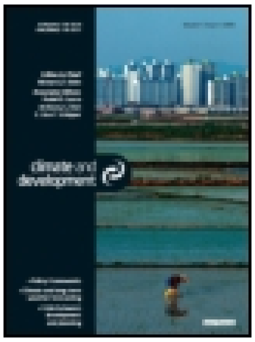

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RESEARCH ARTICLE

Understanding smallholder farmers' capacity to respond to climate change in a coastal community in Central Vietnam

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Climate change as expressed by erratic rainfall, increased flooding, extended droughts, frequency tropical cyclones or saline water intrusion, poses severe threats to smallholder farmers in Vietnam. Adaptation of the agricultural sector is vital to increase the resilience of smallholder farmers' livelihoods in times of climate change. To complement efforts already implemented by farmers to reduce social vulnerability it is important to understand how farmers perceive their current and future capacity to adapt to climate change. This paper aims to explore smallholder farmers' capacity to respond to climate change in current and future agricultural production. We carried out open, in-depth interviews ($n = 13$), focus group discussions, and structured interviews ($n = 114$) in the Thua Thien Hue province. Our findings show that farmers nowadays experience more extreme climate variability. Farmers report increasing stresses due to temperature increase and droughts. The autonomous adaptation strategies adopted by farmers include; adjusting the season calendar, using tolerant varieties and breeds, applying integrated crop production models, and income diversification. The motives for adopting particular planned adaptation options differ between farmers in crop production and livestock production. Four factors were found to be significant ($p < .05$) in influencing the spread of adaptation measures (AMs) farmers adopted: farm income, the number of available information sources, number of workers on the farm, and farmable land available during the summer season. Farmers report several barriers to implement adaptation strategies including; market price fluctuations, lack of skilled labour, lack of climate change information, and lack of capacity to learn and apply techniques in their daily practice. While both crop and livestock farmers participated in one or several training courses on climate change in the past years, livestock farmers were still uncertain about their future capacity and possible AMs.

Keywords: agricultural production; climate change adaptation; smallholder farmers; barrier to adaptation; adaptive capacity; Vietnam

Introduction

Agriculture is a major economic, social, and cultural activity which is the main source of national income and sustains livelihoods in many countries, especially in the developing countries in Asia and Africa (Howden et al., 2007). While the relative contribution of agriculture has declined in recent years due to the rapid growth of the industry and service sector in Vietnam, agriculture still plays an important role in the national economy, contributing to more than 21% of the GDP of the nation[1] and providing employment for 47% of the working population.[2] Vietnam is currently ranked among the 10 most climate-vulnerable countries in the world and without adequate capacity to respond to future climatic disasters (Bruun, 2012; Maplecroft, 2011). Several studies provide evidence that Central Vietnam is increasingly affected by the unpredictable weather connected to climate change (Hanh, 2010; Phuong, 2010; Sen & Phuong, 2011). Climate change impacts are likely to be severe for coastal smallholder farmers whose livelihoods depend largely on natural conditions (Beckman, 2010). The agricultural sector is considered to be particularly vulnerable to current and future climate risks because of low adaptive capacity of farming communities such as lack of education and technical skills, poverty, and lack of assets and capital to recover or to shift to alternative livelihoods (Government of Vietnam, 2011; IFAD, 2014; Le Dang, Li, Nuberg, & Bruwer, 2014b; Oyekale & Ibadan, 2009).

Early adaptation literature characterized adaptive capacity as a dynamic concept (e.g. Eakin & Bojorquez-Tapia, 2008; Vincent, 2007). Lemos, Lo, Nelson, Eakin, and Bedran-Martins (2016) consider adaptive capacity to include specific capacities and associated tools and skills that enable actors to anticipate and effectively response to

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specific threats (e.g. the ability to respond to and manage an identified climate hazards). These specific capacities need to be complemented by, what they refer to as, generic capacities that address the deficiencies in basic human development needs (e.g. the ability to respond to more general social, economic, political, and ecological stressors). They conclude that higher levels of generic capacity are associated with higher levels of specific capacities. The combination between specific and generic capacities is important to identify and assess the adaptive capacity of individual, community, or institution to respond to climate change impacts (Eakin, Lemos, & Nelson, 2014; Lemos et al., 2016).

Recent literature on smallholder farmer climate change adaptation decisions shows that adaptation is driven by multiple stressors (Burnham & Ma, 2016). Climate change adaptation decisions depend on the perceptions of adopters and on contextual factors such as culture, education, gender, age, resource endowments and institutional factors (Prager & Posthumus, 2010). A review of farmers' awareness and adaptation strategies in developing countries shows that smallholder farmers adopt adaptation strategies to respond to climate change impacts at the farm level based on objective determinants of adaptive capacity such as financial responses, agricultural changes, religious and cultural strategies, the use of local, and prevalence of wider support networks (Harmer & Rahman, 2014). Frank, Eakin, and López-Carr (2011) indicate that lack of resources and socio-economic limitations can impair farmers' adaptation decision-making even when they perceive high risks. In addition, smallholders' adaptation decision-making is also based on subjective determinants of adaptive capacity such as farmers' perception of climate risks and self-perceived adaptive capacity (Grothmann & Patt, 2005; Kuruppu & Liverman, 2011). Thus, in order to respond to climate change impacts, researchers may consider both objective determinants (e.g. financial or physical capital) (Burnham & Ma, 2016) and subjective determinants (e.g. how individuals and communities perceive the process of adaptation and their self-efficacy) (Wolf, Allice, & Bell, 2013) of adaptive capacity into future climate change adaptation programmes and policies to facilitate adaptive actions (Burnham & Ma, 2017).

Phuong, Biesbroek, and Wals (2017) show that common components of adaptive capacity referred to in the adaptation literature in the context of climate change responsiveness and natural resource management are: human, social, financial, political, and institutional capital building. Previous studies in the context of smallholder farmers' capacity indicate that adaptive capacity components should refer to the earlier mentioned objective determinants (Brooks & Adger, 2005; Smit & Pilifosova, 2001; Yohe & Tol, 2002). However, Grothmann and Patt (2005) developed a Model of Private Proactive Adaptation to Climate Change (MPPACC) based on Protection Motivation Theory (PMT) (Rogers, 1983) indicated that posited subjective determinants of adaptive capacity are at least as important in determining a person's ability to adapt. The model suggests that understanding smallholders' adaptive capacity is based on two important bottlenecks: risk perception (risk appraisal) and perceived adaptive capacity (adaptation appraisal). Here risk appraisal refers to a person assesses a risk's probability and damage potential of a chosen course of action, while adaptation appraisal refers to a person's self-evaluated ability to cope with these risks and of the costs of taking a particular course of action.

A substantial volume of scholarly work has been devoted to understanding the adaptive behaviour of farmers (Below et al., 2012; Below, Artner, Siebert, & Sieber, 2010; Bryan, Deressa, Gbetibouo, & Ringler, 2009; Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009; Hassan & Nhemachena, 2008). These studies show that any attempt to elicit adaptive behaviour patterns should follow from understanding how climate variability is perceived by stakeholders and what shapes their perceptions (Maddison, 2007; Mertz, Mbow, Reenberg, & Diouf, 2009; Shisanya & Khayesi, 2007; Weber, 2010). Understanding perceptions of climate risks, adaptive capacity, and experiences in handling climate change is crucial for further strengthening smallholder farmers' activities to manage the impacts of climatic risk and their social vulnerability, both at individual and collective levels (Mtambanengwe, Mapfumo, Chikowo, & Chamboko, 2012).

Understanding existing farm-level adaptation strategies and farmers' perceptions of possible future adaptation strategies provides important input for the formulation of additional adaptation initiatives and strengthens farmers' social learning to deal with future climate risks (Mengistu, 2011). The link between farmers' perceptions, learning processes, and their decisions to adopt adaptation strategies in agriculture remains a contested issue in the literature (Harmer & Rahman, 2014). Little empirical research has been done to explore both understanding farmers' adaptive capacity and their motivations to act or not to act in response to climate change. To address this shortcoming, the aim of this study is to explore smallholder farmers' capacity and drivers to respond to climate change in current and future agricultural production. The study addressed the following research questions:

(1) How do farmers perceive current and future climate change and how it might impact their agricultural production?
(2) What are current and future measures farmers use to adapt to climate change and what explains their choices?
(3) How do farmers perceive their capacities to deal with climate changes?

In this paper, we applied the MPPACC to understand smallholder farmers' capacity to respond to climate change impacts (Grothmann & Patt, 2005) and recognize three critical important determinants of adaptive capacity: learning capacity (information, feedbacks, and transparency), decision-making capacity (participation, collaboration, and power), and acting capacity (leadership, networks, and flexible governance) (Bettini, Brown, & de Haan, 2015). The process of applying the MPPACC included two parts: (1) understanding farmers perceive current and future climate change and its impacts and (2) exploring current and future adaptation measures (AMs) that farmers have used to respond to climate change and their motivations for adaptation by collecting data through several different methods.

Research linking perception of climate variability and adaptation has been conducted in several low-income countries, especially in Africa (e.g. Bryan et al., 2009; Gbetibouo, 2009; Hassan & Nhemachena, 2008; Mertz et al., 2009; Prager & Posthumus, 2010; Shisanya & Khayesi, 2007). However, a much smaller body of research has explored how smallholder farmers adapt in Southeast Asia. In Vietnam, most research related to farmers' experience and adaptation of climate risks in agriculture is concentrated in the Mekong Delta (Le Dang, Li, Bruwer, & Nuberg, 2014; Le Dang, Li, Nuberg, & Bruwer, 2014a) with hardly any research in the coastal region in the Central Vietnam. Thus, identifying how farmers perceive their capacity and understanding of how they can enable their adaptive capacity, are critical in climate change adaptation research and policy.

The paper is organized as follows. Section 2 describes the methodology of the study. The findings of this study are presented in Section 3. In Section 4, we discuss our findings followed by our conclusions and recommendations for policymakers.

Methodology

The selecting the study site

The study was carried out in Thua Thien Hue (TTH) province. TTH is located in the Central coastal region in Vietnam (Figure 1). TTH is thought to be one of the most climate-vulnerable areas in Vietnam (TTH Provincial People Committee, 2014) and people are highly vulnerable to more frequent and more intense weather extremes (Fortier, 2010). Several studies show that during the past 10 years, drought was the main climate extreme event in the TTH province (e.g. Lien, 2015; Suong, 2011). While the annual average temperature has decreased in the last two decades, the temperature recorded by the TTH Meteorological Stations from 1956 to 2005 shows an increase in extremes, with the hottest months in June and July and the coldest in December and January. Similarly, meteorological data from the TTH show a changed pattern in monthly rainfall, with an increase during the rainy season and a decrease during the dry period.

To select the most appropriate district and commune for this study we conducted an in-depth interview with the leader of the TTH provincial Department of Agriculture and Rural Development (DARD). The Quang Dien (QD) district was selected because of its large share of agricultural production in terms of area and productivity. It is very vulnerable to climate change. In-depth interviews with leaders of DARD at the district level resulted in selecting QL commune for four reasons: (1) the livelihood of the people strongly depends on agricultural production; (2) it is the most vulnerable commune to climate change especially drought in the QD district (Lien, 2015; Suong, 2011); (3) the ecological conditions and agricultural production practice in the QL are representative characteristics for the coastal area; and (4) most of the farmers in this commune have participated in the agricultural cooperative before.

Quang Loi (QL) is a coastal commune ("Bai ngang" commune) which has high poverty rates and a strong dependency on farming income. The total area cultivated for agricultural production was 1456 ha (QL Commune Peoples' Committee (CPC), 2014). However, due to an increase in extreme droughts, the area used in Winter–Spring season for agriculture has dropped to around 734 ha in 2014. Popular crops for this season include rice, several kinds of beans, peanut, corn, sweet potato, cassava, and several kinds of vegetable. In Summer–Autumn season, around 39% of agricultural land could not be cultivated because of lack of water during the dry season (QL CPC, 2014). Popular crops in this season include rice, watermelon, and local onion. The most recent data from 2014 show that the livelihood of the QL's residents depended significantly on agricultural income (54.5%), of which the main agricultural activities included crop (49%) and livestock (30%) production, aquaculture and fishery (21%).

In the QL, the infrastructure for agricultural production (e.g. irrigation systems, inter-field roads, and dams) is very poor. Before 2010, there were no irrigation systems for agricultural production and no dams to prevent saltwater intrusion. Since 2011, irrigation systems have been built, however, these irrigation systems can serve only about 55% of the farmable lands (QL CPC, 2012). The type of irrigation system mainly consists of water pumping from local streams and rivers of which there are not many in the region. Hence, farming practices remain very sensitive to drought and the changes in temperature. The climatic impact seems to become more severe each year due to the lack of investments in infrastructure improvement (QD District People Committee, 2014).

When it comes to local governance, not unlike in other communes in Vietnam, local officials in the QL are obliged to provide detailed information about a broad range of issues including climate change. Any new initiative requires public discussion prior to being decided by the

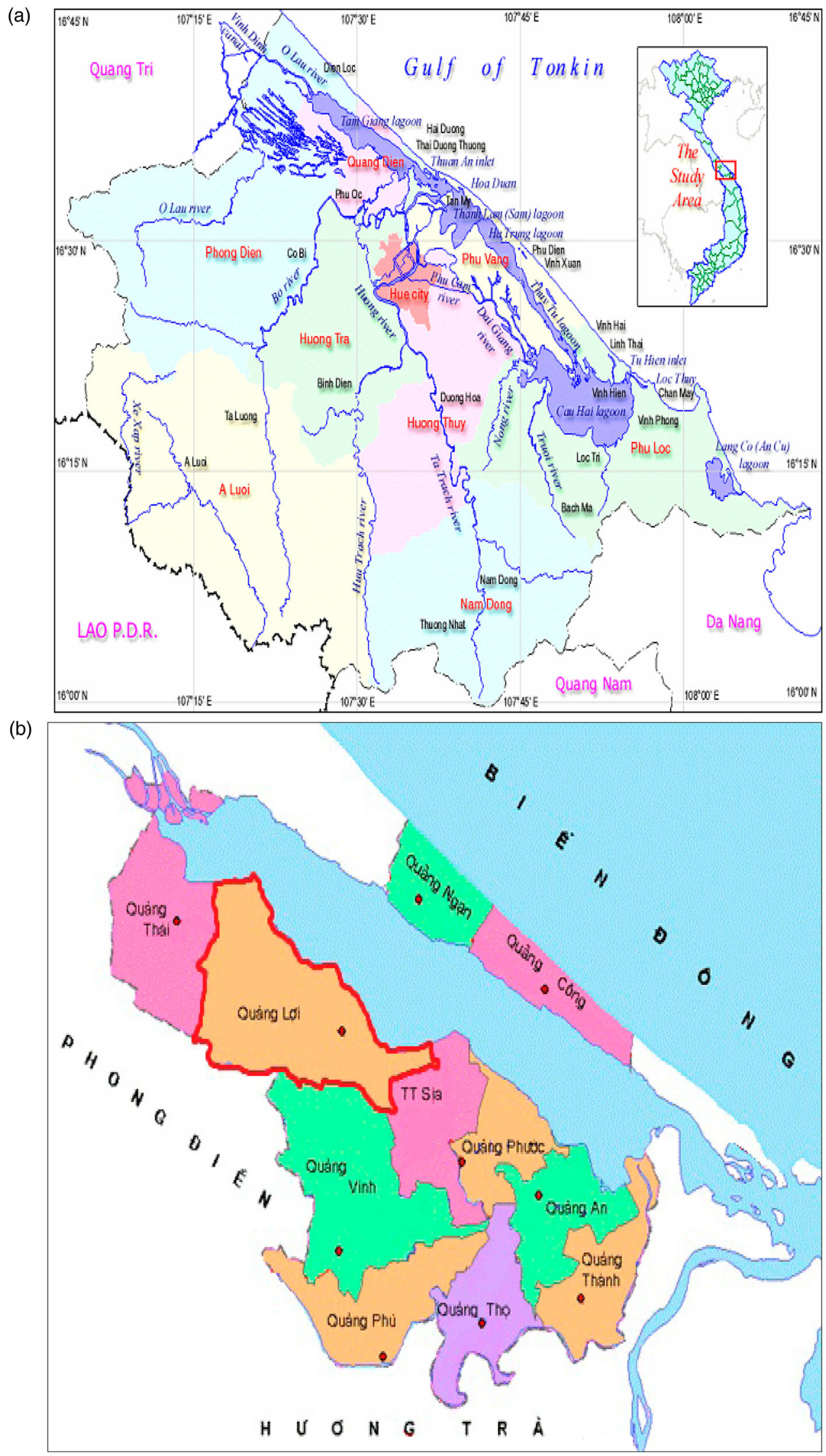

Figure 1. 1(a) TTH provincial map; 1(b) Map of the QD district and the QL commune (source: Lien, 2015).

commune's councils and committees. This form of local governance is important in the context of socio-economic planning, land use planning, and the mobilization of residents' contributions to infrastructure construction as well as to the implementation of national plans on environmental protection, health, and water. Normally, the local government has responsibilities for agricultural development in rural communes (Mattner, 2004). However, in the QL, these responsibilities reside with the agricultural cooperatives that play an important role in the planning, management, and support of agricultural production. Unsurprisingly almost all smallholder farmers participate in activities organized by agricultural cooperatives.

Research methods

This research used both qualitative and quantitative methods for collecting data in the period of March–August 2015. Data collection started with a rapid rural appraisal to gain an overview of the significant social and physical features of the selected villages (Chambers, 1994). A mixture of participatory methods including open, in-depth key informant interviews ($n = 13$), focus group discussions (FGDs), and structured interviews ($n = 114$) were used, allowing farmers to participate by sharing their perceptions, their experiences, and knowledge in various ways (see Figure 2).

Open, in-depth interviews were used to explore various topics related to climate-related agricultural production, climate risks and their impacts, farmer capacities to deal with climate change, and current and planned AMs in agriculture. The respondents at the district and commune level were selected based on their roles in the community, agricultural production, and climate change adaptation. In addition, three representatives of the three agricultural cooperatives were selected for open, in-depth interviews. In total, 13 respondents were interviewed. The face-to-face interviews (Kummar, 2011) were conducted using a structured guide and each interview took between 45 minutes and 1 hour.

The four focus group discussions were conducted with 6–10 key informants, both men and women, to explore the perceptions, experiences, and understandings of the trends in climate risks during the past 5 years, 10 years, and 20 years. The impacts of climate risks and the AMs in agriculture, the learning process for adaptation decisions, the barriers in adaptation, and the adaptive capacity of a local community in agricultural development also were collected. One FGD with commune staff and three FGDs with agricultural cooperative staff and experienced farmers were organized for discussions about climate change, its impacts, and AMs in their agricultural production (Table 1 in SUPPL). On average an FGD lasted around 2 hours. FGD reports were written and condensed using data reduction methods and thematic analysis (Morse, Swanson, & Kuzel, 2001).

Structured interviews: After collecting and classifying information and data from the in-depth interviews, FGDs, and an earlier conducted systematic review on social learning and adaptive capacity (Phuong et al., 2017), a structured questionnaire was designed and implemented (see Figure 2). The majority of questions were closed; however, we included a few open-questions to allow interviewees to explain in greater detail. All interviewees received the official invitation for the interviewing from the leader of the agricultural cooperative. The invitation mentioned the contents and purpose of the interview. Each participant received around 30,000 VND (~1.3 US Dollars) and some tea. In total, 120 households (10% of all agricultural households in the region) were randomly selected to send the invitation for interviews of which 114 households (head of household) in the end participated. Six households did not participate because they had no time or were not interested in participating. The interviews were conducted during April and May of 2015. Respondents were selected when they had at least 10 years of experience in crop or livestock production. Each interview took between 45 minutes and 1 hour. The interview captured the following topics: characterization of the household, perceptions of climate risks, climate risk impact, climate change AMs, barriers in adaptation implementation, adaptive capacity of household, the capacity to access information and networks, participation in climate change activities, and participation in training courses. The English version of the interview can be found in SUPPL A. Data from the interviews were collected, synthesized, and analysed using SPSS 22. Descriptive statistics were used to present farmer's perceptions of changes in long-term temperature, rainfall, and climate risks as well as various AMs being used by farmers. Multiple regression analysis was used to explore which of the variables explain choices in the diversification of AMs. Forward stepwise multiple regression analysis was used to determine the predictive power of the explanatory variables associated with the diversification of their AMs.

A Feedback seminar was organized to verify the preliminary result of the structured interviews ($n = 29$). We presented the main results from the interviews to share and discuss the data. Colour cards and voting systems were used to collect additional opinions from participants about climate change risks and their AMs. The feedback was used to fine-tune findings and increase the research validity.

Results

Farmers' perceptions of climate risks

When asked about their experience of climate change in the past 20 years, almost all farmers reported that, in contradiction with the data provided by the Meteorological station TTH which reports annual tendencies without zooming in on seasonal differences, if we considered the year tendency. When also factoring in seasonal trends, the average temperature in the QL as well as temperature extremes are increasing, both in terms of intensity and frequency (see Figure 3). Less than 5% of the respondents did not experience any change. Similarly, most farmers responded that they perceived more and more extreme droughts and less

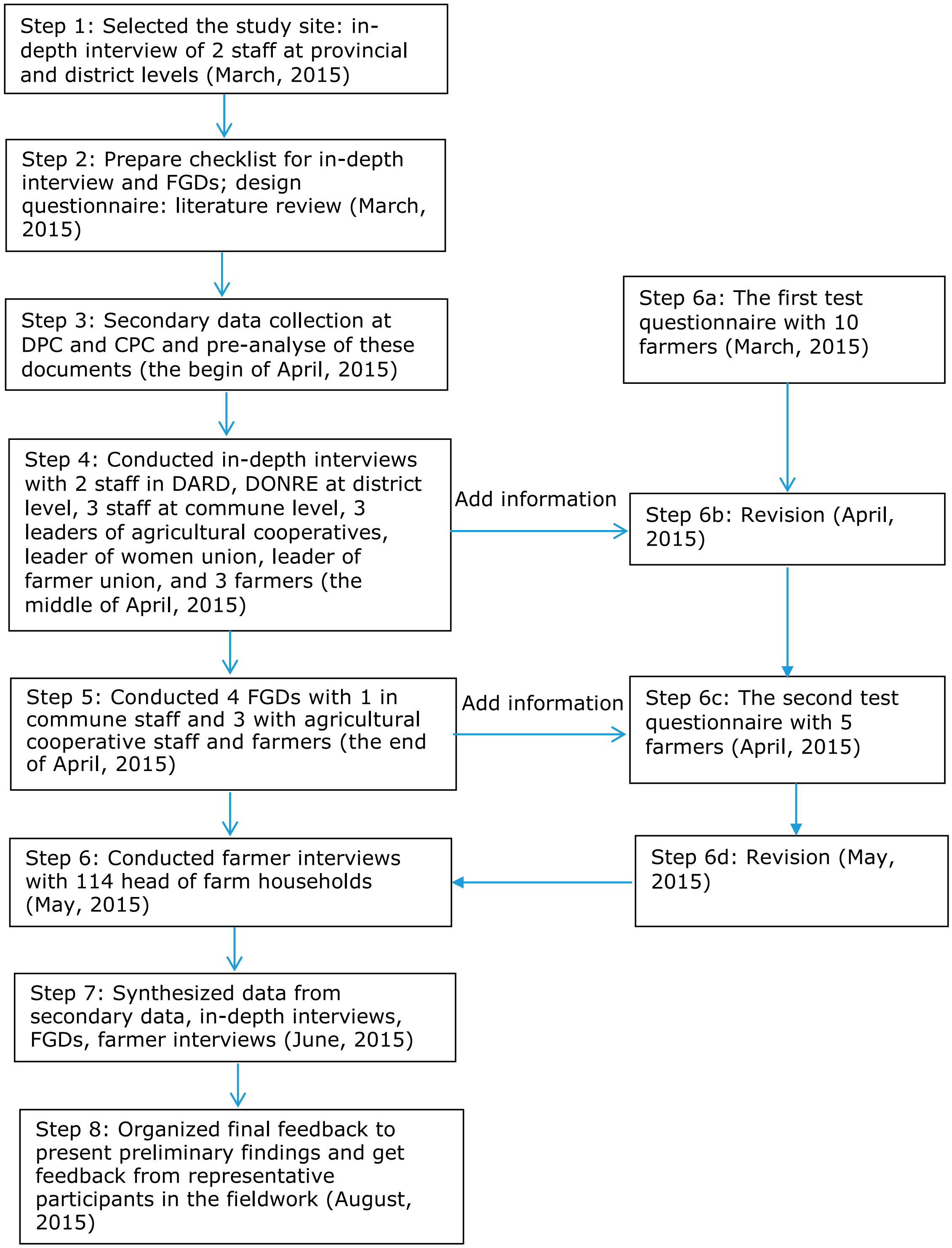

Figure 2. The research design for data collection.

extreme coldness during the last 20 years. Farmers were unaware of the impact of salinization on their farming activities. Out of the 114 respondents, almost all (97.4%) experienced a decrease or a significant decrease in the frequency of precipitation in the last two decades.

The main observed changes are prolonged dry spells, longer intra-season dry spells and a general delay in onset of rains and an abrupt end of the season (TTH Provincial People Committee, 2014). Floods and storms seem to have decreased in both frequency and intensity. Results from in-

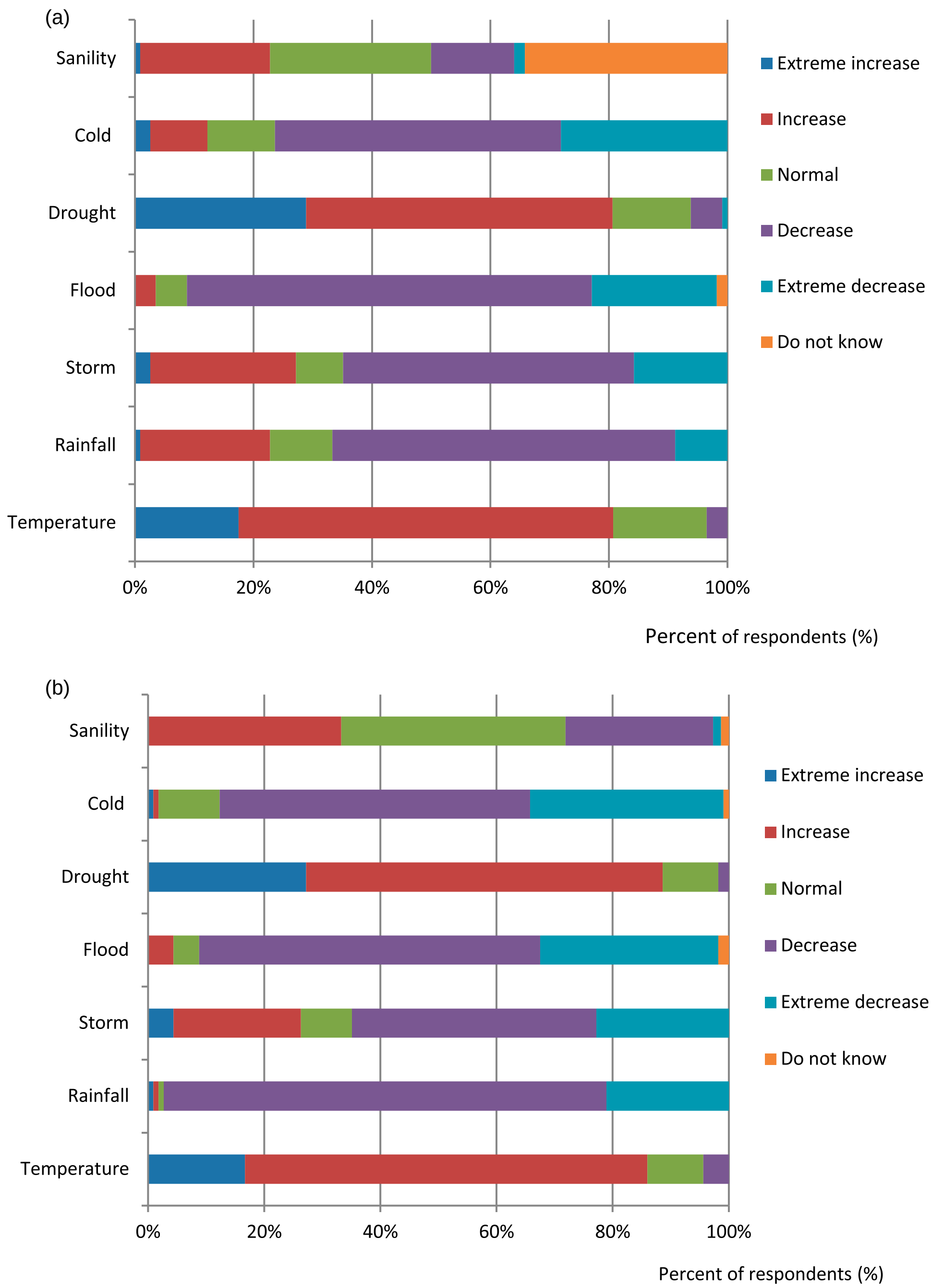

Figure 3. Farmers' perception of intensity (a) and frequency (b) of climate change during the past 20 years in the QL.

depth interviews, on average about 2–3 storms and 2 floods occurred per year over the last 20 years, but during the last 7 years the average dropped to less than 1 storm and 1 flood a year.

Farmers' perceptions of current and future climatic impacts on agricultural production

Farmers were asked to assess and score the impact of climate risks on their crop and livestock production, ranging from having a significant impact (5) to no impact (1). Results show that farmers have a diverging experience of climate impact on their agricultural practices, ranging from serious and very serious impact (48.2%, $n = 55$) to almost no impact (48.2%, $n = 55$). The most frequently identified climate impact for crops are: decrease in crop yield, increase in farming investment cost, increase in crop pests and diseases, decrease in the farmable land, and lack of water for cultivation (see Table 1). For livestock production, the main impacts are: increase in investment

Table 1. The impact of climate change on crop and livestock production
("n" is amount of respondents in the survey, multiple options could be selected).

Crop impact	Ranking	Livestock impact	Ranking
Decrease yield	1 ($n=91$)	Increase investment cost	1 ($n=79$)
Increase investment cost	2 ($n=63$)	Increase livestock diseases	2 ($n=78$)
Increase pests and diseases	3 ($n=47$)	Decrease livestock health and production	3 ($n=38$)
Fallow land, dry land	4 ($n=26$)	Livestock died (chicken and duck)	4 ($n=34$)
Lack of water	5 ($n=7$)	Lack of food for livestock	5 ($n=6$)

cost for farming, increase in number and frequency of livestock diseases, decrease in the number of healthy livestock, increase in numbers of livestock that died because of climate change-related impacts, and lack of food to ensure livestock farming.

During the in-depth interviews and FGDs, a farmer from the Thang Loi agricultural cooperative explained that

> … long periods of sunshine and extremely high temperatures result in high evaporation, especially for the sandy soils. Consequently, the size of the dry area increased over the past years. Rice and sweet potato are the two crops that were most affected by the drought spells because these crops need more water and are more sensitive to air temperature.

Furthermore, the leader of the Tin Loi agricultural cooperative stated that

> … there were several reasons explaining the increase of pests and diseases in crop production; however, drought and high temperature were the major ones. Previously, farmers sprayed pesticides only two or three times per crop season, but recently they had to spray up to seven times per crop season.

Respondents also indicated that in recent years, pests and - diseases developed in unpredictable ways and became more difficult to control. For livestock production, a farmer from the My Thanh agricultural cooperative argued that " … we have to use more medicine for disease control and more investment is necessary to regulate air temperature for the livestock". In addition, main feed sources for livestock including wild grass and agricultural by-products such as sweet potato leaves and roots, have been under pressure due to high temperatures and shortage of water. Farmers noted that their knowledge in determining the manifestation of livestock diseases was very limited leading to an increase in diseases and death rates.

When asked about the future climate impact on agricultural production, 94% of respondents expected that drought will be the most serious climate extreme that would threaten their farm. The variation of temperature both in frequency and intensity as well as the shortage of water will lead to more challenges for cultivation and livestock production, though irrigation systems might be improved in the future. The crop yield and livestock productivity are expected to continue to decrease and could even lead to total losses. The costs for production will also increase. The result is that the farmers will face more constraints in their production if they fail to expand their adaptive capacity.

Current AMs of farmers in the QL commune

Based on results from FGDs and in-depth interviews, the results showed that at least 21 different AMs most commonly used in or advocated for this region of which 12 are for crop production and nine for livestock production (see Tables 2 and 3 in SUPPL). We selected a mixture of household levels and community level AMs in the interviews and asked farmers to identify which measures they already used or were planning to use.

Adaptation measures for crop production

All respondents indicated they adopted the changed crop seasonal calendar (AM1) that was developed by the government at the province and district level and promoted by agricultural cooperatives. In addition, farmers had made other changes in production techniques to adapt to climate change such as change of quantity and timing of applying chemical fertilizer and pesticides (AM2); use of more manure (AM3); change in crop density (AM4); and use of mulching (AM6). Farmers also used more drought-tolerant, pest-tolerant, and disease-tolerant crop varieties (AM8) from DARD since 2004; the agricultural cooperatives encouraged farmers to adapt their rice production areas either in using new rice varieties or in using alternative crops. All farmers adopted tolerated drought varieties for sweet potato and 65.8% of the farmers switched to new rice varieties. Other crops that require less fresh water and are suitable to grow on sandy soil have been cultivated, including cassava, watermelon, chili, onion, and all sorts of beans. As an alternative to the change in the seasonal calendar, farmers applied the intercropping model (AM5) and the rotation model (AM9). Crop diversification (AM7) is considered a feasible "no-regret adaptation strategy" for farmers in this area because of low production risks, high source of income, reduction of production costs, and high resilience to drought. Interestingly, three AMs where hardly implemented: improvement of the irrigation system (AM10), improvement of the inter-field roads (AM11), and adoption of the integrated VAC model (V – garden; A – pond; C – cage) (AM12). During the FGDs, farmers argued that these measures were considered to be the responsibility of the government and/or cooperatives.

Adaptation measures for livestock production

Farmers adopted a range of AMs to reduce the impacts of climate change on their livestock production. The most frequently used measures included: increasing or changing the type and timing of vaccinations (AM13); using supplementary food for the livestock to reduce dependency on local grass and crop by-products (AM14); planting trees around the pig and cattle-shed to create shade (AM15), and changing the design in livestock stables and sheds to improve airflow (AM16). Farmers use local materials to build these sheds and change the shed's design. These changes allowed farmers to increase their poultry production as they could easily be combined with larger livestock animals. Over three-quarters of the farmers changed their livestock breeding programmes to include animals that can cope well with changing environments (AM17). During the FGDs farmers indicated that using local breeds are a major AM in times of drought, especially in the case of chickens, ducks, and cattle. Crossbreeding has been promoted through government programmes and is considered a feasible option for keeping up with changes in market demand.

However, farmers hardly made use of new livestock management techniques for climate change adaptation (AM18). Similarly, the percentage of farmers that changed their management of livestock health (AM19) and livestock diversification (AM20) were relatively low. Adjusting the seasonal calendar (AM21) for livestock production is a flexible adaptation option, but only 11.3% of the respondents used it. The in-depth interviews demonstrated that the capacity of farmers to invest in livestock management was considered low due to the lack of knowledge and the uncertainty of being able to sell livestock to the local market.

Reasons for selecting the AMs

The results of FGDs and in-depth interviews show 10 arguments of why farmers adopted particular AMs, see Table 2. The analysis ignored some AMs that were not used regularly and commonly at the study site, including AMs 10, 11, and 12. For crop production, farmers responded that they mostly selected certain AMs because they are familiar. They learned from demonstrations of other farmers in the community. While there are multiple reasons for farmers to adopt a particular AM, some were selected for a single clear reason, for example, the main reason to adopt crop

Table 2. Adaptation strategies to drought in crop production and the motivation for choice adaptation option.

	Argument 1	Argument 2	Argument 3	Argument 4	Argument 5	Argument 6	Argument 7	Argument 8	Argument 10
AM1 ($n = 114$)	1.8% ($n = 2$)								98.2% ($n = 112$)
AM2 ($n = 104$)	53.8% ($n = 56$)			5.8% ($n = 6$)	1.0% ($n = 1$)	27.9% ($n = 29$)		2.9% ($n = 3$)	8.7% ($n = 7$)
AM3 ($n = 103$	46.6% ($n = 48$)	9.7% ($n = 10$)		13.6% ($n = 14$)	28.2% ($n = 29$)			1.0% ($n = 1$)	
AM4 ($n = 100$)	32.0% ($n = 32$)		1.0% ($n = 1$)	1.0% ($n = 1$)	8.0% ($n = 8$)	33.0% ($n = 33$)		9.0% ($n = 9$)	16.0% ($n = 16$)
AM5 ($n = 87$)	24.1% ($n = 21$)	23.0% ($n = 20$)	2.3% ($n = 2$)	3.4% ($n = 3$)	12.6% ($n = 11$)	9.2% ($n = 8$)	1.1% ($n = 1$)	23.0% ($n = 20$)	1.1% ($n = 1$)
AM6 ($n = 84$)	76.2% ($n = 64$)	2.4% ($n = 2$)		6.0% ($n = 6$)	9.5% ($n = 8$)	1.2% ($n = 1$)		4.8% ($n = 4$)	
AM7 ($n = 79$)	13.9% ($n = 11$)	38.0% ($n = 30$)	1.3% ($n = 1$)	1.3% ($n = 1$)	10.1% ($n = 8$)	6.3% ($n = 5$)	1.3% ($n = 1$)	26.6% ($n = 21$)	1.3% ($n = 1$)
AM8 ($n = 75$)	12.0% ($n = 9$)	2.7% ($n = 2$)	28.0% ($n = 21$)			9.3% ($n = 7$)	8.0% ($n = 6$)	25.3% ($n = 19$)	14.7% ($n = 11$)
AM9 ($n = 59$)	61.0% ($n = 36$)	10.2% ($n = 6$)		1.7% ($n = 1$)	5.1% ($n = 3$)	8.5% ($n = 5$)	3.4% ($n = 2$)	10.2% ($n = 6$)	

Notes: Arguments why the AMs were selected: (1) farmers have experiences in the AM; (2) economic cost-benefit ratio; (3) local support from stakeholders; (4) already familiar strategy; (5) considered to be best option for land characteristic; (6) access to new knowledge and information about the option; (7) change in market price created new opportunities; (8) learning from other farmers about a particular strategy; (9) legislation and policies to adopt a particular measure; and (10) encouragement from of cooperative and government.

Table 3. Adaptation strategies to drought in livestock production and the motivation for choice adaptation option.

	Argument 1	Argument 2	Argument 3	Argument 4	Argument 6	Argument 7	Argument 8	Argument 9
AM13 ($n = 105$)	5.7% ($n = 6$)		2.9% ($n = 3$)	11.4% ($n = 12$)	20.0% ($n = 21$)	21.0% ($n = 22$)	1.9% ($n = 2$)	37.1% ($n = 39$)
AM14 ($n = 105$)	4.8% ($n = 5$)				8.9% ($n = 9$)	76.2% ($n = 80$)	10.5% ($n = 11$)	
AM15 ($n = 103$)	58.3% ($n = 60$)	1.0% ($n = 1$)		39.8% ($n = 41$)		1.0% ($n = 1$)		
AM16 ($n = 95$)	26.3% ($n = 25$)		1.1% ($n = 1$)			25.3% ($n = 24$)		47.4% ($n = 35$)
AM17 ($n = 83$)	14.5% ($n = 12$)		6.0% ($n = 5$)		10.8% ($n = 9$)	59.0% ($n = 49$)	9.6% ($n = 8$)	
AM18 ($n = 41$)	46.3% ($n = 19$)				26.8% ($n = 11$)		26.8% ($n = 11$)	
AM19 ($n = 40$)	52.2% ($n = 21$)				25.0% ($n = 10$)		22.5% ($n = 9$)	
AM20 ($n = 34$)	35.3% ($n = 12$)	50.0% ($n = 17$)	2.9% ($n = 1$)	2.9% ($n = 1$)		5.9% ($n = 2$)	2.9% ($n = 1$)	
AM21 ($n = 12$)	50.0% ($n = 6$)				8.3% ($n = 1$)	33.3% ($n = 4$)	8.3% ($n = 1$)	

Notes: AM = Adaptation measure: AM1: adjust seasonal calendar in crop production, AM2: adjust quality and time of chemical fertilizer and pesticide; AM3: use more manure; AM4: change crop density; AM5:intercropping; AM6: use mulching; AM7: crop diversification; AM8: introduce tolerant varieties; AM9: crop rotation; AM13: livestock vaccination; AM14: use supplementary feeds; AM15: plant trees around the pig and cattle cage; AM16: change the design in house for livestock; AM17: use resilience breeding; AM18: introduce new livestock management techniques; AM19: introduce techniques in managing the livestock health; AM20: livestock diversification; AM21: adjust seasonal calendar in livestock production.

diversification is the anticipated positive economic effect. Overall, farmers were most motivated by cases documenting successful prior experiences support from their cooperative and governmental policies and availability of relevant information and new techniques. For livestock production, farmers were predominantly motivated by changes in market price, forcing them to adopt AMs such as changes in feed and breeding, to improve overall quality and quantity. Similar to crop production, farmers adopted AMs they were already familiar with. Legislation and policies were particularly influential for the application of vaccination for livestock production. Additionally, access to new information and the possibility to learn from other farmers also lead to change in livestock management, see Table 3.

In addition, in order to explore the factors associated with the diversification in applying AMs of farmers, we used multiple regression analysis. We included 17 variables in the structured interviews that could possibly explain diversification (Table 7 in SUPPL), which we collected from earlier work and Pearson's correlational analysis (Table 8 in SUPPL). The coefficients between the explanatory variables and the number of AMs are presented in Table 9 in SUPPL. Twelve explanatory variables have positive coefficients and five variables have negative coefficients with the number of AMs. Five variables can explain the diversification of adaptation at household level: (1) farmable land available during summer season ($P < .05$), (2) number of workers on the farm, (3) amount of farm income, (4) number of available information sources, and (5) access to these sources ($P < .01$). A stepwise multiple regression analysis was conducted to identify which variables could best predict the number of AMs farmers adopted. Four variables were found to be significant predictors: amount of farm income; number of available information sources; number of workers on the farm; and farmable land available during summer season. These four variables jointly explained 33.6% of the variability in the number of AMs adopted. The R^2 change indicates that amount of farm income among farmers contributes most in explaining the number of AMs in agriculture to climate change. The low variance of the variables included in this study may indicate that other variables, not included, could be important in explaining the diversification of adaptation in agriculture to climate change (Table 4).

Future AMs of farmers in the QL commune

When asked about whether or not farmers would consider the AMs identified in Tables 2 and 3 for future AMs most farmers were hesitant. Most of them only considered some routine AMs (see Table 2 in SUPPL) such as crop rotation; use of tolerant varieties of crops; crop diversification, or intercropping. These measures are most likely

Table 4. Stepwise multiple regression of the number of AMs on the explanatory variables.

Variables	*B*	R^2	R^2 change	Overall *F*
Farm income	.040	.174	.174	23.571**
Number of available information sources	.509	.266	.092	13.949**
Number of workers on the farm	1.943	.325	.059	9.620**
Farmable land available during summer season	−.104	.360	.034	5.854*

*Significant at 0.05 level; **Significant at 0.01 level.

considered because other farmers already use these measures and therefore knowledge about the measure is more easily available. Several measures were not considered by farmers for future adaptation, particularly the VAC model, crop diversification, using mulching, and intercropping, partly because these options were already implemented extensively and partly because of lack of workers on the farm and appropriate irrigation systems. Improving irrigation systems and improving inter-field roads were not considered as important measures to farmers as they are considered the responsibility of the government. Ongoing improvements of the irrigation system mean that crop rotation as an AM will become more feasible in the near future. According to the leader of the DARD and members of the commune, the government plans have improved and extended the irrigation system in the QL, allowing enough fresh water to be available to the whole commune by the end of 2017.

Only a small percentage of respondents considered future AMs in livestock production (see Table 3 in SUPPL), with the most frequently mentioned measures related to livestock diversification, change of breeds, change of the building design, and changing the seasonal calendar (7.5%). The main reasons to adopt these measures are smallholder farmers' access to knowledge and information in relation to climate change and adaptation, access financial resources, and their perceived positive economic cost-benefit ratio. Farmers felt constrained by the lack of workers on the farm, lack of knowledge, and lack of financial resources to implement measures such as livestock diversification and change of the seasonal calendar. The interviewees from the DARD noted that the government has plans to change livestock breeding policies, especially for pig production and to develop new policies in supporting the development of vaccines for poultry production.

How farmers perceive their capacities to deal with climate change

As our results show farmers in QL commune have already started to adapt to their changing environments. We asked farmers to assess their capacities to deal with the impact of climate change. We cluster these capacities in three key features of adaptation: capacity to learn, capacity to decide and capacity to act.

"Capacity to learn" in the community was assessed through several questions in the structured interviews. We explicitly asked if farmers felt they have the capacity to learn from others: 43.0% of respondents considered that their capacity to learn was good to very good; 41.2% considered their learning capacity to be average; and only 15.8% perceived their learning capacity to be poor to very poor. Also, the diversification of information sources shows that farmers collect their information on how to adapt to climate change through multiple information channels (see Table 10 in SUPPL) mainly through mass media (93.9%) (mass media in the QL includes commune loudspeakers, bulletin boards, television, radio) and via other farmers in the community (82.5%). However, there was an almost even split in how farmers perceived their capacity to access agricultural information and techniques in relation to climate change: 43.9% indicated this access was poor to very poor, 29.8% indicated that it was average, and 26.3% indicated that it was good to very good. Many respondents were unaware or at least uninformed about other potential AMs such as the VAC model (72.8%), adjusting seasonal calendar in livestock production (66%), management of livestock health (60.4%), or new livestock management techniques (58.5%). When asked what farmers could do to improve their learning capacity, the interviewed farmers suggested more training courses or learning programmes for supporting them in adapting to climate change in livestock production (58 farmers) and crop production (29 farmers).

"Capacity to decide" refers to the possibility of farmers to be actively engaged in the planning and decision-making process. A majority of respondents (75.4%) participated in training courses in agriculture however over half of these farmers felt that they were not actively involved in participation in planning agricultural production in cooperatives. Almost half of the respondents perceived that their capacity to participate in cooperative activities and community activities was good to very good. However, during the FGDs, farmers explained that they were invited to meetings, training courses, and community activities but were only informed about the results of the planning or were provided with information, for example, they were not given the opportunity to interact, ask questions or inform each

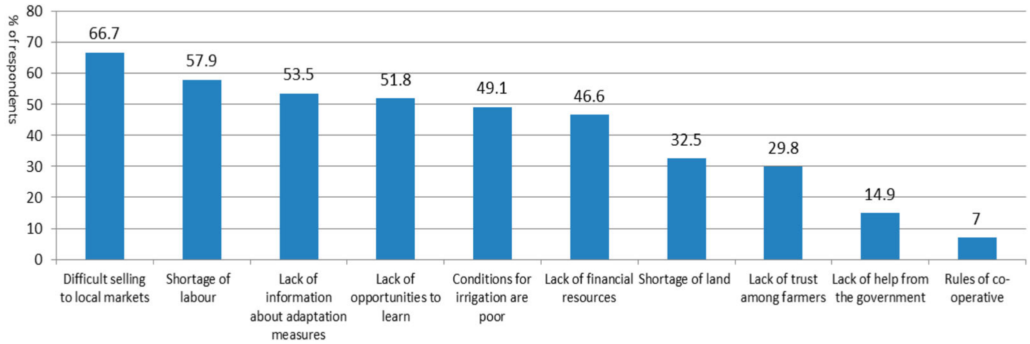

Figure 4. Perceived barriers to adaptation by farmers ($n = 114$).

other of their experiences. During the final feedback session, farmers concluded that their capacity to decide whether or not to adapt to respond to climate change impacts in the community was low.

"Capacity to act" refers to the development of leadership and increased practical involvement in networks. Local authorities have played an important role in helping farmers adapt to climate change, according to the FGDs. However, almost three-quarter of the respondents indicated that the local authorities have just started implementing measures to increase awareness of climate change and to provide limited actionable support. Furthermore, 78.9% of the respondents stated that staff of the agricultural cooperatives introduced some innovative techniques, but these were only focussed on crop production and were often too late for given learning effectives. 43.0% of respondents perceived their capacity to have strong social networks with other actors to solve any adaptation problems as good to very good, 25.4% considered their networks to be average, and 31.6% to be bad to very bad. During the FGDs, the leader of cooperatives indicated that the capacity of the cooperative's staff and of the leaders of community-based organizations (CBO) to facilitate and create new relationships, build partnerships and exploit opportunities to support farmers to act, is generally low.

The results indicate that the respondents experienced various barriers in adopting the above-mentioned AMs. The most important barriers relate to difficulties in selling their products to local markets, making them more vulnerable to secure household income. Other reasons were also noted such as; a shortage of workers on the farm for applying AMs and the lack of information about climate change risks and appropriate adaptation responses. About half of the respondents mentioned the lack of opportunities to learn and to apply new techniques. Farmers noted that the poor irrigation system proved to be an important barrier to secure agricultural production. Less than one-third of the respondents mentioned the lack of trust among farmers, as well as prevailing local norms and practices as keeping them from making changes. Although the assistance from the government and agricultural cooperatives was not mentioned as a main barrier to change, farmers expressed that the lack of institutional capacity to facilitate agricultural adaptation at the household level created an important barrier to future adaptation (Figure 4).

Discussion

The findings of this study show that farmers are highly aware of climate risk and of how this impacts their livelihoods. Most of the farmers are already adapting quite extensively but this likely remains rather conservative and dependent on the agricultural cooperative or local government. We showed that there are substantial differences between farmers engaged in crop production versus farmers engaged in livestock production, in terms of the number of AMs considered and in terms of how farmers perceive their capacity to adapt to future changes. Farmers have faced several barriers in implementing AMs. They are hampered by a lack of capacities with again some differences between crop production and livestock production.

Four key findings of this study warrant further discussion. First, awareness of climate change, climate variability, and climate impacts has positively influenced the adoption of AMs in agriculture (Reidsma, Ewert, Lansink, & Leemans, 2010). We found that particularly crop producing farmers are very aware of climate change and variability and therefore they already have and are most willing to invest in AMs. This is consistent with the numerous earlier studies regarding the interplay between climate variability perception and AMs in agriculture in, for example, India (Dhanya & Ramachandran, 2015; Vedwan, 2006), Nigeria (Apata, Samuel, & Adeola, 2009), and the Mekong Delta, Vietnam (Le Dang et al., 2014). Grothmann and Patt (2005) concluded that the prevalent social discourse is a determinant of people's risk perception and their perceived adaptive capacity. In the past, there have been ad hoc or incidental trainings which contributed to the overall awareness of climate risks. Our findings indicate that much more can be gained by sustaining a continuous process of social learning about the ways to increase adaptive capacity in QL. Most of the farmers indicated that the lack of knowledge and disconnected social networks are major barriers to adaptation. Social networks in the community (Apata et al., 2009; Deressa et al., 2009), the participation in social activities in rural areas (Igodan, Ohaji, & Ekpere, 1988), or access to agricultural services (Hassan & Nhemachena, 2008; Maddison, 2007; Nhemachena & Hassan, 2007) have proven to play an important role in enhancing social learning of farmers. As the community has experienced high vulnerability, the social networks are tightly coupled between stakeholders and farmers, providing them with some foundation to start to learn together. Our findings suggest that the provision of tailor-made courses and training, as well as the mediated communication between peers, friends, neighbours, cooperatives, etc. will increase social learning and likely will improve adaptive capacity and resilience. However, a word of caution is needed here for as Berkes (2009) shows, although learning is important, not all or any learning will to improved adaptation strategies or increased adaptive capacity: when poorly designed and/or supported it could even have opposite effects.

Second, most of the AMs explored in this paper are autonomously implemented by smallholder farmers. The climate change policies at local and district level have already helped farmers prepare; even though they were not framed as adaptation policies at that time (see also Dupuis & Biesbroek, 2013). For example, the agricultural staff in the QD district introduced new varieties of seeds and had policies for vaccination in livestock which was adopted unequivocally by almost all farmers. Although farmers and communities are familiar with and use some AMs, new practices and policies are required to enable them to become more proactive adapting to the changing climate. Further efforts to integrate local adaptation strategies within local and district policy could increase local adaptive capacity in response to climate change, while also contributing to wider (sustainable) development goals in the region. Efforts to improve these practices often ignore social-economic conditions and other motivations of farmers (Reidsma et al., 2010). To improve the success of adaptation strategies in agriculture, the motivation of farmers should be the first consideration (Adger, Arnella, & Tompkins, 2005; Smit, McNabb, & Smithers, 1996).

Clearly, the perception of climate risk has long been recognized as an important determinant of human responses to climate change. Grothmann and Patt (2005) concluded that perception is a key determinant explained as influenced by the model's determinant of adaptive behaviour. In addition, Burnham and Ma (2017) who applied the MPPACC model in practice, argue that perception of hazard risks is not only a critical determinant of adaptation decisions, but also are perceptions of self-efficacy, adaptation-efficacy, and adaptation cost. Frank et al. (2011) concluded that social identity may play important role in the process of adaptation. This study adds that to understand smallholder farmers' capacity to respond to climate change, the link between adaptation decision-making and farmers' motivations needs to be considered as well. Our study shows that different motivations strongly influence the successful application of AMs including personal, environmental, and policy-driven ones. In addition, other factors such as market conditions, household composition, agricultural labour force, the available information sources and the main income sources of households also influence smallholder farmer's adaptation motivation and their capacity to learn, to decide and to act in responding to climate change impacts. As farmers do not adapt to only to climate change, it is paramount for these strategies to represent the aggregated result of multiple motivations, needs, and aspirations operating over different time and spatial scales. Farmers typically respond rapidly and opportunistically to new incentives and tend to pursue a variety of activities simultaneously depending on their motivation in each AM (Below et al., 2010). Our findings, therefore, support the notion that a mixture of multiple motivational factors is paramount in transitioning towards more sustainable farming practices.

Third, as Rubin (2014) indicates, social vulnerability is understood as an inadequate capacity of individuals or groups to cope with and recover from the impact of hazards. Considering and addressing underlying social, economic and political conditions in reducing such vulnerability is crucial. Our findings seem to support this. Many farmers indicate strong concerns related to the economic situation, their ability to learn from other farmers and their familiarity with local knowledge and geography to adapt. Farmers' willingness to adapt to climate change and diversify adaptation strategies depended on their economic interests and their understanding of the market (Burnham & Ma, 2016) as well as on the quality of their social network and social communication (Below et al., 2010). Farmers are also willing to change their choices and decisions based on the information they received (Grothmann & Patt, 2005). Agricultural adaptation to climate change does not only depend on making changes in agronomic practices and attitudes but also on supportive functions provided by other farm enterprises and institutions both at micro and macro levels (Nyanga, Johnsen, Aune, & Kalinda, 2011). Fourth and finally, many studies have ignored the fact that in the Vietnamese context in general and the QL in particular, workers in the agriculture sector are older men and women. Young workers with higher education in rural areas have migrated to the big cities or to other countries to find jobs. This explains why most farmers mentioned that lack of workers in agriculture as one of the foremost reasons for not applying forward-looking adaptation strategies. Evidence from various sources indicates there is a positive relationship between education level of the household head (Maddison, 2007; Obayelu, Adepoju, & Idowu, 2014); age of head of household (Bayard, Jolly, & Shannon, 2007); and diversification of adaptation to climate change (Igodan et al., 1988; Maddison, 2007). This implies that farmers with higher levels of education and more farming experiences are more likely to adapt better to climate change. However, the result from this research shows the reverse is taking place as the education level of the older people in the rural area is low. We also found a positive association with the number of workers on the farm and the numbers of AMs considered (see also Apata et al., 2009 and Burnham & Ma, 2017).

Conclusion

People in rural area Vietnam still are poor, especially in the QL commune, with a large part of their income depending on agriculture. The QL commune has already started to adapt to climate change in both crop and livestock production. While a lack of local knowledge in times of rapid global change can promote the depletion of natural resources, local knowledge also may serve as an important asset in the design and implementation of adaptation practices (Below et al., 2010). For this purpose and to achieve long-term benefits, planned adaptation should be combined with autonomous adaptation and should be co-created and carried out by the state government in their development planning. Farm income, number of workers on the farm, the number of available information sources, and farmable land available in the summer season are all major factors associated with the availability of climate change adaptation strategies in agriculture. The majority of farmers used adaptation strategies that not only deal with climate change, but also the changes in the market and household-related economic conditions. Previous studies concluded that understanding adaptive capacity requires the consideration of risk perception, perceived adaptive capacity (Grothmann & Patt, 2005), social identity (Frank et al., 2011), perceived self-efficacy, and adaptation intent (Burnham & Ma, 2017). Frank et al. (2011) have shown that social identity plays a role in the motivation for engaging in adaptation. Our study adds to this that in order to understand smallholder farmers' motivations to respond to climate change their understanding of climate change and its socio-economic impacts need to be investigated as well.

This factor might enrich Grothmann and Patt's (2005) MPPACC. Moreover, in the rural culture of Vietnam, the social networks and social capital are critically important in the adoption of agricultural activities. This requires more understanding of the processes of decision-making in agricultural adaptation. Besides that, the government will need to support research and development in the agricultural sector, disseminate appropriate technologies, ensure that cheap technologies are available to smallholder farmers and promote market development. More specifically, increasing the roles of stakeholders in the community through, for example, CBO will be critical in increasing farmer's capacity and promoting continuous social learning to adapt to climate change.

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Notes

1. FAO Vietnam Country Profile: http://www.fao.org/countries/55528/en/vnm/
2. Vietnam Employment Trends 2010.

Supplemental data

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