolan, D., Prell, C., Rickenbach, M.G., Ritsema, C., Schwilch, G.S., Stringer, L.C. and Thomas, A.A. (2013), "Combining analytical frameworks to assess livelihood vulnerability to climate change and analyze adaptation options", *Ecological Economics*, Vol. 94, pp. 66-77.
- Teh, L., Zeller, D., Zyllich, K., Hguyen, G. and Harper, S. (2014), "Reconstructing Vietnam's marine fisheries catch 1950-2010", working paper #2014-17, Fisheries Centre, University of British Columbia, Vancouver, p. 10.
- Trinh, T.Q., Rañola, R.F., Camacho, L.D. and Simelton, E. (2018), "Determinants of farmers' adaptation to climate change in agricultural production in the central region of Vietnam", *Land Use Policy*, Vol. 70, pp. 224-231.
- Thomas, K., Hardy, R.D., Lazrus, H., Mendez, M., Orlove, B., Rivera-Collazo, I., Roberts, J.T., Rockman, M., Warner, B.P. and Winthrop, R. (2019), "Explaining differential vulnerability to climate change: a social science review", *Wiley Interdisciplinary Reviews: Climate Change*, Vol. 10 No. 2, pp. 1-18.
- Tran, T.D., Thu, V.T.H. and Toan, P.N. (2014), "Vulnerability and adaptation of coastal livelihoods to the impacts of climate change: a case study in coastal districts of Nam Dinh, Vietnam", *Journal of Economics and Development*, Vol. 16 No. 2, pp. 39-60.
- Tran, T., Thang, N.V., Huong, H.T.L. and Khiem, M.V. (2016), "Climate change and sea level rise scenarios for Viet Nam: summary for policymakers", Technical report, Ministry of Natural Resources and Environment (MONRE), Hanoi, Vietnam.
- Van, S.T., ; Boyd, W.E., Slavich, P. and Van, T.M. (2015), "Perception of climate change and farmers' adaptation: a case study of poor and non-poor farmers in Northern Central Coast of Vietnam", *Journal of Basic and Applied Sciences*, Vol. 11, pp. 323-342.
- UNFCCC (2019), "What do adaptation to climate change and climate resilience mean?", available at: <https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/what-do-adaptation-to-climate-change-and-climate-resilience-mean> (accessed 20 February 2021).
- Wang, J., Wang, Y., Li, S. and Qin, D. (2016), "Climate adaptation, institutional change, and sustainable livelihoods of herder communities in Northern Tibet", *Ecology and Society*, Vol. 21 No. 1.
- Weatherdon, L.V., Magnan, A.K., Rogers, A.D., Sumaila, U.R. and Cheung, W.W.L. (2016), "Observed and projected impacts of climate change on marine fisheries, aquaculture, coastal tourism, and human health: an update", *Frontiers in Marine Science*, Vol. 3 No. 48, pp. 1-21.
- Zamroni, A. and Yamao, M. (2014), "Livelihood strategy in Indonesian coastal villages: Case study on seaweed farming in laikang Bay, South Sulawesi province", in Behnassi, M., Syomiti Muteng'e, M., Ramachandran, G. and Shelat, K.N. (Eds), *Vulnerability of Agriculture, Water and Fisheries to Climate Change: Toward Sustainable Adaptation Strategies*, Springer, pp. 289-300.
- Žurovec, O. and Vedeld, P.O. (2019), "Rural livelihoods and climate change adaptation in laggard transitional economies: a case from Bosnia And Herzegovina", *Sustainability (Sustainability)*, Vol. 11 No. 21, pp. 1-27.

About the authors

Dr Phuong T.A. Huynh works as a Senior Lecturer and Researcher. She is also the head of the Social Work Department, Faculty of Sociology and Social Work at Hue University of Sciences, Hue University, Vietnam. She received her PhD degree on Gender and Development Studies from the Asian Institute of Technology (AIT), Thailand in 2014. Her research interest includes vulnerability and adaptation, social policy and gender. She has a number of publications in vulnerability and adaptation of rural livelihoods to climate change at national and international journals. Phuong T.A. Huynh is the corresponding author and can be contacted at: phuonghuynh@husc.edu.vn

Dr Ngoan D. Le is presently a Professor in Animal Sciences at the Department of Animal Sciences and Veterinary Medicine of Hue University of Agriculture and Forestry, Hue University, Vietnam. He

has been teaching and doing research in animal sciences and climate change in agriculture. He has a number of publications in his fields, including climate change adaptation in agriculture.

Dr Sen T.H. Le got her PhD degree in Germany in 2005 in the field of agricultural systems. She is currently the Vice Dean of the faculty of Agricultural Extension and Rural Development at Hue University of Agriculture and Forestry, Hue University, Vietnam. Her research and teaching focus on Agricultural Extension Methods; Climate Change Adaptation; and Household Livelihoods. She has published more than 40 papers in the field of farmers' decision-making; Community development; and households' climate resilience. Dr Sen is also a member of the Global Forum for Rural Advisory Services and the Asian Pacific Network for Rural Advisory Services.

Dr Thang N. Tran is an Associate Professor at the Faculty of Forestry, University of Agriculture and Forestry, Hue University. He had a forestry background and got his PhD in Natural resource management from AIT, Thailand in 2011. He has 20 years of experience and research interests in community forestry development, biodiversity conservation, forest restoration, agro-forestry and rural livelihood development.