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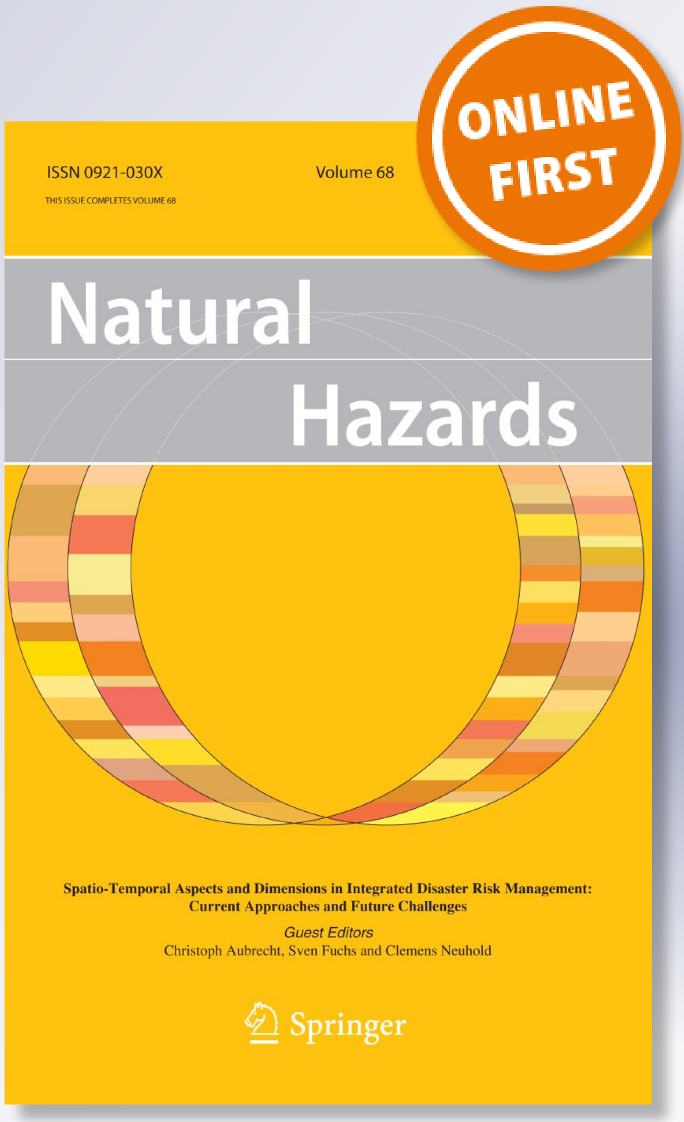

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ORIGINAL PAPER

Unpacking local impacts of climate change: learning with a coastal community in Central Vietnam

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Abstract Large-scale climate models (LCM) have been used to understand climate change and its effects, but there remains a concern about their inability fully to reflect local contexts and about a high degree of their uncertainty. Through a case study that involved residents of a coastal community in Central Vietnam, this paper presents how local people perceive climate change and characterize climate impacts on their life. Findings of the study show that local people perceive a variety of important manifestations of climate change, especially temperature, rainfall, sea level rise and monsoons, although they have limited ideas about future climate change. In addition, local people unpack the complexity of climate impacts through interactions among climatic events, livelihoods and the five capitals (physical, natural, financial, human and social resources). Findings of the research suggest that it will be necessary to move away from viewing coastal villages in Vietnam as homogenous units with shared climate experiences, and to combine both local experience and scientific evidence based on LCMs to promote the synergies and address the limitations of the two sources of information for climate interventions at the local level.

Keywords Climate change · Coastal communities · Five capitals · Livelihoods · Natural hazards · Vietnam

1 Introduction

Vietnam's coast accommodates approximately 50% of the national population or 45 million inhabitants. The coast is characterized by its high density and rapid growth of population, from 37 million in 2004 to 45 million people in 2013 (GSO 2014). Most key economic activities such as agriculture, tourism and manufacturing industries are

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concentrated along the coast and they have significantly contributed to the national and local economies (Sekhar 2005; UNDP 2011). Agriculture, aquaculture and fisheries in the coast are primary livelihoods of local communities and a major food supplier for world markets (MPI 2014; UNDP 2011).

Vietnam's coastal communities and their livelihoods have been heavily threatened by climate hazards, especially storms and floods. For instance, the 2009 Ketsana storm not only killed 179 people and injured 1140 others, but it also damaged 9770 houses, 13,147 clinic centers, and 5581 schools across 15 central provinces (CCFSC 2009). As a secondary disaster, the flood that was induced by the 2006 Ketsana caused a loss of 100,000 and 18,000 ha of rice and aquaculture production, respectively (CCFSC 2009). In addition, it is expected that adverse impacts of many climate-related hazards will likely be aggravated by future climate change (MONRE 2009).

The Vietnamese government has made significant efforts to reduce risks of future climate change (GOV 2007, 2008). One of such efforts is the climate risk assessment based on large-scale climate models (LCM) and the assessment has been used to develop long-term action plans for climate change at the national and provincial levels (Kirsch-Wood 2015). These models are essential as they have the advantage of setting broader parameters for developing the action plans. However, LCMs are critiqued because they disconnect with local people who are impacted directly by climate change and they contain a high level of uncertainty (Dowlatabadi and Morgan 1993; van Aalst et al. 2008; Wilbanks 2005). Consequently, the models cannot fully understand the realities of cultural, socioeconomic and environmental contexts at a particular location as well as concerns and needs of local people in climate policies (Byg and Salick 2009).

Community-based participatory research is increasingly advocated as a useful tool to reinforce climate risk assessments based on LCMs because it provides local people with opportunities to conceptualize climate impacts that they experience throughout their life (Shameem et al. 2015). This paper reports a case study that involves members of a coastal community in central Vietnam to obtain local knowledge about manifestations and impacts of climate change at the local level. The field research is guided by two overarching research questions: (1) How do local people perceive and explain climate change? (2) How do local people characterize climate impacts on their life? The paper is structured as follows. The two sections that follow illustrate the conceptual and methodological backgrounds for the research. Section 4 provides a brief description of environmental and social-economic characteristics to set a foundation for exploring manifestations of climate change and for an in-depth analysis of their impacts on the community in Sect. 5. Finally, discussions are made in Sect. 6 before the paper ends with conclusions.

2 Conceptual roots for unpacking complex impacts of a changing climate on local communities

This research builds on three interconnected areas of the literature including climate risk, "five capitals" and cross-scale interactions. Climate change research has used a wide range of climatic parameters and phenomenon such as temperature and rainfall over a long time period to understand changes in climate systems (Srinivasa Rao et al. 2016). Climate change is expected to pose risks to communities around the world (IPCC 2014). Climate risk is commonly assessed through the exploring of the interactions between climate hazards and the vulnerability of a community (Brooks et al. 2005; Cardona 2011; UNDP 2004).

Not all climatic events that occur naturally in the daily life of coastal communities are hazardous, but they become hazards when they pose threats to the communities and their property (Bryant 2005). Climate hazards do not occur independently, but they interact with other environmental and social-economic factors (Thomalla et al. 2006). For instance, the 2006 Ketsana storm in Vietnam coupled with their resulting violent floods, threatening to significant populations residing in the low lying areas (CCFSC 2009). Moreover, many hazards occur as a result of complex, multiple, interrelated processes, either concurrently or in chain reactions (Lechat 1990; Thomalla et al. 2006).

Coastal communities are complex systems with a diverse set of entities, which might not be impacted by a changing climate in the same way as they have different characteristics such as levels of vulnerability and resilience. Similarly, climatic events might not threaten the community in the same way because they vary in the magnitude, frequency, duration, extent, onset speed of the events, as well as spatial and temporal scales (UNDP 2004). As such climate risks facing a community cannot be fully understood without unpacking the complexity of both the changing climate and the community.

In a community, humans play the most important roles, but they cannot live without basic resources such as freshwater and foods as they are an essential foundation for livelihood development and sources of capacity to deal with the changing climate (Bebbington 1999; Brklacich 2006; Tompkins and Adger 2004). Coastal communities often have a diverse set of resources, which are commonly classified into five capitals: financial, physical, natural, human and social (Porritt 2007). Resource-based assessments of climate risks are needed to identify which important resources are available for the communities to address a changing climate, how these resources are impacted by changes in climate (Herslund et al. 2015; Joseph et al. 2013; Wang et al. 2013).

Finally, it notes that communities are not static, but they change across the temporal and spatial scales. Many events or processes in communities take place at different levels of temporal scales (Cash et al. 2006). For instance, coastal residents in Vietnamese Mekong Delta daily look after their crops and their communities are expected to be flooded by sea level rise in the next century (MONRE 2009). In addition, communities might also be impacted by environmental processes that occur across multiple spatial scales. For instance, crop production of various communities in Quang Tri Province takes place in gardens and farming zones (Oxfam 2008), while storms initially develop in the South China Sea and then brings strong winds and surges. As such it is important to consider interactions across multiple scales in climate risk assessments.

3 Methods

3.1 Study site

Tuong Van village was selected as a case study for this research. It is administrated by Trieu An commune of Trieu Phong district in Quang Tri Province. Quang Tri is located on the central coast of Vietnam (Fig. 1) and covers a total land area of 4700 square kilometers. In the province, mountains and hills are concentrated to the west and they occupy 80% of the provincial territory. The remaining quarter accounts for plains and sandy areas along the coast, where agriculture, aquaculture, and fisheries are concentrated (QT-SO 2011).

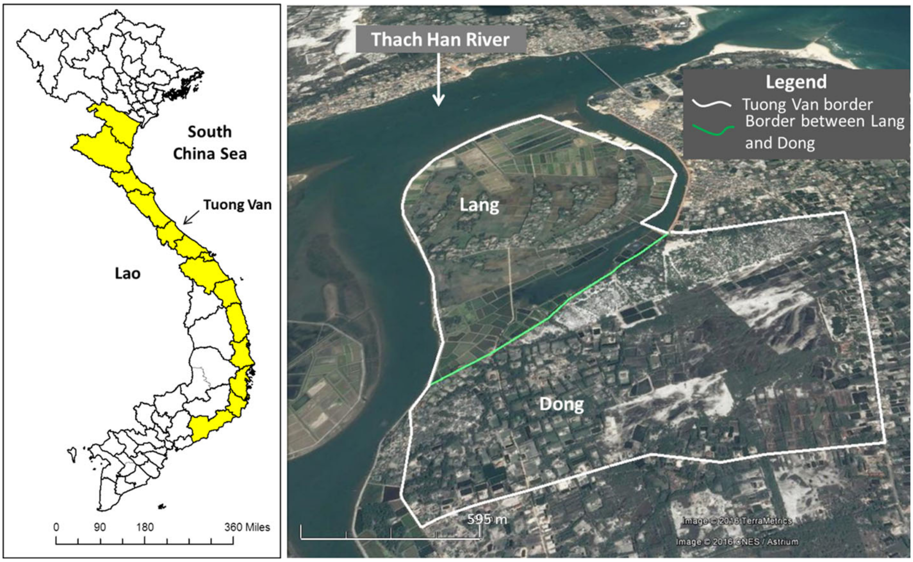


Fig. 1 Geographical location of Tuong Van community. The shaded area of the left map illustrates Vietnam's central coast, where Tuong Van (left map) is located. *Source*: the maps were adapted from the Google Earth

Quang Tri has a tropical monsoon climate, with the daily maximum temperature varying between 7.7 and 42.1 °C (QT-PPC 2010). The rainy season usually lasts from September to December, and it is characterized by heavy rains, storms, and floods. The dry season typically starts from March and ends in late August, and it is characterized by hot and dry southwest monsoons and droughts (Nguyen et al. 2010). The province has been impacted by a wide range of climate hazards, of which floods and storms are considered as the key threats (QT-PPC 2008).

Tuong Van village is located on the coast and about 20 km away from the capital of the province (Dong Ha city). The village has 210 ha of land, which accommodates nearly 1500 habitants living in 350 households across two residential areas, Lang and Dong. These two areas accommodate a similar number of households. The village is exposed directly to the Thach Han River, which is approximately 800 m wide and about 1.5 km away from the mouth of the river opening to the Cua Viet Sea. Moreover, most land of the community is no more than 4 m above sea level.

3.2 Data collection and analysis

This research used multiple methods of data collection including focus group discussions (FG), interviews, surveys, community observations and archival retrievals. The research was conducted between June and October of 2013 to understand climate impacts on the community in both dry and rainy seasons.

FGs and surveys were the primary tools to obtain experiences and opinions of local people about climate change and its impacts. Twenty-four villagers (12 men and 12 women) were recruited throughout the research process by using a random strategy, which was assisted with random numbers generated in an Excel Spreadsheet and the official list of the village's households. Villagers were recruited with the same number and gender from each of Lang and Dong. Participants from each of these areas were divided into two groups for focus discussions. It is also essential to note that as soon as the first FG was started, an additional man from Lang came and asked to participate in the research. His interest was accepted, and he participated in one of the Lang groups.

Two sets of FGs were conducted. The first set was used to unpack the complexity of the community by identifying existing livelihoods and resources that are important for the community. In the second set of FGs, participants assessed changes in climate and their impacts on the community. Since participants viewed changes in climate through the trends of climatic phenomena, the second set of FGs started with identifying climatic phenomena/hazards, and then discussed patterns of individual climate-related hazards over time. Finally, participants discussed how individual climatic events and their interactions impact their livelihoods and resources. Each FG was held in the meeting room of the community for 2.5–3.5 h.

Surveys were used to quantify and rank the importance of resources and climatic events rather than to provide any statistical tests. A survey matrix was used to collect the perception of individual participants about the importance magnitude of individual resources and the impact level of individual hazards that they identified in the first set of FGs. The matrix consisted of two components. The first was used to quantify and rank the importance of individual resources for each of Lang and Dong. The importance of a resource was scored at four scales: 0: no importance, 1 little importance, 2: moderate importance, and 3: high importance. The second component aimed to quantify the extent to which each hazard impacts individual resources. The impact of a hazard on a resource was scored at four scales: 0: no impact; 1: low impact; 2: moderate impact; and 3: high impact.

Before conducting the surveys, the survey matrix was pretested and revised. At the end of the second set of FGs, the survey was conducted for 45–60 min. Following the surveys, all scores that each participant gave were put into an Excel Spreadsheet. In order to rank the importance of resources for each of Lang and Dong, the importance indices for individual resources were calculated separately for the two residential areas. The importance index of a resource for Lang was calculated as the average score from 13 participants of Lang given to such a resource, while the index for Lang was the average score from 12 participants of Dong given to the resource.

In order to assess the extent to which climate hazards impact the community, and to rank their importance, three types of the index were used. The first is "overall impact index", which is defined as the impact magnitude of individual hazards on the five capitals (physical, financial, natural, human and social), each of which is a group of resources. The overall impact index of a hazard on a capital is tabulated as the sum of scores from 25 participants given to all resources of that capital. The index is calculated for each of the five capitals in order to provide cross-capital comparisons.

When the overall impact index of a hazard on individual capitals is tabulated, the "total impact index" of individual hazards is generated. The total impact index of a hazard is calculated by summing all the overall impact indices of such a hazard. The total impact indices of hazards will be then ranked in order of importance for the community.

The last type is "specific impact index" and it refers to the impact magnitude of a hazard on a resource. This index is calculated as the average score from all 25 participants given to a hazard for a resource. When all specific impact indices are generated, they will be used to examine the extent to which each hazard impacted individual resources, and to compare the impact magnitude of a hazard on different resources among each of the five capitals.

In-depth interviews, community observations and archival retrievals were used to complement and validate the information obtained from FGs and surveys. Ten villagers were interviewed, and they were identified by snowball sampling strategy. The interviews were conducted for 30–90 min depending on the availability of informants. In addition, the researcher also conducted, by himself or with local people, a number of community observations about past and recent impacts of climatic events on key resources and livelihoods of the community. Finally, historical data from governmental agencies were also collected and used to assess the changing patterns of climate in the region.

4 An overview of livelihoods and "five capitals" in Tuong Van community

Through group discussions, a diverse set of livelihoods were identified as recently important for local people. Most households have a mixture of livelihoods, but agriculture is the key sector. Agriculture consisted of animal production including poultry (e.g., chicken and duck), husbandry (e.g., pigs and cows) and subsidiary crop,[1] and rice production. In addition to agriculture, about 50% of the households in the community were involved in aquaculture and forestation. A small portion of the village participated in the exploitation of aquatic and terrestrial resources.

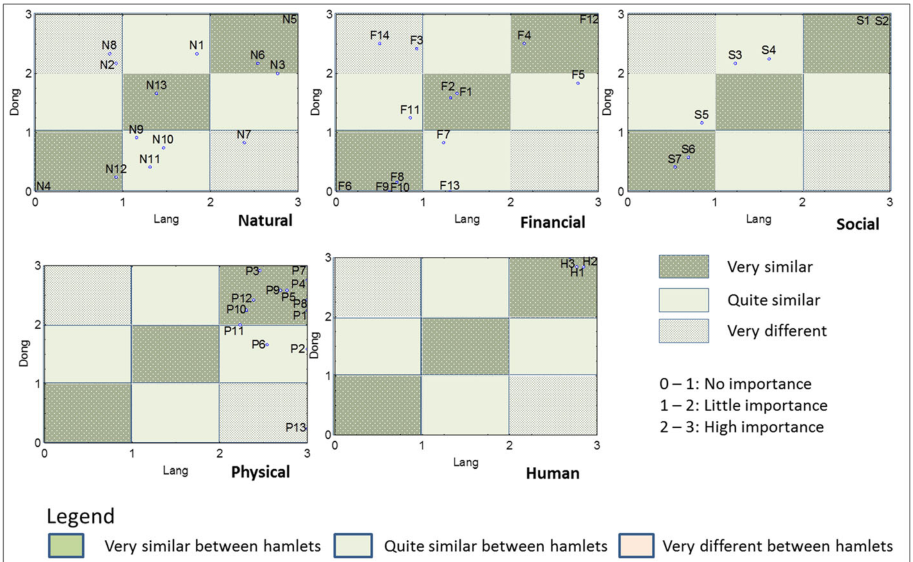
The community has at least 50 resources that are used to develop livelihoods and as sources of capacity to address a changing climate. Each resource plays its own roles in enhancing community resilience and reducing climate risks. For instance, bamboo rings around households are used as barriers against storms and floods throughout rainy seasons, while Tram forests protect villagers from extreme heats of southwest monsoons during summers. Resources of the community are classified into five forms of capital including natural, physical, financial, human and social resources (Fig. 2).

The community had at least 13 *natural* resources. Some resources such as groundwater and gardens were common for both Lang and Dong, but many others were not distributed evenly between the two areas. Among 13 forms of natural capital, land for subsidiary crop (N3) as well as water for crop production (N6) and domestic use (N5) are highly important for both Lang and Dong, while land for salt production (N4) and bitter vegetables (N12) are not appreciated by the two areas. However, many resources were evaluated differently between Lang and Dong. Bamboos (N7), salt-tolerant trees (N9), clams (N10) and nut grasses (N11) were important for Lang, but they were less appreciated by Dong residents. In contrast, land for rice production (N1), shrimp farms (N2) and Tram forests (N8) were highly critical for Dong, but they were of low importance for Lang.

Thirteen *physical* resources have been invested in the community. Some resources, for instance, a system of concrete roads is available in both Lang and Dong, but others such as the system of flood dikes and shrimp farms are situated in either Lang or Dong although they have been used by the two areas. Most physical assets were ranked as highly important for both Dong and Lang, while the bridge (P2) and the system of domestic water supply (P13) were highly appreciated only by Dong.

The village has a diverse set of *financial* resources including cash, loans, bank saving, credits, and insurance. Among these resources, bank saving, credits, and insurance are not common in the village. In contrast, local people commonly keep some cash from sales of crops for daily expenses and livelihood reinvestment. In addition, approximately a half of the community had loans from different sources such as banks and their relatives.

[1] Subsidiary crops include vegetable, sweet potato, beans, peanut.



Natural	Code	Physical	Code	Financial	Code	Social	Code
Rice land	N1	Dykes	P1	Loans	F1	Neighborhood	S1
Shrimp land	N2	Bridge	P2	Village funds	F2	Kinship	S2
Crop land	N3	Drainage	P3	Shrimp farming	F3	Farmers' Union	S3
Salt land	N4	Roads	P4	Rice production	F4	Women Union	S4
Domestic water	N5	Drilled wells	P5	Subsidiary crops	F5	Veteran	S5
Crop water	N6	Ground wells	P6	Salt production	F6	Youth Union	S6
Bamboo	N7	House	P7	Remittants	F7	Fatherland Front	S7
Melaleuca	N8	Electricity	P8	Clam exploitation	F8	**Human**	
Salt trees	N9	Equipment	P9	Nut collection	F9	Knowledge DRR	H1
Clam	N10	Clinic center	P10	Vegetables collection	F10	Knowledge livelihood	H2
Nut grass	N11	Life vests	P11	Collection of Coc Thanh Thao	F11	Health	H3
Bitter vegetable	N12	Storm shelters	P12	Animal production	F12		
Coc tinh thao (CTT)	N13	Water tower	P13	Wild fish and shrimp exploitation	F13		
				Melaleuca forestation	F14		

Fig. 2 The importance index for individual resources perceived separately by Lang and Dong. The codes for individual resources in this figure are used throughout the remainder of the paper

Livelihoods, especially animal, rice and subsidiary crop production are the main source of finance for Lang and Dong residents.

Besides natural, physical and financial resources, Tuong Van also has *social* and *human* resources that are essential to enhance community capacities and reduce climate risks. Throughout group discussions, seven forms of social capital were identified, among which neighborhood and kinship were viewed as the most important for the community. In addition, all residents have their own personal resources to deal with climate hazards, for instance, personal health and knowledge on livelihood development and disaster risk reduction. Both Lang and Dong residents ranked the three human resources as the highest importance.

5 Local perceptions of climate change and its impacts

5.1 Temporal and spatial patterns of climatic phenomena and their impacts

Participants discussed changes in climate through nine climate-related events that impact directly their community. These climatic phenomena involve rapid-onset events such as storms and floods. Apart from these events, the community is also impacted by gradual and prolonged stressors, including droughts, salinization, erosion, northeast and southwest monsoons, flooding[2] induced by heavy rains and high tides (Table 1).

The rainy season, characterized by heavy rains, floods, and storms, takes place between September and December. The most extreme period in this season lasts from late September to November because it is a season of storms and floods, which have not only caused human loss and injuries but also damaged valued resources. Over the last three decades, the community has threatened by significant floods that occurred in 1983 and 1999, caused human and economic losses. Besides adverse impacts of these two floods, participants also claimed that their community has been beneficial from many other minor floods since they could bring wild fish and shrimps into post-harvest rice farms and enrich the farms with alluvial materials. In addition, villagers claimed that floods have also reduced the adverse impacts of salinization as they wash away salt contaminated on their rice farms and gardens.

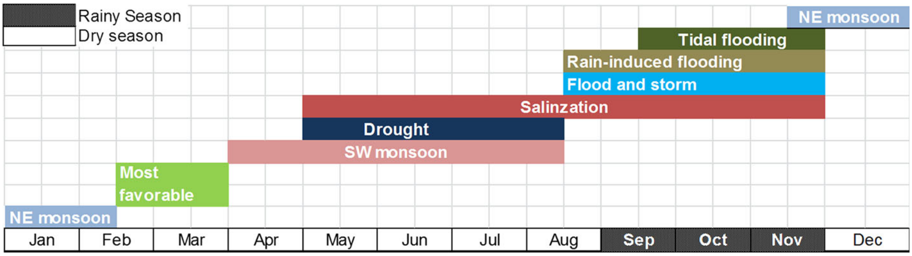
Tuong Van is affected by flooding induced by heavy rains, high tides, and northeast monsoons during the rainy seasons. Annually, flooding often persists for 1–3 months. Although flooding is not deadly like river floods, it usually affects garden livelihoods and daily life of villagers. For instance, the flooding not only kills subsidiary crops, but it is also difficult for the daily travels of local people and promotes infectious epidemics such as diarrhea and dengue fever. Yet, recently many villagers in Dong viewed rain-induced flooding and the extension of rainy seasons as opportunities for development of new livelihoods. Dong residents claimed their gardens previously used to be abandoned during rainy seasons, but recently they have used for paddy-rice crops and freshwater aquaculture.

The change in the pattern of northeast monsoons and their impacts was observed by the community. The monsoons commonly last from December to February and are characterized by cold airs and strong winds. However, local people claimed that the monsoons have become warmer and shorter. This change has brought some benefits to the community. Villagers claimed that the seasons of rice and shrimp farming have been extended, leading to higher production as they could stock seedlings earlier and their rice and shrimps could grow better than three decades ago.

The period of January to August is the dry season. The village suffers from southwest monsoons (hot and dry), droughts and salinization, which commonly occur between May and August. Yet, group discussions and interviews show that the climate during this period has been changed over the last three decades. Most participants affirmed that rains have occurred more often over this period. This observation is supportive to data collected by a local hydrological station, which show increases in the rainfall and the number of rain days during dry seasons (January to August) between the two periods of 1981–1995 and 1995–2010 (Fig. 3). In addition, local people also claimed that the rainy season has also been extended. They explained that rains during December to March have appeared more frequently than the last three decades. This claim is quite consistent with data of the Dong

[2] Local people refer flooding to inundation that persists for a long period, 1–3 months, while they conceive a flood as a rapid overflow of water from the river onto their plains and houses.

Table 1 Temporal pattern of climate-related events in Tuong Van



NE and SW denote north east and south west

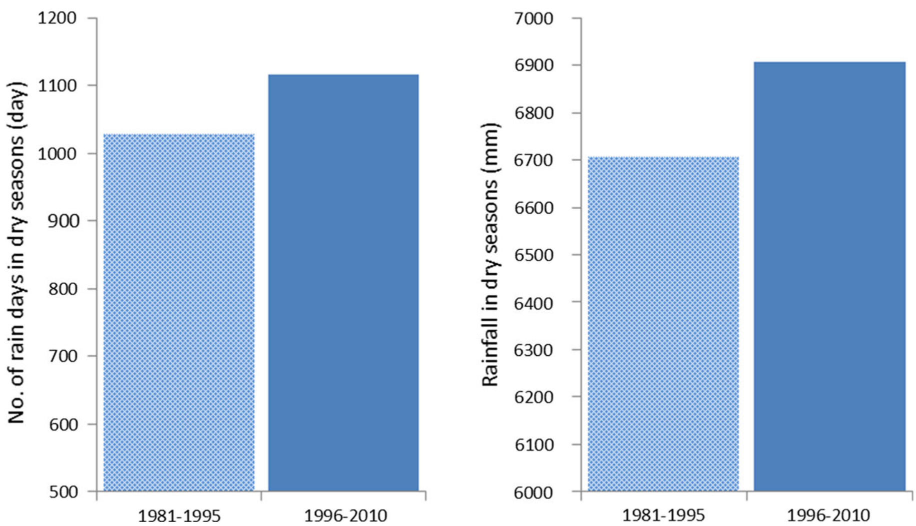


Fig. 3 The total number of rain days and the total rainfall of dry seasons (between Jan and July) over the periods of 1981–1995 and 1996–2010 at the Dong Ha hydrological station. *Source*: Vietnam's National Hydro-meteorological Centre

Ha hydrological station (Fig. 4). Participants claimed that the increased frequency of rains and the extension of rainy seasons have provided their community with more rainwater for domestic use during dry seasons and reduce adverse impacts of droughts. They added that heavy rains have also helped them wash away salt contaminated on rice farms and gardens, thus reducing the adversity of salinization.

The community has experienced storms, floods and droughts for many decades, but recently it has been impacted by other emerging threats such as rising sea level and increased salinization. Lang villagers claimed that tidal flooding has significantly increased over the last two decades as they noticed many dunes near their houses are now submerged at a higher level than 15–20 years ago. However, all participants from Lang did not have

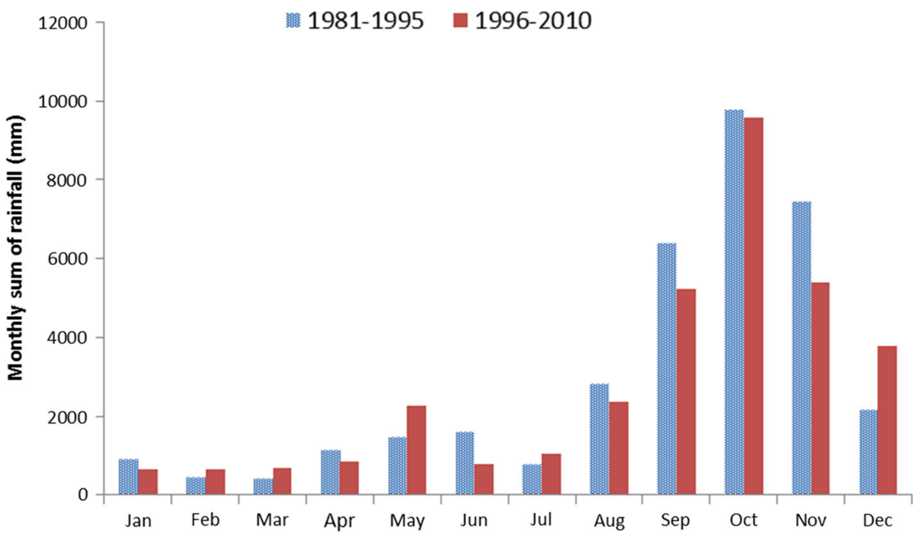


Fig. 4 Cumulative rainfall by months over the periods of 1981–1995 and 1996–2010 at the Dong Ha hydrological station. *Source*: Vietnam's National Hydro-meteorological Centre

any ideas when they were asked why the sea level has risen and they were concerned about the increase of sea level in the future. Evidence of the rising sea level observed by Lang residents is supported by scientific data, which shows an increase in the mean height of monthly maximum tides between 1976 and 2012 (Fig. 5). Besides the sea level rise, Lang residents also found that groundwater in their area has been increasingly salinized.

Despite being in the same village, Lang and Dong are impacted by climatic events in different ways due to biophysical and social-economic differences. Lang is more likely to experience annual floods because of its more exposure to the river. In addition, Lang is located closer to the sea and most of its land is no more than 4 m above sea level. As such,

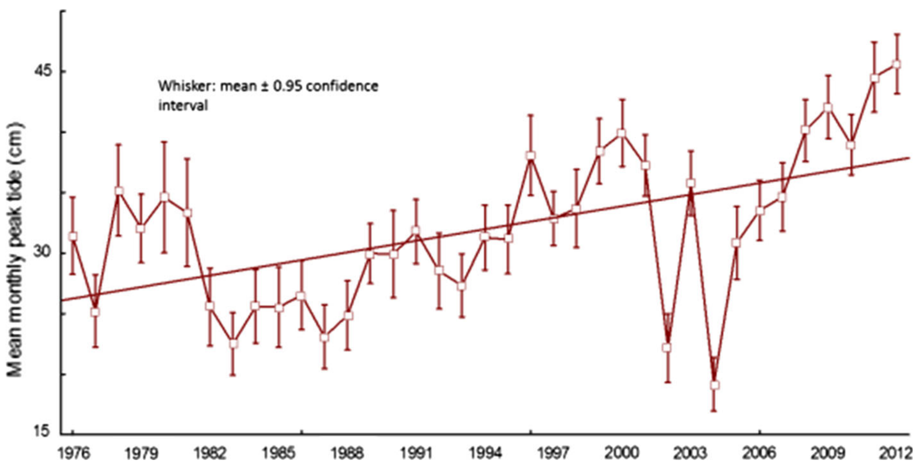


Fig. 5 Rising sea level observed at the Dong Ha hydrological station during 1976–2012. *Source*: Vietnam's National Hydro-meteorological Centre

Lang is not only inundated by high tides but also threatened by storm surges coming from the sea. Unlike Lang, Dong is not threatened by annual floods and tidal flooding due to its location on higher land. However, Dong suffers more from heavy rain-induced flooding. Dong residents live in valleys below sandy dunes, where most of their livelihoods mainly take place. Dong has several canals draining water to the Thach Han River, but they are too narrow and regularly blocked by brush and debris from nearby erosion. Thus, not only are the lives of Dong residents threatened annually by flooding throughout the rainy seasons, but their livelihoods from gardens are as well. During summers, Dong residents suffer from the southwest monsoons and droughts.

5.2 Impacts from interactions among climatic events

Group discussions revealed that climatic events seldom occur independently, but rather they interact with one another in complex patterns (Fig. 6). Some hazards are viewed primary events such as storms and monsoons and others are results or outcomes of the primary threats. As an example, surges are induced by storms and northeast monsoons. Primary hazards could induce a series of resulting threats, sequentially or simultaneously. For instance, floods mainly cause serious erosion along the Thach Han River, whereas storms might create high surges and tidal flooding, which then induce erosion and salinization.

Tuong Van residents witnessed the increased adversity from interactions among rapid-onset hazards. Surges induced by the co-occurrence of the storm and flood 1985 are an example. Participants explained that the development of the storm in the South China Sea during the period of the 13th to 15th of October 1985 induced heavy rains and created a river flood. When the storm arrived onshore on the 16th, high surges were created. Their accounts of the surges were consistent with tide heights of 115 cm measured by the governmental agencies of Quang Tri province during the storm (Fig. 7). Because of the combination between the storm and the flood, besides human injuries and house damage, participants claimed that the surges swept away nearly all of rice, livestock and poultry of the village.

The compounding impacts have also been observed from interactions among gradual and prolonged stressors. For example, villagers claimed that annual droughts, which persist for long periods, often magnify adverse effects of salinization induced by tidal flooding on

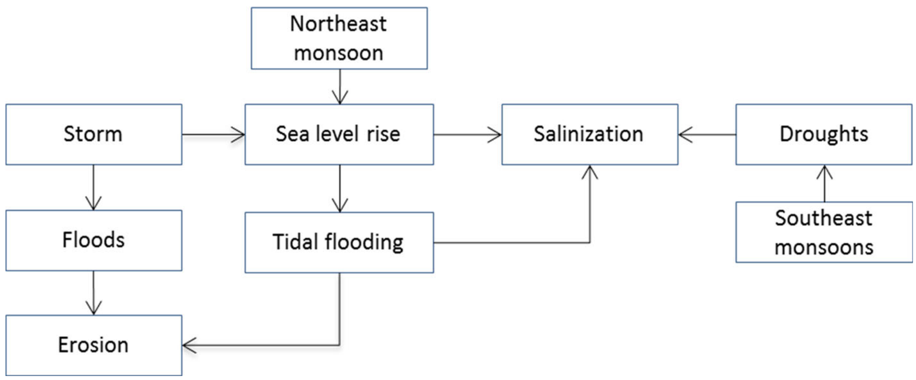


Fig. 6 The relationships of climate-related hazards identified in focus group discussions

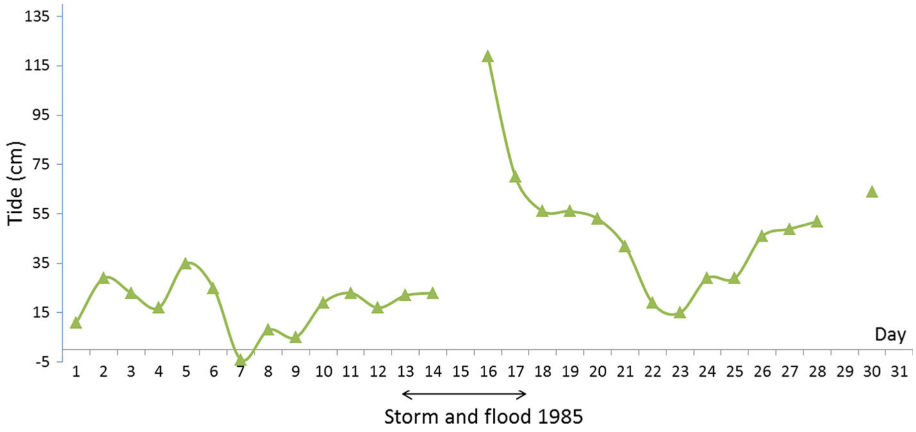


Fig. 7 Flood periods and the mean of daily peak tides in October of 1983 and 1985. *Source*: Vietnam's National Hydro-meteorological Centre. Disconnected points are resulted from unavailable data

rice and subsidiary crops as they increase evaporation. The compounding effects of salinization and droughts often burn plant leaves or even kill the plants. Besides collective effects, the discussions also showed that interactions among climate-related events can also be inhibitive. For example, local people claimed that floods have also reduced salinization of their rice farms and gardens, which is annually induced by tidal flooding.

Table 2 Overall impact index of individual hazards on the five capitals in Tuong Van community

Hazards	Overall impact index of hazards on individual capitals					No. of impacted resources	Total impacts (ranked)
	Physical	Natural	Financial	Human	Social		
Flood	423	230	118	48	0	25	819 (1)
Drought	81	334	162	51	0	20	628 (2)
Salinization	179	231	90	41	0	22	541 (3)
Tidal flooding	177	172	84	17	0	21	450 (4)
Rain flooding	195	97	104	36	0	20	432 (5)
Storm	90	101	105	46	0	11	342 (6)
SW monsoon	28	140	63	35	0	11	266 (7)
Erosion	176	11	49	8	0	11	244 (8)
NE monsoon	28	19	61	37	0	10	145 (9)
Total scores	1377	1335	836	319	0		

5.3 Climate impacts on the five capitals

Table 2 shows that overall, floods, droughts and salinization were ranked on the top among the nine identified hazards, while southwest and northeast monsoons, as well as erosion, were evaluated as the least important. Storms were considered less important than salinization and droughts, even than flooding induced by high tides and heavy rains although they were reported as one of the top two hazards across the coast of Vietnam and in Quang Tri Province (GOV 2007; QT-PPC 2008). Most participants explained that storms could cause human losses and damage to their houses, but these have occurred with low frequency, while some of the gradual stressors, such as flooding and salinization, have impacted them annually for a longer period.

The number of resources that were identified as impacted varied among the nine hazards. Floods impacted 25 out of 50 resources that participants identified in the first set of FGs, while storms, southwest and northeast monsoons, as well as erosion, impacted no more than 11 resources. Table 2 also reveals that the more resources a hazard threatened the higher total impact it had. Yet, it notes that the total impact of a hazard might also be determined by the extent to which the hazard threatens individual resources.

Table 3 shows the extent to which climate hazards individually impacted the 13 physical resources. Overall, the physical capital was threatened the most by floods, salinization, flooding, and erosion, but it was much less impacted by droughts, storms, southwest and northeast monsoons. Floods had the highest impact on physical resources as they threatened more resources than other hazards, while southwest and northeast monsoons had no impact on almost all physical resources.

The extent to which hazards individually impacted 13 natural resources is illustrated in Table 4. Overall, floods, droughts, salinization, and tidal flooding had the highest impact on natural resources, but droughts and salinization were ranked on top. Natural resources were impacted by hazards at different levels. Freshwater for domestic use and crop production (N5 and N6, respectively) suffered the most as it was highly impacted for

Table 3 Specific impact indices of climate hazards on physical resources in Tuong Van community

Hazards	Specific impact index of a hazard on individual physical resources													Total
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	
Flood	**2.9**	**2.8**	**2.4**	**2.2**	*1.0*	*1.9*	**2.1**	*1.6*	0.0	0.0	0.0	0.0	0.0	16.9
Rain flooding	*1.7*	*1.0*	*1.0*	*1.9*	0.0	0.9	*1.3*	0.0	0.0	0.0	0.0	0.0	0.0	7.8
Salinization	*1.6*	*1.8*	0.0	0.5	*1.6*	*1.4*	0.3	0.0	0.0	0.0	0.0	0.0	0.0	7.2
Tidal flooding	*1.7*	**2.2**	*1.0*	*1.2*	0.0	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	7.1
Erosion	**2.6**	**2.5**	0.0	*1.8*	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	7.0
Storm	0.0	0.0	0.0	0.0	0.0	0.0	*1.8*	*1.8*	0.0	0.0	0.0	0.0	0.0	3.6
Drought	0.0	0.0	0.0	0.0	*1.3*	*1.7*	0.3	0.0	0.0	0.0	0.0	0.0	0.0	3.2
SW monsoon	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.8	0.0	0.0	0.0	0.0	0.0	1.1
NE monsoon	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6	0.0	0.0	0.0	0.0	0.0	1.1
Total score	10.4	10.2	4.4	7.6	3.9	6.5	7.3	4.7	0.0	0.0	0.0	0.0	0.0	

Cells with italic and bold illustrate moderate and high levels of impact, respectively. The last column and row is the total score for individual hazards and physical resources, respectively. Physical resources are coded as in Fig. 2

Table 4 Specific impact indices of climate hazards on natural resources in Tuong Van community

Hazards	Specific impact index of a hazard on individual natural resources													Total
	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	
Drought	**2.0**	0.0	**2.2**	0.0	**2.1**	**2.2**	0.0	0.9	*1.2*	0.4	0.8	0.1	*1.4*	13.4
Salinization	*1.8*	0.0	*1.6*	0.0	*1.6*	*1.3*	*1.0*	0.6	0.0	0.4	0.4	0.5	0.0	9.2
Flood	*1.0*	*1.0*	0.0	0.2	**2.2**	*1.4*	0.0	0.7	*1.0*	0.2	0.6	0.8	0.0	9.2
Tidal flooding	*1.1*	0.0	*1.1*	0.0	0.9	0.9	1.0	0.2	0.0	0.6	0.6	0.6	0.0	6.9
SW monsoon	0.0	0.0	*1.8*	0.0	*1.6*	*1.4*	0.0	0.7	0.0	0.0	0.0	0.0	0.0	5.6
Storm	0.0	0.0	0.0	0.0	0.0	0.0	*1.0*	*1.4*	*1.6*	0.0	0.0	0.0	0.0	4.0
Rain flooding	*1.0*	0.0	0.0	0.1	*1.2*	*1.0*	0.0	0.1	0.0	0.0	0.3	0.2	0.0	3.9
NE monsoon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.8
Erosion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.4
Total score	6.9	1.0	6.7	0.3	9.5	8.3	3.0	4.6	4.2	1.5	3.0	3.0	1.4	

Natural resources are coded as in Fig. 2 and the backgrounds of cells are filled as in Table 3. The last column and row is the total score for individual hazards and natural resources, respectively

throughout much of the year and by a wider range of threats, especially by droughts and floods. In contrast, shrimp and salt production land (N2 and N4), as well as river clams and Coc Thanh Thao, were least impacted and by only a few hazards.

Table 5 illustrates the impact of individual hazards on the 11 financial resources. Of the nine hazards, droughts, floods, storms and rain flooding were the most important to the financial capital. Like the natural capital, droughts were ranked at the top. Among 11 financial resources, rice and subsidiary crops (F4 and F5, respectively) suffered much more than the other resources as the crops were killed by the shortage of freshwater as well as by

Table 5 Specific impact index of climate hazards on financial resources in Tuong Van community

Hazards	Specific impact index of a hazard on individual financial resources											Total
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	
Drought	0.0	0.0	1.0	**2.1**	**2.4**	0.0	0.0	0.0	0.0	0.0	0.9	6.5
Flood	0.0	0.0	0.9	0.9	**2.4**	0.1	0.0	0.0	0.2	0.2	0.0	4.7
Storm	0.0	0.0	0.8	0.9	**2.4**	0.0	0.0	0.0	0.0	0.0	0.0	4.2
Rain flooding	0.0	0.0	0.7	*1.4*	*1.8*	0.1	0.0	0.0	0.0	0.1	0.0	4.2
Salinization	0.0	0.0	0.0	*1.7*	*1.5*	0.1	0.0	0.0	0.0	0.2	0.0	3.6
Tidal flooding	0.0	0.0	0.8	*1.3*	*1.0*	0.0	0.0	0.0	0.0	0.2	0.0	3.4
SW monsoon	0.0	0.0	0.2	0.7	*1.6*	0.0	0.0	0.0	0.0	0.0	0.0	2.5
NE monsoon	0.0	0.0	0.5	0.8	0.8	0.0	0.0	0.0	0.0	0.3	0.0	2.4
Erosion	0.0	0.0	0.6	0.6	0.7	0.0	0.0	0.0	0.0	0.0	0.0	2.0
Total score	0.0	0.0	5.6	10.4	14.7	0.3	0.0	0.0	0.4	1.2	0.9	

Financial resources are coded as in Fig. 2 and the backgrounds of cells are filled as in Table 3. The last column and row are the total score for individual hazards and financial resources, respectively floods and salinization. In contrast, loan (F1), village fund (F2) and remittance (F7) were not directly impacted by climate hazards.

Table 6 shows the extent to which individual hazards impacted three human resources. Among the three surveyed human resources, only personal health (H3) was impacted by climate hazards. Droughts were particularly detrimental to personal health, while the other two hazards had a moderate impact. Participants gave zero scores to the other two human resources including knowledge on disaster risk reduction and on livelihoods. Participants interpreted the term "impact" used in the questionnaires as a negative conation rather than a positive meaning. They argued that climate hazards did not affect negatively the two resources. Some participants added that climatic events also had positive impacts on the knowledge. They claimed that their knowledge about storm and flood prevention was much improved from experiences with the flood in 1983 and the storm in 1985.

Participants also gave zeros for the impact of individual hazards on all social resources because they argued that climate hazards did not directly threaten social resources. Yet, two contesting explanations were given during the FGs with respect to climate impacts on these resources. First, climate hazards had some positive effects on social capital. For instance, kinship and neighborhood seemed to become tighter when villagers provided their neighbors and relatives with financial support or labor to repair houses or buy medicines following storm and flood. However, hazards also had negative impacts on social capital. For example, the connections between some villagers were interrupted by the conflicts occurred when aid was not delivered fairly after the storm in 2005.

6 Discussions

The paper uses information obtained from FGs and interviews with residents of the Tuong Van village in the North-Central Coast Region of Vietnam to analyze and how local people perceive and explain climate change, and how they characterize climate impacts on their

Table 6 Impact indices of hazards by individual human resources in Tuong Van community

Hazards	Specific impact index of a hazard on individual human resources			Total
	H1	H2	H3	
Drought	0	0	**2.1**	2.1
Salinization	0	0	*1.9*	1.9
Flood	0	0	*1.8*	1.8
Storm	0	0	*1.6*	1.6
Rain flooding	0	0	*1.5*	1.5
Tidal flooding	0	0	*1.4*	1.4
SW monsoon	0	0	*1.4*	1.4
NE monsoon	0	0	0.68	0.7
Erosion	0	0	0.32	0.3
Total score	0	0	12.76	

Human resources are coded as in Fig. 2 and the backgrounds of cells are filled as in Table 3. The last column and row is the total score for individual hazards and human resources, respectively life. Overall findings of the research with Tuong Van villagers include: (1) local people have observed and explained a various important manifestations of climate change in great details, especially temperature, rainfall, sea level rise and monsoons, and in most cases these perceptions are consistent with scientific evidence; (2) local people unveiled the uneven, interactive and multidimensional impacts of climate change and hazards, which are resulted from complex interactions among climatic events, livelihoods, and resources. The findings and their policy and theoretical implications are discussed below.

6.1 Manifestations of climate change

Evidence showed that villagers have observed warming temperature over the last three decades, especially in the winter (between December and January), which has become warmer and shorter as a result of the increased temperature in the season. The understanding of the villagers fitted to the LCM estimate by MONRE (2016), which shows an increase of the annual average temperature across Vietnam over the last five decades, with stronger warming in the winter. In addition, the perceptions of increased temperature by Tuong Van villagers are also consistent with the observations by local people in the Mekong Delta of Vietnam (Le Dang et al. 2014).

Using LCMs, researchers estimate that the average rainfall in the region of central Vietnam has increased between 12.4 and 26.8% for the period of October to March (MONRE 2016). This estimate supports the perceptions of Tuong Van villagers, which reveal the increased frequency of rains and the extension of rainy seasons toward the beginning of the year. Yet, the villagers claimed an increase in rainfall between July and August, whereas the LCM estimate shows a decline of 20.7% in rainfall, leading to potential severe drought during this period. Niles and Mueller (2016) argue that the climatic trends perceived by local people may be wrongly remembered. However, the historical data measured by the local hydro-meteorological station (Figs. 3, 4) support the claims of Tuong Van villagers.

A little knowledge about changes of southwest monsoons in Asian countries has been generated from LCMs. Tuong Van villagers reported that the monsoons have become cooler and more humid. They explained the changes as a result of the increased frequency of rains during the dry seasons (Jan to August) and the extension of rainy seasons. Although no scientific data was available to reconfirm these claims, the logical explanations by the villagers about the linkages among climatic phenomena can be used to validate their observations. In addition, the perceptions of the monsoons by Tuong Van villagers are supported by those in the western region of Nepal (Manandhar et al. 2011).

Based on the medium scenario for climate change (B2), DONRE (2011) estimated that the sea level along the coast of the province is expected to have risen by 60–71 cm by the year 2100 in comparison with the early 2000s. Such rise of sea level will likely inundate about 0.9–1.4% or 4200–6600 ha of the total land area of Quang Tri. However, the use of CLM to project sea level rise in future has two limitations. First, there is no specific estimate how much of Tuong Van village's land area is likely to be submerged. Second, it remains unclear who and which livelihoods and resources in Tuong Van will be impacted by the sea level rise. The detailed understanding of local people about the impacts of climate change and how they could help climate interventions and policies are discussed further in the section below.

6.2 Perceived impacts of climate change and hazards

Local people unpacked the complexity of climate impacts through the interactions of climatic events with the two main components of their community including the five capitals and livelihoods (Fig. 8). The two components are threatened by multiple climate hazards, which include rapid-onset events such as storms and floods as well as gradual and prolonged stressors, for instance, droughts and salinization induced by tidal flooding and sea level rise. Some of these climate hazards are recurring events, for example, floods and droughts, while others are emerging events associated with climate change, especially sea level rise, and resulting salinization. These climate hazards are also observed in other coastal provinces of central Vietnam, such as Thua Thien Hue and Quang Binh (Chau et al. 2014; Nguyen et al. 2014; Souvignet et al. 2014; Thi Hoa Sen and Bond 2017).

Local people unveil the multidimensional, uneven and interactive impacts of climate change and hazards on their livelihoods and the five capitals. The two components have been threatened differently by the same hazards. For instance, floods have suffered more physical infrastructures than natural resource-based livelihoods, while the reverse pattern is for droughts. Since the two components are interdependent, if one component is threatened by climatic events; then the other is also impacted accordingly. For instance, if a violent flood broke the dike system of the community, not only livelihoods but the live of villagers could also be threatened.

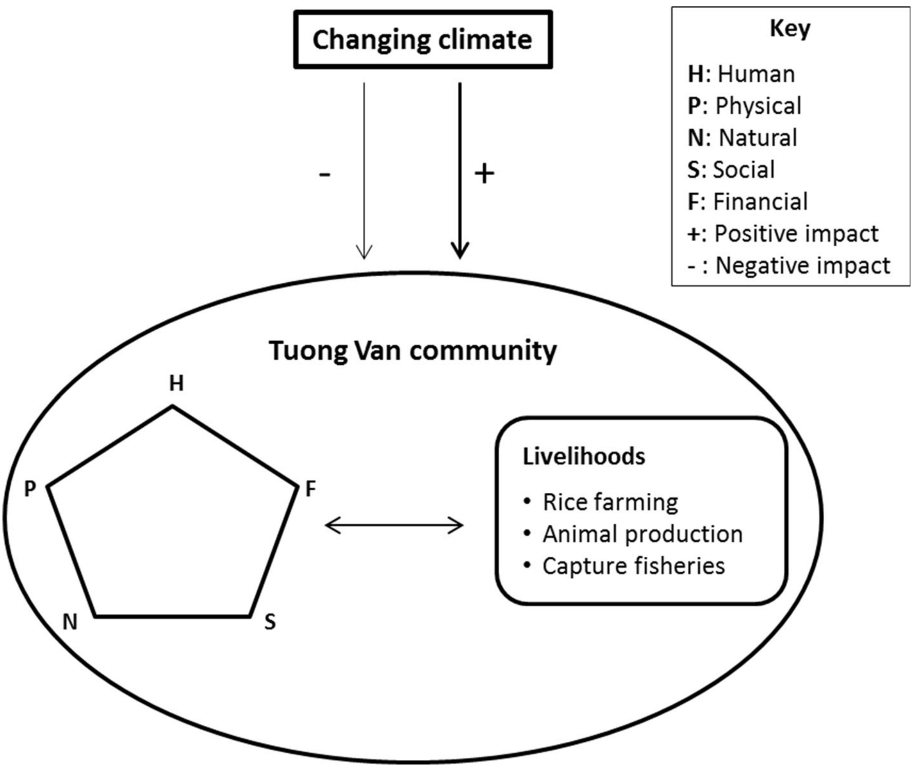


Fig. 8 Complex impacts of changing climate on three main components of the community

A report by UNDP (2004) shows that climate impacts are characterized by the characteristics of climate hazards and human communities. The report is consistent with the perceptions of Tuong Van villagers. The hazards pose threats to the villagers throughout the year, with devastating losses in both rainy and dry seasons. Rapid-onset hazards including storms and floods happen in rainy seasons and have caused human deaths and injuries as well as damage to physical infrastructure. Unlike storms and floods, gradual and prolonged stressors have not killed people and resulted in less damage to physical resources, but they routinely affect natural resource-based livelihoods and the well-being of the community.

IPCC reports that the adverse impacts of many climate hazards on ecosystems and human communities in many places will likely be magnified by climate change (IPCC 2007, 2014). This is true for Tuong Van, where local people have noticed that their livelihoods (e.g., vegetable and rice production) and important resources (groundwater and productive land) have increasingly impacted by sea level rise and the resulting salinization. However, FGs and interviews show several benefits owing to climate change. For instance, the extension of rainy seasons and the increased frequency of heavy rains have not only provided the villagers with more freshwater to be stored for domestic use during the dry seasons but also have helped the community by washing away salt that had contaminated production land.

6.3 Theoretical and policy implications

Global climate models have widely been used to understand climate change and support designing strategies to reduce climate risks. In Vietnam, LCMs have been used to project the changes in climatic parameters such as temperature and rainfall (MONRE 2009, 2016). In addition, the use of the climate models has also estimated the potential impacts of future climate change. For example, there are approximately 63 million of Vietnamese people and 1.1 million hectares of land at risk of flooding by the year 2100 due to a sea level rise of 1 m (MONRE 2009, 2016). These estimates have been used to inform policy decisions at the provincial and national level such as action plans in response to the changing climate (GOV 2008, 2012).

The use of LCMs, however, has several drawbacks for climate interventions and policies at the Tuong Van community. First, the models cannot provide sufficient information about climate impacts for designing climate interventions at the Tuong Van community. For instance, the LCMs could not provide specific estimates of the village's land area potentially submerged by sea level rise because they can only generate vertical and horizontal resolutions of more than 10 km (Timbal et al. 2009), while the total land area of the community is 210 ha. Second, LCMs cannot fully understand climate impacts because of the complexities and uncertainties of the community (Byg and Salick 2009; Mertz et al. 2009). For instance, LCMs could not identify who and which livelihoods and resources will be impacted by sea level rise. This suggests that climate risk assessment and climate policy design should move away from reviewing communities as homogenous units with shared climate experiences.

Findings of the research show several advantages of local perceptions about climate change and its impacts, which can address the limitations of LCMs at the local level. Local people have detailed understandings of their biophysical and socioeconomic conditions, and climate impacts on their livelihoods and the five capitals. For instance, sea level rise and the resulting salinization have increasingly reduced the quality of groundwater as well as rice and vegetable production, while no impacts have been observed on CTT and

Melareuca trees. Consequently, Lang and Dong residents have suffered differently from the two threats since they depend on different livelihoods. The detailed understanding of complex impacts of climate change and hazards on local people could inform policy decisions on who, what and when should be supported to reduce climate risks.

Besides the advantages, local perceptions have limitations. Local people perceive unusual rather than average patterns and occurrences and have limited understandings of climatic changes into future (Le Dang et al. 2014; Reyes-García et al. 2016; Shameem et al. 2015). As such local perceptions are of limited help to develop long-term interventions at large scales. Yet, these limitations of local perceptions can be addressed by the capacity of LCMs to visualize future climate change. For instance, while Tuong Van villagers have no ideas of future rainfall, leading to unawareness of potential floods, LCMs estimate an average increase of 16.6% in the annual rainfall in the Quang Tri Province over the period of 2046–2065 (MONRE 2016). Since the increased rainfall concentrates between September and November and most of the rivers in the province are short and steep (QT-DONRE 2011), putting local people at greater risk of violent floods. The knowledge based on LCMs could better inform to prepare for future climate change.

7 Conclusion

Local people have perceived four important manifestations of local climate change over the last three decades: warming winters, rising sea level, the declined incidence of southwest monsoons and increased frequency of rains in dry seasons. These perceptions are consistent with scientific evidence, but rarely reflect climatic changes into future. In addition, local people have noticed that the climatic changes have modified the patterns of climate-related hazards and their impacts. For instance, sea level rise has magnified the adverse impacts of salinization and tidal flooding, while southwest monsoons, which used to be extremely hot and dry and to strongly impact the lives and livelihoods of local people, have become less adverse because of the increased frequency of rains during dry seasons.

Local people have unveiled complexity of climate impacts (multidimensional, uneven and interactive) at the local level. They are impacted by a diverse set of climatic events, which are not only rapid-onset hazards but also gradual and prolonged stressors. Besides routine events, local people have also been impacted by emerging effects of climate change, for example, sea level rise and salinization. These events are not equally important, but their impacts vary with socioeconomic and geographical conditions. In addition, the adversity of a climatic event can also be modified, either reduced or magnified, by others since they interact. It is also necessary to note that climate change does not always threaten local people, but it has also provided new opportunities depending on their residency location and livelihoods.

The analysis of local perceptions and scientific evidence of LCMs showed that local knowledge remains an important source to inform policy decisions when the capacity of mathematical modeling remains inadequate to capture "too small" communities, and to address the complexities and uncertainties of communities. It is also essential to note that local people commonly have limited ideas about future climate change and its potential impacts. As such the scientific data generated from LCMs are important for local people to plan for potential impacts of climate change. The complex impacts of climate change and hazards suggest that it will be necessary to move away from viewing coastal villages in Vietnam as homogenous units with shared climate experiences, and to combine both local experience and scientific evidence based on LCMs to promote the synergies and address the limitations of the two sources of information for climate risk reduction at the local level.

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