

**MINISTRY OF NATURAL RESOURCES AND  
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AND CLIMATE CHANGE**

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**Nguyen Thi Ngoc Anh**

**RESEARCH AND EVALUATION OF LOSSES  
AND DAMAGES OF MANGROVE  
ECOSYSTEMS IN MUI CA MAU NATIONAL  
PARK RELATED TO CLIMATE CHANGE**

Field of study: Climate Change

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**SUMMARY OF DOCTORAL THESIS**

The thesis is completed at:

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The thesis shall be defended in front of the Thesis Committee at Institute Level at Institute of Meteorology, Hydrology and Climate Change

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- Library of Institute of Meteorology, Hydrology and Climate Change

- Vietnam National Library

## **LIST OF ANNOUNCED WORKS OF AUTHOR RELATED TO THE THESIS**

1. Nguyen Thi Ngoc Anh, Nguyen Trung Thang (2019) “Some issues about loss and damage caused by climate change”, *Journal of Natural Resources and Environment*, Issue 1 – October 2019.

2. Nguyen Trung Thang, Nguyen Thi Ngoc Anh (2020), “Community-based assessment of losses and damages related to climate change – experiences of some countries and directions for application to Vietnam”, Theme III No. 9, *Environmental Journal*.

3. Nguyen Thi Ngoc Anh, Tran Dang Hung, Le Phuong Ha (2021), "Application of machine learning methods - decision trees in assessing mangrove changes in Dat Mui commune", *Journal of Change Science. climate* number 20, December 2021.

4. Nguyen Trung Thang, Nguyen Thi Ngoc Anh, Nguyen Sy Linh, Dao Canh Tung (2022), "Assessment of loss and damage caused by climate change: from theory to practice", *Monograph*, Dai Publishing House. Hanoi National University.

5. Nguyen Trung Thang, Nguyen Thi Ngoc Anh, Dao Canh Tung, Tran Quy Trung (2022), Overview of methods of assessing loss and damage related to climate change, *Journal of Science: Political Research Books and Management* (No. 02/2022), Hanoi National University

## INTRODUCTION

### 1. Make a problem

Mangroves and ecosystems Coastal areas play a great role in economy, ecology and environment, have important functions for the population community such as: providing food, foodstuffs and medicinal herbs; coastal protection, windbreak, wave break; improve coastal water quality; carbon storage; is the habitat of wild animals; is an educational, research and entertainment environment. However, according to the recent Intergovernmental Panel on Climate Change (IPCC) forecast, due to the impacts of climate change, mangrove forests along the coast are predicted to decrease in area and function., growth ability. Located between land and sea at low latitudes, mangroves are a vulnerable area to climate change.

Around the world, the loss and damage (*L&D*) *caused by climate change has been mentioned*, formed and developed by the United Nations Climate Change Summit (UNFCCC). through the Conference of the Parties (COP) from 2007 to present. The 2015 Paris Agreement also mentioned that the parties recognized the importance of preventing, minimizing and addressing loss and damage related to the adverse effects of climate change, including climate change events. extreme weather and slow-moving events and the role of sustainable development in reducing the risk of loss and damage. Participants must increase understanding, action, and support, on a cooperative basis, about the losses and damages resulting from the adverse impacts of climate change. Article 8 of the Agreement stated 8 areas of cooperation and facilitation to enhance mutual understanding, action and support, of which non-economic losses are one of the mentioned contents.

In Vietnam, the loss and damage to mangrove ecosystems due to climate change has not been studied much to measure and evaluate. Stemming from this practice, the thesis “***Research on, assessment of loss and damage to mangrove ecosystems in Ca Mau Cape National Park related to climate change***” was built with the expectation of the results of the study. the study will provide a scientific basis for managers and experts to identify and determine the damage caused by climate change to the mangrove ecosystem; develop orientations for management and conservation of mangroves in the context of reasonable climate change.

## **2. Research objective**

(i) Identify appropriate methods and procedures to assess loss and damage to mangrove ecosystems in Ca Mau Cape National Park related to climate change

(ii) Assess the loss and damage to the mangrove ecosystem in Ca Mau Cape National Park related to climate change and propose solutions to minimize.

## **3. Objects and scope of research**

### **3.1. Research subjects**

The object of the study is the loss and damage caused by climate change to the mangrove ecosystem in Mui Ca Mau National Park, namely (i) loss and damage to services provided ( supplies of wood, firewood, medicinal herbs, aquatic products/seafood); (ii) loss and damage to support services (losing the area of mangrove forest which is a breeding ground for mangrove species and species); (iii) loss and damage to regulatory services (reducing protection against coastal erosion) and; loss and damage to cultural and entertainment services (focusing on tourism services).

### **3.2. Research scope**

- Spatial scope: loss and damage assessment for the mangrove ecosystem in Ca Mau Cape National Park, which is concentrated in the area of Dat Mui commune.

- Time range: assessment of loss and damage to mangrove ecosystems in Ca Mau Cape National Park in the period from 1989-2020 (20-30 years ago) and forecast to the year 2050-2100.

### **4. Research question**

- What methods and processes can be used to combine public and scientific knowledge to assess loss and damage to mangrove ecosystems ?

- How is the loss and damage to the mangrove ecosystem in Ca Mau Cape National Park related to climate change over the past 20-30 years? Where are the focus losses and damages ?

- What solutions can reduce the loss and damage to the mangrove ecosystem? Ca Mau Cape National Park ?

### **5. Dissertation defending points**

Point 1. Community knowledge is valuable information in the assessment of loss and damage to mangrove ecosystems. However, community knowledge is not enough, it needs to be combined with scientific knowledge to be able to assess the loss and damage to mangrove ecosystems related to climate change.

Point 2. The mangrove ecosystem of Mui Ca Mau National Park suffers from many losses and damages related to climate change, in which the services of providing aquatic products and services, and the prevention and control of landslides. Coastal erosion is the main loss and damage.

Point 3. Structural and non-structural solutions can be applied

to minimize loss and damage to mangrove ecosystems related to climate change.

## **6. Scientific and practical significance**

### **6.1. Scientific significance**

Provide a theoretical basis for the loss and damage caused by climate change; International experience on loss and damage assessment in general and loss and damage to mangrove ecosystems in particular, is a useful reference for scientific research and policy planning. book on climate change response, management and restoration of mangroves.

### **6.2. Practical significance**

Research results are the basis to help managers and policy makers identify the type and extent of loss and damage in general related to climate change and the mangrove ecosystem in particular; on that basis, propose solutions to proactively respond to abnormal manifestations of climate change and natural disasters in the coming time, and at the same time, sustainably manage the mangrove ecosystem in the context of climate change. post.

## **7. New contributions of the Thesis**

- Currently, comprehensive research on loss and damage is still limited, there are no guidelines for assessing loss and damage due to climate change as well as processes, methods and tools to apply., especially with non-economic losses and damages. In Vietnam, the issue of non-economic loss and damage, particularly with mangrove ecosystems related to climate change, has not been studied. Therefore, within the scope of implementation, the thesis has clarified the scientific basis for loss and damage mangrove ecosystems related to climate change on the basis of an overview study of loss and damage

assessment in general and for mangrove ecosystems in particular related to climate change.

- The thesis has proposed methods and procedures for assessing loss and damage to ecosystems mangroves in relation to climate change. On that basis, by combining qualitative and quantitative assessment methods, the thesis has assessed the loss and damage to the mangrove ecosystem in Mui Ca Mau National Park related to climate change and propose solutions to minimize loss and damage to ecosystems mangrove forests in the context of increasingly complex climate change.

## **8. Thesis structure**

In addition to the Introduction, Conclusion and Recommendations, the thesis consists of Chapters with the following main contents:

Chapter 1. Overview of assessment of loss and damage to mangrove ecosystems related to climate change

Chapter 2. Approach and methodology to study loss and damage to mangrove ecosystems in Mui Ca Mau National Park related to climate change

Chapter 3. Results of assessment of loss and damage to mangrove ecosystems in Ca Mau Cape National Park related to climate change.

## **CHAPTER 1. OVERVIEW OF ASSESSMENT OF LOSS AND DAMAGE TO THE MASSROVAL FOREST ECOSYSTEM RELATED TO CLIMATE CHANGE**

### **1.1. Theoretical basis for assessment of climate change-related loss and damage to mangrove ecosystems**

There are many authors and organizations that offer the concept of loss and damage caused by climate change. “The loss and damage caused by climate change is understood as the inevitable loss after implementation of mitigation and adaptation measures. Loss and damage can be the result of sudden-onset events, such as storms, floods, droughts, heat waves, etc., or slow-moving processes over time. slow-onset events such as temperature rise, sea level rise, saltwater intrusion, ocean acidification, desertification... According to UNFCCC, climate change related losses and damages can be classified into two categories: (i) economic loss and damage and; (ii) non-economic loss and damage.

Loss and damage to the mangrove ecosystem related to climate change can be understood as the inevitable loss and damage to the services that the mangrove ecosystem provides after the implement solutions to mitigate and adapt to climate change. In which, the most obvious manifestation that climate change causes to the ecosystem Mangroves are sea level rise that causes loss of mangrove areas, causes coastal erosion, and reduces the services that mangrove ecosystems provide.

According to IPCC 2012, there are currently 02 approaches to loss and damage assessment, including: (i) assessment from the perspective of disaster risk reduction (DRR) and; (ii) climate change adaptation (CCA) assessment. For each approach, it is divided into pre- or post-disaster assessment, qualitative or quantitative assessment.

## **1.2. Overview of Vietnam's policies and laws on assessment of climate change related losses and damages to mangrove ecosystems**

In Vietnam, recently, a number of documents related to the assessment of losses and damages related to climate change have also been issued, such as the Law on Environmental Protection 2020, the National Strategy on Climate Change in the second half of the year. period to 2050, National plan to adapt to climate change for the period of 2021-2030, with a vision to 2050, Circular No. 01/2022/TT-BTNMT dated January 7, 2022 of the Ministry of Natural Resources and Environment...

Protect and restore ecosystems Mangrove forest in the current period is the right orientation that the Party and State continue to pay attention and promote through documents such as Resolution No. 06/NQ-CP dated January 21, 2021 of the Government issued by the Government. 24-NQ/TW, Vietnam's forestry development strategy for the period of 2021 - 2030, with a vision to 2050, the project "Protecting and developing forests in coastal areas"to respond to climate change and promote green growth in the 2021-2030 period".

### **1.3. Overview of domestic and international research on assessment of loss and damage to mangrove ecosystems related to climate change**

- *Research abroad:* in each study, the authors use different methods to assess loss and damage. The method that can be used for qualitative assessment is the participatory method of the local community. To quantify ecosystem loss/damage basically use valuation techniques (environmental valuation methods) or remote sensing image analysis to assess damage to mangroves such as the extent of erosion coast (affecting services provided by mangroves).

- *Domestic research:* In Vietnam, there have also been a number of studies and assessments of losses and damages related to

climate change, but there has not been any specific research on assessment of losses and damage to ecosystems. mangrove forest. Vietnam still lacks research on scientific basis, selection of appropriate methods to assess loss and damage caused by climate change to non-economic types in general and mangrove ecosystem in particular..

#### **1.4. Overview of the study area**

National Park is the land located at the end of the Ca Mau peninsula. This is the only area in Vietnam with 3 sides bordering the sea, affected by two water regimes. Ca Mau Cape National Park is an area that is adversely affected by natural disasters and climate change due to its geographical characteristics, located in the area affected by the monsoon climate, which is directly adjacent to the impacts of natural disasters and climate change. tidal dynamics in the East and West Seas. This is a natural mangrove ecosystem with high value in terms of biodiversity, natural landscape, environment and is very important in coastal protection, windbreak, anti-erosion breakwater, land immobilization in coastal areas. the process of land formation into the East Sea. However, the livelihood of local people is highly dependent on the resources provided by the mangrove ecosystem of the National Park.

#### **1.5. Identify gaps and issues to be researched**

- There have not been many studies on methods of assessing loss and damage to mangrove ecosystems in the world and in Vietnam.
- There are no studies on assessment of loss and damage to mangrove ecosystems in Vietnam in general as well as for Ca Mau area and Ca Mau Cape National Park in particular.

- There are no studies to propose solutions to minimize loss and damage to the mangrove ecosystem in Ca Mau Cape National Park.

## **CHAPTER 2. ACCESSORY AND METHODOLOGY OF RESEARCH DAMAGE AND LOSSES**

### **2.1. Approach**

- Interdisciplinary approach: Climate change affects many sectors and fields and occurs continuously with the movement of the earth. Therefore, the assessment of losses and damages should be done in a comprehensive, interdisciplinary approach.

- Top-down and bottom-up approaches: A top-down approach to clarify the current situation, organizational structure, and model of mangrove ecosystem management in Mui Ca Mau National Park in the context of climate change.. In order to grasp the actual situation of loss and damage, the PhD student conducted an investigation and survey to collect information and data of the parties related to the loss and damage. mangrove ecosystems due to climate change.

- Historical approach: To assess the loss and damage to the mangrove ecosystem of Mui Ca Mau National Park, it is necessary to understand the historical characteristics of the study area, the specific manifestations of natural disasters. historical distinction and its impact on mangrove ecosystems.

- Integrated approach, combining qualitative and quantitative assessment: The community-based assessment method is applied through surveys, surveys, and interviews with people to identify and determine its quality. extent of loss and damage to mangrove ecosystems in Ca Mau Cape National Park. On that basis, the thesis applies remote sensing, GIS and economic valuation methods to

determine fluctuations in coastal erosion prevention and control services.

- Market Access: From the market approach, it is possible to propose a market-based solution in mangrove protection and climate change response to encourage and motivate all economic sectors to participate in this activity.

## **2.2. Research Methods**

- Method of document review: carried out through the inheritance of existing studies on international, regional and Vietnamese losses and damages. The thesis has collected and researched domestic and international documents on the theoretical basis and international experience related to loss and damage.

- Methods of information collection, sociological investigation: implemented in community-based loss and damage assessment for mangrove ecosystems in Ca Mau Cape National Park.

- Remote sensing method and geographic information system: used to assess shoreline changes, on that basis to determine loss and damage of coastal erosion prevention services of Mui Ca Mau National Park under the impact of climate change and sea level rise.

- Valuation method: The replacement cost method is used to estimate the damage value of coastal protection and anti-erosion services of Ca Mau Cape National Park; the market price method is used to estimate the damage value and the value transfer method is used to determine the loss value of the services provided by the ecosystem.

- Methods of statistics, synthesis, comparison and analysis: are used in the process of developing the content of the thesis, helping to

establish the data and scientific basis for the statements and conclusions used in the thesis. judgment.

- Expert method: used to determine and select methods of loss and damage assessment The mangrove ecosystem related to climate change of Ca Mau Cape National Park is suitable.

### **2.3. Analysis and selection of methods and procedures for assessing loss and damage to mangrove ecosystems in Mui Ca Mau National Park related to climate change**

The thesis selects the main method to assess the loss and damage to the mangrove ecosystem of Mui Ca Mau National Park related to climate change :

- Qualitative assessment through community-based survey and assessment;
- Quantitative assessment by remote sensing/GIS method and economic evaluation.

The evaluation process includes the following steps: (1) Determining the objectives, scope, and plan of the assessment; (2) An overview study of climate change, impacts and identification of losses and damages; (3) Selection of assessment methods and tools; (4) Organizing field surveys; (5) Synthesize and analyze the evaluation results.

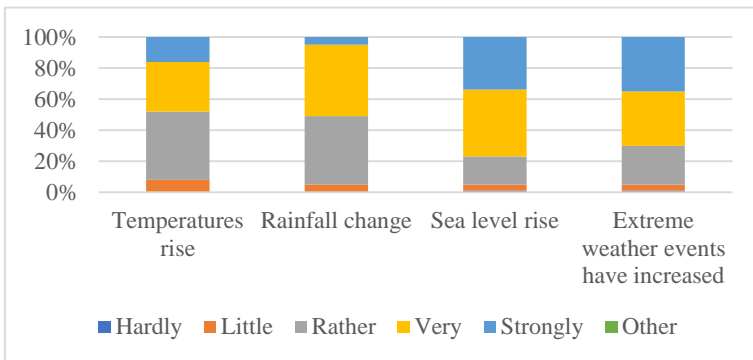
## **CHAPTER 3. RESULTS OF ASSESSMENT OF DAMAGE AND DAMAGE TO THE ECOLOGY OF THE MULTI-GROUNDED FOREST ENVIRONMENTAL GARDEN EVERY CA MAU RELATED TO CLIMATE CHANGE**

### **3.1. Community-based assessment results**

#### ***3.1.1. About the manifestation of climate change***

Most people noticed changes in temperature, rainfall, sea level

rise and weather phenomena such as storms and floods during their stay in the National Park. In which, 48% of the interviewees said that the temperature has increased significantly to a sharp increase; 51% said that the amount of rain showed a change from many to strong; especially 77% said that there is a sign of sea level rise of many to strong levels and; 70% said that there are many to strong and clear manifestations of extreme weather phenomena.



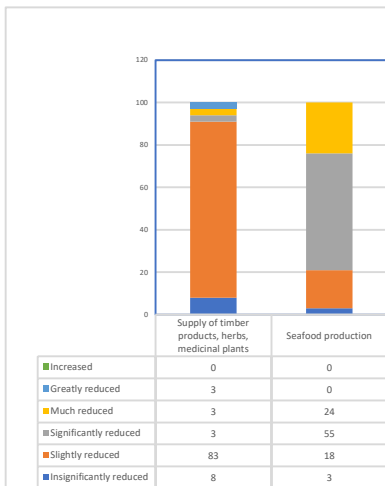
**Figure 3. 1. Manifestations of climate change according to people's assessment**

### ***3.1.2. About loss and damage to mangrove ecosystem services***

#### ***- Loss and damage to services provided:***

For the supply of wood, firewood and medicinal herbs of mangroves: The survey results showed that 96% of the respondents said that there is a decrease in the supply of wood, firewood and medicinal herbs of the mangrove forest. in which 83% assessed the decline at a low level. The reasons for the assessment were selected due to many factors, from the impact of climate change (38%), land use conversion (50%), over-exploitation and pollution from production activities, activities (45%). For aquatic and marine

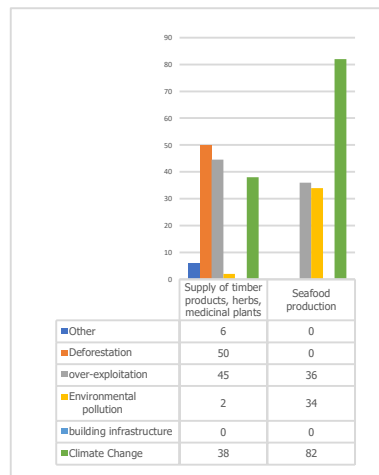
products of mangrove forests, 100% of the respondents answered that there was a decrease in the production of aquatic and marine products of mangroves, of which 24% assessed the decline at a strong level; 55% rated the decline as moderate. The impact of climate change is the main cause of the decline in fishery production (82%), in addition to being assessed due to other causes such as overfishing (36%), water (34%).



**Figure 3.3. Survey results on the level of service supply decline of Mui Ca Mau National Park**

*- Loss and damage of support services*

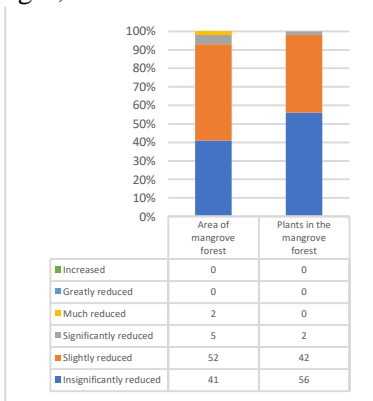
Regarding the area of mangroves and mangrove species, 99% of the respondents answered that there was a decrease in the area of mangroves, however, 41% said that the reduction was not significant; 52% have a slight decrease. The majority attributed the decline to the impact of climate change (about 96%), the rest attributed the destruction of mangroves to aquaculture (21%) and the over-



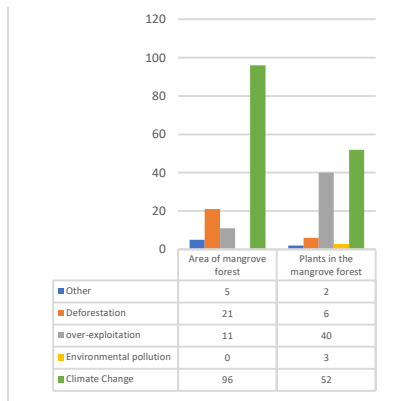
**Figure 3.4. Survey results on causes of service supply decline in Mui Ca Mau National Park**

exploitation of firewood. level (11%).

Regarding mangrove species, 97% of the respondents answered that there was a decrease in the number of mangrove species, however 56% said that the reduction was not significant; 42% have a slight decrease. The reason for the decline is the impact of climate change (about 52%). Some species that people consider to be in decline are: fish sauce, parrots, tigers, red cotton parakeets, price, pages, red toads...



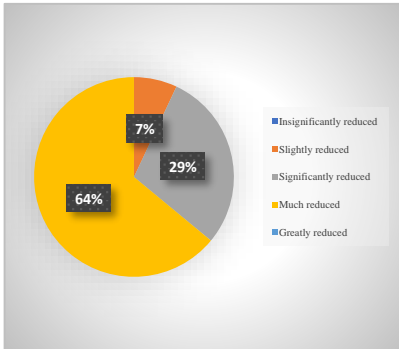
**Figure 3.5. Survey results on the level of decline in support services of Ca Mau Cape National Park**



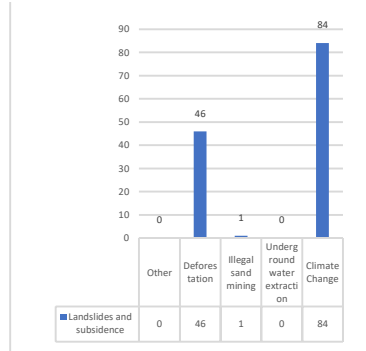
**Figure 3.6. Survey results on causes of decline in support services of Ca Mau Cape National Park**

*- Regulatory service loss and damage*

For coastal protection and anti-erosion services, 96% of respondents said there was a decline in coastal protection and anti-erosion services, of which 64% rated the decline at a strong level; 29% rated the decline as moderate; 7% rated the decline as low level. The majority of people identified the impact of climate change as the main reason for the reduction in protection services (84%).



**Figure 3. 7. Survey results on the decline in coastal erosion prevention and protection services of Mui Ca Mau National Park**



**Figure 3.8. Survey results on the causes of decline in coastal erosion prevention and protection services of Ca Mau Cape National Park**

*- Loss and damage to cultural services*

Regarding tourism services, the majority of people believe that the number of tourists to the National Park increases every year, only 30% think that there is a decrease in the number of tourists visiting the National Park. In which, 80% rated the decline at a negligible level.

**3.1.3. About adaptation solutions to climate change**

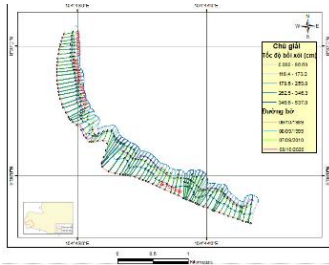
For solutions to adapt to climate change, reduce the impact of climate change on the mangrove ecosystem of Ca Mau Cape National Park, 100% of the people answered yes. in households, mainly embankment to prevent saline intrusion, job change, cropping season... However, the effectiveness of the solutions is not high. 85% of respondents said that after solutions have been implemented at households or from local authorities over the years, losses in fish and seafood production or the extent of coastal erosion still remain. take

place. The assessed solutions can only partially reduce the impact of climate change. 6% think that these solutions are not really effective (do not reduce the impact of climate change).

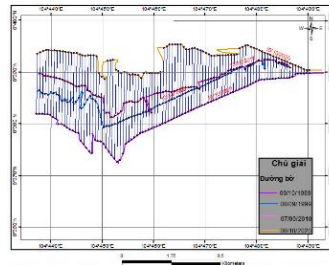
### ***3.2. Assessment results by remote sensing/GIS method combined with economic evaluation***

#### ***3.2.1. Assessment of changes in mangroves through shoreline changes in Ca Mau Cape National Park under the impact of sea level rise***

The results of shoreline variability in Ca Mau Cape show that, from 1989 to 2020, in the western coast area, the accretion process prevails, in the east coast area, the coastline changes sharply. complicated developments, in which erosion predominates. On the East coast, the average erosion rate was about 7.62 m/year during the period 1989-2020 (Figure 3.18). In contrast, on the west coast in the period from 1989-2020, the accretion trend took place strongly, the average accretion rate was about 77.4 m/year. However, in general, compared with the baseline in 1989, by 2020, the erosion process on the East coast will still prevail with an average landslide length of 12.89 m/year, while the West coast will still be dominant. is always accreted with an average accretion length of about 11.5 m/year (Figures 3.18, 3.19).



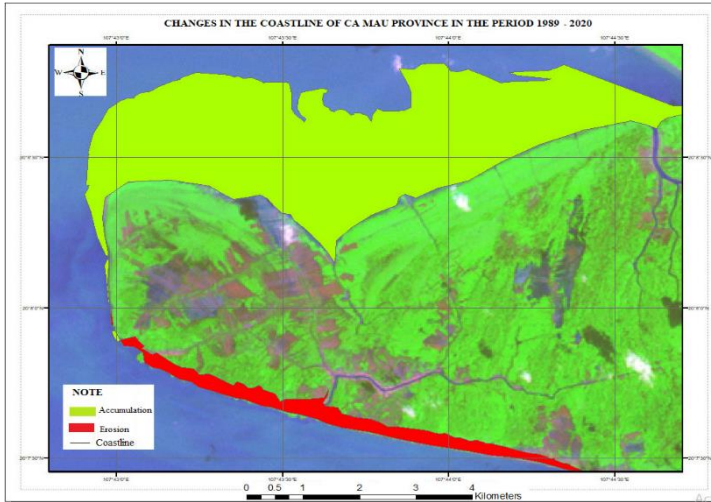
**Figure 3.18. Changes in the East Coast of Cape Ca Mau in the period 1989-2020**



**Figure 3.19. Changes in the West Coast of Cape Ca Mau in the period 1989-2020**

Based on the results of the shoreline calculated from the DSAS software to evaluate in more detail the area of erosion changes for the whole period 1989 - 2020. Carry out overlapping of the shoreline 1989 - 2020 with more details on the area of change. erosion for the whole period 1989-2020. Conduct overlapping of two shorelines 1989 and 2020.

The annual loss of land due to erosion ranges from a few tens of meters to hundreds of meters depending on each year and location, however, in the period from 1989 to 2020, the results show that the average area of land lost is 248,133 ha/ five.



**Figure 3.20. Overlapping shorelines for the period 1989-2020**

*3.2.2. Estimating loss and damage to mangrove ecosystems through economic valuation*

***a. Quantification of damage, protection value, against coastal erosion***

The thesis uses information on construction costs of artificial structures, specifically dykes in Ca Mau province. Currently, there is a project to build a coastal protection embankment in Vam Vuy estuary area with a length of 3,343 m, a cost of VND 118,154 billion [92]. Thus, each 1 km (1,000m) of coastline needs about 35.34 billion VND to build the embankment. As above analysis, in the study area, the east bank erosion averaged 12.89 m/year in the period 1989-2020. The project of building a coastal protection embankment in the area of Vam Vuy estuary belongs to class IV sea dykes, with a lifespan of 50 years. Consider the same level of support in coastal erosion prevention of the embankment system for each time unit (year). Thus, the annual

cost of landslide prevention for 50 years by building protective embankments is: 335,064 million VND/year, ie the value of loss and damage due to coastal erosion at the coast in this area is about 335,064 million VND/year.

***b. Quantification of damage to services providing aquatic resources***

Results of interviewing 114 households in the study area, the average income per household from aquatic resources is about 66 million VND/household/year. According to statistics of the People's Committee of Dat Mui commune, the total number of aquaculture and fishing households is 1338. Thus, the estimated total income from aquatic resources is: 88,308,000,000 VND/year. According to local people, under the impact of climate change and extreme weather events, about 8% of respondents assessed that their income from aquatic resources and seafood decreased from 30 -40%; 52% of people rate the level of income reduction from 40-60%; The remaining 40% assess the level of income reduction from 60-70% (compared to the current cash flow value).

Therefore, if the average income from aquaculture and fishing activities decreases by about 55% compared to 20-30 years ago, the estimated value of fishery resources lost each year is about 1,619,000,000 – 2,428,000,000 VND/year

***c. Quantification of damage to the value of mangrove ecosystem services***

thesis uses the value transfer method to estimate the damage value of services provided by the mangrove forests of Mui Ca Mau National Park. According to the report "Value of ecosystem services in Ngoc Hien district, Ca Mau province" under the Ecosystem Services

project of the Institute of Strategy, Policy on Natural Resources and Environment in collaboration with UNEP and GEF [34] implemented (2013), the total value of mangrove ecosystem services in Ngoc Hien district is 33,080,091 VND/ha/year, including supply services (wood, firewood, fishery catch, aquaculture). ), coastal protection services, carbon sequestration services, tourism landscape services. As analyzed above, in the period 1989-2020, the land area in the study area was lost about 248,133 ha.

Therefore, the estimated loss and damage of the mangrove ecosystem in the study area in Ca Mau Cape National Park for the period 1989-2020 (calculated at 2013 prices) is about 8,188 million VND/year.

### **3.3. General assessment of loss and damage to mangrove ecosystems in Ca Mau Cape National Park related to climate change**

Loss and damage to mangrove ecosystems are assessed using a community-based qualitative assessment of the service provided; Support Services; regulatory services; entertainment and cultural services. The services are assessed to decline at different levels, in which, the service of providing aquatic products and seafood and the protection and prevention of coastal erosion are the two services that suffer the most losses and damages in the National Park. Cape Ca Mau in relation to climate change. Loss and damage to the mangrove ecosystem in Ca Mau Cape National Park is considered to be declining for many reasons, from human activities such as exploitation, fishing, deforestation. Mangrove and climate change are among the causes of loss and damage.

Estimated loss and damage to mangrove ecosystem services in the study area of Mui Ca Mau National Park is about VND 8.188 million/year (price as of 2013). In fact, this value may be much higher

because the values of culture, education... as well as the current price are not taken into account.

### **3.4. Uncertainties of the assessment process**

- The methods used to assess loss and damage to mangrove ecosystems related to climate change have not been studied much.

- The separation of causes of loss and damage to mangrove ecosystems due to human activities or potential impacts of climate change is very complicated and difficult to define clearly. clear.

- Due to limited resources, the number of samples used for investigation and survey in Ca Mau Cape National Park is not large enough.

- The thesis has not comprehensively and fully assessed all the losses and damages of the ecosystem mangroves

### **3.5. Proposing solutions to minimize loss and damage to mangrove ecosystems related to climate change**

#### *3.5.1. General assessment of response to climate change and loss and damage in Ca Mau Cape National Park*

National Park has implemented activities in the management and protection of mangrove ecosystems: organize for households to participate in forest co-management, inspection and supervision of afforestation, forest protection and development; applying advanced techniques to aquaculture practice; focus on developing types of community eco-tourism...

However, there are still some difficulties: staff with high scientific and technical qualifications is still lacking, especially in the field of biodiversity conservation and climate change; The situation of free migrants and illegal residents in and around the National Park has not been arranged, arranged or relocated. There is no plan to change

stable occupations to create a long and sustainable life. sustainable for the people...

*3.5.2. Forecasting trends on changes in mangrove ecosystems in Ca Mau Cape National Park related to climate change*

According to the scenario of climate change and sea level rise in 2020 of the Ministry of Natural Resources and Environment, the rainfall in Ca Mau area tends to increase in recent years and by 2100 may reach an increase of 4-8% compared to the previous year. with the period 1990-1999.

The study area belongs to area 6 - Coastal area from Cape Ke Ga to Cape Ca Mau and 7 - Coastal area from Cape Ca Mau to Ha Tien among 7 areas where sea level rise scenarios are developed in Vietnam Male. Assuming the mangrove area does not change and applying the RCP 8.5 scenario, the research results predict the specific changes in the mangrove area as follows: if the sea level rises by 28 cm by 2050, the area will increase by 28 cm by 2050. The area of mangroves has been reduced by about 2000 ha (24.5%), leaving only about 76% of the current mangrove area. If the sea level rises by 75cm by 2100, the mangrove area will decrease by about 5,226 hectares (equivalent to 71.8%), only about 20% of the current mangrove area.

*3.5.2. Proposing solutions to minimize loss and damage to mangrove ecosystems related to climate change*

*a) For the national level*

- Implement the National Program on GHG emission reduction through limiting forest loss and degradation; conservation, enhancement of carbon stocks and sustainable management of forest resources (REDD+ Program) to 2030 approved in Decision No. 419/QĐ-TTg dated April 5, 2017 of the Prime Minister.

- Strengthening the system of state management agencies on mangrove management and biodiversity conservation in the context of climate change in the direction of clearly delineating management functions; strengthen the coordination mechanism among ministries, branches and localities in mangrove restoration and protection.

- Continue to perfect legal documents on protection, restoration and development of mangroves in the context of climate change. Integrate solutions to respond to climate change in strategies, master plans, plans, programs and projects to manage and restore mangrove ecosystems.

*b) For provincial level*

- The Department of Natural Resources and Environment of Ca Mau province should coordinate with Mui Ca Mau National Park to develop and implement the implementation of payment for ecosystem services in Mui Ca Mau National Park in accordance with the law.

- Departments/divisions/sectors of the province soon implement tasks and prioritized projects to implement the Action Plan to respond to climate change in Ca Mau province related to ecosystem protection and restoration. mangrove forests such as the Ca Mau Province Mangrove Planting Project, Livelihood support for communities in the buffer zone of the National Park, sustainable aquaculture development...

- Strengthen communication, integrate issues related to ecosystems and biodiversity resources, protect biodiversity in the teaching process or extracurricular lessons at all levels above. province area.

*c) For Cape Ca Mau National Park*

- In the study area, coastal erosion control and regulation services have been significantly reduced, therefore, it is necessary to continue to implement solutions to build embankments to protect the National Park, in the immediate future, embankments to create beaches. restore the protection forest of the East coast and the embankment to protect the working area of Mui Ca Mau National Park.

- Mobilize financial resources for afforestation, forest restoration and protection. Take advantage of more funding from domestic and foreign cooperation activities to implement projects on sustainable management and use of ecosystems, projects to respond to climate change.

- Focus on forestry development projects to support local communities participating in forest protection contracts; effective livelihood models under the forest canopy for sustainable economic development.

- Implement models of forest co-management, promote the coordination between district/commune People's Committees, National Park Management Boards and communities in sustainable management of mangroves and natural resources.

## **CONCLUSIONS AND RECOMMENDATIONS**

### **1. Conclusion**

1. By combining community knowledge and scientific knowledge, the thesis has built an appropriate method and process to assess and evaluate the loss and damage to the mangrove ecosystem of Mui Ca Mau national park related to climate change.

By combining qualitative and quantitative assessment methods, it is possible to identify the types of loss and damage to the

mangrove ecosystem in Ca Mau Cape National Park with many causes, including: climate change. Services provided by the mangrove ecosystem such as SUPPLY services (supply of timber, firewood, medicinal herbs, aquatic/seafood); support services (mangrove area is the habitat of organisms, about mangrove tree species); regulatory services (protection services, coastal erosion control) are assessed to decline at different levels. Cultural and entertainment services (focusing on tourism) in recent years have tended to increase due to the implementation of the province's tourism development policy and orientation.

The thesis used remote sensing/GIS method and economic evaluation to quantitatively assess damage to mangrove ecosystem services of Ca Mau Cape National Park. Among the services that the mangrove ecosystem provides, the production of aquatic products and seafood and the protection and prevention of coastal erosion are identified as the two services that suffer the most loss and damage in Mui Ca Mau national park in relation to climate change.

Coastline evolution is an important data source to assess the extent of erosion and accretion of the beach. Because the East coast is eroded every year, loss and damage to the SEA protection and anti-erosion services is still happening. In the period from 1989-2020, each year the length of the East coast is eroded about 12.89 m/year on average, the value of loss and damage due to coastal erosion at the coast in this area is estimated to be about 335 million VND/year. Therefore, the coastal erosion prevention service of the ecosystem mangrove forests is reduced. The service of supplying aquatic products and seafood has also been reduced. It is estimated that the value of aquatic resources lost each year had been about

1,619,000,000 - 2,428,000,000 VND/year in the past 20-30 years. With 248,133 hectares of land being eroded on average each year in the period 1989-2020, the loss and damage to the mangrove ecosystem in the study area is about 8,188 million VND/year.

In addition, according to the scenario of climate change and sea level rise in 2020, the thesis also estimates that the area of mangroves will be reduced and the extent of landslides on the East coast in 2100, and accordingly the services provided by the ecosystem will be affected. The supply of mangrove forests also tends to decline. According to the RCP 8.5 scenario, it is forecast that the mangrove area will be reduced by 28% in 2050, about 72% in 2100; Estimated east bank erosion in 2100 ranges from 2,350.6m to 2,415m.

2. To minimize loss and damage to the ecosystem mangrove forests related to climate change, contributing to the management, protection and rehabilitation of mangroves in Vietnam in general and minimizing loss and damage to mangrove ecosystems in Mui Ca National Park Mau in particular, it is necessary to develop and implement specific structural and non-structural solutions. In particular, in the area of Mui Ca Mau National Park, it is necessary to implement solutions to build embankments to protect the National Park according to Decision No. 1332/QĐ-UBND dated July 16, 2020 of the People's Committee of Ca Mau province.. The Department of Natural Resources and Environment of Ca Mau province should coordinate with MUI Ca Mau National Park to develop and conduct the implementation of payment for ecosystem services in Mui Ca Mau National Park in accordance with the law, considering it as a strategy to create a financial mechanism for natural resource conservation, contributing to poverty reduction for people in the region. Local

authorities at all levels need to coordinate and implement models of forest co-management, mobilize financial resources for afforestation, forest restoration and protection; strengthen the work of regulating dikes and sluices to prevent salinity in order to limit the impact of sea level rise and saline intrusion on the ecosystem in the province.

## **2. Recommendations**

1. The application of the community-based assessment method combining remote sensing/GIS and economic evaluation is suitable for Vietnam's conditions because it does not require specialized techniques, information sources, and complex data. However, the results of this assessment also have some limitations such as difficulty to separate the causes of loss and damage, the inaccurate results of qualitative assessment of loss and damage to the mangrove ecosystem with the subjectivity of the respondents, The unqualified entire loss and damage value of the mangrove ecosystem. Assessment results are representative of the study area, not representative of local or national losses and damages.

Within the framework of implementation, the thesis has not fully assessed the types of loss and damage to the mangrove ecosystem. Therefore, it is necessary to continue to develop other research directions to assess the loss and damage of mangrove ecosystems more comprehensively, such as loss and damage to cultural heritage, indigenous knowledge, local knowledge about the number of species of animals and plants. Particularly, in the field of forecasting, there is a need for further studies to assess future losses and damages under climate change scenarios.

2. Future studies can be based on the results of this thesis to get more complete and specific assessment information about the loss

and damage to the mangrove ecosystem. Managers can use research results as a basis for identifying priority solutions in mangrove management and restoration in the context of complex and unpredictable climate change. In addition, it is possible to conduct a loss and damage assessment of other mangrove ecosystems nationwide, especially in the Mekong Delta.