MINISTRY OF RESOURCES AND ENVIRONMENT
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Hoang Thi Ngoc Ha

STRENGTHENING THE RESILIENCE TO CLIMATE CHANGE OF THE ECOSYSTEM - SOCIETY IN GIAO THUY DISTRICT, NAM DINH PROVINCE

Speciality: Climate Change
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SUMMARY
PHD THESIS ON CLIMATE CHANGE

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Science Supervisor:

1) GS. TSKH TSKH Truong Quang Hoc
2) TS. Bach Quang Dung

Reviewer 1:……..……

Reviewer 2:……..……

Reviewer 3:…….……

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LIST OF SCIENTIFIC PUBLICATIONS OF THESIS AUTHOR
RELATED TO THE THESIS

1. Hoang Thi Ngoc Ha & Norma RA Romm (2020), Systemic Research Practices Towards the Development of an Eco-Community in Vietnam: some Joint Post-Facto Reflections. *Springer Journals - Systemic Practice and Action Research* (2020), ISSN 1094-429X, 33:599–624. DOI 10.1007/s11213-020-09533-w.
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INTRODUCTION

1. Necessity of the chosen thesis topic

The impacts of climate change on the coastal areas of Vietnam, including the Red River Delta, are increasing [147]. This can weaken the resilience of social-ecological systems (SES).

In Vietnam at present, the theory of social-ecological systems (SES) is still new, there are very few studies on assessing of the impact of climate change (CC) according to ecological zoning and the assessment of the resilience to climate change of the SESs. Giao Thuy district of Nam Dinh province is an area bordering the sea with high biodiversity, dense population, agro-fishery economy depends heavily on nature and it is facing great challenges from CC. There have been a number of studies on natural disasters and CC in the area, but the impact has not been assessed by region, not to mention the resilience to CC or the risks of ecosystems; In addition, the approach of "ecosystem-based climate change adaptation" (CCA) is rarely mentioned while the assessment of CC impacts and local resources are essential for development and CC response.

Therefore, the PhD student chose to carry out the research of the thesis named "***Strengthening the resilience to climate change of the ecosystem - society in Giao Thuy district, Nam Dinh province***".

2. Research Objectives

Overall objective: to assess the resilience to CC of the social-ecological system in the study area and propose solutions to enhance the resilience according to the ecosystem-based approach.

Specifically: 1) The evolution of natural disaster and climate factors and the main impacts of CC on the SES will be assessed according to social-ecological sub-regions; 2) The CC resilience of the SES will be assessed by indicators suitable to local conditions; 3)

Solutions for enhancing climate resilience under an ecosystem-based approach will be proposed.

3. Research Questions

1) How will climate change affect the sub-regions of the social-ecological system in Giao Thuy district and how should it be assessed?

2) How to develop a set of indicators for assessing the CC resilience of SES in Giao Thuy district?

3) What solutions to enhance CC resilience under the ecosystem-based approach are suitable for the local context?

4. Defending points

Climate change has different impacts on sectors and regions/sub-regions of the social-ecological system. Climate change resilience of the SES depends on the development resources of the system, including: Nature, Society, Economy, Physics/Infrastructure, and Policy. The assessment of resources by disaster-climate indicators will be the basis for proposing solutions to enhance the CC resilience of the SES according to the ecosystem-based approach/ in harmony with nature and in accordance with the local context.

Research subjects: climate change resilience of the social-ecological system of Giao Thuy district.

Survey subjects: i) Natural, ecological, economic and social characteristics of the study area and social-ecological sub-regions; ii) Evolution of CC factors and impacts of CC on typical fields and regions; iii) Resources demonstrating the CC of the study area.

Research scopes: Spatial scope is Giao Thuy district, Nam Dinh province. Scope of time: conducted the study from January 2016 to June 2019; Updating information and data to 2020; The data are retrospective for about 50 years.

Areas of expertise: i) Social-ecological systems and zoning in CC impact assessment; ii) CC resilience and resources and criteria for assessment; iii) Ecosystem-based Climate Change Adaptation (EbA).

5. New contributions of Thesis

i) A set of indicators for assessing the resilience to climate change of Giao Thuy district' SES have been developed in accordance with Vietnamese conditions on the basis of the CDRI assessment method; ii) The study has carried out the socio-ecological zoning for Giao Thuy district in assessing the impacts of climate change and CC resilience as well as proposing solutions to strengthen the resilience of the SES according to the EbA; iii) and the thesis has applied the theory of SES in the specific context of the northern coastal plain of Vietnam.

6. Scientific and practical significance of the PhD thesis

Scientifically, i) Developing the "socio- ecological ecosystem" approach in the local context to assess resilience and adaptation to climate change; ii) Develop a method to assess the resilience to CC of the socio - ecological system through a set of indicators to assess the actual resources for CC adaptation and socio-economic development.

Practical significance, proposed solutions to enhance resilience and adaptation to CC according to the ecosystem-based approach; và ii) The results from the thesis can be applied to the implementation and integration into plans to adapt to CC and develop local livelihoods associated with nature conservation, also apply to localities with similar conditions.

7. Thesis structure

In addition to the Introduction, Conclusion and Recommendations, the thesis has the following three chapters:

CHAPTER I. Literature overview on Social-ecological system, Climate change resilience, and Ecosystem-based Adaptation.

CHAPTER II. Theoretical foundations, Research approaches and Methods.

CHAPTER III. Results of impact assessment of climate change and assessment of climate change resilience of the social-ecological system of Giao Thuy district.

CHAPTER I. LITERATURE OVERVIEW ON SOCIAL-ECOLOGICAL SYSTEM, CLIMATE CHANGE RESILIENCE AND ECOSYSTEM BASED ADAPTATION

1.1. International Studies Review

1.1.1. Social-ecological system and impacts of climate change on Social-ecological system

The social-ecological system and related systems: The world's research on social-ecosystems (SES) has developed continuously, typical for the systematic and interdisciplinary approach. SES has been applied in many scientific fields such as environment, society, economy, and agriculture. However, there is still no unified and comprehensive definition of SES. The current gap is the overall assessment of the resilience of the SES in a particular locality.

Regarding zoning for the social-ecological system: Typical authors for research on ecological zoning include: Rizvi et al. (2015), Xiaolei et al. (2014), Omernik (1987), Zhang (2007). There are very few studies on social-ecological zoning for the assessment of impacts, climate risks or climate change resilience of SES.

Regarding assessment of impacts of climate change on SES: Typical authors include Lance H. (2000), Céline (2012), Hai-Long et al. (2015), Bergamini et al. (2013), Selvaraju et al. (2009), Folke et al (2003). Studies have focused on the role of natural ecosystems, risk warnings, but have not mentioned long-term climate resilience and how to evaluate it [144]. A notable gap is the lack of clarity on the role and importance of physical and non-physical resources.

1.1.2. Assessment of the resilience to climate change of social-ecological system and assessment method by indicators.

Regarding the the system's resilience: In the most general sense, resilience is a concept that describes the ability of a system to absorb or recover/return to its original state/shape/size from external disturbances or perturbations.

climate change resilience of the SES: is understood as the ability of the social-ecological system to: i) absorb stress and maintain its function in the face of external pressures due to CC causes, and ii) can be adapted and reorganized to enhance the sustainability of the system, helping to better prepare for future CC impacts. Strengthening the resilience of the system is to increase the function and health through physical and non-physical resources.

About the method of assessing resilience through indicators: There have been a number of studies on indicators around the world to assess the resilience to CC of each field, community or economic and social systems. According to the authors, the assessment of resilience is an overall assessment of the whole system based on representative components [69]. Indicators and criteria are important tools to measure and determine the ability to respond to the impacts of CC and reduce risks; Evaluation of the resilience of the SES is very complicated, it is necessary to continue to study and evaluate the resilience at different scales and landscapes [69], [77], [87].

1.1.3. Ecosystem-based adaptation to climate change

It is briefly understood as using ecosystem and biodiversity services to help people adapt to adverse impacts of CC and reduce vulnerability [99], [133]. Notable authors include Colls et al., 2009; Julia, Andrade et al., 2012; Nathalie, 2014; Doswald, 2014; Cohen, 2016; etc It is recommended that further research on potential climate risk assessment for coastal ecoregions is continued prior to the application of EbA and resilience assessment.

1.2. Literature overview of studies in Vietnam

1.2.1. Research on the impact of climate change on the SES

The interdisciplinary scientific approach to "social-ecological system" is still new in Vietnam, both in environmental management and CC response. Up to now, there have been pioneering organizations and individuals in research direction such as GIZ, Rosa Luxemburg, WWF, Truong Quang Hoc, and ECODE, however, there are still very few scientific publications on SES. Regarding research to assess the impact of CC on the social - ecological system: there have been many studies on assessing the impact of natural disasters and CC on rural, coastal or socio-economic fields, but there are very few studies on the " social-ecological system", on the risks to ecosystems or the impact of CC on the social-ecological sub-regions.

1.2.2. Assessment of climate change resilience of the SES

Some typical authors such as Huynh Thi Lan Huong, Truong Quang Hoc et al. (ECODE), Mai Trong Nhuan discussed methods and indicators of CC adaptation in a number of fields. The proposed criteria are quite diverse and they represent important aspects such as ecosystems, environment, policies, etc.,… Although research on climate resilience makes a positive contribution to the development of SES, assessment of resilience of the SES in Vietnam is still limited because of the complexity of the research, which requires the development of suitable assessment tools. The set of indicators according to the CDRI method was initially studied in Vietnam and the ECODE team has piloted the indicators for the assessment of climate resilience in the Red River Delta (2015-2016), but the evaluation process then the weight of the criteria is not taken into account.

1.2.3. Regarding studies on Ecosystem-based Adaptation

Ecosystem-based approach was started to be studied in Vietnam around the late 90s of the twentieth century and started mainly in the field of resource management with some authors such as Pham Binh

Quyen and Truong Quang Hoc (1998).), Hoang Van Thang (2005); Truong Quang Hoc (2008, 2010); Vo Thanh Son (2006), GIZ, Hoang Thi Ngoc Ha (2015-2017),... Recently, ecological solutions have been mentioned more, but there are few studies for rural areas, coastal plains and for CC response.

1.3. Overview of the study area

Giao Thuy is a coastal district of Nam Dinh province with 32km of coastline, a natural area of 238.24 km2 (2017) with 22 communes and towns; Its topography is plain, high biodiversity including wetland ecosystems. There have been many studies on Giao Thuy area related to natural disasters, CC, land use, mangroves and livelihoods, typically some authors: Ho Thanh Hai et al (2013), Dang Thi Hoa et al (2013), Khuat Thi Hong and Nguyen An Thinh (2015), Le Duc Quynh (2013), Bui Minh Tang and Bui Duc Long (2016), Hoang Thi Ngoc Ha et al (2014 – 2017). Some gaps in these studies are: not clear about impacts and potential risks from climate change to ecosystems or impacts on social-ecological sub-regions; still mainly a "bottom-up" approach and qualitative assessment, has not studied long-term climate risks, and has not assessed resources according to quantitative indicators.

CHAPTER II. THEORETICAL FOUNDATIONS, RESEARCH APPROACHES AND METHODS

2.1. Theoretical basis

2.1.1. Related concepts:

Climate change, Ecosystem, Social - Ecological system; Ecological-based adaptation, Climate change Resilience of Social - Ecological System, Resources, Zoning.

2.1.2. The systematic, interdisciplinary nature of the research issue

The current social-ecological system is under the simultaneous impact of natural and rapidly developing human activities. According to the IPCC, climate-related risks and impacts on social-ecological system are due to the interaction of hazards caused by climate change

with the exposure and vulnerability of human and natural systems. The EbA approach - in harmony with nature is being effectively applied for CC adaptation and sustainable development by EbA, NbS provides multi-benefit solutions through wise use of ecosystem services.

2.1.3. Analytical framework of the thesis

The analytical framework of the research topic is shown in Fig. 6.

The social-ecological system of Giao Thuy district is divided into social-ecological sub-regions with their own characteristics and they have representative resources in terms of Nature, Economy, Society, Physical and Policy. Evaluate these resources by a system of criteria and indicators to help determine the system's resilience to CC. This is the scientific and practical basis for proposing solutions to CC adaptation and local development based on a nature-based approach.

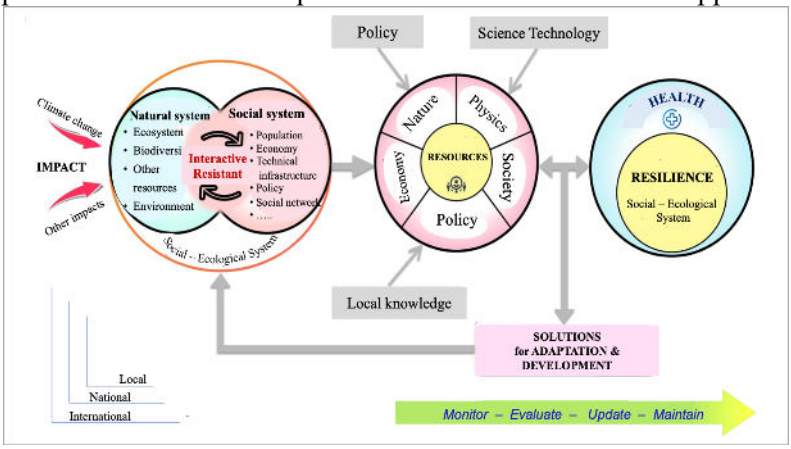

Fig. 2.5. Analytical framework of the research issue enhancing the CC resilience of the social-ecological system of Giao Thuy district

2.2. Research approaches and methods and data

2.2.1. Approaches: Key approaches: Systemic, interdisciplinary and participatory approach" to effectively achieve a cross-sectoral approach; Combination of "Top down" and "Bottom up", and EbA.

2.2.2. Research Methods

The main groups of methods: 1) Collecting, synthesizing and analyzing secondary data and information; 2) Field survey (collection of primary data); 3) Impacts Assessment of Climate Change; 4) CDRI – Disaster and Climate Index; and 5) AHP - Analytic hierarchy process.

Thesis uses the CDRI method – a set of climate resilience indicators, and 25 criteria and 125 indicators have been developed to measure resilience to disasters and CC. Two tools to collect information are 5*5 matrix and 5*5 questionnaire, which combines quantitative and qualitative assessment, and calculates weights of criteria, indicators, and resources.

2.3. Data used in Thesis

Includes data from field surveys and secondary data on the following contents: climate change, ecosystems, infrastructure and socio-economics, land use through periods; ii) meteorological and hydrological factors; iii) types of natural disasters, frequency of occurrence in the locality and statistics of physical damage; iv); data on infrastructure and other resources.

CHAPTER III. RESULTS OF IMPACT ASSESSMENT OF CLIMATE CHANGE AND ASSESSMENT OF CLIMATE CHANGE RESILIENCE OF THE SOCIAL-ECOLOGICAL SYSTEM OF GIAO THUY DISTRICT

3.1. Assessment of impacts of natural disasters and climate change on the social-ecological system of Giao Thuy district

3.1.1. Zoning eco-society according to ecological function

Giao Thuy district has been divided into socio-economic sub-regions based on criteria, uniformity in terms of: topographical, ecological, land use, socio-economic characteristics and the possibility of being affected by climate change.

Fig. 3.2. Map of social -ecological zoning of Giao Thuy district

The functional-ecological zoning of Giao Thuy district resulted in two main social-ecological sub-regions, including: The area within the dike (including: Buffer zone of the national park, with tourism and salt fields, inland fields); The area outside the dyke (the core sub-region of the national park) has mangroves and mudflats; Typical communes, representing social-ecological sub-regions include: i) Giao An commune: the area bordering the sea, greatly affected by rain, storm, saline intrusion; ii) Giao Tien Commune: in the inner field, bordering the So River, affected by storms, heavy rain/flood and damaging cold.

3.1.2. Variation of climatic factors and its frequency

3.1.2.1. Past and present fluctuations in temperature, precipitation and sea level (50 years retrospective data)

- Temperature fluctuations: the annual average temperature tends to increase gradually from 1951 to now and has increased by 0.3°C in the past 50 years;
- Fluctuations in rainfall: tends to decrease slightly in the past 50 years but has an increasing period (2006-2015).
- Fluctuations in river level and sea level: tend to increase sharply, up to nearly 30cm/50 years.
- Sea level rise: the average sea level rises 2.15mm every year, the coastline is eroded due to both natural and human causes.

3.1.2.2. Increase in dangerous natural disasters

In the coastal area of Nam Dinh province, especially Giao Thuy district, every year, it is affected by climate phenomena such as storms, sea level rise, saltwater intrusion, flooding, cold and hot weather. Storms and tropical depressions tend to increase. Storms and tropical depressions: there has been a marked increase in the number of storms over the last 2 decades (1985-2017). In the period 1960-2017, there were 73 storms in Giao Thuy district. Flooding usually occurs in June and July every year, but in the last 10 years, it has gradually changed to October and November. In the period 1986-2016, there were many cold and severe cold spells, on average, there are 3-4 cold spells/year. The annual average temperature background increases. Increased water surge and saltwater intrusion. Drought appeared more frequently in the last 3 decades (1998–2017).

- ***Frequency of occurrence and impact of natural disasters:***

Synthesized and analyzed results of the trend of changes in climate factors over the past 5 decades (1961-2016), and statistics and field surveys in 2016 - 2018 gave information on the impact of CC and extreme natural disasters on: i) key components of the SES of Giao Thuy district/field; and 2) social-ecological sub-regions/regions. The assessment results are based on the assessment of the frequency of occurrence of natural disaster factors in the area, exposure and susceptibility of activities and fields, combined with past damage statistics. Adaptability is analyzed in the resilience assessment on the basis of detailed assessment of resources using criteria and indicators.

Climate factors and extreme natural disasters appear frequently in the last 3 decades and are more frequent than in the previous period, including: peak heat, storms - tropical depressions, heavy rains, floods, sea level rise, saline intrusion, harmful cold and drought.

The extent to which socio-economic activities and ecosystems are affected by CC: the most impacted and potentially risky sectors are

agriculture, saltwater aquaculture, water resources, and natural ecosystems.

3.1.3. Impacts of natural disasters and climate change on all fields

3.1.3.1. Impact on the mangrove ecosystem

The total area of mangroves and casuarinas both decreased while the tidal flats increased due to natural accretion. Analysis of remote sensing images of 1986, 1995, 2005 and 2015 shows that there is a great change in the area and distribution of ecosystems, especially mangroves and casuarina forests, caused by impacts from nature and human. Natural hazards include heavy storms, prolonged heavy rains and sea level rise.

3.1.3.2. Impact on agricultural production activities

The greater the dependence of agricultural livelihoods on nature, ecosystems and climatic conditions, the greater the risk. Summarize the dependence of key livelihoods of the community on natural factors (water and natural ecosystems) as shown in Table 3.6. Natural disasters, saltwater intrusion have affected the decline in the area of rice cultivation and salt production.

Table 3.6. The degree of dependence of livelihood activities on natural resources.

Hoạt động sinh kế	Hệ sinh thái tự nhiên		
	Rừng ngập mặn	Bãi bồi	Nước
Trồng trọt: lúa và rau màu	0	0	++
Chăn nuôi (lợn, gia cầm)	0	0	++
Nuôi thuỷ sản nước ngọt	0	0	++
Nuôi thuỷ sản nước mặn	+++	+++	++
Đánh bắt hải sản ven bờ	+++	+++	+
Du lịch – Dịch vụ	++	++	++

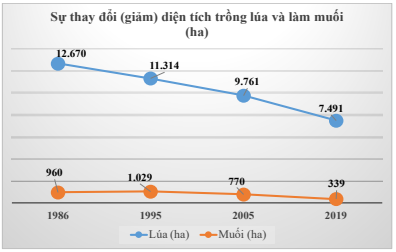

Fig. 3.11. Change (decrease) in the area of rice and salt production

3.1.3.3. Impact on water resources

The major flood seasons are July, August, September, the amount of water accounts for 50-70% of the water volume of the whole year. Water flow in 7 months of dry season is usually very low (November to May). The shortage of fresh water in major rivers in the dry season

combined with the dispersal of wastes along the river route from upstream has reduced surface water quality in rivers and canals. Widespread saline intrusion has greatly affected water resources. The peak and prolonged heat wave causes prolonged drought, combined with the blocking of upstream hydroelectric dams and the rise of sea level rise leading to stronger saltwater intrusion.

3.1.3.4. Impact on coastal infrastructure works

The main types of coastal infrastructure are affected: sea dyke systems, river dykes, irrigation works, roads, coastal The whole sea dike route in Giao Thuy district is 31.16 km long and more than 20 km long for large rivers such as Red River and So River. The dyke body is mainly covered with sandy soil, the cross-section is small, the crest is low and eroded. When there is a big storm, waves will overflow the dyke. The period 2010 - 2019 recorded an increase in river bank landslides and sea dyke protection, threatening the safety of dyke and embankment works, accompanied by the impact from an increase in rainstorms leading to flooding and subsidence.

3.1.3.5. Impact on changes in land use

Remote sensing analysis of land use in Giao Thuy district over the period 1986-1995- 2005–2015 shows that there is a big change in the structure of land use for each type of land, caused by both human and natural causes, including impacts from climate change. Land for rice cultivation, salt production and mangrove land decreased while aquaculture area increased sharply and natural embankment increased in alluvial areas.

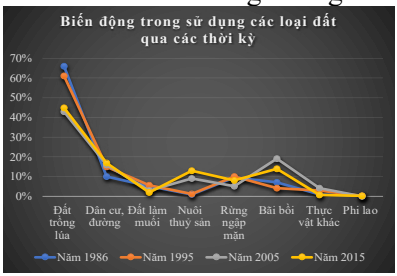

Fig. 3.13. Changes in land use over time

3.1.4. Impacts of disasters and climate change on SES sub-regions

In each sub-region, the risk and degree of impact and influence of natural disasters and climate change are very different. Storms and sea level rise, saltwater intrusion have the strongest impact on the area outside the dyke (B1, B2, B3) - where there are mangrove ecosystems, tidal flats, alluvial flats, large water surface with aquaculture pond. land areas - inside the dyke (A1, A2, A3) are mainly affected by heavy rain and flooding. Storms and sea level rise, saline intrusion have the strongest impact on the area outside the dyke (B1, B2, B3) – a typical place with mangrove ecosystems, tidal flats, alluvial flats and large areas of water with aquaculture and fishing.

The sub-region inside the dike – inland fields (A1, A2, A3) is strongly affected by heavy rain, high tide and flooding. These areas are typical for agricultural ecosystems with rice fields, freshwater and brackish aquatic ponds. About 25–30% of the mangroves and aquaculture lagoons of Giao An commune are regularly affected during the rainy and stormy season. The hierarchy of impacts of typical natural disasters and climate change on the regions is shown as Fig. 3.14, 3.15.

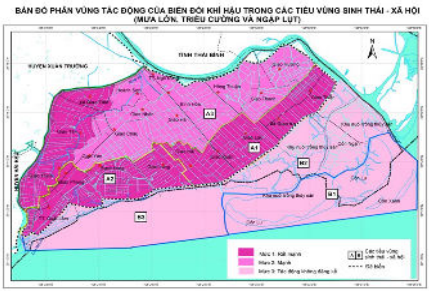

Fig. 3.14. Impact of heavy rain and high tide on sub-regions

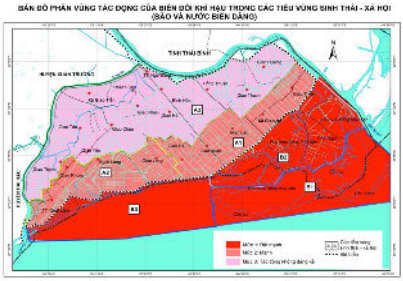

Fig. 3.15. Impact of storms and sea level rise on sub-regions

3.1.5. Potential impacts of climate change according to the scenario

It is predicted that in CC scenarios, the Giao Thuy district will continue to face high risks from storms and sea level rise, these can increase saltwater intrusion, flooding, coastal erosion, and the risk of

land loss [47]. The forecast of the trend of climate factors is as follows: The average summer temperature tends to increase, being the highest compared to the seasons of the year, especially at the end of the century in all medium and high scenarios; Rainfall: in the middle of the 21st century, annual rainfall tends to increase with a range of 3 to 5%; If sea level rises by 100 cm, Nam Dinh province could be flooded by 43.67% and Giao Thuy district by 64.53% (Climate Change Scenario, 2020) [3].

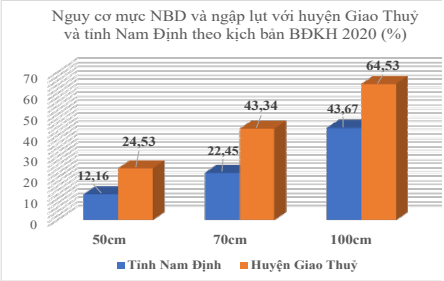

Fig. 3.16. Risk of flooding due to sea level rise in Giao Thuy district according to Climate Change Scenario, 2020 (Climate Change Scenario, 2020)

3.2. Assessment of climate change resilience of Giao Thuy district

3.2.1. Proposing the indicators to assess the resilience of Giao Thuy district

Resilience includes adaptability, which represents the health of the system. This characteristic varies across space, time and influencing factors, often being assessed semi-quantitatively without a defined threshold like the tolerance of a particular physical object (mangroves or a dyke/embankment work) by the effects of a specific environmental factor (such as salinity, temperature...).

3.2.2. Bases and principles for proposing indicators

Comprehensively, assessing the resilience to climate change of a social-ecological system like Giao Thuy district is to consider the responsiveness and availability of the system's resources, to adapt and withstand the extreme impacts of CC and take advantage of opportunities conducive to development. Resources include: Nature; Economy, Society, Physics/Infrastructure and Policy. Principles in determining and selecting criteria and indicators: representativeness; The role of natural resources, local characteristics; Weighted - different

levels of importance of indicators, criteria and resources; Involvement of stakeholders; Ability to respond to data and information sources; Refer to the criteria of the New Rural program.

3.2.3. Indicators to assess the resilience of Giao Thuy district

A set of 125 indicators belonging to 25 criteria representing 5 resources has been developed to assess the CC resilience of the SES of Giao Thuy district. The assessment is based on information and data collected through many surveys at commune and district levels as well as additional consultations with provincial agencies. Information and data are processed and analyzed in the direction of combining qualitative and quantitative. The weighting is applied to all three assessment levels (Level 1: Resources; Tier 2: Criteria; and Tier 3: Indicators), this is to compare the importance of indicators and criteria.

3.2.4. Resilience of Giao Thuy distric's social - ecological syste

3.2.4.1. Results of assessment of resilience to climate change

The results of the combined quantitative and qualitative assessment of 5 resources of Giao Thuy district have been synthesized and ranked, thereby showing an overview of the climate change resilience of Giao Thuy district.

Accordingly, the average ranking score of 5 resources of Giao Thuy district is 3.59 - medium high. Among them, Physical and Social resources have the highest scores of 3.82 and 3.75. Giao Thuy has strengths in transport infrastructure, housing and public works. Following the scores of Policy, Natural and Economic resources are at average level, at 3.53, 3.49 and 3.44, respectively, in which, policies for strengthening CC response and disaster risk reduction have shortcomings in implementation, monitoring and evaluation.

Table 3.12. Summary of the results of the evaluation of the criteria.

Resources	Criteria	Score of criteria	Weight of criteria	Score of resources	Ranking of resources	Weight of Resources
NATURE	1. Geographical location (Position resources)	4.07	0.06	3.49	Average	0,093 (4th)
	2. Natural resources	4.39	0.14			
	3. Development in harmony with nature (eco-landscape)	3.69	0.52			
	4. Natural hazards	2.44	0.23			
	5. Environmental Quality	3.11	0.05			
PHYSICS/ INFRASTRUCTURE	6. Electricity	4.26	0.18	3.82	High	0.274 (2nd)
	7. Water/irrigation works	3.89	0.11			
	8. Traffic infrastructure	3.79	0.06			
	9. Housing	3.74	0.27			
	10. Works, and equipment for disaster response/climate change	3.63	0.37			
ECONOMY	11. Income	3.90	0.21	3.44	Average	0.401 (1st)
	12. Organization of production and employment	3.48	0.53			
	13. Finance and Budget	2.97	0.15			
	14. Assets and accumulation	2.89	0.07			
	15. Subsidies and resource mobilization	3.18	0.04			
SOCIETY	16. Population	3.06	0.36	3.75	High	0.076 (5th)
	17. Medical - health	4.15	0.09			
	18. Education, communication, culture	3.88	0.18			
	19. Social organization	4.35	0.30			
	20. Stakeholder's willingness to participate	3.86	0.08			
POLICY	21. Practicality and effectiveness of policy implementation	3.63	0.45	3.53	Average	0.156 (3rd)
	22. Integration and coordination	2.83	0.12			
	23. Governance (social organization for effective policy implementation)	3.26	0.41			
	24. Policy Dialogue	2.91	0.04			
	25. Monitoring and evaluation	2.93	0.03			
→ SUMMARY POINT 5 RESOURCES: 3.59 points; Ranking: Average High						

Table 3.14. Ranking resources that demonstrate CC resilience.

Table 3.14. Ranking resources that demonstrate resilience to climate change

Resources	Score	Ranking	Weight of Resources	Average score of SES	Ranking of SES
Nature	3.49	Medium	0,093 Fourth important	3.59	High medium
Physics	3.82	High	0.274 Second most important		
Economy	3.44	Medium	0.401 Most important		
Society	3.75	High	0.076 Fifth important		
Policy	3.53	Medium (high medium)	0.156 Third most important		

(*Ranking: <=1.8: Very low, <=2.7: Low, <=3.6: Medium low, <=4.6: High, <=5: Very high

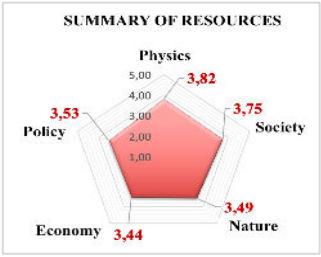

Fig. 3.19. Score of resources of Giao Thuy district

The chart summarizes the results of the assessment of each resource: Nature, Society, Physics, Economy, Policy. (Fig.3.20). Similarly, applying the CDRI method and the AHP method with the 5*5 index set to assess the resilience to CC at the commune level with the case that 2 communes represent 2 social - ecological zones along the coast coast and in the field, the following results were obtained: Giao An commune is 3.64 points - High and Giao Tien commune has 3.75 points - High average. (Fig. 3.20).

Table 3.14. Ranking resources that demonstrate resilience to climate change

Resources	Giao An commune		Giao Tien commune	
	Score of Resources	Weight of Resources	Weight of Resources	Weight of Resources
Nature	3.55	0,250	3.52	0,034
Physics	3.76	0,500	3.92	0,492
Economy	**3.48**	**0,140**	**3.60**	**0.271**
Society	3.72	0,030	3.81	0,070
Policy	3.46	0,080	3.48	0,135
Score of SES:	**3.64**		**3.75**	
Ranking	**Medium**		**High medium**	

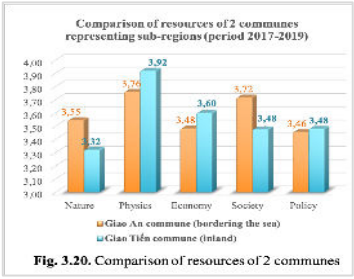

Fig. 3.20. Comparison of resources of 2 communes

3.2.4.2. Current status of resources for disaster risk reduction

❖ *Natural resources:* Location adjacent to the sea and estuaries - positional resources, high biodiversity, favorable land and surface water resources, these are advantages - important natural capital of Giao Thuy district. The coastal location with 3 large estuaries and where 2 big rivers flow through - this is a source of fresh water and alluvium, creating great advantages for agriculture, fishing, aquaculture, mangrove development and tourism. However, mangrove ecosystems and wetlands are at high risk from storm surge.

❖ *Economic resources*: Economic responsiveness is reflected in the status of Employment, Income, Finance and budgeting, Assets and accumulation, and Subsidies and resource mobilization. Currently, Giao Thuy meets at a high medium level with many advantages in terms of employment, diversity of livelihoods and incomes, etc. but difficulties in budget and finance for climate change response.

❖ Physical resources/infrastructure: reflected in the

responsiveness of electricity, water and irrigation works, transport infrastructure, houses and works, and equipment for disaster response ad CC reponse. Currently, Giao Thuy has a high medium level. In general, infrastructure in particular and material resources in general meet about 70% (2017-2019) but it will be very difficult when there are big storms and super storms; high risk for coastal communes.

❖ *Social resources*: considered on the main factors are population, health, education - communication, culture, social organization and community readiness, in which human factor and network Social organization is the most important. The main limitations are skills and knowledge and skills of government, health, and educational staff on long-term response to climate change.

❖ *Policy:* assessed through factors such as policy availability and effectiveness, mainstreaming and coordination, governance, dialogue and monitoring and evaluation. Accordingly, Giao Thuy district still has many limitations and difficulties in policy implementation, integrating CC adaptation into development plans, and substantive monitoring and evaluation. The participation of women and disadvantaged groups in planning and decision-making is unclear.

3.3. Proposing adaptation solutions according to the ecosystem approach to enhance the climate change resilience of the SES

Based on: i) research results on impacts, risks due to climate change and resilience to climate change of the social-ecological system; ii) solutions in 8 adaptive action groups of IPCC; and iii) local suitability.

3.3.2. General solutions

It is necessary to carry out the assessment of risks of natural disasters and climate in the planning of sustainable management of the National Park; integrating biodiversity conservation objectives into socio-economic development; Develop and share a general database on natural disasters and climate change; Strengthen interdisciplinary

cooperation between natural resources - environment management and natural disaster prevention and control; Capacity building for local staff on ecosystem-based approaches and nature-based solutions.

3.3.3. Solutions for Economic and Natural Resources

Implement climate-disaster risk assessment in planning sustainable management of nature reserves; Integrate biodiversity conservation goals into development planning. Strengthen interdisciplinary cooperation between the sectors of natural resources - environment, climate change and socio-economic development and infrastructure; Apply EbA and nature-based solutions.

3.3.3.1. Applying Eco-system based Approach and Nature-based Solution (EbA, NbS) in climate-resilient livelihood development.

Fig. 3.24. Nature-based solutions for the social-ecological system in the coastal area of Giao Thuy district

Development of a circular eco-farm model for agro-ecosystems in the inland area (fresh water) (Fig. 3.25), and Aquaculture in mangroves combined with community-based tourism for eco-sub-regions outside the dyke (Fig. 3.26).

3.3.3.2. Proposing climate change resilient livelihood models for social-ecological sub-regions

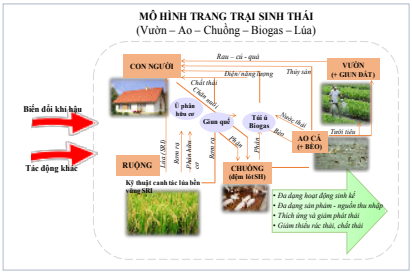

Fig. 3.25. The model of circular eco-farm for agro-ecosystems in the inland area (fresh water)

Fig. 3.26. Model of Aquaculture in mangroves combined with community-based tourism for eco-sub-regions outside the dyke

3.3.4. For Policy resources:

Local authorities review and evaluate the results of the implementation of policies for the period 2016-2020. Integrate the disaster risk reduction and climate change adaptation into the five-year and annual socio-economic plans for the period 2021-2030.

3.3.5. For social resources:

Digitize and widely and timely disseminate disaster-climate and environmental risk information via social media to support decision-making (risk informed development).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The social-ecological system analysis framework developed for Giao Thuy district is appropriate based on the theory and general international analytical frameworks and the characteristics of the study area - high-risk coastal areas due to climate change. Compared with the Ecological-human approach, the approach of social-ecological system pays more attention to the institutional, policy and social organization factors of the social system - the key factor for development, so increase the practical significance of thesis in the context of Vietnam.

The social-ecological system of Giao Thuy district is characterized by the natural system, the social system and the mutual interaction between the two systems. In terms of nature, Giao Thuy is a coastal plain, an estuary with high biodiversity and strongly affected by CC and sea level rise. In terms of society, this is a traditional agricultural economic region associated with fisheries, a large population, and a transformation in economic structure and development planning. The SES of Giao Thuy district is divided into 2 large zones: i) The inland zone is characterized by fresh water, less affected by storms and sea level rise; main livelihoods include cultivation, animal husbandry and freshwater aquaculture, and ii) SES sub-region bordering the sea, including the area outside the dyke, characterized by saline water, strongly and directly affected by storms, floods and sea level rise, associated with saltwater aquaculture livelihoods; and areas within the dyke, associated with brackish water aquaculture livelihoods.

Giao Thuy district is strongly affected by climate change and sea level rise, specifically storms, heavy rains, floods, saltwater intrusion and harmful cold, causing great risks to crop livelihoods, aquaculture and water resources. Typical ecosystems such as mangroves and coastal protection forests also face increased challenges from storms and super typhoons. Storms and floods tend to increase in frequency, intensity and irregularity in recent decades. If the sea level rises by 100cm by the end of the 21st century, about 64.53% of the area of Giao Thuy district will be at risk of being flooded.

Climate change resilience has been assessed based on resources including: Nature, Economy, Society, Physics/Infrastructure and Policy. Assessment results by CDRI method with 125 developed indicators, showing that CC resilience is at high medium (3.59 point), in which the strongest resource is Physics/Infrastructure, followed by Society, Policy, Nature and Economy. Resources are often mentioned

including finance, physics and human, but in the current reality torespond to climate change in the long term, it is necessary to have comprehensive resources, including both material and immaterial, both internal and external. The CDRI method, therefore, can be further developed to be replicated in other localities.

The process of evaluating resources with weighted AHP method - comparing and determining the importance of specific criteria and indicators has helped to clarify the strengths and practical concerns of the locality for resources and sectors. This approach is very necessary when assessing the resilience and adaptability of a SES at different scales. For a commune or smaller scale such as a village or a community area, it is also possible to apply weighting to criteria and indicators when assessing resilience, adaptation to climate change, or assess New Rural areas or support decision-making, select options for risk reduction and CC adaptation.

The thesis proposes solutions for enhancing resilience to CC according to the ecosystem-based approach, including solutions for resources such as economy, policy, Physics, nature, and society. In addition, 02 climate-resilient livelihood models following the EbA approach to achieve multiple benefits and low emissions (symbiotic/circular economy) have also been proposed for two typical subdivisions: inland and coastal.

Determining the climate resilience of the social-ecological system of Giao Thuy district through the response of resources will support local decision-making in the future when socio-economic development plans, disaster risk reduction and CC adaptation plans as well as natural resource management.

The limitations of the thesis:

Thesis's analytical framework from the point of view of " social – ecological system" has basically achieved the goals originally set out in a systematic, interdisciplinary approach, however, there are also

limitations in the analysis and quantitative assessment of the system's resilience, for example assessing the "resistance limit" of s SES.

There have not been in-depth studies and more detailed calculations on social-ecological zoning, and spatial and vegetation factors have not been fully studied. In addition, the research is limited in terms of comprehensive quantitative assessment of impacts of CC on sectors, especially natural ecosystems, due to the reliance on availability of the database and the duration of the study.

Significance of the results achieved and replicability:

In addition to theoretical contributions to research and implementation in Vietnam on SES and EbA approaches and CC resilience assessment, the results from the development of resource assessment indicators can be applied to research and implementation practice in other localities.

Results from CC impact assessment and CC resilience that have provided updated information and data for local reference and application to relevant plans, programs and projects to respond to CC in the 2021-2030 period, thereby contributing to resource management and socio-economic development of Giao Thuy district and other areas with similar conditions.

Recommendations

Continuing to research and deploy the theory of social-ecological systems in different localities to get more results with higher scientific and practical basis in the context of Vietnam, in which consideration is given to the system's CC "resistance threshold".

There is a need for quantitative assessment of climate vulnerability for natural ecosystems and cost-benefit analysis of climate-resilient livelihood models and ecological solutions with a “nature-based” approach; Integrating EbA, NbS and climate risks into policies and development plans for the period 2021-2030, and in resource management, and at the same time monitoring and evaluation.