

Assessing the Adaptive Capacity of Coastal Urban Households to Climate Change (Case Study in Liên Chiểu District, Đà Nẵng City, Vietnam)

Mai Trọng Nhuận^{1,*}, Nguyễn Thị Hồng Huế¹, Nguyễn Tài Tuệ¹, Trần Mạnh Liễu²

¹VNU University of Science, 334 Nguyễn Trãi, Thanh Xuân, Hanoi, Vietnam

²VNU Center for Urban Studies, 144 Xuân Thủy, Hanoi, Vietnam

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Abstract: The present paper aimed to develop the theoretical framework for assessing the adaptive capacity of coastal urban households to climate change. The adaptive capacity framework consisted of six dimensions and 23 indicators, which were applied to households in Liên Chiểu district, Đà Nẵng city. The result revealed that the communities in Hòa Khánh Nam and Hòa Hiệp Nam ward were the highest and lowest adaptation to climate change, respectively. The adaptive capacity of households was relatively correlated with the inherent capacity of economic, human and social capitals and external capacity of municipal services, environmental quality, and the level of urban stability and security. For better adaptation to climate change, the urban planning and policies should enhance the household economy, human and social capitals. The adaptive capacity indicators were relatively simple, but promised framework to assess the complexity and adaptation processes of a socio-natural system in coastal areas. The theoretical framework could be used to study the adaptive capacity of households in other coastal areas with appropriate modification.

Keywords: Adaptive capacity, climate change, coastal urban, Liên Chiểu district.

1. Introduction

Climate change (CC) has caused severe impacts on socioeconomic development, natural resources and environment in Vietnam. The major consequences of climate change include precipitation variability, temperature rise, and severe disasters such as storms, floods, droughts, and salinity intrusion. Over the past 50 years, the average temperature has increased approximately 0.5°C in the whole country while

rainfall has decreased by 5-10% in the north and increased by 5-20% in the south, respectively [1]. The projected sea level rise at 1 m in height will cause an encroachment of the salinity and flooding areas of 39% in Mekong Delta, 10% in Red Delta and Quang Ninh province, and >2.5% in the central areas. Thus, the coastal urbans in Vietnam with high population density and fast socioeconomic development will be highly vulnerable to CC. For coastal Da Nang city, the projected sea level by 2030 will increase from 11.6-11.8 cm and cause a flooding area of 2.4 km² [2].

* Corresponding author. Tel.: 84-913341433.
Email: mnhuan@yahoo.com

In order to reduce the vulnerability to CC impacts, it is necessary to build adaptive capacity (AC) by supporting adaptive action [3]. The AC researches aim to determine existing adaptive plans and strategies for the purpose of increase adaptation to climate risks [4]. Recently, several researches in Vietnam have conducted for proposing measures to reduce vulnerability and to enhance adaptation to CC, for example, assessing the vulnerability of coastal communities in Red River Delta [5] and the adaptation to flooding risks in Ho Chi Minh city [6].

CC adaptation has been currently concerned in different sectors and scales toward specific objectives of socio-natural systems. In which, the household is an important element of the complex socio-natural system that appears to be vulnerable to climate change. Therefore, a research on CC adaptation at household scale is

necessary to build the effective strategies for enhancing adaptation and reducing vulnerability. Adger et al. [7] indicated that decision of investment strategies, political support, and education should be made at the household scale and greater influence vulnerability and sustainability of the system [8].

Da Nang city is one of the fastest growing cities in Viet Nam and strongly threatened from CC. Assessment of the adaptive capacity of households in Da Nang city is needed to propose measures and strategies to reduce vulnerability and increase adaptation to CC. The present paper aims to develop the theoretical framework for assessing the adaptive capacity of coastal urban households to climate change and to apply this framework to measure the adaptive capacity of households in Lien Chieu district, Da Nang city.

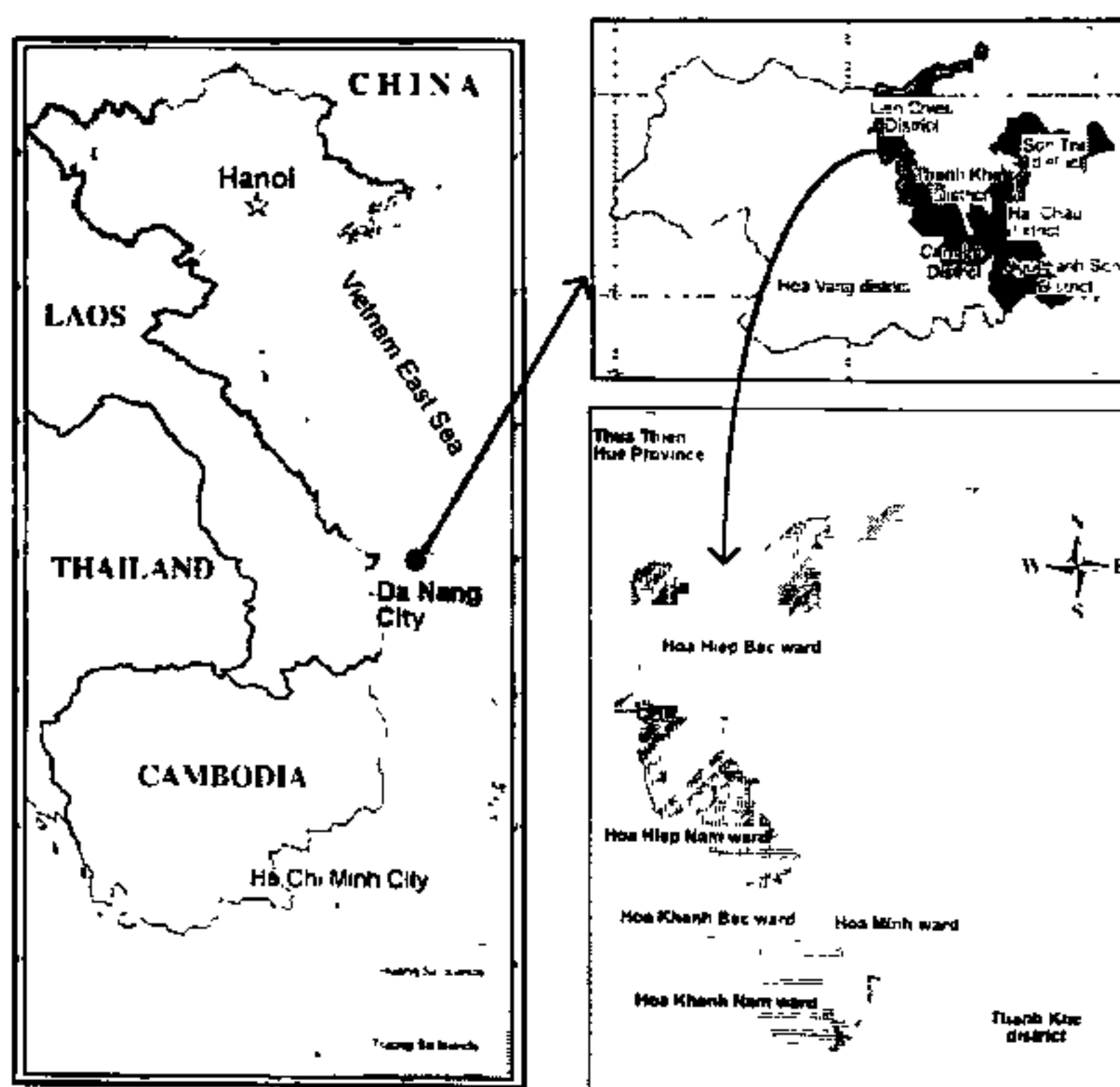


Fig. 1. The study area and five wards of Lien Chieu district.

Table 1. Area and population of five wards in Lien Chieu district

Ward	Area (km ²)	Population (person)
Hoa Minh	7.92	41,807
Hoa Khanh Nam	9.77	27,728
Hoa Khanh Bac	9.97	45,605
Hoa Hiep Nam	7.88	17,285
Hoa Hiep Bac	43.59	15,047
Total	79.13	147,472

Source: [9]

2. The study area

Lien Chieu district is located in the northwestern Da Nang city. The district consists of five wards of Hoa Minh, Hoa Khanh Nam, Hoa Khanh Bac, Hoa Hiep Nam and Hoa Hiep Bac that cover a total area of 79.13 km² (Table 1, Fig. 1). The population of Lien Chieu district in 2012 was 147,472 people with the highest proportion from Hoa Khanh Bac ward. The major economic sectors are industry and handicraft, occupying approximately 44% labour force. The district has two large industrial zones named Lien Chieu and Hoa Khanh [9].

Lien Chieu district is located within a tropical monsoon climate zone with a rainy season from August to December and a dry season from January to July. Mean of temperature and rainfall was 26°C and 7,682 mm in the period of 2004-2013, respectively [10]. The temperature is often higher from May to August in comparison with the rest of the year. Lien Chieu district has frequently faced with severe disasters and extreme weather events. The statistical data showed that rainfall mainly happened from September to December, accounting for 75% annual rainfall and tended to increase in the period from 1978-2013. The high rainfall levels caused 80 flood events in the same period [11]. From 1998 to 2013, the district has been affected by 26 tropical storms,

13 tropical depressions, and 46 flood events [2]. Among them, a flood event occurred in November 2013 caused serious damage [12]. The local people said that disasters often cause blackout and displacement of 48% and 52% households in Lien Chieu district.

3. Theoretical framework and methodology

3.1. Theoretical framework

Adaptive capacity is defined as “the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences” [13]. Assessment of adaptive capacity will provide important information in establishing and developing efficient strategies for CC adaptation [14]. Adaptive capacity has been assessed in different scales from household, community, sector, region, to country and is an important component in the vulnerability [14-16] and resilience assessment [5,17].

The adaptive capacity of households can be determined by economic [18] and social resource [19] indicators. The economic and social indicators consist of household income, employment, assets, health, gender, age, education, institution, science and technique

[14,15,19]. Wall and Marzall [20] indicated that household having better knowledge in disaster mitigation and CC adaptation will cope better with CC and obtain opportunities from changing conditions [20]. In general, adaptive capacity to CC is assessed by integrated indicators (e.g., economic, human, social, physical, and governance capitals) of the socio-natural system.

In the present paper, the theoretical framework for household's adaptation to CC is divided into six dimensions, containing 23 indicators (Table 2). The adaptive capacity of households to CC could be measured by the inherent capacity (economic and human capitals) and the external capacity (social, infrastructure, natural resources, and governance capital). The external capacity is exterior sources that will improve the inherent capacity, for example, governance is a major mechanism to increase the inherent capacity [21]. In the present paper, the hypothesized indicators are chosen to ensure three major criteria: easy to understand, represent to adaptation of household, and data availability. The below definitions are shown for six dimensions:

Economic capital refers to the economic potential of the household to adapt with CC, consisting of wealth, livelihood diversity, durable assets and insurance coverage.

Human capital represents the ability of skill, knowledge, and awareness of the household members.

Social capital/social relation can be measured by the social relations and cohesion, comprised social communication, participation in social organization and community funds, and the supports from the community and relative.

Infrastructure capital refers to the ability to access the municipal services, including health care, electricity supply, and waste collection and treatment services.

Natural capital includes the environmental quality and natural resources that can directly improve other capacities of household to adapt to CC.

Governance capital denotes the democratic chance for household to involve in urban planning and the level of urban stability and security.

3.2. Scoring methods of AC indicators and index

The adaptive capacity indicators are normalized on the scale of 0-1 by three scoring methods (Table 3), consisting of (1) standardized based on min-max theory [22], (2) converted to the scale of 0-1 for semi-quantitatively indicators based on weights for adaptation practices, and (3) calculated the value of 0 or 1 score based on the qualitative data. For the 0-1 scale, if the indicator value is more asymptotic to 1, it will indicate a higher adaptive capacity, and *vice versa* if that indicator value is more asymptotic to 0, it will indicate lower adaptive capacity.

The min-max theory ranks the level of each indicator following Eq. (1):

$$x_{ij} = \frac{X_{ij} - \text{Min}X_{ij}}{\text{Max}X_{ij} - \text{Min}X_{ij}} \quad (1)$$

Where x_{ij} is the standardized value of indicator i of the household j ; X_{ij} is the value of the indicator i corresponding to household j ; Max and Min denotes the maximum and minimum scaled values of indicator i .

Table 2. Indicators hypothesized to influence urban household'adaptation

Dimensions	Variables	Indicators
Economy	Wealth	Household income
	Livelihood diversity	Type of livelihood activities
	Durable assets	Housing conditions Household goods, communication equipment, transportation Rate of households using flush toilet
	Insurance coverage	Number of insurance coverage
Human	Education	People graduated above secondary level
	Skills and experience for CC adaptation and disaster mitigation	Tools for disaster mitigation and CC adaptation Skills and experience of CC adaptation and disaster mitigation
	Awareness about disaster, CC	Participation in training courses, propagation, rehearsal for disaster mitigation and CC adaptation Sharing and exchanging information on disaster and CC
Social	Social communication	Participation in social organizations
	Social power	Participation in community funds Supports from communities and relatives
Infrastructure	Health services	Quality of health facilities
	Waste service	Household waste collection and treatment services
	Power supply	The quality of electric supply
Natural resources	Water quality/quantity	Water contaminated Water sources using during disaster
	Soil quality	Soil contaminated
	Air quality	Air pollution
Governance	Democratic policy	Household involvement in urban planning
	Urban stability and security	The level of urban stability and security

The adaptive capacity index of household ($AC_{household}$) and ward (AC_{ward}) are calculated as sum of the AC indicators (ACI_i), households, and wards using Eq. (2), and (3), respectively.

$$AC_{household} = \sum_{i=1}^n ACI_i$$

(n is the number of AC indicators; $i = \overline{1, n}$;
 $n=23$) (2)

$$AC_{ward} = \frac{\sum_{j=1}^m AC_{household_j}}{m * n}$$

(m is the number of interviewed households,
 $j = \overline{1, m}$) (3)

Table 3. Variables hypothesized to influence the adaptive capacity of households and scoring methods

Indicator	Explanation and scoring methods
Scoring method (1): indicators are quantified by Eq. (1) based on the number of hypothesized indicators	
Durable assets	The number of durable assets in household (e.g. refrigerators, electric fans, air conditioning, television, telephone, radio, computer, bicycles, motorcycles, cars).
Number of insurance coverage	The number of health insurance, life insurance, boat insurance, vehicle insurance, etc.
Tools for disaster mitigation and CC adaptation	The number of tools for disaster mitigation and CC adaptation (<i>sandbag, life-jacket, rope, line to brace the house, water storage items, boat, medicine, ladder, string piece, water pump</i>)
Skills and experience for CC adaptation and disaster mitigation	The number of skills and experience for CC adaptation and disaster mitigation (bracing house, strengthen roof, evacuating to safe areas, adjusting cultivation)
Participation in training courses, propagation, rehearsal for disaster mitigation and CC adaptation	The number of training courses, programs for disaster mitigation and CC adaptation that household participated
Participation in social organizations	The number of social organizations that households participated (e.g. Women's Union, Farmer Union, The Old Union).
Supports from communities and relatives	The number of support sources from relatives and others during and post-disasters
People graduated above secondary or higher level	The number of people graduated above secondary level
Scoring method (2): indicators are converted into the 0-1 scale based on weights for adaptation practices	
Wealth	Household wealth is categorized by four levels with respective scores: 0: poor 1/3: near poor 2/3 : moderate 1: rich
Livelihood diversity	Score is assigned by the livelihood activities: 0. 1 type 1/3. 2 types 2/3: 3 types 1: more than 3 types
Housing condition	Indicator is categorized by level of housing condition 0: temporary structure 1/3: semi-permanent 2/3: permanent house with one floor 1: permanent house with more than one floor

Indicator	Explanation and scoring methods
Sharing and exchanging information on disaster and CC	Indicator is scored by level of sharing and exchanging information on disasters and CC 0: no 1/3: seldom 2/3: occasionally 1: often
Quality of health facilities	Indicator is scored by effective level of health facilities (hospitals, clinics, private health care establishment) 0: bad 1/2: moderate 1: good
Quality of electric supply	Indicator is scored by the frequency of blackout 0: often 1/2: occasionally 1: seldom
Water resource assess during disaster	Water resource assess during disaster is scored based on quality of water sources: 1/3: well water 2/3: rain water 1: tap water
Urban stability and security	Indicator is scored by level of stability and security in urban area 0: unstable 1/2: stable 1: very stable
Scoring method (3): For quantitative indicators yes or no	
Households using flush toilet	0: not in use 1: in use
Participation in community funds	0: no participation 1: participation
Household waste collection and treatment services	0: no service 1: good service
Water contaminated	0: contaminated 1: no contaminated
Soil contaminated	0: contaminated 1: no contaminated
Air pollution	0: pollution 1: no pollution
Household involvement in urban planning	0: no involvement 1: involvement

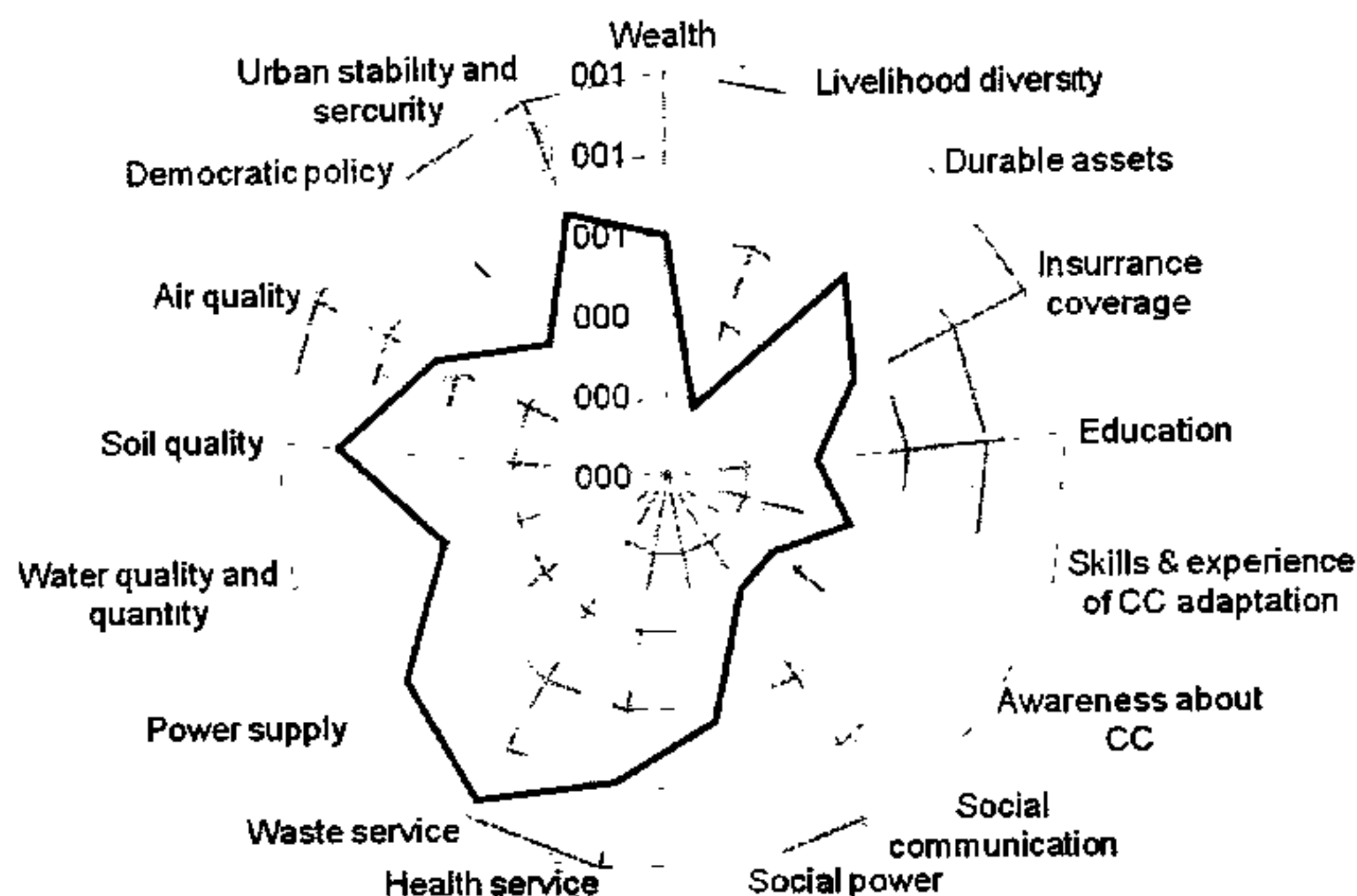


Fig. 2. The pattern of adaptive capacity variables of household in Lien Chieu district.

3.3. Data collection and processing

The household interview was completed using a questionnaire to collect the data and information on 23 indicators (Table 2) for assessing the household's adaptation to CC. The household survey was conducted in June 2014. In each ward, the number of questionnaire samples is randomly distributed to 25 households from the household list. The quick interview method was also used to gather other information on strategies and policies to CC and disasters of local areas. The interviewed data were processed by Microsoft Excel (version 2013) and MapInfo (version 10).

4. Results and discussion

4.1. Adaptive capacity characteristics of households in Lien Chieu district

The means of adaptive capacity variables are shown in Fig. 2 for household in Lien Chieu

district. The data showed that households in Lien Chieu had relatively high scores in wealth, durable assets, and skills and experience for CC adaptation. The household also satisfied with *the external capacity* of social power, the municipal services of health, waste and electric supply, environmental quality, and the level of urban stability and security.

The household economy was measured by wealth, housing condition and insurance coverage. In which, the wealth of the household was a major factor that determined the housing condition, as our observation in Hoa Khanh Nam and Hoa Khanh Bac wards (Fig. 3).

The human capital was mainly measured by the education levels and skills and experience for CC adaptation and disaster mitigation. The percentage of people graduated from above secondary level was 62.1%, 46.4%, and 40.4% for Hoa Khanh Bac, Hoa Khanh Nam, and Hoa Hiep Bac ward, respectively (Fig. 4). In

addition, more than 61.5% households in Lien Chieu districts had more than three CC adaptation tools, even 84% households in Hoa Khanh Nam ward. This pattern suggests the urban households in Lien Chieu district were proactive to respond to CC and disasters. In social capital, the proportion of households participated in community funds was 100 and 61% for Hoa Khanh Nam and Hoa Minh ward, respectively (Fig. 5).

The adaptive capacity indicators of municipal services of waste collection and treatment, soil quality, and the level of urban stability and security had the high scores. Results showed that 92% household in Lien Chieu district could assess the municipal services of waste collection and treatment.

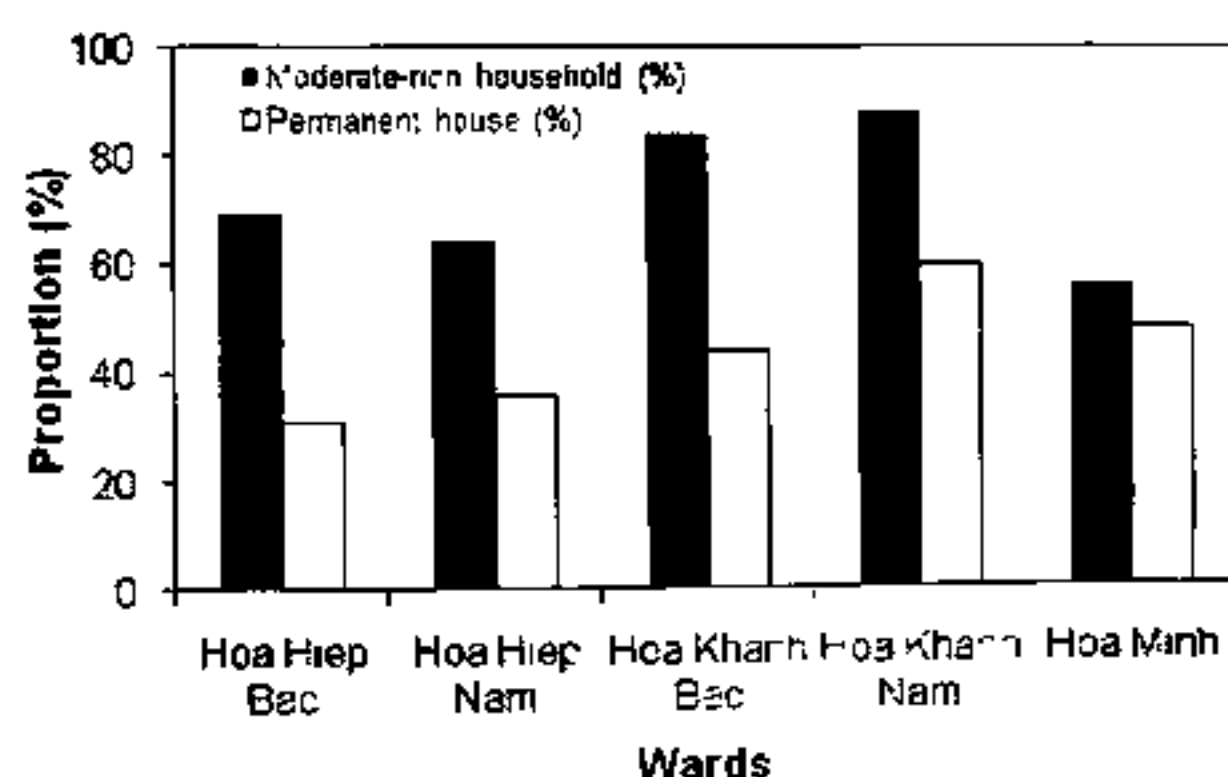


Fig. 3. Proportion of household wealth and permanent house for households in Lien Chieu district.

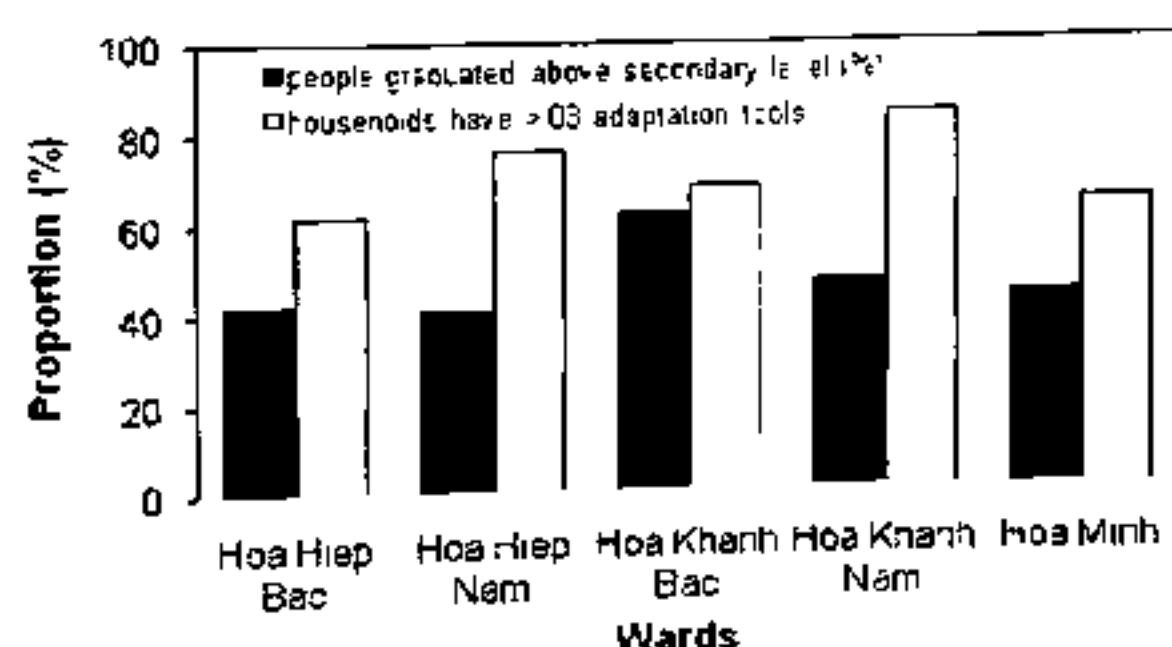


Fig. 4. Education level and tools for disaster mitigation and CC adaptation of households.

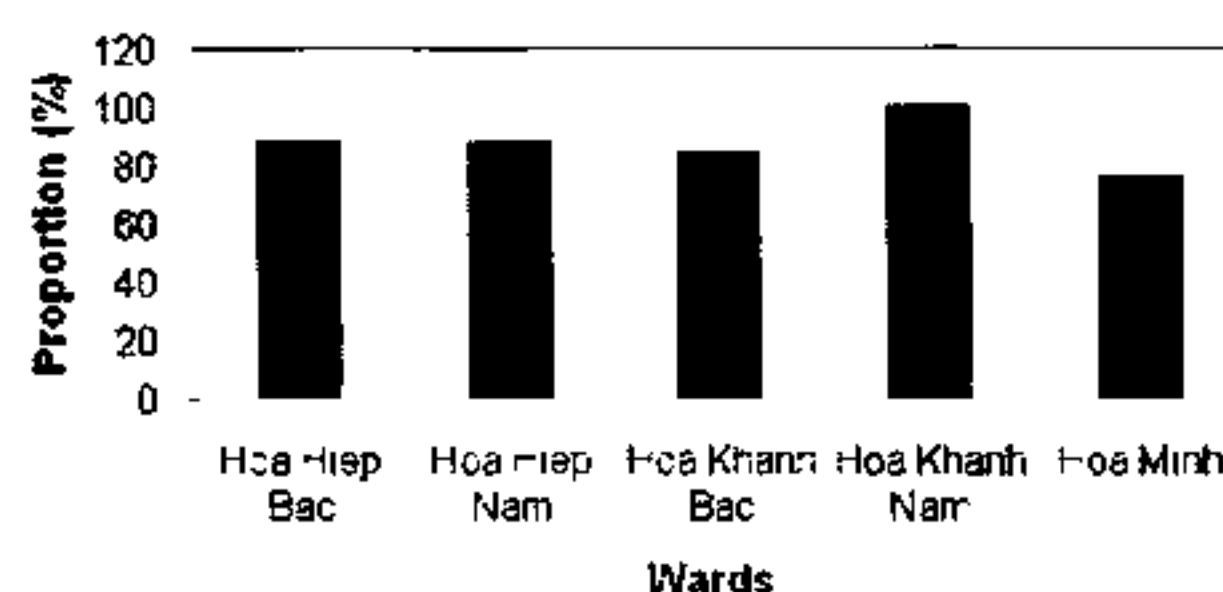


Fig. 5. Proportion of households participated in community funds.

In sum, the present results suggested that wealth and skills of climate change adaptation and disaster mitigation of households were major contributors to the total adaptive capacity to climate change and disasters. In addition, the external resources, including social power, municipal services, urban stability and security also played significant roles in enhancing the household's adaptation to climate change.

4.2. Adaptive capacity characteristics of wards in Lien Chieu district

The present results showed that the adaptive capacity index of five wards varied in a small range, from 0.56 (for Hoa Hiep Nam and Hoa Hiep Bac) to 0.59 (for Hoa Khanh Nam) (Table 4, Fig. 6). The highest adaptive capacity index for Hoa Khanh Nam ward was mainly related to the highest economic, human and infrastructure capitals. The lowest adaptive capacity index for Hoa Hiep Nam and Hoa Hiep Bac wards was determined by low economic and human capitals despite of the highest adaptive capacity score of social capital. Two wards Hoa Khanh Bac and Hoa Minh had similar indices and had the highest scores in natural capital and governance capital, respectively.

Table 4. The adaptive capacity indices of six dimensions and five wards in Lien Chieu district

Wards	Economic capital	Human capital	Social capital	Infrastructure capital	Natural resources	Governance capital	Adaptive capacity index
Hoa Hiep Bac	0.57	0.40	0.57	0.84	0.57	0.49	0.56
Hoa Minh	0.51	0.39	0.50	0.82	0.73	0.67	0.57
Hoa Khanh Bac	0.52	0.39	0.46	0.81	0.76	0.63	0.57
Hoa Khanh Nam	0.59	0.42	0.54	0.91	0.67	0.43	0.59
Hoa Hiep Nam	0.52	0.35	0.58	0.85	0.59	0.64	0.56

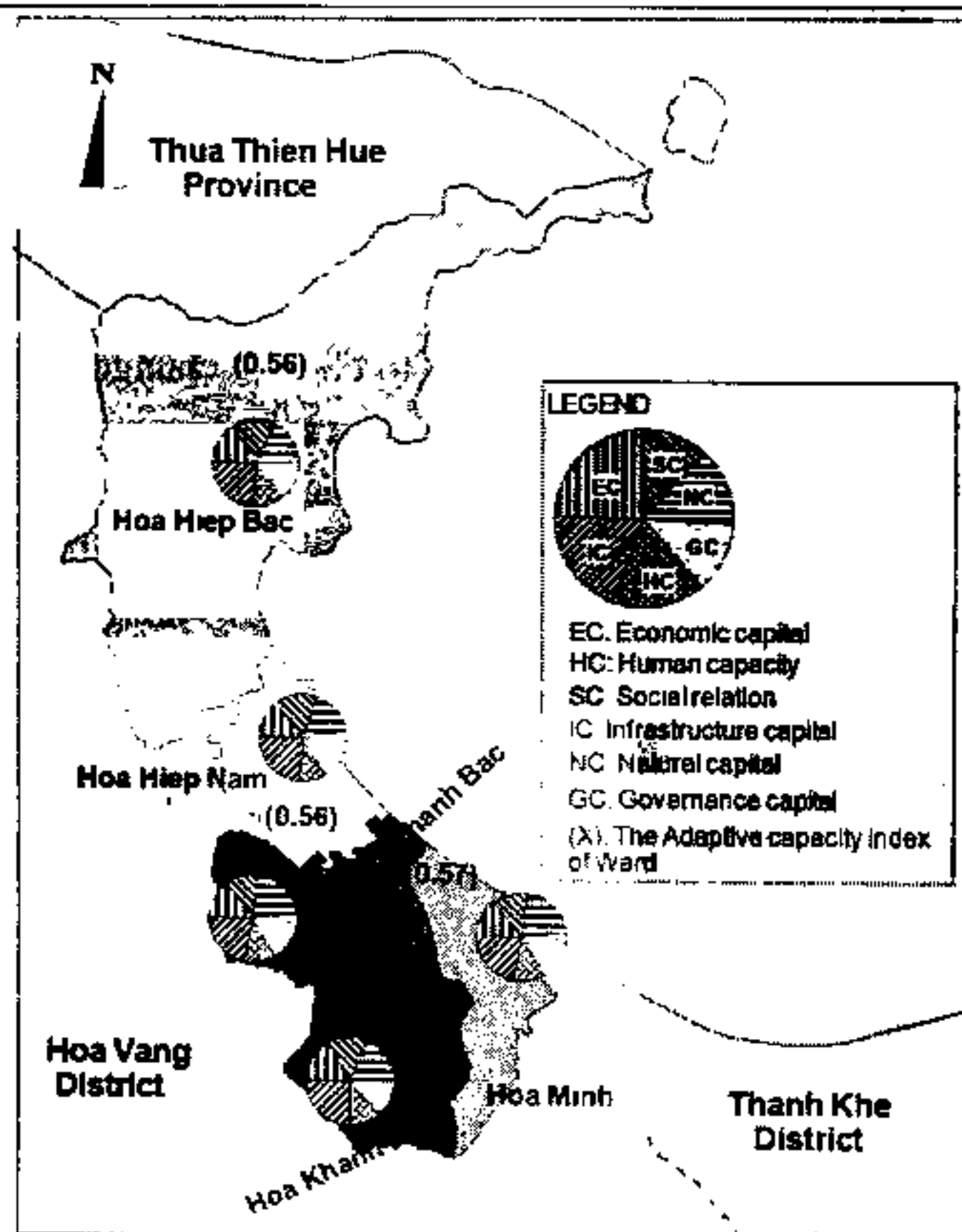


Fig. 6. Adaptive capacity for each ward in Lien Chieu district.

4.3. Lessons learned from AC of households in Lien Chieu district

The present paper demonstrated that the inherent capacity of economic and human capitals, and the external capacity of social relation, the municipal services, environmental quality, and the level of urban stability and security were major contributors of the adaptive capacity of households to CC in Lien Chieu

district. The urban planning and policies should include following measures to enhance adaptive capacity to CC of households in Lien Chieu district:

Developing labour programs for households in order to increase income of the household, including sustainable livelihoods, reduce employment rate and, transformation of the climate change challenge to opportunities

(e.g. shift the cultivated techniques, agricultural product to higher adaptation to variable condition);

- Enhancing social relations for households by promoting social cohesion in social organizations and community funds;

- Enhancing awareness of households by increasing knowledge and information on adaptation to climate change through targeted education and outreach efforts.

Supporting institutions by establishing policies and strategies for enhancing the efficiency and quality of health facilities, schools, democracy, and the level of urban security and stability enhance.

5. Conclusions

The objectives of the present paper were to develop methods for assessing the AC at the household level in the coastal districts of Vietnam. The indices were relatively simple but promised framework to assess the complexity and adaptation processes of a socio-natural system in coastal areas. The theoretical framework consisted of six dimensions and 23 indicators for assessing adaptive capacity of households to climate change. For the Lien Chieu district, the results showed that the communities in Hoa Khanh Nam and Hoa Hiep Nam wards could be ranked as the highest and lowest adaptation to CC, respectively. The adaptive capacity of households was reasonably correlated with economy, human and social capital. It is recommended that the urban planning should increase the adaptive capacity levels of households by implementing the policies and strategies to enhance the inherent capacity of household (economy, human and social capital) and the external capacity

(municipal services, environmental quality, and the level of urban stability and security). The theoretical framework from the present study could be used to study the adaptive capacity of households in other coastal areas with appropriate modification.

Acknowledgements

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Đánh giá khả năng thích ứng với biến đổi khí hậu của các hộ gia đình ở đô thị ven biển (lấy ví dụ ở quận Liên Chiểu, thành phố Đà Nẵng)

Mai Trọng Nhuận¹, Nguyễn Thị Hồng Huệ¹, Nguyễn Tài Tuệ¹, Trần Mạnh Liễn²

¹Đại học Khoa học Tự nhiên, 334 Nguyễn Trãi, Thanh Xuân, Hà Nội, Việt Nam

²Trung tâm Nghiên cứu Đô thị, Đại học Quốc gia Hà Nội, 144 Xuân Thủy, Hà Nội, Việt Nam

Tóm tắt: Mục tiêu của bài báo này nhằm đề xuất khung đánh giá khả năng thích ứng với biến đổi khí hậu của hộ gia đình ở đô thị ven biển. Khung đánh giá gồm 6 hợp phần và 23 chỉ tiêu được áp

dụng đánh giá khả năng thích ứng với biến đổi khí hậu cho các hộ gia đình ở quận Liên Chiểu, thành phố Đà Nẵng. Kết quả chỉ ra rằng cộng đồng tại phường Hòa Khánh Nam và Hòa Hiệp Nam lần lượt có khả năng thích ứng với biến đổi khí hậu cao nhất và thấp nhất. Khả năng thích ứng của hộ gia đình có mối tương quan với đặc trưng của hộ gia đình gồm các hợp phần kinh tế, con người và mối quan hệ xã hội và các đặc trưng của đô thị như các dịch vụ công cộng, chất lượng môi trường và an ninh trật tự tại đô thị. Như vậy, để nâng cao khả năng ứng phó của hộ gia đình với biến đổi khí hậu, các địa phương tại quận Liên Chiểu nên có các chính sách và quy hoạch đô thị phù hợp nhằm phát triển các hợp phần kinh tế, con người và xã hội cho các hộ gia đình. Khung đánh giá khả năng thích ứng cho cấp hộ gia đình ở đô thị lần đầu tiên được đề xuất tại Việt Nam, có ý nghĩa cung cấp phương pháp nghiên cứu, đánh giá khả năng ứng phó của hệ thống tự nhiên - xã hội và cộng đồng ở các đô thị ven biển.

Từ khóa: Khả năng thích ứng, biến đổi khí hậu, đô thị ven biển, quận Liên Chiểu.