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Article:
Huynh, Lam Thi Mai and Stringer, Lindsay C. (2018) Multi-scale assessment of social vulnerability to climate change: An empirical study in coastal Vietnam. Climate Risk Management. pp. 165-180. ISSN: 2212-0963

https://doi.org/10.1016/j.crm.2018.02.003

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Climate Risk Management 20 (2018) 165–180

Contents lists available at ScienceDirect

Climate Risk Management

journal homepage: www.elsevier.com/locate/crm

Multi-scale assessment of social vulnerability to climate change: An empirical study in coastal Vietnam

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ARTICLE INFO

Keywords:
Climate variability
Vulnerability assessment
Resilience
Capital assets
Governance
Household level
Collective level

ABSTRACT

Climate change poses significant threats to the livelihoods of people living in coastal areas, especially in the developing world. There is a critical need to assess vulnerability to inform both scientific debates and policy makers in facilitating adaptation and coping strategies at different scales. This study advances existing approaches to assessing vulnerability by focusing on both household and collective scales in a coastal district in Vietnam: Ngu Hanh Son district. A mixed-method approach was used including 100 household questionnaires, 12 key informant interviews and data from direct observations. At household scale, results indicate large variation in the degree of vulnerability to climate change among households in the same agro-climate zone. These differences are attributable to variations in socio-economic household characteristics and ability to access livelihood assets. Diversifying livelihoods and reducing poverty are important in contributing to the resilience of households. At a collective scale, qualitative data indicates a lack of multi-directional flows of information and highlights gaps in the current governance system. Findings suggest the need to bridge the governance gaps and establish an effective communication system to reduce collective vulnerability in the district. Findings also highlight the need to promote social equity, equality and democracy in formulating climate policies in an effort to reduce the overall vulnerability to climate change.

1. Introduction

Climate extremes and sea level rise related to climate change significantly threaten the livelihoods of people in coastal areas, especially in the developing world. According to the Intergovernmental Panel on Climate Change (IPCC, 2001), an increase in frequency and magnitude of typhoon events accompanied by 9–88 cm of sea level rise is projected by the year 2100. While climate change is a global phenomenon, how its consequences manifest in the human and physical environment will differ across scales. Together with development of scientific understanding on the nature of and physical exposure to climate change, there is a critical need to investigate the social vulnerability and capacity of populations to prepare for short-term and long-term adjustment to these future changes at different scales (Lemmen and Warren, 2004).

Vulnerability can be defined as a function of exposure, sensitivity and adaptation capacity regarding a specific risk (IPCC, 2007). Vulnerability and resilience are often presented as opposites (Cutter et al., 2008; Reed & Stringer, 2016), although this has been critiqued because depending on the particular risks, a system can be both resilient and vulnerable at the same time (Dixon and Stringer, 2015). *Resilience* refers to the capacity of the population or system to cope with the change in hazard exposures (Cutter et al., 2008).

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https://doi.org/10.1016/j.crm.2018.02.003
Received 27 June 2017; Received in revised form 8 February 2018; Accepted 8 February 2018
Available online 22 February 2018
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Before vulnerability can be addressed, it is vital to identify who is vulnerable. Vulnerability assessments offer insights into this, allowing investigation of the complex relationships between humans and their socio-physical environments (Fraser et al., 2011; Antwi-Agyei et al., 2012). Social vulnerability explicitly concentrates on all socioeconomic and demographic factors affecting the magnitude of impacts of environmental stress on a given population (Tierney et al., 2001; Heinz Center, 2002). According to Adger (2006), social vulnerability consists of two distinct aspects: collective and individual vulnerability, which differ in their indicators and scales. Collective vulnerability is often analysed at community, national or regional scale, while individual vulnerability is linked to the household and individual scale. Most social vulnerability assessments adopt top-down approaches which rely on existing national scale data for analysing collective vulnerability. Nevertheless, empirical evidence on the factors that influence individual vulnerability at household scale remains limited, despite that households are connected to wider socio-economic processes in the community and have great influence in making decisions about climate change adaptation (Yaro, 2006). There is so far no generally agreed method of measuring vulnerability to climate change, and limited literature considers this issue at household scale. This study targets these gaps by assessing vulnerability at both household and collective (city) scales in a coastal district in Vietnam, building on and extending existing vulnerability assessment approaches.

The overall aim is to explore the factors that influence both individual and collective vulnerability to climate change in Ngu Hanh Son District. Collective vulnerability is analysed at city scale and individual vulnerability assessment is considered at household scale. We:

- Identify the factors associated with individual *household vulnerability* and develop a household vulnerability to climate change index;
- Explore the major factors that influence *collective vulnerability* regarding the current governance structure and institutional capacity in Da Nang city; and
- Analyse both *individual household* and *collective vulnerability*, identifying the political and socio-economic characteristics that both increase and decrease the overall vulnerability of the district.

Section 2 presents our methodology. The results of the household vulnerability and collective vulnerability analyses are provided respectively in Sections 3 and 4. The final section presents our discussion and conclusion.

2. Research design and methodology

2.1. Study area: Da Nang city and Ngu Hanh Son district

Ngu Hanh Son District (NHSD) is located in Da Nang city, in coastal south-central Vietnam. NHSD has a population density of 1890 people/km^2, and covers an area of 39.12 km^2, divided into four wards: My An, Khue My, Hoa Hai and Hoa Quy (Da Nang Statistical Year Book, 2011). Average summer warming for the South-east Asia region in which NHSD is located is projected to increase by 4.5 °C by 2100 (World Bank, 2013). NHSD's proximity to the coast, topography, and its present levels of economic development, make it highly vulnerable to climate change. Projected climate change stressors include: long-term sea level rise, coastal floods, increased typhoons intensity, saline intrusion and erosion (World Bank, 2013). Among these, the most severe impact to the district is likely to be caused by the increase in intensity and frequency of typhoons (General Statistics Office, 2012).

NHSD's economy is under a formal and sophisticated governance system. According to the Da Nang's People Committee (2014), there are four levels in Vietnam's administrative structure: i) central, ii) provincial/municipal, iii) district and iv) commune/ward. At each level, the People's Council and People's Committee are the highest authorities, responsible for all long-term and short-term development plans. The People's Committee is the executive agency of the People's Council. In Da Nang City, all power is in the hands of the central and corresponding authorities with more adaptable and flexible systems devolved to the lower levels. Each sector department at the lower level reports vertically to the higher authorities, as well as horizontally to the People's Committee.

2.2. Data collection and analysis

A mixture of qualitative and quantitative approaches were used in this study (Table 1).

2.2.1. Quantitative methods for assessing individual household vulnerability

Vulnerability assessments have shifted from qualitative assessment based on conceptual frameworks to more quantitative measures based on indices. In particular, vulnerability indices have gained prominence in the literature related to climate change (Moss et al., 2002; O'Brien et al., 2004; Brooks et al., 2005). Quantitative methods were employed to calculate our social vulnerability to climate change index at individual household level. My An ward and Hoa Quy ward were chosen for data collection as they are the most resilient and vulnerable ward in NHSD respectively, according to secondary data from Da Nang governmental reports (Appendix A, Table A1). Vulnerability assessment in the most resilient and most vulnerable areas allows comparisons to be made between households within the same agro-climatic zone (Antwi-Agyei et al., 2012).

Data collection took place in July 2015 and began with transect walks with two community members (leaders of My An and How Quy wards). These provided an overview of important social and physical characteristics of these communities through conversations and direct observation. Data were noted down or audio-recorded with permission of the participants.

Quantitative household questionnaires including basic questions about households' capital assets and livelihoods were then

Table 1
Summary of data sources for analysis of vulnerability in Ngu Hanh Son District, Vietnam.

Objective	Method	Scope
1. Identify the factors associated with *individual household vulnerability* and calculate the household vulnerability index to climate change	Quantitative household survey	50 household surveys, participants randomly selected from My An and Hoa Quy ward. Surveys were designed to assess household capital assets for 6 indicators: human, natural, financial, physical, social capital and diversification of livelihood
2. Explore the major factors that influence *collective vulnerability* regarding current governance structure and institutional capacity in Da Nang city	Qualitative interviews, quantitative household survey, field observation by transect walk and secondary data	9 officials and 3 experts in semi-structured interviews, combined with results from quantitative method and field observation. Governance structure is analysed against five criteria: decentralisation and autonomy, transparency and accountability, participation and inclusion, responsiveness and flexibility, experience and support
3. Analyse both *individual household* and *collective vulnerability* across scales, identifying the political and socio-economic characteristics that both increase and decrease the overall vulnerability of the district	Concept mapping	Map and analyse the results from all of the data collection methods using diagrams

administered (see Appendix B), following the method of Antwi-Agyei et al. (2012). This information was used to develop a vulnerability index to climate change at household level. Pilot testing for the questionnaire was initially conducted with 10 households. Responses and feedback from the pilot survey were analysed to make minor changes to improve the questionnaire in terms of clarity. Data from pilot testing were included in the final sample.

The next stage was to select individual vulnerability indicators. Indicators are 'quantitative measures intended to represent a characteristic or a parameter of a system of interest' (Cutter et al., 2008, p. 7). Individual vulnerability, according to Adger (1999), is 'determined by access to resources and the diversity of income sources, as well as by social status of individuals or households within the community' (p. 258). The theory-driven (deductive) approach was used by applying existing theoretical insights into the causes and nature of vulnerability to select indicators for inclusion (Niemeijer, 2002). After conducting a literature review, several indicators were chosen that were linked to six components: i) social, ii) financial, iii) human, iv) natural, and v) physical assets, and vi) livelihood diversification. During pilot testing, participants were also asked for their perceptions on the appropriateness of the indicators that we identified from the literature review. 10 indicators presented in Table 2 were suggested as appropriate to the situation in NHSD. Two other indicators: 'access to climate information during typhoon event' and 'availability of clean drinking water during typhoon event', were suggested by community members and added into vulnerability assessments.

After the pilot testing, households in each ward were classified into wealth groups. Criteria for wealth ranking were developed during the transect walks with the leaders in each ward. A random sampling approach was then used to select households to participate in the questionnaire survey (total n = 100; 50 in each ward). Although the demographic background of the sample might not be representative of the entire population in each ward, this sample size provided a sound illustration in which all income levels, educational level, livelihood activities and household size categories were well represented.

The next stage was quantitative data analysis. Table 3 summarises the twelve indicators of household vulnerability to climate change used in this study, and the scores given for each in calculating the vulnerability index, drawing on Antwi-Agyei et al. (2012).

A standardisation system following the UNDP (2007) procedure of calculating the life expectancy index was applied to all indicators to ensure comparability. Following Eq. (1), all indicators were Standardized to values between 0 and 1 (see Vincent, 2004; Antwi-Agyei et al., 2012).

$$\text{Standardized value} = \frac{\text{Actual value} - \text{minimum value}}{\text{Maximum value} - \text{minimum value}} \quad (1)$$

An unequal weighting system was then used based on relative importance of each indicator in vulnerability assessment. A five-point Likert scale as used by Antwi-Agyei et al. (2012) was applied by asking 100 households, 9 officers and 3 experts to rank the five most important indicators that have biggest impacts on household vulnerability to climate change. The number of times a particular indicator was ranked was converted to the relative weight.

The calculation was made as outlined in Eq. (2) taking into account all indicators with their relative weights.

$$\text{HLVI} = \sum_{i=1}^{12} SVi * Wi \quad (2)$$

where HLVI refers to household livelihood vulnerability index, SVi is standardized value for each indicator. Table 4 summarises relative weights for the 12 indicators.

The household vulnerability index ranged from 0 to 1; close to 0 means high vulnerability and close to 1 means high resilience. Since indicators are dynamic, HLVI does not capture long-term changes but is a snapshot of vulnerability of particular households at a particular time (Antwi-Agyei et al., 2012). Nevertheless, it provides a general picture that allows comparisons among communities, identification of vulnerable households and can inform appropriate policy for climate change adaptation.

Table 2
Indicators of individual household vulnerability.

Individual household vulnerability components	Indicators of individual household vulnerability	Relevant References
Social capital consists of social resources such as networks, social claims, relations, affiliations and associations. Social capital is divided into three main types, including bonds, bridges and linkages.	*Indicator 1*: Number of community-based organisations that household members belong to. Households that belong to higher numbers of community-based organisation tend to be less vulnerable because of better social safety nets and grassroots insurance to cope with climate change impacts.	Scoones (1998) OECD (2007) Vincent (2007) Antwi-Agyei et al. (2012) Fraser (2007)
Human capital entails the skills, knowledge, ability to work and good health and physical capability to survive during climate-related crises. Human capital is a function of education, health, employment and the factors that affect these.	*Indicator 2*: Highest education attainment of household heads. Household heads with higher educational levels are assumed to have higher human capital and be well-informed with greater adaptive capacity to climate change. *Indicator 3*: Health status of household. Households with significant illness will be more vulnerable as treating illness put substantial strain on household resources.	Scoones (1998) Antwi-Agyei et al. (2012) Haines et al. (2006) Allison et al. (2009)
Natural capital refers to the natural resource stocks and environmental services which are useful for households to withstand climate change.	*Indicator 4*: Form of land tenure. The tenure system largely determines the quality of land management including the quality of soil, underground water, environmental protection and agricultural productivity.	Scoones (1998) Antwi-Agyei et al. (2012) Butt et al. (2006)
Financial capital refers to financial assets, including cash, credit, debt, saving, infrastructure and technology.	*Indicator 5*: Household income *Indicator 6*: Credit accessibility It is assumed that households with higher income and access to credit will be less vulnerable as they are able to absorb financial losses and invest in improvements to their adaptive capacity.	Scoones (1998) Antwi-Agyei et al. (2012) Adger (1999) Butt et al. (2006)
Physical capital encompasses factors of production, including e.g. machinery, buildings, equipment and computers.	*Indicator 7*: Presence of communication gadgets. *Indicator 8*: Presence of transport vehicles. *Indicator 9*: The quality of the house. These assets determine the adaptive capacity of the households as they are important for effective communication, accessing potentially risk-mitigating weather forecasts, better transport and safe shelters during extreme weather.	Antwi-Agyei et al. (2012) NSW (2013) Zhang et al. (2007)
Diversifying livelihoods can be recognized as one of the main components of a resilient household in the context of climate change.	*Indicator 10*: Main household livelihood activities. It is assumed that households with more livelihood activities can have more sources of income and spread risk, which can increase financial capital and contribute to decrease their overall vulnerability to climate variability	Antwi-Agyei et al. (2012) Ellis (1998) Barrett et al. (2001) Fraser et al. (2005)

As indicators fall into six distinct components, sub-indices were created for comparisons among the different components of vulnerability. The six sub-indices mapped onto the questionnaire survey structure and considered social assets, human assets, natural assets, financial assets, physical assets and livelihood diversification. The first five contain multiple indicators; therefore, aggregation on an unequal basis was employed regarding their relative weights.

Quantitative data were analysed using SPSS version 21.0.0.0. First, descriptive statistics were used to summarize and assess the normality of the data set. Independent t-tests were then applied to compare the relative vulnerability among households and among wards. The differences resulting in $p \leq 0.05$ were considered statistically significant. Finally, k-mean cluster analysis was applied to group households with similar vulnerability indices. This permitted identification of the general characteristics of households that belong to vulnerable or resilient communities.

2.3. Methods for assessing collective vulnerability

According to Adger (1999), collective vulnerability refers to 'vulnerability of a group or community to the impacts of climate change, involving a complete set of factors, including the institutional arrangements for preparedness for hazards' (p. 251). Indicators of collective vulnerability vary but the most important relate to governance and institutional capacity (Adger, 1999). Agrawal (2008, p. 5) defined institutions as 'human created formal or informal mechanisms that shape social and individual expectations, interactions and behaviour'. Agrawal considers climate change will have disproportionate impacts on different communities and that institutional capacity significantly influences community resilience through its influence on processes of gaining and using resources of social groups.

In assessing the ability of cities to cope with climate change, the Institute of Development Studies (2009) introduced an analytical framework for two indicators of collective vulnerability: good urban governance and institutional capacity for climate change adaptation. Table 5 introduces five criteria relevant to good governance and increasing climate resilience at a collective level building on the IDS framework and other literature, setting out the criteria used in the present study.

Qualitative methods were used to investigate institutional capacity for climate change adaptation at collective scale. 12 semi-structured interviews were conducted with 9 officials and 3 experts. With permission of interviewees, audio-recording was used. Interviewees were selected based on contacts made before fieldwork with a key informant at the Technology University of Da Nang. The selection of others was via snowball sampling (Babbie and Benaquisto, 2002) targeting officials and experts in different

Table 3
Indicators of individual household vulnerability to climate change for vulnerability assessment in the literature (). adapted from Antwi-Agyei et al., 2012

Component	Indicators	Questions in survey to obtain information on this indicator	Scoring procedure
Social assets	Number of community-based organisations that household members belong to	Does any member of your household belong to any community-based organisation? Please list them	- Households that did not belong to any organisation: score 1 - Household members belonged to 1 organisation: score 2 - Household members belonged to 2 organisations: score 3 - Household members belonged to > 3 organisations: score 4
	Access to climate information during typhoon events	From scale 1 to 3, how do you rank your accessibility to climate information before and during the event of typhoons or floods, which 1 means no access and 3 means your household is well informed?	A score from 1 to 3 was given according to rank provided
Human assets	Education level	What is the highest educational achievement of your household members	- No formal education: score 1 - Primary education: score 2 - Secondary education: score 3 - Tertiary education or higher: score 4
	Health status	Have any members of your household been ill enough to obtain medical treatment in the last year?	- Households with members that had obtained medical treatment within this period: score 1 - Households that had not sought medical attention within this period: score 2
Natural assets	Tenure system	By what arrangements do you have access to your landholding for your house?	- Rented the house: score 1 - Purchased the house: score 2 - Inherited the house: score 3
	Availability of clean drinking water during typhoon event	On a scale of 1 to 3, how do you rank your accessibility to clean drinking water during typhoon period, when 1 means no access and 3 means clean drinking water is always available?	Scores were equal to the chosen option
Financial assets	Access to credit	Do you have access to credit for your business activities?	- No access to credit: score 1 - Being able to access to credit: score of 2.
	Household income	Can you choose the category that best describes the monthly income of your household: 1. < 150£; 2. 150-300£; 3. 300£-600£; 4. > 600£	Score was equal to the chosen option
Physical assets	Ownership of communication gadgets	Does your family have any of these communication gadgets? Include: TV, mobile phone, radio, computer with network	- Households without any of these gadgets: score 1 - Households have all of them: score 2
	Ownership of vehicles	What type of transportation does your household possess: 1. No; 2: Bicycle; 3: Motorbike; 4: Car	Score was equal to the chosen option
	Category of house	Please choose the category of your house: 1. Bungalow; 2. One-story house; 3. Duplex house; 4. Detached house	Score was equal to the chosen option
Livelihood diversification	Livelihood diversity index	Please list the main livelihood activities of your household	- One livelihood activity: score 1 - Two livelihood activities: score 2 - Three livelihood activities: score 3 - Four livelihood activities: score 4 - More > 4 livelihood activities: scored 5

departments across scales. As gendered values and attitudes have profound effects on all social aspects (Jarviluoma et al., 2003), the research was also designed to have an equal gender representation; therefore numbers of female and male interviewees were the same. Table A2 provides a brief description of all interviewees (see Appendix A). To reduce bias in snowball sampling and ensure inclusivity of analysis, gathering data on collective vulnerability also relied on observations and secondary data from government reports. Data were triangulated with information obtained from the questionnaires.

The whole dataset was used to elucidate a narrative for the collective vulnerability assessment. Data from all methods which were either transcribed from audio recordings or typed from notes were put into NVivo version 10. Thematic coding identified key factors in the current governance structure, institutional capacity, relationships among specialized departments, coping mechanisms, current climate change policy and citizen participation. As themes emerged, similarities and differences within the data were further analysed to validate the findings and understand the circumstances that affect the patterns, attitudes and relationships between relevant sectors. Finally, background information from participants was analysed to explain any discrepancies in the themes.

Table 4
Weighting system based on households, officials and experts perceived relative importance of indicators.

Components	Indicators	Number of times ranked as most important	Relative importance	Weighting of indicator%	Rank
Social assets	Access to climate information during typhoon events	15	13.39	13	2
	Membership of community-based organisations	5	4.46	4	9
Human assets	Educational attainment of household	7	6.25	6	6
	Health status of the household	8	7.14	7	5
Natural assets	Form of land tenure system	7	6.25	6	6
	Availability of clean drinking water during typhoon events	7	6.25	6	6
Financial assets	Access to credit facility	4	3.57	4	9
	Income level of household	29	25.89	26	1
Physical assets	Ownership of communication gadgets	3	2.68	3	11
	Ownership of transportation modes	2	1.79	2	12
	Category of house	11	9.82	10	4
Livelihood diversification	Alternative livelihood options	14	12.50	13	2
N = 112 households, 9 officials and 3 experts		112	100	100	

Table 5
Indicators of collective vulnerability.

Indicators of collective vulnerability	Relevant criteria	Explanation in climate change context	Relevant References
Good Governance	Decentralisation and autonomy	This criterion refers to the integration among all scales from national, state and city. It is important to maintain the balance between top-down and bottom-up approaches and the necessity to include participation of citizens and all climate science agencies in the process of decision-making, planning and implementing.	Walker (2014) OECD (2009) IDS (2009) Rhodes (1997)
	Transparent and accountability	Discussions surrounding accountability in the literature focus on actors and their ability to hold upper or lower levels to account as well as whether or not they are held accountable by other levels through processes that allow openness in financial management and funding. Factors involved in enhancing transparency and accountability include legislation and administrative systems that facilitate access to information, as well as local media.	IDS (2009) Ribot (2003) Tsai (2007) Rhodes (1997)
	Participation and inclusion	Promotion of involvement of all local citizens in decision-making progresses and information exchanges is a key characteristic in improving resilience of the system. Many literature find that the poorest seem to be the most vulnerable since they often have marginal voices in community and lack of knowledge about climate change. Including citizens in decision-making and policy processes, and providing them with sufficient information are prerequisites to obtaining meaningful participation and inclusion	Holstein (2010) IDS (2009) Ribot (2003) Rhodes (1997)
Institutional capacity	Responsiveness and Flexibility	Climate change science contains many uncertainties, requiring flexible agencies and management systems to respond to unexpected and uncontrolled events. Presence of an inter-agency, cross-government body to deal with the impact of climate change and enhance human resources is needed, especially in order to involve qualified officials to integrate the work of climate scientists and promote the flexibility of institution.	IDS (2009) Stringer et al. (2014) Klintenberg et al. (2007) Dougill et al. (2012)
	Experience and support	Literature indicates that a resilient system requires the presence of existing experience on planning and implementation of integrated warning systems for extreme events. The success of implementation and adaptation strategies relies on technical and financial support, including support from NGOs, civil society organisation, research institutions and external donor agencies. All of these kinds of support enable knowledge exchange and better enhance adaptive capacity	IDS (2009) Pesket and Stephenson (2010) Phiri et al. (2012)

3. Results for individual household vulnerability assessment

Descriptive statistics on household vulnerability in My An and Hoa Quy wards are presented in Fig. 1. Standard deviations are relatively small compared to the means, indicating little variation. Since the significance values from the Test of Normality are > 0.05

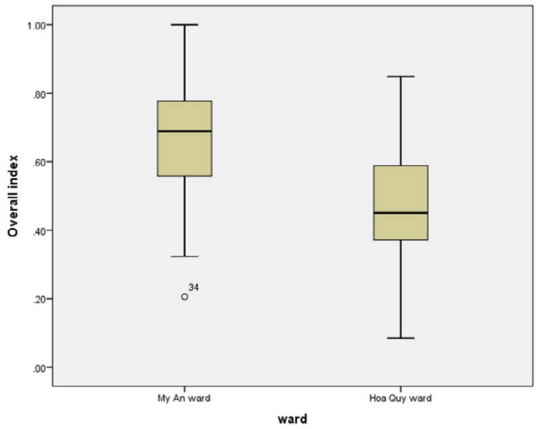

Fig. 1. Distribution of household vulnerability indices in My An and Hoa Quy ward.

in both wards, data sets are normally distributed.

An independent *t*-test indicates a statistically significant difference in vulnerability indices in these two wards ($p < 0.05$). My An recorded a higher vulnerability index on average (0.67) while Hoa Quy recorded a mean vulnerability index of 0.45. With the lower index, Hoa Quy was more vulnerable than My An. Fig. 1 demonstrates the distribution of vulnerability indices in these two wards.

Fig. 2 summarises the vulnerability sub-indices in My An and Hoa Quy. Financial assets recorded the highest sub-indices in both, indicating financial capital is relatively high and the biggest contributor to overall resilience. By contrast, the lowest sub-indices are for livelihood diversification. The number of livelihood activities that households engaged in was low. This contributes to increasing the vulnerability of these households.

Within the same ecological zone, households were classified into three major clusters of high, medium and low vulnerability. K-mean cluster analysis grouped the households that have similar vulnerability indices in one particular cluster. The significance value for the test is < 0.05, indicating the means of these clusters are statistically different. Fig. 3 shows the proportion of households in these three vulnerability index clusters.

Fig. 3 shows that the more vulnerable ward, Hoa Quy, recorded the higher percentage of households within the high vulnerability cluster (82%) with only 17% belonging to the low vulnerability cluster. My An (the more resilient ward) recorded 18% and 83% of households within the high and low vulnerability cluster respectively.

Households belonging to clusters of high and low vulnerability were explored in greater depth to provide insights into factors that contribute to increased or decreased household vulnerability. Results reveal some similar characteristics in access to assets and livelihood activities among the households within a particular cluster.

Overall the quantitative data suggest four main findings. First, there is a large variation in the degree of vulnerability to climate change among households within the same agro-climatic zone. Second, average household vulnerability in the district is relatively high. This indicates that the majority of households in NHSD have limited capacity to access livelihood assets, thereby reduced capacity to withstand the impacts of climate change. Third, findings consistently demonstrate that vulnerable communities in the district are characterised by households that have low educational levels, narrow livelihood portfolios and less access to physical, natural, financial and social capital. Fourth, governance and institutional support are important factors that determine the asset portfolio of a household. Many cases in Hoa Quy ward support this finding, since inappropriate land policy and lack of institutional support constrain the capability of poor households to access natural and financial assets (Adger, 2004), therefore increasing their overall vulnerability to climate change.

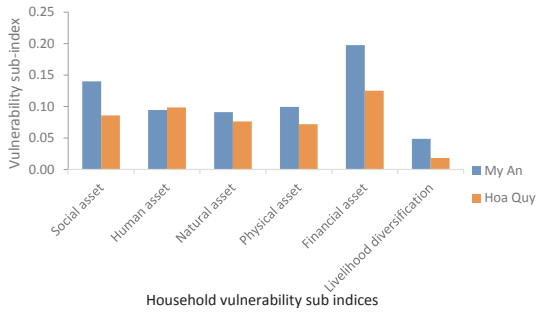

Fig. 2. Vulnerability sub-indices for six components in the study wards.

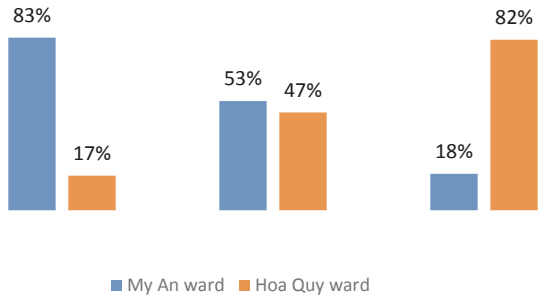

Fig. 3. Proportion of households in different vulnerability clusters in NHSD.

4. Results for collective household vulnerability assessment

The themes that emerged from the qualitative data are analysed alongside the five criteria of good governance and institutional capacity to climate change, two indicators for collective vulnerability.

4.1. Decentralisation and autonomy

Correlating with changes at national level, current governance in Da Nang city has slowly shifted from a traditional model based on central control to a more decentralised system with substantial authority devolved to local government (see Appendix A, Fig. A1 which presents key actors in the governance system and the relationships among them in building adaptive capacity of the community to climate change). However, in terms of climate risk reduction, the capacity and power of an actor seem to increase with the higher level in the governance hierarchy. This indicates the absence of successful decentralisation within the system. Results from key informant interviews show some aspects of climate change governance, such as enforcement and monitoring, have been prioritized for devolution to local actors. Most projects related to flood control and local climate change adaptation and are conducted by district and ward actors under supervision of the relevant specialized departments. Nevertheless, other aspects such as financial resources and autonomy have been passed to ward actors in a very limited way, resulting in low capacity to implement projects effectively and be accountable to citizens.

Interviews and secondary data show many explanatory factors contribute towards such partial decentralisation in the climate change governance system. First, local officials have limited financial and human resources to hold actors to account and pro-actively promote enforcement. A member of Hoa Quy ward said '*It is very difficult for us to deal with a significant amount of issues from citizens. There are only about 50 people handling over 20,000 residents with many critical issues related to immigration, urbanisation and natural disasters in this ward.*' Second, there are overlapping management functions in the current three-level model. Functions, powers and responsibilities are not defined clearly among specialized authorities. An official said: '*Lack of information transfer and lack of co-operation among the specialized departments are problems*'. Therefore, devolving power from municipal level is somewhat ineffective and many actors do not have sufficient power to fulfil their management role as well as coordinate with other actors. Finally, interviews reveal misjudgement of officials at municipal level about decentralisation within the system. Without a track record of effectiveness of decentralisation at lower levels, the municipal government neither recognises the need for improving the capacity of the local level nor modifies the governance structure to be more effectively decentralised. Lack of decentralisation in the city governance system is associated with ineffectiveness in implementing many climate change adaptation programmes at local level. The adaptive capacity of communities and institutions therefore declines over time, leading to increased collective vulnerability to climate change.

4.2. Transparency and accountability

In terms of transparency, land administration and land use are the weakest areas. Questionnaires and secondary data reveal that the lack of published information on government portals regarding land maps, land price frames and house reallocation, affects financial and physical assets of households, leading to a change in vulnerability of households to climate change. In Ngu Hanh Son district, due to construction of bridges and public hospitals, thousands of households have been relocated. The municipal government compensates these households by granting new land or giving them a flat in public accommodation on a temporary basis. However, in Hoa Quy ward (the more vulnerable ward), replacement land for these households is in very poor condition. People in many areas have no access to clean drinking water, electricity or acceptable quality housing. Reducing physical capital results in a reduction of overall household resources and increases vulnerability to climate change, especially when a typhoon or any climate extreme event is in place. In December 2014, an investigation by the Department of Planning and Investment found 1700 ha of land hidden by state-owned construction companies (Da Nang Department of Planning and Investment, 2015). These lands had been owned illegally by state-owned enterprises instead of being granted to citizens who are in need. When investigators asked officials about the reasons for hiding these lands, they gave very general answers, blaming non-transparency in withdrawing lands from private agents and granting lands to public enterprises during the Economic Reform in 1982. Lack of transparency in land administration is an important

explanation for increasing household vulnerability to climate change in this case.

In terms of accountability, unequal distribution of capacity (power, human resources and financial resources) among climate change actors leads to inequitable institutions of accountability in implementing adaptation programmes. When actors have higher capacity to deal with climate problems, it tends to be when they are located at a higher level within the governance system. At the same time, the level of citizen participation decreases, and so do upward flows of information. This makes the actor less accountable to citizens and other actors in terms of financial management, exchange of climate information and legal processes of implementing adaptation. Delivery of a climate resilient system at collective level is thus limited. Consequently, both collective vulnerability and household vulnerability are increasing due to the limitations in accountability and transparency in climate governance system.

4.3. Participation and inclusion

There is a lack of citizen participation in decision-making processes targeting climate change issues in Da Nang city. Promoting citizen awareness of grassroots democratic rights and creating incentives for people to engage in climate policy decision making present key challenges. Results from qualitative data indicate the presence of constructive citizen participation only at ward level, resulting in little benefit for communities. Interviews also show that the majority of disaster management plans are created by officials or neighbourhood leaders without public consultation. Once the plan is approved, information is then delivered from local authorities to people via mass media or community meetings.

Each of these issues significantly affects citizen participation in climate change adaptation. First, the lack of multidirectional information and the dominance of upward information flows only, between citizens and ward government, gives little meaning to the notion of citizen participation in climate change decision-making processes within the rest of the governance system. Downward flows of information in most cases represent enforcement of regulations rather than provision of information that can enhance knowledge and improve adaptive capacity of citizens to climate change. Second, the lack of education and climate change knowledge on the part of the poor households limits their capacity to participate in climate change decision-making processes. Even if there are platforms for citizen involvement in each ward, they only promote participation of wealthier citizens, and have negligible effects on the poor- the most vulnerable. When asking households to score their accessibility to climate information before and during the events of typhoons or floods (1 means no access, 2 means sometimes and 3 means always), 9% of households scored 1, 39% scored 2. Of these households, 80% were located in Hoa Quy, the more vulnerable ward. Access to information is an issue for half of the surveyed households. Lack of citizen participation in decision-making, especially of the most vulnerable, constrains the effectiveness of long-term development and climate change policy goals, and reinforces the disconnection between climate actions and people's everyday needs and priorities.

4.4. Responsiveness and flexibility

In Da Nang city, a number of institutions have been established to deal with climate change related issues. Da Nang Climate Change Coordination Office (CCCO) is the leading body responsible for development of climate policy, strategies adaptation programmes in the city. Results show a lack of governance processes and information flows between lower actors and the CCCO, affecting the representation of multiple district actors and limiting understanding of community circumstances. Interviews also show that the CCCO has limited capacity to implement international climate change adaptation and mitigation projects due to lack of human and financial resources. Respondents noted that '*Establishing the CCCO Steering Committee is more like a must-do response to the national climate change plan rather than finding experts that are capable of addressing climate change problems*'.

With a long history of withstanding natural disasters, city administrative staff and systems are reasonably proactive and flexible to address changes in climate. Although capacity of ward actors is still limited, results from interviews show that many of the public officials at higher levels are competent, informed, ready for challenges, and open to new technologies. Interviewee C said: '*Even though there have been many limitations in designing and implementing, I think what we have done so far is quite good. Compared to other cities in Vietnam, Da Nang is one of the pioneers in tackling climate change'.* Overall, the current governance system in terms of responsiveness and flexibility seems to have moderate capacity to respond rapidly to different scenarios of climate shocks, making good progress in increasing the resilience of the city to uncertainties in the climate system.

4.5. Experience and support

Da Nang is significantly vulnerable to climate hazards such as sea level rise, typhoons and floods. While citizens have thousands of years of historical experiences in coping with these disasters, promoting adaptive capacity and increasing resilience to long-term human-induced climate change are still relatively new concepts for the communities. Enhancing climate resilience in the city thus entails integration of climate change adaptation plans and risk management together with existing infrastructure and institutional capacity in related areas. Evidence from qualitative interviews and official documents reveals that financial shortfalls are the main constraint to building the city's resilience. Past recovery schemes for natural disasters have been financially supported by international donors and the central state. Centralised budgeting is associated with a delay in relief schemes and ineffectiveness of project implementation.

Overall, findings show numerous challenges within the governance system in Da Nang city to deal with climate change problems. This is not conducive to good governance, thereby hampering collective scale adaptive capacity to climate change. Evaluation of the current governance system to climate change adaptation against the five criteria indicates that overall climate vulnerability in Da

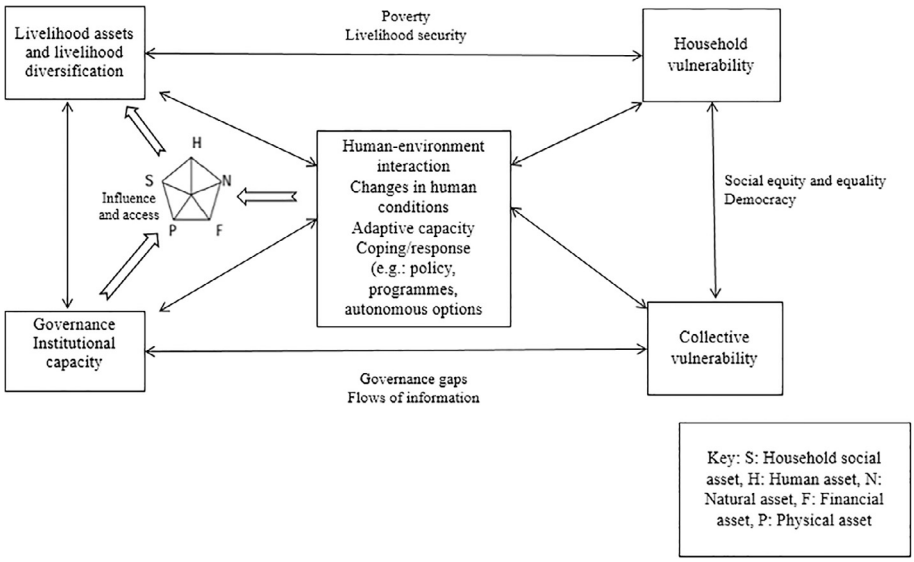

Fig. 4. Analysis of overall vulnerability across scales.

Nang city is moderate to high at the collective scale.

5. Discussion

This section is divided into three parts. Objectives 1 and 2 are addressed by discussing the factors that affect vulnerability at household scale (Section 5.1) and collective scale respectively (Section 5.2). Section 5.3 addresses objective 3 which covers the complex interaction between household vulnerability and collective vulnerability, discussing the factors that influence the overall vulnerability of the district. Policy implications are considered at the end of each part.

Fig. 4 emerges from the data and synthesises vulnerability across scales and its indicators with diverse and complex linkages, and informs the structure of the discussion. Changes in *human-environment interaction, human conditions, adaptive capacity* and *coping/response* are common interconnections found among these indicators and vulnerability at different levels. Four smaller feedback loops represent the relationships among the indicators and the vulnerability across scales. The bigger loop, taking all elements into account, represents the complex feedback system of the overall vulnerability. Each of these smaller loops is discussed. We then return to Fig. 4 at the very end to consider the links between household and collective vulnerability.

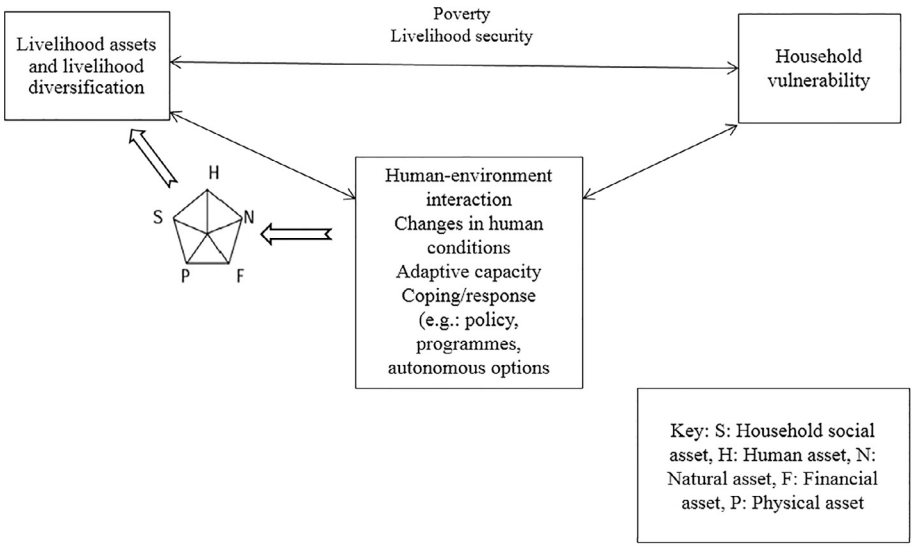

Fig. 5. Factors influencing household vulnerability.

Table 6
Key characteristics of vulnerable and resilient households.

Household vulnerability indicators	Resilient households	Vulnerable households
Human assets	Most households have no > 4 members. Numbers of financial dependents are relatively low in these households. 93% of these households have members who attain higher education.	Most households have 5–8 members. One adult worker in these households often is financially responsible for more than three people. Only 45% of these households have members who attain higher education.
Physical assets	73% of households have detached or duplex houses and none of these households lives in a bungalow. Households possess most of the communication gadgets and transport vehicles in the list.	75% of households live in bungalows and only 6% of households have duplex houses. None of these households possesses a car or a mini electricity generator.
Financial assets	All households earn more than £300 a month. None of these households is classified as poor.	Most households have income less than £150 a month. 75% are classified as poor households. There are 5 extremely poor households without access to credit
Natural assets	All households are able to access clean drinking water during typhoon events	51% of these households are unable to access clean drinking water during typhoons. Their houses were granted by the government under the land allocation policy. Houses are in areas of poor infrastructure. They find it difficult to access clean water and electricity during typhoons.
Social assets	Both bonding and bridging social capital are present in most households. Their social networks are highly connected with the wider community. Some households have political power in the ward.	Most households do not belong to any identifiable community-based organisation. They rarely engage in decision making processes
Livelihood Diversification	Households' income sources are diversified into non-agricultural jobs. Non-agricultural jobs include engineers, teachers, doctors or jobs in business and hospitality sectors. All households have at least two sources of livelihood	Agriculture is the only source of income in these households. Growing crops and grazing are their main livelihood activities. No form of non-agricultural job is found.

5.1. Household scale vulnerability

The first small loop represents the factors affecting household vulnerability (Fig. 5), where *livelihood assets* and *livelihood diversification* are the vulnerability indicators considered.

Findings indicate that households with access to capital assets and diversified livelihood portfolios are less vulnerable to climate change, improving their *adaptive capacity* to cope with climate change. The influences these indicators have on household vulnerability is discussed in relation to two underlying elements: *poverty reduction* and *livelihood security*.

The role of poverty reduction in enhancing adaptive capacity of households has been widely discussed (see Moser, 1998; Sen, 1999; Brooks et al., 2005; Antwi-Agyei et al., 2012). Moser and Satterthwaite (2008) argue that poverty is associated with narrow asset portfolios of households and significantly increases their vulnerability to withstand climate change. Results from Table 6 support this argument, showing the most vulnerable households in NHSD are those in poverty. Poverty, which constrains access to resources, affects household vulnerability in terms of limiting ability to mitigate risks, reducing their coping range and recovery from damages, and decreasing their resilience to impacts (Adger, 1999). We have also demonstrated that poverty is institutionally shaped and directly related to policy. Inappropriate land policy and lack of transparency in municipal government directly push more households in NHSD into poverty, thereby increasing their vulnerability to climate change.

Livelihood security refers to a livelihood that 'can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation' (Chambers & Conway, 1992). Livelihood diversification provides a meaningful way to approach livelihood security (Hussein and Nelson, 1998). People who are highly vulnerable to climate change generally rely on climate-sensitive resources for their livelihoods (Füssel, 2012; Okpara et al. 2017). Table 6 indicated that the households that rely only on agricultural activities largely belong to the most vulnerable cluster while the most resilient households have diversified their income into non-agricultural sources. Supporting early studies by Ellis (1998) and Barrett et al. (2001), our research has shown a negative relationship between number of livelihood activities and household vulnerability. Our study therefore provides additional evidence to demonstrate that diversifying livelihood activities into non-agricultural forms offers potential to help vulnerable households buffer the negative impacts of climate change.

Three policy implications emerge from this to help improve household resilience in NHSD. First, policy makers need to formulate targeted and specific climate policies that promote more equitable access of households to livelihood assets so as to increase adaptive capacity to climate change. Second, poverty reduction should be placed at the centre of considerations when designing and implementing climate adaptation policies and programmes. The poor are the most vulnerable to climate change and should be targeted in terms of increasing their financial capital first, followed by increasing their overall resources that can be used to reduce climate change impacts. Third, policy should support multiple livelihood strategies and enhance livelihood diversification. Encouraging agriculturally-dependent households to diversify their incomes into non-agricultural sources will help reduce their vulnerability to climate change.

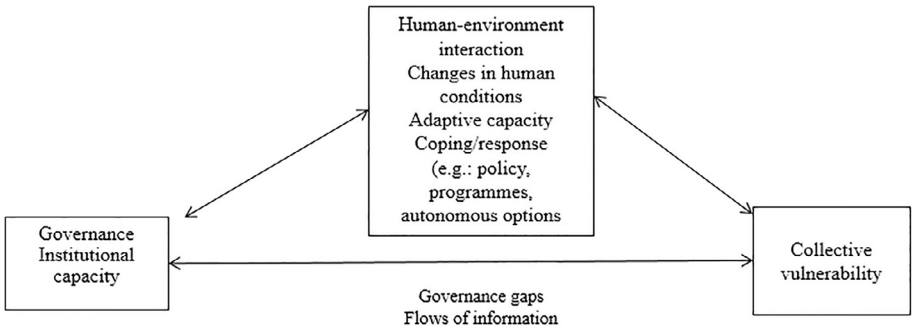

Fig. 6. Factors influencing collective vulnerability.

5.2. Collective scale vulnerability

The second small loop (Fig. 6) which we extract from Fig. 4 provides insight into factors that affect vulnerability at a collective scale. Results indicate that the indicators *governance structure* and *institutional capacity* determine how resilient the *coping* range is, the effectiveness of the *response* and *policy*, and the *capacity* of communities to withstand climate change, thereby directly influencing the degree of *collective vulnerability*. There are also two underlying elements involved in these interactions that have not been discussed in the previous sections: *governance gaps* and *flows of information*.

Governance gaps refer to 'the lack of an active and responsible actor or process within the governance system that elicits the necessary qualities to contribute to good governance' (Harrison et al., 2014, p. 30). Findings indicate two significant governance gaps in Da Nang city that result in failure in building resilience to climate change: the lack of governance processes between the CCCO and lower actors, and the lack of citizen participation in the governance system (Appendix A, Fig. A1). These gaps have created confusion in terms of the implementation of climate programmes across scales and inappropriate channels of participation and representation. Many studies have discussed the need to establish cross-boundary processes, mechanisms and responsible actors in climate change governance in order to improve the adaptive capacity of communities and eliminate climate risks (see Lemos and Agrawal, 2006; Fröhlich and Knieling, 2013). Our study provides additional evidence that highlights the necessity to find routes to bridge these governance gaps to reduce vulnerability at a collective level.

Multidirectional information flows across the governance system can either amplify or attenuate the vulnerability of communities to climate change. Results show a lack of effective downward information flow that could empower and update actors at lower levels and a lack of upward links that garner participation and representation in Da Nang city. This significantly constrains the effectiveness of collective climate actions and increases collective vulnerability. Various studies have discussed the role of information exchange in risk analysis and climate change risks in particular (see Kasperson et al., 1988; Sala, 2010). Our study augments evidence on how information flows affect social experiences and public responses to climate change. Two policy implications emerge that could decrease collective vulnerability to climate change in NHSD. First, there is a critical need to bridge the governance gaps in the city. The municipal government and the CCCO should work more directly with communities in implementing and designing new adaptation projects. Administration reform, especially of financial, human and infrastructural resources, is needed to enhance the effectiveness of decentralisation to lower level actors, enabling them to fulfil their obligations. The second proposal is to build an effective communication system which frames communication within development planning. This requires systematic application of principles, strategies and processes of communication and information transfer to obtain positive social changes (Sala, 2010). The scale and quality of stakeholder involvement in collective climate change actions are important in determining financial resources, legitimacy and effectiveness of implementation. Any communication system should therefore involve participation of multiple stakeholders including governmental and non-governmental organisations, research institutes, citizens, public institutions and representatives from the private sector.

5.3. Overall vulnerability

5.3.1. Interactions among indicators of vulnerability across scales

The third small loop represents the two-way interactions between indicators of collective vulnerability (*governance* and *institutional capacity*) and indicators of household vulnerability (*livelihood assets* and *livelihood diversification*) (Fig. 7).

Governance processes, policies and institutional capacity determine exchanges between different types of household assets, as well as access to assets and livelihood strategies. In NHSD, local government has provided physical infrastructure for shelters and financial support to help people recover from damage caused by typhoons. Financial support schemes which provide start-up capital for citizens to start businesses has increased the choice and flexibility that people have in their livelihood options. Provision of extensive social services has enhanced social safety nets and promoted citizen well-being. However, corruption and incompetent governance related to the land allocation policy constrain the opportunity for poor people to access sufficient physical assets, thereby increasing their vulnerability to climate change. This evidence demonstrates how vulnerability indicators at collective level directly influence those at household level. This influence has also been discussed in the Sustainable Livelihood Framework (Scoones, 1998).

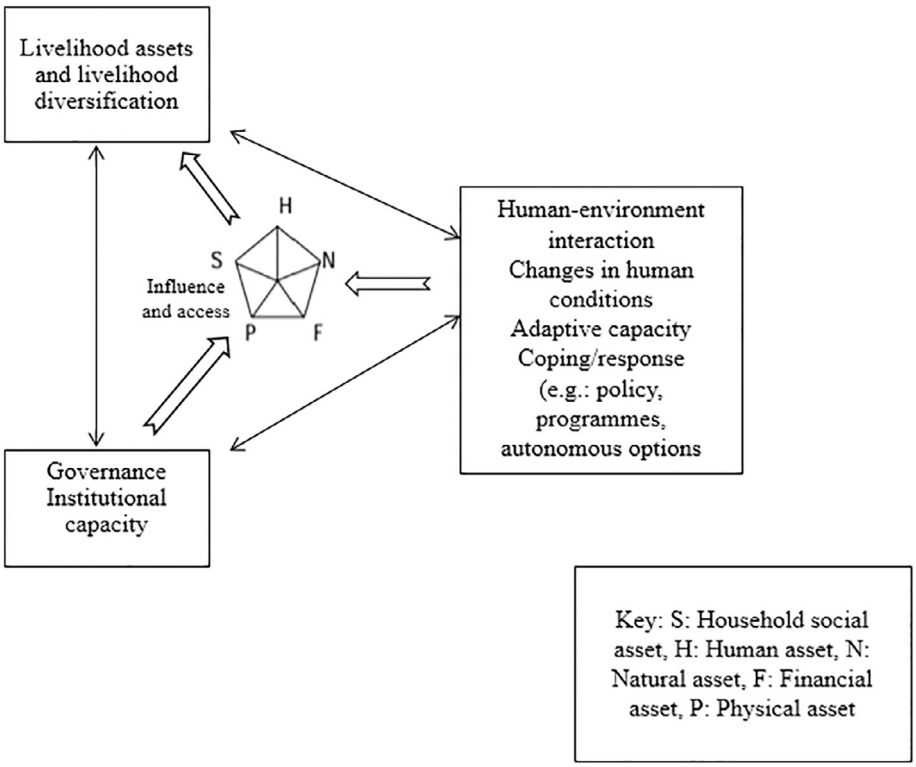

Fig. 7. Interaction among vulnerability indicators across scales.

Policies and governance processes can determine the distribution of assets and the livelihood strategies of households.

Indicators of household vulnerability (livelihood assets and livelihood diversification) can also influence indicators at collective level (governance and institutional capacity). Increased capacity of households to access livelihood assets and diversify livelihood activities can result in increased human well-being and economic development. Economic development then is correlated with better education systems, increased awareness of climate change and more incentives for citizens to participate in decision-making processes (Sachikonye, 2002). All of these changes facilitate political stability and contribute to good governance and increased institutional capacity to adapt climate change (Adger, 2004).

Evidence presented in this study suggests a complex feedback loop between the indicators of vulnerability across scales. This further strengthens Adger's (1999) argument that household vulnerability and collective vulnerability are interlinked and should not be considered independently in vulnerability assessment.

5.3.2. Interactions between collective vulnerability and household vulnerability

Interactions between collective vulnerability and household vulnerability involve both direct and indirect linkages (Fig. 4). Direct interaction is firstly discussed in relation to the final small loop (Fig. 8).

Change in vulnerability at one level through changes in *policy, responding programmes* and *adaptive capacity* leads to a change in vulnerability at other levels. Although the relationship between collective and household vulnerability has not been clearly defined in previous literature, Adger (1999) who also focused on Vietnam, found this relationship to be positive. That is, a decrease in vulnerability at collective level leads to a decrease in household vulnerability and vice versa. However, our research provides a new insight that this relationship can be either negative or positive. The extent to whether it is positive or negative depends on *social equity and equality* and *democracy*.

Social equity refers to the idea of moral equality, that all human beings should be treated equally (Jones, 2009). The procedural and distributive dimensions of equality and equity are important in determining how vulnerability at collective level affects household vulnerability. Ikeme (2003) suggested that equality and equity should be considered in the distribution of climate change impacts, costs and benefits, responsibility and in the progress of designing, implementing and monitoring adaptive policies and programmes. Equity and equality play important roles in determining the variation in the degree of household vulnerability in the community (Otto et al., 2017) and the effectiveness of climate policies. Findings from NHSD demonstrate a common problem, that policy does not benefit the most vulnerable households. All policies that have been discussed related to enhancing climate change education, encouraging citizen participation and financial support from the government directly benefit upper and middle class income households, with negligible effects on improving the resilience of poor households in Hoa Quy ward. Without considering equity in policy making, a resilient collective system does not necessarily correlate with decreased household vulnerability in the entire population. Instead, it correlates with increased inequality in vulnerability among communities.

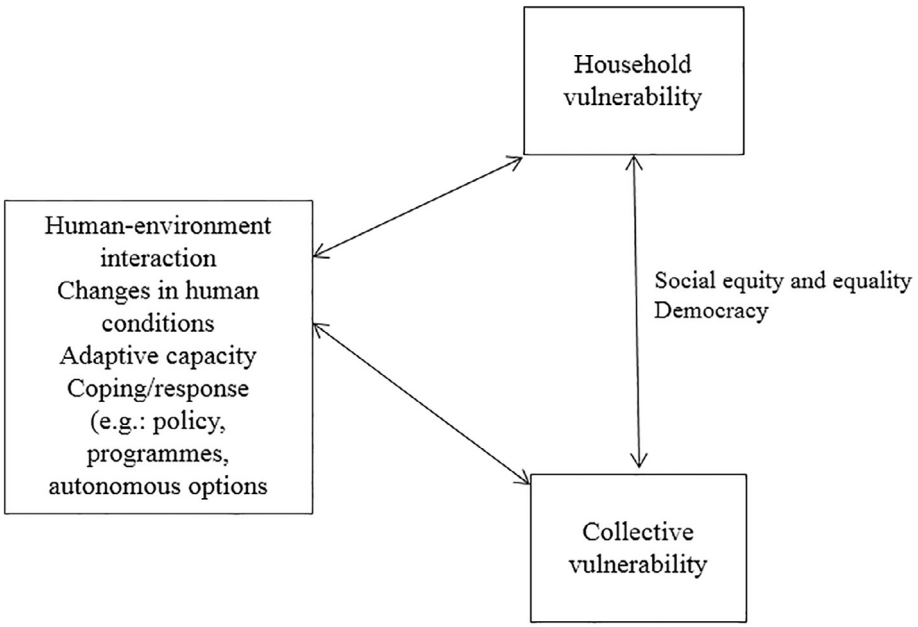

Fig. 8. Interaction between household and collective vulnerability.

Democracy is defined as 'a basic right of citizenship to be exercised under conditions of freedom, equality, transparency and responsibility, with due respect for the plurality of views and the interest of the polity' (Inter-Parliamentary Union, 1998, p. 4). Democracy shapes how household vulnerability affects collective vulnerability. Even though household vulnerability on average in My An ward (the more resilient ward) is lower than in Hoa Quy ward (the more vulnerable ward), collective vulnerability seems not to differ between these two wards. Due to limited democracy in Da Nang city, the level of citizen participation in these two wards is quite similar regardless of differences in degree of household vulnerability. This demonstrates that reducing household vulnerability does not necessarily have a positive impact on collective vulnerability. Without democracy, levels of citizen participation decrease, government is less accountable and transparent to citizens, leading to an increase in collective vulnerability. Therefore, a community with resilient households can also have high collective vulnerability.

The complexity of interactions between household vulnerability and collective vulnerability was presented in Fig. 4. Through these smaller feedback loops, the bigger loop takes all elements into account, providing insight into the various factors that influence overall vulnerability. Relationships between household and collective vulnerability, between their indicators and between the indicators and vulnerability are dynamic and highly context dependent. All factors in Fig. 4 influence overall vulnerability and many more underlying factors exist in reality but have not been considered. This suggests that policy-makers should consider the complex system as a whole in designing climate policies, and seek a win-win solution, which simultaneously decreases vulnerability at both household and collective level. In NHSD, there is a need to promote social equity and equality as well as democracy in decision-making processes. By improving these factors, the relationship between collective vulnerability and household vulnerability is more likely to deliver positive outcomes. The effectiveness of climate policies therefore can be enhanced as policy targeting vulnerability reduction at one level can also have desirable impacts on reducing vulnerability at other levels.

6. Conclusion

This study investigated factors that influence the social vulnerability to climate change in Ngu Hanh Son District, Vietnam. It developed and applied a livelihood vulnerability index at household scale, identifying the characteristics of resilient and vulnerable households. It then analysed collective vulnerability in terms of current governance and institutional capacity in Da Nang city. Findings provided insight into the complex system of overall vulnerability with all its interlinked elements across scales in the district. In general, the population in NHSD experiences moderate vulnerability at both scales. Results indicate that vulnerable households tend to have limited access to human, natural, physical, financial, social assets and a diversified livelihood portfolio. Findings suggest policy should promote equitable household access to livelihood assets, reduce poverty and encourage livelihood diversification into non-agricultural sources in order to reduce vulnerability at household level. In terms of collective vulnerability, numerous challenges in the climate change governance system have been indicated. The most important challenges are the lack of multidirectional flows of climate information, the lack of good governance processes between the CCCO and the lower actors as well as the lack of citizen participation in the governance system. It is critical to find ways to bridge these governance gaps and establish an effective communication system to reduce the collective vulnerability to climate change in NHSD.

Overall, this study has articulated the complex feedback system of vulnerability across scales, using a study of NHDS in Vietnam. Different communities experience different challenges and threats due to climate change. Developing a comprehensive multi-scale

vulnerability assessment that is applicable to different circumstances requires rich, mixed, method analyses that unpack the complex interactions between human and environment, as has been advanced in this study.

Acknowledgement

We sincerely thank officials in Da Nang city who assisted during the period of data collection. The second author was supported by the Economic and Social Research Council's Centre for Climate Change Economics and Policy (CCCEP), grant number: ES/K006576/1.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.crm.2018.02.003.

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