



Original Article

Identifying the Role of Determinants and Indicators Affecting Climate Change Adaptive Capacity in Da Nang City, Vietnam

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Abstract: Identifying the role of determinants and indicators affecting climate change adaptive capacity (AC) in developing Da Nang city's climate change adaptation policies is necessary. However, the methods of identifying the role of determinants and indicators affecting AC are relatively limited. This study used the exploratory factor analysis (EFA), confirmative factor analysis (CFA), structural equation modeling (SEM) and set of five determinants affecting to the city's AC related to finance, society, infrastructure, human resources, nature. A socio-economic data was conducted in the survey of 1,168 households in Da Nang city. The results indicate that city's AC is strongly correlated with infrastructural, social and natural resources. Thus, the infrastructural, social and natural determinants are the decisive determinants affecting to the city's AC. The AC indicators and the used methods in this study can be applied to determine the role of those determinants and indicators affecting to AC in other coastal provinces in Vietnam.

Keywords: Climate change, EFA, CFA, adaptive capacity, Da Nang.

1. Introduction

Climate change adaptive capacity is defined as the adjustment of natural or human systems to cope with circumstances or environments in order to reduce the likelihood of vulnerability due to fluctuations and alternations of existing or potential climate variables and also to take advantage of this situation [1]. The AC of a social system can be influenced by many social

variables or AC determinants [2]. Quantification of AC determinants can provide essential data for AC assessment [3,4] and development of successful climate change adaptation strategies [5]. However, depending on national, regional or community scale, so that, different kinds of AC indicators structure have been applied. For local and community scales, previous studies have used sustainable livelihoods frameworks to analyze the relationship between livelihood

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resources and households and communities' AC, assessing vulnerability to natural disasters and climate change impact and risk assessment [6-12]. And the AC indicators are mainly developed from local expert experience. Therefore, the development and replication of AC indicators need to be adjusted for appropriate spatial and social contexts [13].

The methods used to assess AC and identifying the role of determinants and indicators affecting AC are mainly unequal weighting methods with the calculation according to Iyengar - Sudarshan method (1982) [14], and the Analytic Hierarchy Process (AHP) [11] and especially Nelson et al. [7,9,15] had used the primary component analysis method (PCA) to assess AC at different scales. This study, using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) to determine the weights of AC indicators. In comparison to traditional methods such as multivariate regression, the use of SEM is more advantageous related to calculating measurement errors [16].

In Da Nang City, there were some studies on AC for households and identifying determinants affecting to households' AC [17,18]. However, these studies focus on urban households and use PCA, multivariate linear regression equations to assess AC and determine the role of

determinants affecting AC for urban households [19] and households of Lien Chieu district [17], and Hoa Vang district [18].

Therefore, the use of Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) to identify the role of determinants and indicators affecting to AC in DaNang city is chosen for this paper research.

The objectives of the study are (1) Developing AC indicators for Da Nang City, (2) Identifying the role of determinants and indicators affecting AC for coastal city Da Nang. The results of this study can provide useful information to Da Nang city authority in developing climate change adaptation policies. Moreover, the results of this study can be used to identify the role of determinants and indicators affecting to the AC for other coastal provinces in Vietnam.

2. Background and Method

2.1. Research Area

Da Nang is a leading city located on the central coast of Vietnam with a number of natural, economic, social, infrastructural and human characteristics affecting to AC as follows (Figure 1).

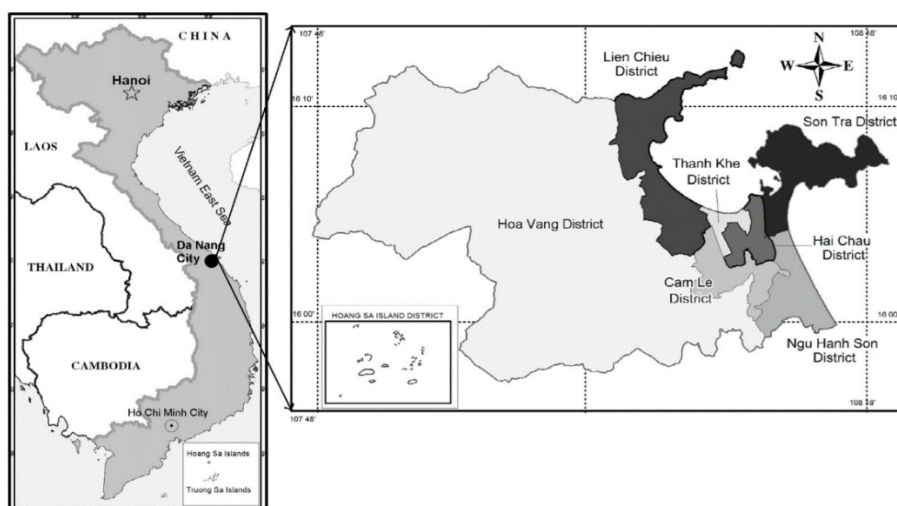


Figure 1. Da Nang city Map [17].

Nature: Total area of Da Nang city is 1,283.42 km² including the mainland and archipelago in the East Sea. The topography of Da Nang City has both delta and mountains where concentrated high and sloppy mountains are located in the West and Northwest and the coastal delta is a Eastern salinized plain. The aquaculture area is nearly 0.5 thousand hectares [20].

Economy: The Gross Regional Domestic Product (GRDP) in 2018 at current prices has reached USD 3,909.8 million, an increase of USD 325 million compared to the number in 2017. Regarding economic structure in 2018, the agricultural, forestry and fisheries sector have accounted for 1.83% of GRDP; industry and construction sector have accounted for 29.32%, in which the industry have accounted for 22.24%; service sector have accounted for 56.17%; Product taxes minus product subsidies have accounted for 12.68% [21].

Society: Da Nang is a well-known city for tourism with spectacular landscapes and unique culture, 20 festivals every year including 18 folk festivals, 1 religious festival and 1 tourism cultural festival [20].

Infrastructure: Four types of transport forms including road, railway, waterway and airway are popular in Da Nang city. Water supply and electricity supply systems for daily life and production are gradually being upgraded and newly developed to better serve the lives of people as well as for production and business activities. Communication system has flourished, modernized and become the third leading center in the country [20].

Human Resources: By 2019, the total city population has reached 1,134,310 people including 576,000 male population (accounting for 50.7%) and more than 558,000 female population (accounting for 49.3%). A number of urban population is nearly 990,000. The population density is 883 people/km² [22].

2.2. Research Method

2.2.1. Selecting Climate Change Adaptation Capacity Framework (AC)

Some studies on the AC indicator structure at city scale present the description of AC determinants. Gay Defiesta proposes 6 determinants of the AC indicator structure: human resources, material resources, financial resources, information and livelihoods [11]. U.S.Thatsarani proposes 4 determinants of the AC indicator structure: finance, society, human resource, infrastructure [23]. Mai Trong Nhuan proposed 6 determinants of AC indicator structure: household economy, social relations, human resources, adaptation practices, urban services and governance [19].

Remy Sietchiping proposed 3determinants of the AC indicator structure including culture-society, economy and institution-infrastructure [24]. Darren Swanson proposes 6determinants of the AC indicator structure including economy, technology, information-capacity-management, infrastructure, institution-management, fairness [25]. Katharine Vincent proposes 5 components of the AC indicator structure: stability and status of the household economy, demographic structure, information, resources, and household quality [26]. (Figure 2).

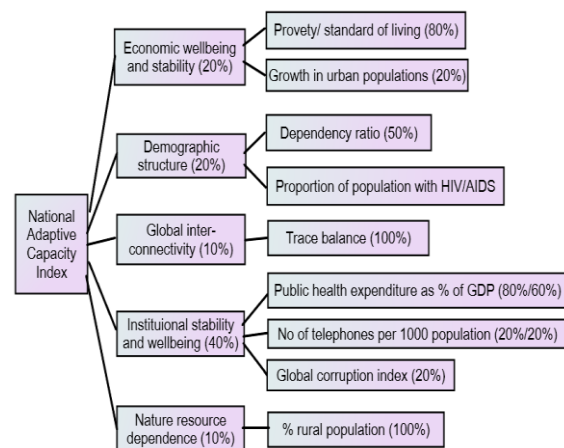


Figure 2. Structure of AC indicator for national and regional scales [25].

In this study, a sustainable livelihood framework of the UK Agency for International Development [27], AC indicators for Northwest Victoria, Australia [24], AC indicators for Pairai, Canada [25] and AC indicators for Da Nang City, Vietnam [17] are chosen to apply and

developed the determinants and indicators structure for assess Da Nang city’s AC. The expectation of the relationship among the determinants and indicators in the proposed research model is shown in Figure 3.

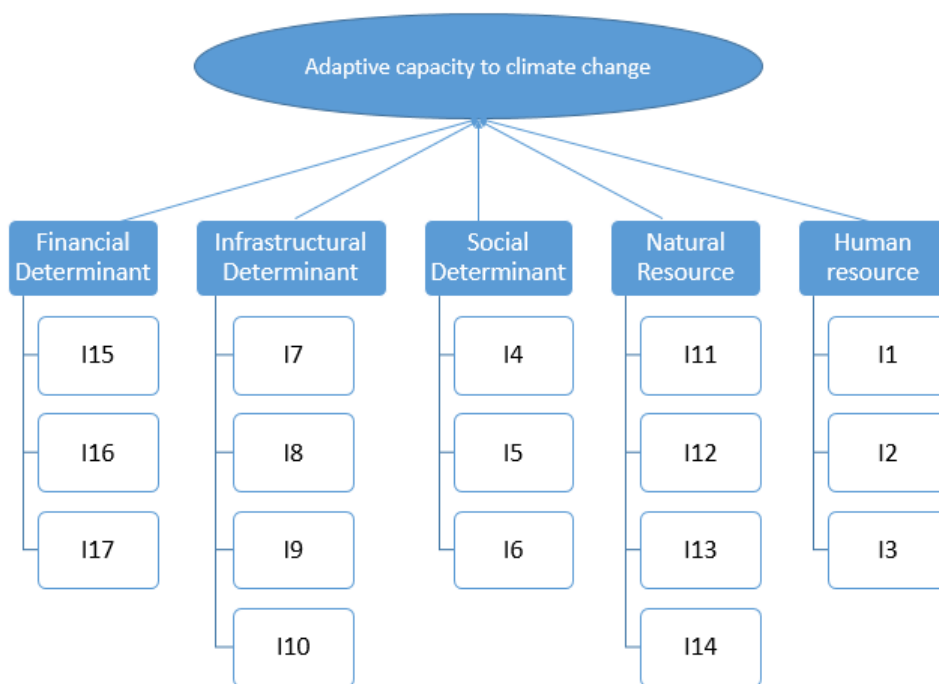


Figure 3. The proposed research model. (Source: From the studies [17, 23, 24, 26]).

In this study, 20 AC indicators have been identified (Table 1 below), including 17 AC indicators described independent variables and 3 AC indicators described dependent variable. These selected AC indicators are assumed as

meeting all following criteria: understandable easily, available data, consistent with local culture and characteristics. The proposed AC determinants and indicators are detailed in Table 1 as follows:

Table 1. Danang city’ AC determinants and indicators

Variable	Definition	Question	Authors
Financial Variables			
I15: Household Income	People's income has a role in climate change AC	How is role of people's income in climate change AC?	Remy Sietchiping (2007)
I16: Livelihood diversity	People's livelihood diversity in climate change AC	How is role of people's livelihood diversity in climate change AC?	Remy Sietchiping (2007)

I17: Livelihoods	People's livelihood has a role in climate change AC	How is role of people's livelihood in climate change AC?	Mai Trong Nhuan (2015)
Social Variables			
I4: Community support	Community care for responding to climate change	How was support of community while disaster and climate change occur?	Remy Sietchiping (2007)
I5: Government/province Support	Social support for responding to climate change	How was support of Government/province while disaster and climate change occur?	Remy Sietchiping (2007)
I6: Social participation	Household participation in local climate change policy making	How often is household participation in local climate change policy making?	Remy Sietchiping (2007)
Natural Variables			
I11: Crops	The diversity of crops in climate change AC	How is the role of crops in climate change AC?	Mai Trong Nhuan (2015)
I12: Livestock	The diversity of Livestock in climate change AC	How is the role of livestock in climate change AC?	Mai Trong Nhuan (2015)
I13: Aquaculture	The diversity of aquaculture in climate change AC	How is the role of aquaculture in climate change AC?	Mai Trong Nhuan (2015)
I14: Wild fishery	The diversity of wild fishery in climate change AC	How is the role of wild fishery in climate change AC?	Mai Trong Nhuan (2015)
Human Variables			
I1: Knowledge	Access to climate change information and related responding activities	How often is monitoring information on climate change response?	J. Hamilton-Peach & P. Townsley (2002)
I2: Experience Exchange	Exchange, discuss about climate change information and related responding activities	How often is exchange, discuss about climate change information and related responding activities?	J. Hamilton-Peach & P. Townsley (2002)
I3: Skills	Skills to adapt to climate change	How is role of experience in manufacturing and trading to adapt to climate change?	J. Hamilton-Peach & P. Townsley (2002)
Infrastructural Variables			
I7: Water supply	The level of meeting water demand	How is the satisfaction of supplying water at the local?	Remy Sietchiping (2007)
I8: Water quality	The level of meeting water quality	How is the satisfaction of meeting water quality?	Remy Sietchiping (2007)

I9: Electricity supply	The degree of stability of the Electricity supply	How is the satisfaction of stability of the electricity supply?	Remy Sietchiping (2007)
I10: Power capacity	Guaranteed level of power electrical	How is the satisfaction of power electrical quality?	Remy Sietchiping (2007)
Climate change adaptive capacity			
I18: Natural knowledge	Feedback about climate and disaster information	How to feel when listening about climate and disaster information?	Mai Trong Nhuan (2015)
I19: Adaptative capacity	Capacity to adapt to climate change	How to assessment about adaptive capacity to adapt to climate change?	Mai Trong Nhuan (2015)
I20: Social knowledge	Feel of policies to cope with climate change	How to feel about policies to cope with climate change?	Mai Trong Nhuan (2015)

2.2.2. Methods of Data Collection and Analysis

a/ Data Collection

Data in the study was collected from socio-economic data of 1,168 households in Da Nang where distributed in all 7 districts of Da Nang city including: Hai Chau, Lien Chieu, Son Tra, Ngu Hanh Son, Thanh Khe, Cam Le, Hoa Vang. The questionnaires were conducted in June 2014 for coastal household heads in Da Nang City. Data in this study was supported by Viet Nam National Project “Studying and proposing coastal urban models for strengthening adaptive capacity to climate change (No. BDKH.32/10-15)”.

According to Hair et al. (2006) the sample size for factor analysis (EFA) is at least 5 times the total number of observed variables. The proposed research model has 17 observed variables so the sample size is at least 85. The research uses SEM method for the research model with 5 groups of determinant and each determinant has at least 3 variables and sample size is 1,168 observations.

b/ Methods for data verification and analysis

The study used Cronbach's Alpha reliability coefficient test to test the tightness of the scale in the model, then used exploratory factor analysis (EFA) to test the variables and identify appropriate variables for inclusion in the confirmative factor analysis (CFA). Then, use

the SEM to determine the impact of each determinants and indicators on climate change AC of Da Nang City. In the research model, the financial, social, human resources, infrastructure, natural variable are independent variables and dependent variables are AC variables.

3. Results and Discussion

3.1. Cronbach's Alpha Test Results

Before conducting exploratory factor analysis, it is necessary to implement reliability analysis through Cronbach's Alpha coefficient and total correlation coefficient. A scale with a coefficient of Cronbach's Alpha ≥ 0.6 is acceptable for reliability. Variables with a total correlation coefficient less than 0.3 will be excluded.

Cronbach's Alpha test results for component scales with Cronbach's Alpha coefficient of human resource determinant of 0.850; Nature is 0.904; The society's is 0.749; Finance's is 0.914; The infrastructure's is 0.872. Cronbach's Alpha test results scale of self-assessment of climate change with 0.817. Thus, the Cronbach's Alpha test results for the component scale and the CC scale with climate change indicate $0.9 > \text{Alpha} > 0.6$ indicating a scale that satisfies reliability requirements (Nunnally & Burnstein, 1994).

3.2. Exploratory Factor Analysis Results

KMO coefficient = 0.752 > 0.5 shows the data suitable for conducting EFA analysis. The P-value of the Bartlett test is zero, meaning that the variables are correlated with each other.

The results of exploratory factor analysis shows that the extracted variance of these 5 groups reaches 66.16 > 50%: Satisfactory. These factors explain 66.16% of the variance of the collected data.

Table 2. Results of clustering based on EFA

Rotated Component Matrix^a

	Component				
	1	2	3	4	5
I1				.853	
I2				.898	
I3				.865	
I4					.750
I5					.874
I6					.794
I7		.839			
I8		.844			
I9		.835			
I10		.864			
I11	.838				
I12	.883				
I13	.898				
I14	.881				
I15			.930		
I16			.915		
I17			.901		
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.					
a. Rotation converged in 5 iterations.					

The results of Table 2 show that: Factor 3 is Financial determinant include 3 observed variables: I15, I16, I17. Factor 1 is Natural determinant include 4 observed variables: I11,

I12, I13, I14; Factor 5 is Social determinant include 3 observed variables: I4, I5, I6; Factor 4 is Human resource determinants include 3 observed variables: I1, I2, I3; Factor 2 is Infrastructural determinant include 4 observed variables: I7, I8, I9, I10.

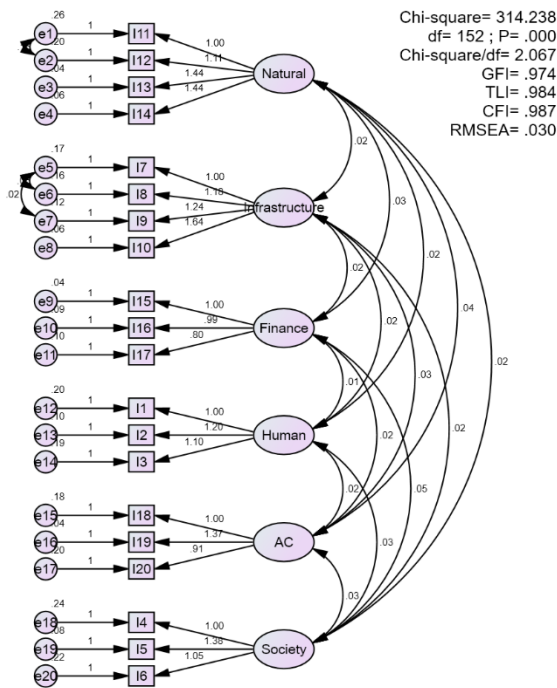
3.3. The Confirmative Factor Analysis Result

Due to 5 determinants include financial determinant, social determinant, natural determinant, human resource determinant, infrastructural determinant are latent variables formed observed variables so the study uses CFA analysis to quantify latent variables. Then the result was used for estimating the relationships of variables. The result of CFA analysis indicate that some indicators reflected the model's relevance, however, RMSEA = 0.069 < 0.08 and Chi-square/df (c_{min}/df) = 6.586 > 3 meaning that the results of CFA analysis are not good thus the study uses MI indicator to improve the fit of the model, with the pair that has the highest M.I indicator then re-estimate the model until the test criteria are met.

Table 3. Composite Reliability and Average Variance Extracted of all determinants

Determinants	Composite Reliability	Average Variance Extracted
Nature	0.886	0.666
Infrastructure	0.853	0.573
Finance	0.916	0.784
Human	0.852	0.659
Society	0.765	0.527
AC	0.828	0.622

The CFA analysis results in Table 3 show that the composite Reliability (CR) and Average Variance Extracted (AVE) for each financial determinant, social determinant, natural determinant, human resource determinant, infrastructural determinant are CR > 0.7 and AVE > 0.5 [28]. The model reaches convergence value.



The CFA analysis results in Figure 5 show that the Standardized Regression Weights of all variables are greater than 0.5, meaning the model achieved the convergence value. The CFA results show: Chi-square = 314.238 ($p = 0.000$); Chi-square/df = 2.067 < 3; GFI = 0.974, TLI = 0.984, CFI = 0.987 are all greater than 0.9 and RMSEA = 0.03 < 0.08 (Figure 5). In short, the model results are consistent with the collected data.

3.4. Structural Equation Modelling result (SEM)

The result of SEM in Figure 6 indicated that Chi-square value is 467.913, degrees of freedom is 162, with P-value= 0.000 should meet the requirements of data compatibility. When adjusting Chi-square with degrees of freedom C_{min}/df , this value reaches $2.888 < 3$, furthermore the indicators GFI, CFI, TLI are 0.959; 0.969; 0.974 > 0.9 respectively; RMSEA is $0.040 < 0.08$

Figure 5. Confirmative factor analysis result.

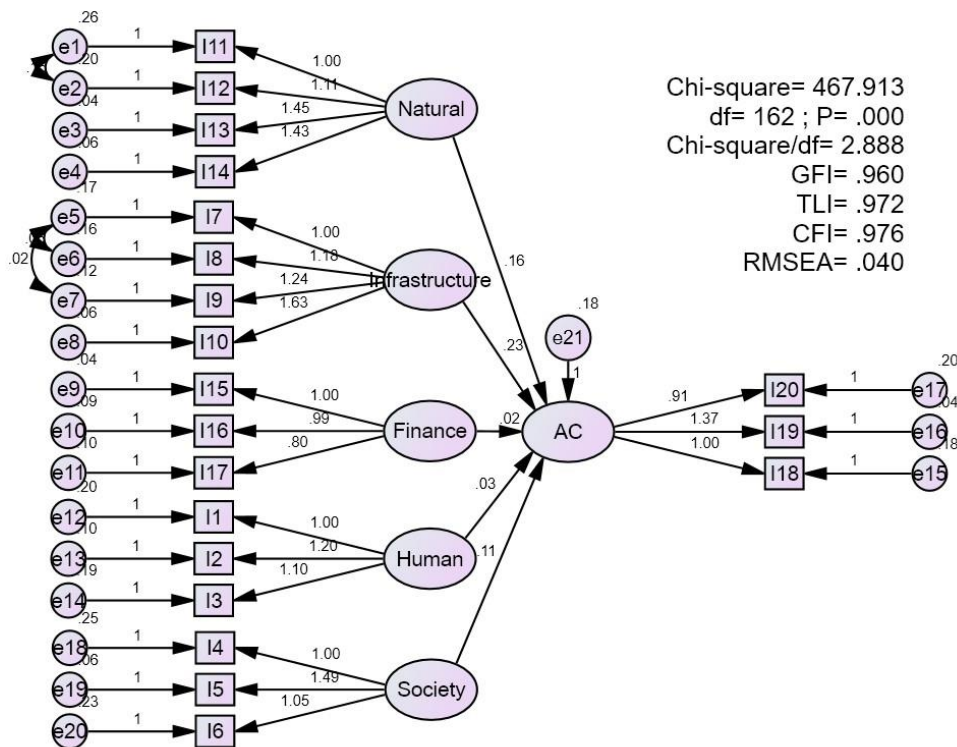


Figure 6. Standardized Confirmative Factor Analysis result.

The result of SEM shows that the model is well compatible with the collected data. The testing results of SEM in Figure 6 show that the influencing of Infrastructural determinant has significant influence on Da Nang city's AC with the reliability reached 99% (Estimate = 0.228, $P = 0.01 < 0.05$). Followed the influencing of Natural determinant, Social determinant with the reliability reached 95% (Estimate= 0.160 and 0.107; $P < 0.05$). Due to P_value of the Financial and Human resource determinants, are > 0.05 so the Financial and Human resource determinants has not statistical meaning.

The Standardized Regression Weights show that the degree of impact of independent variables to dependent. The Standardized Regression Weights of Infrastructural determinant is highest, reached 0.182, followed by the Standardized Regression Weights of Natural resource determinant, reached 0.152. The Standardized Regression Weights of social determinant reached 0.091. The Standardized Regression Weights of human and financial determinant are 0.020 and 0.035. Thus, the Infrastructural determinant has the most

considerable influence on Da Nang city's AC and the determinant of natural has the second considerable influence on Da Nang city's AC, followed by social resource determinant. The result shows that if Infrastructural determinant, natural determinant, social determinant are improved, it will positively impact to Da Nang city's AC.

3.5. Testing the Reliability of Estimation with Bootstrap

The Bootstrap method is used to test the model estimates in the final model with the number of repeating samples $N = 300$. The estimated results from the 300 samples averaged together with the deviations are presented in Table 4. The results in Table 4 show the results of the difference (bias column) between the estimated value and the mean value column. The mean has a very small absolute value and the CR value is less than or equal to 2, meaning a very small bias at the 95% certainty level or the estimated results from the original model and from average of 300 other estimates giving the same or reliable model.

Table 4. Estimation result by Bootstrap

Determinant			Estimation	SE	SE-SE	Mean	Bias	SE-Bias	CR
AC	<---	Nature	.160	.034	.001	.154	.002	.002	1
AC	<---	Infrastructure	.228	.033	.001	.179	-.003	.002	-1.5
AC	<---	Finance	.015	.031	.001	.022	.003	.002	1.5
AC	<---	Human resource	.031	.037	.001	.037	.002	.002	1
AC	<---	Society	.107	.036	.001	.094	.003	.002	1.5

4. Discussion

Results from the analysis of survey data from 1,168 households in 7 districts of Da Nang city by using the exploratory factor analysis (EFA), confirmative factor analysis (CFA), structural equation modeling (SEM) show that if infrastructural determinant, natural determinant, social determinant are improved, it will positively impact to Da Nang city's AC. This result is quite consistent to previous studies showing social support networks and infrastructural of city were

important contributor to increase city's adaptation to climate change [19].

Another important result of the present study was that 5 determinants were extracted from the adaptive capacity indicators (Table 1). The high variance in the infrastructural determinant was shown. Enhancing the capacity to supply electricity and water resource while it has disaster and climate change appearance, could increase the adaptive capacity of city's AC. The determinant of social relation was engagement with social activities to respond to disasters and

climate change. This includes supporting of community, supporting of province authority support and participating in social organizations. Social determinant has been recognized as necessary to build community capacity for a sustainable future [29]. Previous studies have shown that people's relationship with each other through networks and the associational life in their community increase the adaptive capacity [16]. For natural determinant, protecting and developing ecosystem could enhance city's AC. The exchange of information on climate change as well as the experience of producing and business in aquaculture, livestock, crops among households may contribute to increasing adaptive capacity.

The findings of the present study suggest that strengthening social organizations, social support networks, community funds, and protecting and developing natural ecosystem; strengthening a wide range of urban infrastructural including water and power supplying system to improve the efficiency, effectiveness and sustainability of urban service.

5. Conclusion

According to the research results, the scale of climate change AC of Da Nang city includes 5 determinants and 17 indicators of AC: Financial, infrastructure, human resources, natural and social resource. In which, the infrastructural, natural and social determinant has the significant correlation to the city's AC.

The study has devoted a indicator structure of the climate change AC for Da Nang city and evaluate the role of the determinants in the indicator structure of the climate change Da Nang city's AC by using the exploratory factor analysis (EFA), confirmative factor analysis (CFA), structural equation modeling (SEM).

Using the indicator structure of the climate change AC (including determinants and indicators) and the calculation method of this study to determine the role of the decisive factors in the framework for other coastal localities of

Vietnam is possible. In order to enhance the reliability, representativeness and certainty of applying the research approach, it is necessary to set up a survey questionnaire with a larger scale, appropriate question structure and interview method.

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