BUILDING CLIMATE CHANGE ADAPTATION INDICATOR SET FOR MOC HOA DISTRICT, LONG AN PROVINCE

Nguyen Thi Tinh Au
Ho Chi Minh City University of Technology and Education, Vietnam

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ABSTRACT

To date, work in the field of climate change adaptation has resulted in many strategies for adaptation. In Vietnam, there have been many climate change adaptation activities implemented but has not been evaluated fully on effectiveness so that we can modify or make a replica of them systematically. In order to evaluate the effectiveness of carried out climate change adaptation activities, it is necessary to assess the current status of climate change adaptation for each local. In this paper, a set of CCA status evaluation indicators was developed and appreciated for Moc Hoa district, Long An province, to support a comprehensive assessment of the adaptation ability of this study area, the validity of investment resources allocation, and vulnerability to expose suitable policies. This set includes three indicators which are natural environment resilience, climate change vulnerability and climate change risk mitigation. The results showed that the environmental resilience indicators and the risk mitigation indicators were arranged at the medium level, while the climate change vulnerability indicators were high.

Keywords: *Climate change; CCA indicators;* vulnerability; *environment resilience; risk mitigation.*

1. INTRODUCTION

Climate change is impacting social and ecological systems, as well as the interactions between them. Around the world, many places have already experienced dramatic impacts due to warmer temperatures, sea-level rise, and stronger and more frequent extreme events (Mimura et al., 2014).

Vietnam is one of the countries apprised as being severely affected by climate change. Climate change has a strong impact on sectors, localities, especially provinces in the Mekong Delta.

Long An is a province in the Mekong Delta and currently belongs to one of the provinces in the southern main economic region. Currently, the situation of saline intrusion in Long An province is quite complicated, from February 27 to March 5, 2020, the salinity at most stations on the Long An river system is approximately higher than in the same period in 2016 from 0.1 - 3.9 g / L. The prediction of prolonged hot weather combined with strong winds and high tides is capable of pushing the salinity deep, fast, and strong into the rivers and planted soil.

Due to the effects of salinity, Long An had thousands of hectares of rice damaged. Tan Tru district alone had about 4,100 ha of rice and dragon fruit damaged. Meanwhile, in Thu Thua district, the rice area likely to lose yield from 30% to 70% is over 1,700 ha. The shortage of freshwater for daily life takes place seriously in the communes of Tan Lap, Phuoc Vinh Dong (Can Giuoc district); Long Huu Dong, Long Huu Tay (Can Duoc); Binh Hoa Dong, Binh Hoa Trung (Moc Hoa); ... so local people have to buy fresh water at high prices (sometimes up to 200-300 thousand VND / m^3), causing many difficulties in their life.

Therefore, climate change issues need to be assessed to consider the vulnerability as

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well as the resilience of the natural environment and the community. This study builds a set of indicators to assess the current climate change adaptation status and applies it to the test in Moc Hoa District, Long An province. The indexes are built including (1) Natural environment resilience index, (2) Climate change vulnerability index, and (3) Climate change risk mitigation index.

2. METHODOLOGY AND DATA

Up to now, there have been many types of research on climate change to assess the impact of climate change on the natural and human environment. There are many approaches to assess issues related to climate change and adaptation solutions.

The assessment of the effectiveness of indicator climate change adaptation can be done in three main steps: (i) Assessing the current local situation before climate change; (ii) Evaluate the effectiveness of the adaptation activities already being carried out in the locality; (iii) Summary of results and adaptation assessment.

This paper focuses on the research and proposes assessment indicators for the current climate change adaptation status. Through analysis of indicators applied in the world and in Vietnam, indicators to assess the current state of climate change adaptation are selected, including (1) The set of indicators of environmental resilience nature; (2) Set of indicators for assessing vulnerability caused by climate change; and (3) Set of climate change risk mitigation indicators. In which, the resilience of the natural environment represents the ability to adapt and reduce the vulnerability of the community; Vulnerability and risk mitigation capacity due to climate change are general information about the community's ability to respond to climate change.

The process of calculating indicators can be done in three steps: (i) Collect data; (ii) Data processing; and (iii) Expression and analysis of results (Figure 1).

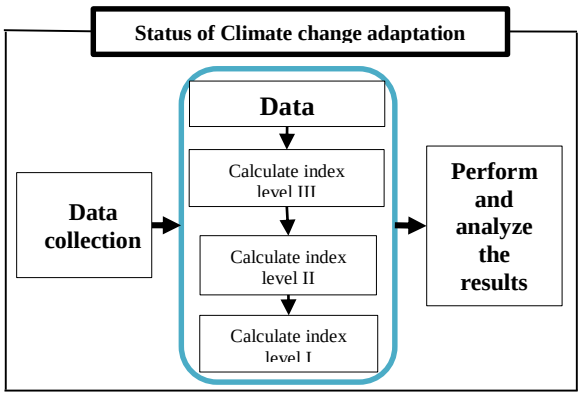

Fig1. *The process of calculating the status of climate change adaptation indexes*

2.1 Natural environment resilience index

To determine indicators of the resilience of the natural environment, it is necessary to evaluate the characteristics of a natural environment that is well resilient to climate change [2].

Characteristics of a resilient natural environment include: (i) The diversity of the natural environment (D): ; (ii) Flexibility in natural environment management (F); and (iii) Ability to continue to provide natural environmental ecological services (ES).

These three features are denoted by 3 indicators of level I. Each index of level I is detailed via criteria for level II and III. (Table 1)

Indicators of the resilience natural environment (RI) are calculated by formula

$$RI = (D + F + ES)/3 \quad (1)$$

In which: RI has a value from 0 to 1, the larger RI, the more resistant natural environment to climate change.

2.2 Climate Change Vulnerability Index

Climate change vulnerability can be assessed through three level I indicators: Exposure Index (E); the sensitivity index (S) and the adaptability index (AC). The levels II and III indicators corresponding to the level I indicators are shown in Table 2.

The Climate change Vulnerability Index (CVI) index is determined based on the

values of the three above-mentioned factors by the following formula:

$$CVI = [E + S + (1-AC)]/3 \quad (2)$$

In which, CVI arranges from 0 to 1, the larger CVI, the higher vulnerability to climate change.

2.3 Climate Change Risk Mitigation Index

Risk Mitigation Index (RMI) due to climate change can be determined by the following characteristics: (i) Environment and resources (M_1); (ii) Socio-economic (M_2); and (iii) Policy and management (M_3). The evaluated fields and indicators for level II corresponding to the level I indicators are shown in Table 3.

Assuming the weight for the 3 level I indicators is the same, the risk mitigation index is determined by the following formula:

$$RMI = (M_1 + M_2 + M_3)/3 \quad (3)$$

Table 1. *Natural environment resilience index*

Level I	Level II	Level III
The diversity of the natural environment (D-Diversity)	The extent of semi natural habitat	(1) Natural land area; (2) Agricultural land area; (3) Forest land area; (4) Specialized land area; (5) Aquaculture land area; (6) Residential land area
	The diversity of vegetation	(1) Forest area; (2) Protection forest area; (3) Special-use forest area
Flexibility in natural environment management (F-Flexibility management)	Effective in climate change assessment / planning	Number of environmental protection plans integrated with climate change
Ability to continue to provide natural environmental ecological services (ES-Ecological Services)	Support Services	Air quality

Table 2. *Climate Change Vulnerability Index*

Level I	Level II	Level III
Exposure Level (E)	Extreme climate phenomenon	(1) Annual average number of storms and tropical depressions; (2) The average number of floods per year; (3) Heavy rain.
	Climate fluctuation	(1) Annual average temperature increase; (2) Annual rainfall change.
Sensitivity Level (S)	Water resource	The water level change
	Society	(1) Total population; (2) Population density; (3) Rate of population growth; (4) Rural population; (5) Urban population; (6) The amount of domestic water per capita; (6) Proportion of women; (8) Proportion of children <15 years old; (9) Proportion of the elderly> 60 years old
	Agriculture	(1) Agricultural land area; (2) Agricultural land per capita; (3) Crop productivity; (4) Agricultural output; (5) Agricultural production value; (6) Number of cattle and poultry; (7) Rural population.
	Fishery	Aquaculture area

Level I	Level II	Level III
	Industry	(1) Number of enterprises in production and business activities; (2) Total number of employees in enterprises; (3) Total number of other industrial production establishments outside industrial zones or industrial clusters
	Energy	Number of the petroleum business
	Tourism	Ecotourism area
Adaptability Capacity (AC)	Health	(1) Number of medical facilities; (2) Number of patient beds; (3) The proportion of rural population having access to hygienic drinking water
	Education	(1)Percentage of people attending school; (2) Number of staff working on state management of environmental protection; (3) The proportion of teachers and students
	Financial resource	(1) Total funding for propaganda, education, and awareness-raising activities on environmental protection; (2)Total investment cost to collect domestic waste; (3) Total state budget expenditure on environmental protection activities

Table 3. *Climate Change Risk Mitigation Index*

Level I	Assessed fields		Level II
Environment - Resource	State		(1) Structure of agricultural land use; (2) Structure of forest land use; (3) Structure of aquaculture land use; (4) Structure of specialized land use; (5) Structure of residential land use
	Competence		Percent new planted forest area
Economy - Society	State	Medical infrastructure	(1) Number of patient beds /100 person; (2) Number of medical facilities; (3) Number of human resources in the health sector/ 100 person
		Educational infrastructure	(1) Schools number; (2) The rate between student and teacher; (3) The rate of high school graduates
		Social conditions	(1) The unemployment rate in working age; (2) The rate of poor households; (3) The proportion of near-poor households; (4)The proportion of female teachers; (5) The proportion of female students
	Competence	Social competence	(1) Rate of trained workers over 15 years old; (2) The proportion of households using clean water; (3) The proportion of households using the sanitary toilet
		Medical competence	(1) Rate of children under 1 year of age who are fully vaccinated; (2) Rate of people participating in health insurance; (3) Rate of meeting national criteria for commune health
		Cultural competence	Number of households obtain cultural standards
Management policy			(1)Natural disaster prevention and mitigation plan; (2) Climate change adaptation plan; (3) Climate change propaganda work; (4) Environmental management work

2.4 The state of climate change adaptation

Climate change adaptation state is evaluated synthesizing from 3 sets of indicators: the natural environment resilience, vulnerability, and risk mitigation capacity due to climate change, with the assumption that the above three indicators are equally important. These weights can be changed based on mind expert opinion.

2.5 Data

Data used in this paper include (i) General available local statistical data such as statistical yearbooks (2018), annual final reports, overall plans, economic-society development plans; (ii) Data were collected through surveys in each commune/district, group meetings, and community consultation to assess local people's awareness level on climate change and its impacts; (iii) Map data and GIS technique for overlap maps to determine the vulnerability to climate change of commune in Moc Hoa district.

3. RESULTS AND DISCUSSION

3.1 Natural environment resilience

Results of the calculation of the natural resource resilience index in Moc Hoa province are shown in Table 4 and Figure 2. Based on the calculation results, the natural resource resilience index in Moc Hoa district is average. It can be seen on map that the resilience index of the 3 communes - Binh Hoa Trung, Binh Hoa Dong, Tan Thanh are quite low compared to the rest of the communes. So, some sections where the district needs to prioritize investment and development to increase resilience is environmental management flexibility and enhancement of the ecological service index. These two problems can be solved collectively by building and developing national parks and nature reservation, attracting tourists, and promoting the integration of climate change into existing environmental protection plans. Besides, the district can also plant more forests, increase the area of green infrastructure to enhance the diversity of the natural resource.

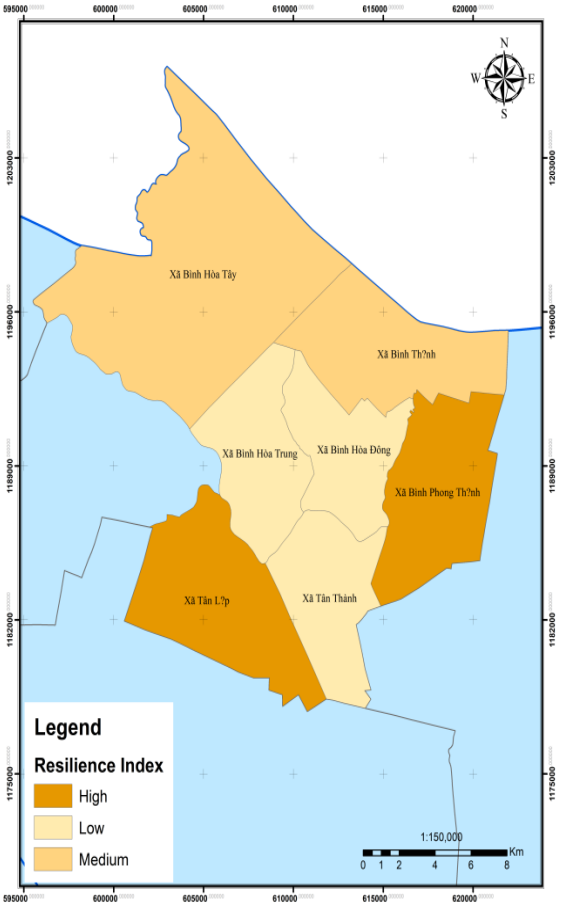

***Fig. 2** Partition map of natural environmental resilience in Moc Hoa*

3.2 Climate change vulnerability

Climate change Vulnerability index in Moc Hoa province is presented in Table 5 and Figure 3. Vulnerability due to climate change is assessed through 3 levels: Low (CVI <0.35), medium (0.35≤CVI≤0.65) and high (CVI> 0.65).

Arccording to show that the vulnerability in Moc Hoa district is high to the impacts of climate change because Moc Hoa district is an underdeveloped district. The commune with the lowest of vulnerability index among 7 communes is Binh Phong Thanh, which is a densely populated place with many important facilities in health, education and economy of the whole district. The remaining communes all have high vulnerability levels.

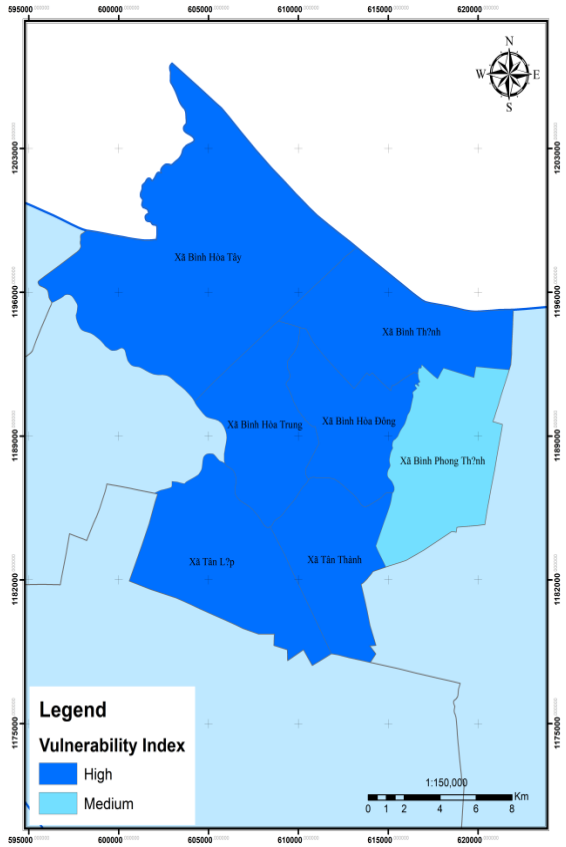

***Fig. 3** Partition map of climate change vulnerability in Moc Hoa*

3.3 Climate Change Risk Mitigation

The results of the risk mitigation index due to climate change in Moc Hoa district are shown in Table 6 and Figure 4.

According to the calculation results, the climate change risk mitigation index for the communes of Moc Hoa district is average. The commune with the highest risk mitigation indicator is Binh Phong Thanh. Because this is where the Moc Hoa district government focuses on developing many important infrastructure in education, health, science and technology, new rural projects, the poverty is quite low. The proportion of households using clean water and hygienic toilet is relatively higher than the rest of the communes. Therefore, Binh Phong Thanh commune has the highest environmental - resource and socio - economic index in the district. The commune also has the largest number of staff engaged in the task of State management on environmental protection among the 7 communes. The whole district performed well the environmental protection activities, in addition to strengthening propaganda to raise awareness of people in environmental protection.

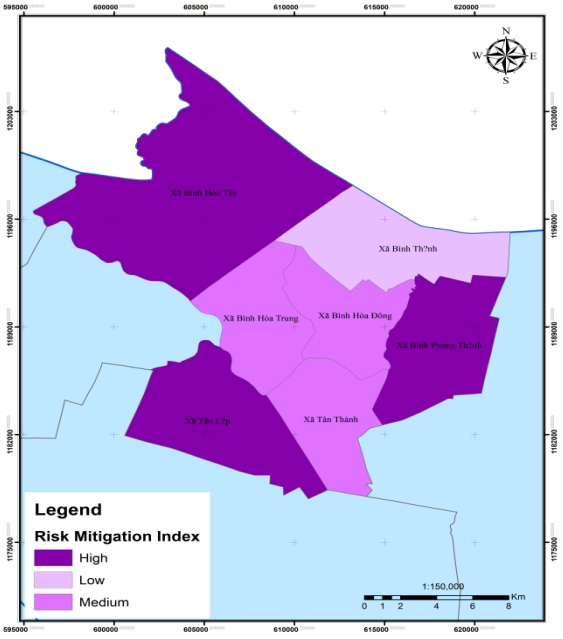

***Fig. 4** Partition map of climate change risk mitigation in Moc Hoa*

***Table 4.** The value of the natural resource resilience index of Moc Hoa district*

Level I Index	Binh Hoa Tay	Binh Hoa Trung	Binh Thanh	Binh Hoa Dong	Binh Phong Thanh	Tan Thanh	Tan Lap
(D-Diversity)	0.4335	0.1884	0.3990	0.0764	0.6008	0.2388	0.5529
(F-Flexibility management)	0.7500	0.2500	0.5000	0.2500	1.0000	0.0000	0.7500
(ES-Ecological Services)	0.48	0.42	0.45	0.40	0.53	0.32	0.55
RI	**0.5545**	**0.28615**	**0.4497**	**0.24217**	**0.7103**	**0.1862**	**0.6176**

Table 5. *The value of the vulnerability index due to climate change of Moc Hoa district*

Commune	Binh Hoa Tay	Binh Hoa Trung	Binh Thanh	Binh Hoa Dong	Binh Phong Thanh	Tan Thanh	Tan Lap
E	0.0483	0.0601	0.0775	0.0595	0.0502	0.0602	0.0247
S	0.4953	0.4991	0.4187	0.4967	0.3936	0.4786	0.52
AC	0.1749	0.1738	0.2034	0.1682	0.0318	0.2271	0.1362
CVI	**0.719**	**0.733**	**0.700**	**0.724**	**0.476**	**0.766**	**0.681**

Table 6. *The value of climate change risk mitigation index of Moc Hoa district*

Level I Index	Binh Hoa Tay	Binh Hoa Trung	Binh Thanh	Binh Hoa Dong	Binh Phong Thanh	Tan Thanh	Tan Lap
Environment - Resource	0.5799	0.3948	0.3103	0.5719	0.3227	0.2471	0.5019
Economy - Society	0.5615	0.4105	0.1318	0.4790	0.8185	0.4245	0.6828
Management policy	0.7	0.6	0.65	0.6	0.75	0.55	0.7
RMI	**0.6138**	**0.4684**	**0.3440**	**0.5503**	**0.6504**	**0.4072**	**0.6282**

3.4 The state of climate change adaptation

Climate change adaptation is dominated by many different factors. Depending on geographical location as well as socio-economic and natural conditions, each commune will have a high or low adaptability. According to the evaluation results (in Table 7), the seven studied communes all have little disparities, the district's overall climate change adaptation index is medium. Binh Phong Thanh commune has the highest adaptation index, followed by Tan Lap commune. The lowest is the three communes of Binh Hoa Trung, Binh Thanh and Tan Thanh, so resources for climate change adaptation should be prioritized in the three above communes.

These communes all have a relatively low adaptation status assessment compared to the remaining communes. In particular, adaptation activities for these communes need to focus on advancing the resilience of the natural resources and improving the capacity of climate change risk mitigation.

Table 7. *The climate change adaptation status of Moc Hoa district*

Commune	Binh Hoa Tay	Binh Hoa Trung	Binh Thanh	Binh Hoa Dong	Binh Phong Thanh	Tan Thanh	Tan Lap
RI	Medium	Low	Medium	Low	High	Low	High
CVI	High	High	High	High	Medium	High	High
RMI	Medium	Medium	Low	Medium	High	Medium	Medium
Adaptation Index	**Medium**	**Medium**	**Medium**	**Medium**	**High**	**Medium**	**Medium**

4. CONCLUSION

The study has developed and tested a set of indicators for assessing the status of climate change adaptation for Moc Hoa district. Research results can help policy makers have a general assessment of the status of implementing climate change adaptation activities, the effectiveness of resource allocation and current vulnerability,

from which to propose appropriate policies for the present and the future. The set of indicators is highly feasible because most of the input data are statistic and reported annually in the local statistical yearbook. Results of calculation of climate change adaptation status will be used to evaluate the effectiveness of climate change adaptation solutions, on the basis of which decisions are made to allocate most appropriate resources for climate change adaptation. However, the assessment is somewhat subjective in determining the value of the component indicators. To overcome this limitation, it is necessary to consult of managers, scientists and community in determining the values of component indicators.

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Corresponding author:
Nguyen Thi Tinh Au
Ho Chi Minh City University of Technology and Education
Email: tinhau@hcmute.edu.vn