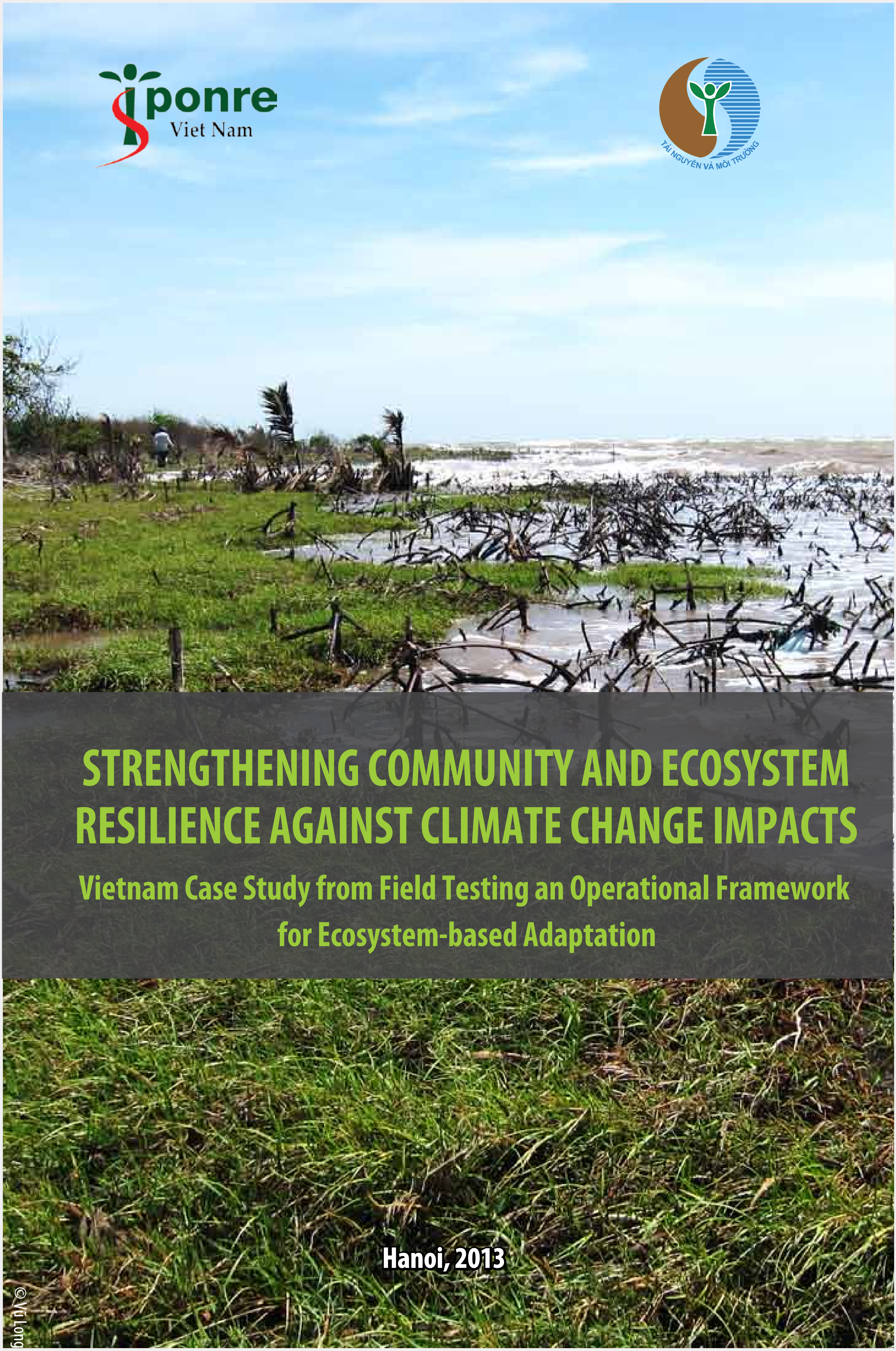

STRENGTHENING COMMUNITY AND ECOSYSTEM RESILIENCE AGAINST CLIMATE CHANGE IMPACTS

Vietnam Case Study from Field Testing an Operational Framework for Ecosystem-based Adaptation

Hanoi, 2013

Project name	**"Strengthening Community and Ecosystem Resilience against Climate Change Impacts: Developing a Framework for Ecosystem-based Adaptation in Lao PDR and Viet Nam", study in Viet Nam**
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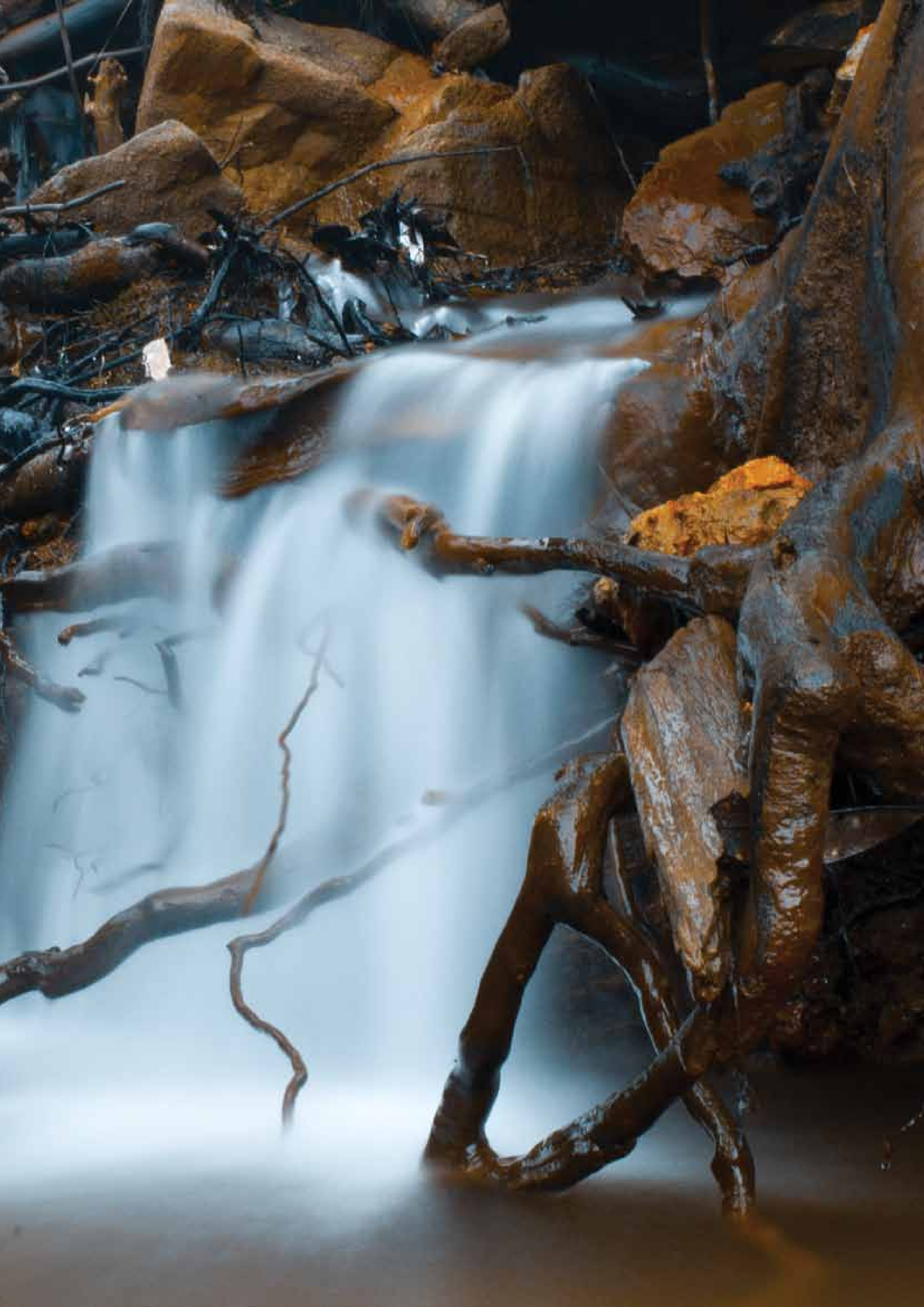

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List of abbreviations

ADB	Asian Development Bank
CC	Climate Change
CBD	Convention on Biological Diversity
CEA	Cost-Effectiveness Analysis
DARD	Department of Agriculture and Rural Development
DONRE	Department of Natural Resources and Environment
DOT	Department of Transportation
DPI	Department of Planning and Investment
EbA	Ecosystem-based Adaptation to Climate change
FGD	Focus Group Discussion
GIZ	German International Cooperation and Development Agency
GMS	Greater Mekong Sub-Region
IMHEN	Institute of Meteo-hydrology and Environment
InVEST	Integrated Valuation for Environmental Services and Trade-offs
IPCC	Inter-Government Panel on Climate Change
ISPONRE	Institute of Strategy and Policy on Natural Resources and Environment
IUCN	International Union on Conservation of Nature
MARD	Ministry of Agriculture and Rural Development
MONRE	Ministry of Natural Resources and Environment
MOT	Ministry of Transportation
MPI	Ministry of Planning and Investment
M&E	Monitoring and Evaluation
MCA	Multi-criteria Analysis
NTP-RCC	National Target Program to Respond to Climate change
PPC	Provincial People’s Committee
SEDP	Socio-Economic Development Plan
SID	Swedish International Development Agency
SP-RCC	Support Program to Respond to Climate Change
SWOT	Strengths, Weakness, Opportunities, Threats
UNCC	United Nation Convention on Combating Desertification
UNFCC	United National Framework Convention on Climate Change
WB	World Bank
WWF	World Wide Fund For Nature

Technical terms

Adaptation: The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2001).

Adaptive Capacity: The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC 2001). Adaptive capacity of individuals and communities are shaped by their access and control to important resources and assets, such as access to land, access to water etc.

Climate Change: Changes in climate over a prolonged time. The IPCC (2011) defines climate change as a change caused by natural internal processes or external forcings, or by persistent anthropogenic changes in the composition of the atmosphere or land use.

Climate Impacts: The consequences of *climate change or climate hazards* on natural and human systems.

Ecosystem-based Adaptation: is "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change" (CBD 2013). Ecosystem-based Adaptation uses sustainable management, conservation, and restoration of ecosystems to build resilience and decrease the vulnerability of communities in the event of climate change.

Ecosystem services: Benefits that people obtain from ecosystems. These include provisioning services such as food, water, timber, and fiber; regulating services that affect climate, floods, disease, wastes, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling (Millennium Ecosystem Assessment 2005).

Exposure: The level at which a country/region experiences the risks of climate change based on its geographic location. For example, coastal communities will have higher exposure to sea level rise and cyclones, while communities in semi-arid areas may be most exposed to drought.

Hazard: A hazard is defined as a harmful event that affects communities or ecosystems. A climate hazard is an event cause by climatic changes with the potential to cause harm, such as heavy rainfall, drought, storm, or long-term change in climatic variables such as temperature and precipitation.

Multi Criteria Analysis (MCA): A structured approach used to determine overall preferences among different alternative options, where the options accomplish several objectives that may not always complement one another (Department for communities and local government, London 2009). In MCA, desired objectives are specified and corresponding attributes or indicators are identified. The measurement of these indicators is often based on a quantitative analysis (through scoring, ranking, and weighting) of a wide range of qualitative impact categories and criteria.

Risk: The likelihood of a hazard happening that will affect natural or human systems.

Scenario analysis: A method that describes the logical and internally consistent sequence of events to explore how the future might, could, or should evolve from the past and present (van der Sluijs et al. 2004).

Sensitivity: The degree to which the community is affected by climatic stresses. Communities dependent on rain-fed agriculture are much more sensitive to changes in rainfall patterns than ones where the main livelihood strategy is labor in a mining facility, for instance.

Spatial analysis: A set of methods whose results change when the locations of the objects being analyzed change (Longley et al. 2005).

Spatial planning: A method used to influence the future distribution of activities in space (European Commission 1997). It goes beyond traditional land-use planning to integrate and bring together policies for the development of land-use and other policies and responses that influence the use of land (Office of Disaster Preparedness and Management, UK 2005). Spatial planning is critical for delivering economic, social, and environmental benefits by creating more stable and predictable conditions for investment and development, by securing community benefits from development, and by promoting prudent use of land and natural resources for development.

System dynamics: An aspect of systems theory used to understand the dynamic behavior of complex systems. The basis of the method is the recognition that the structure of any system-and the many circular, interlocking, sometimes time-delayed relationships among its components-is often just as important in determining the system's behavior as the individual components themselves.

Vulnerability: "The degree to which a system is susceptible to, or unable to cope with the adverse effects of climate change, including climate variability and extremes (IPCC 2001)." Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. In EbA the ecosystems and their vulnerabilities are included in the analysis together with the vulnerability of communities.

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1. INTRODUCTION

1.1. Background for the case study

Ecosystem-based Adaptation (EbA) is the use of biodiversity and ecosystem services as a part of an overall climate change adaptation strategy to help people adapt to the adverse effects of climate change. The rich natural capital endowment and ecosystem services in the Greater Mekong Sub-region (GMS) have continued to play a crucial role in supporting economic growth. Recognition of the role of ecosystem services and sustainable management of the natural resources play a key role in addressing emerging development and climate change adaptation challenges. Therefore, EbA has great potential to be an important part of the adaptation strategy for the GMS. EbA is still a relatively new concept. An operational framework for EbA could assist in the institutionalization of the concept in the region and help countries develop, implement, and mainstream EbA as a part of their development and adaptation strategies.

To respond to the needs in the GMS countries for more knowledge and expertise on EbA, a study was carried out in joint collaboration between the World Bank and the World Wild Fund for Nature (WWF). The long-term goal of this study was to contribute to the adoption of EbA as a part of the overall adaptation strategy in the GMS. The role of ecosystems in strengthening resilience against climate related hazard events is gaining recognition both in this region and on a worldwide level. However, there are still gaps in the available knowledge and practical application of EbA that are relevant and specific to the national and sub-national context. The project has the following specific objectives to fulfill these gaps:

- Develop an operational framework (herein referred to as the Framework), which enables governments to understand, consider, identify, develop and implement robust EbA solutions in response to climate change. Part of the Framework provides guidance in mainstreaming EbA solutions into planning processes.
- Field-test the developed Framework in two critical landscapes in the GMS region – a wetland/forest catchment and a coastal area. Develop case studies and subsequently modify the framework based on lesson learned.
- Identify the entry points for using EbA framework as a tool to support the adaptation policy and planning processes of sub-national governments in Laos and Viet Nam.

This report presents the process and results of the testing in Ben Tre province in Viet Nam. The results of the study have been used to contribute to the generic EbA framework and very importantly to elaborate the EbA customized framework for Viet Nam; which exists as a separate document.

Apart from helping to contextualize and improve the applicability of the framework for Viet Nam, the case study also meets the following objectives:

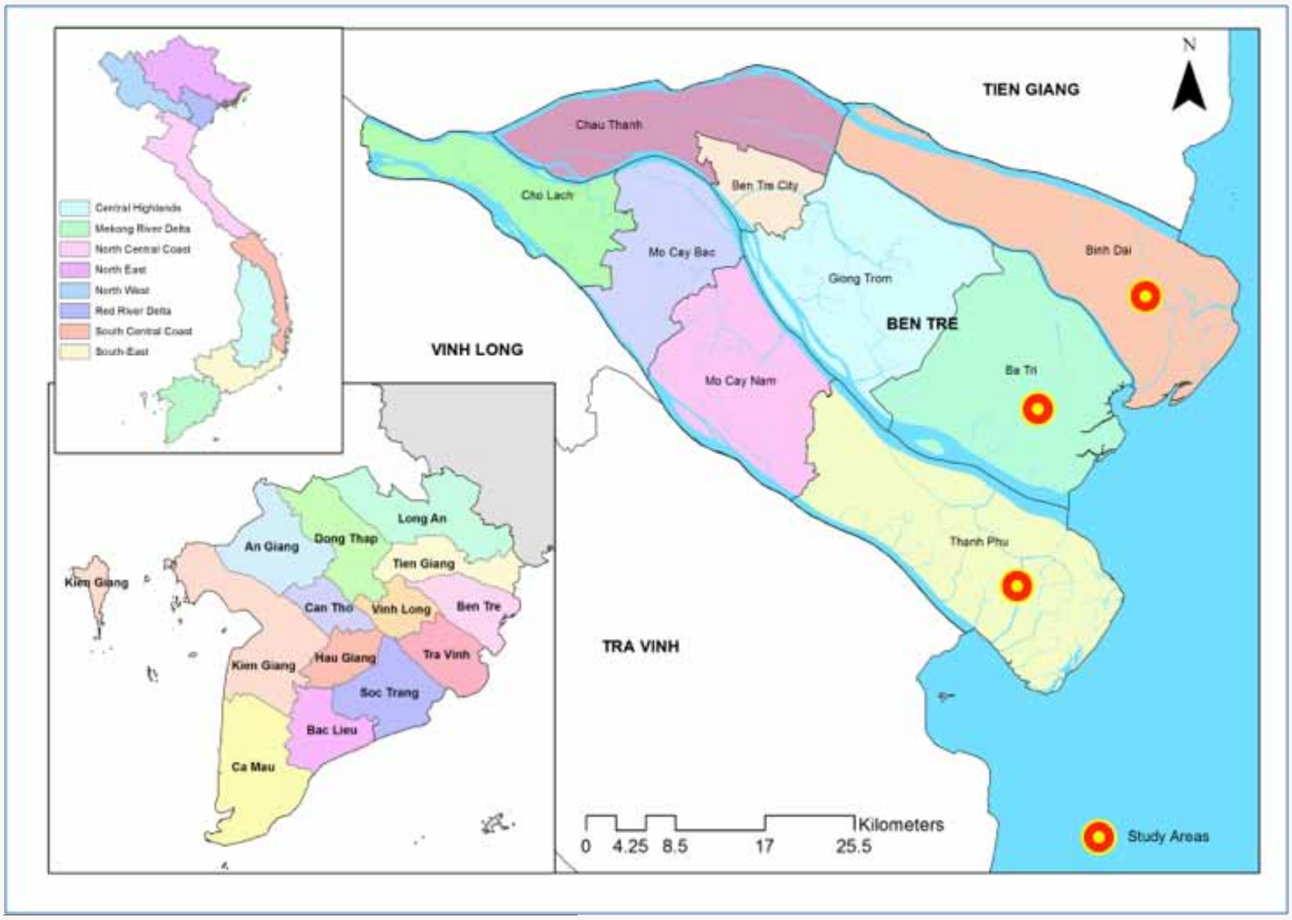
- Develop capacity and increase ownership of local government agencies and other stakeholders using EbA approaches to increase resilience of coastal communities in Ben Tre province.
- Select, based on systematic and evidence-based analysis, ecosystem based adaptation solutions for Ben Tre province.
- Identify the entry points for the EbA framework to support better and more explicit climate change adaptation strategies for Ben Tre province and provide evidence for EbA guidelines in Viet Nam.

This case study has subscribed to several core principles of best practice EbA (as set out in the draft framework):

- Promote long-term and local innovations and solutions to improve outcomes for people and for maintaining natural capital;
- Prioritize the application, by communities and/or other jurisdictional units, of no-regrets[1] actions so as to avoid and/or reduce the adaptation deficit[2]; this includes focusing on reducing non-climate stresses;
- Involve local communities in addressing governance and social and environmental justice issues;
- Reflect multi-partner, multi-sector, and multi-scale considerations and approaches;
- Build on existing NRM good practices and recognize that the climate is not static;
- Adopt adaptive management approaches;
- Integrate with and embed EbA approaches and actions within wider climate adaptation strategies; and
- Promote communication and education, sharing and exchange.

1.2. Study Area

Ben Tre is one of the 13 provinces in the Mekong Delta. The province has a 65 km coast line and its four main rivers—Tien (83 km), Ba Lai (89 km), Ham Luong (71km) and Co Chien (82km)—have been depositing and enriching the soil with layers of alluvium for centuries. They also carry heavy silt from the upstream Mekong River to four estuaries—Cua Dai, Ba Lai, Ham Luong, and Co Chien. They are a great advantage to Ben Tre's development of water transportation, irrigation systems, marine economic development, commercial agriculture, and trade with neighboring provinces.
This study focuses on the three coastal districts of Ben Tre: Binh Dai, Ba Tri, and Thanh Phu districts.



[1] 'No-regrets' describes adaptation options that provide benefits regardless of future climate conditions. It allows climate change adaptation to start now with actions that reduce non-climate threats while building resilience and reducing exposure and sensitivity, otherwise known as the adaptation deficit.
[2] See Footnote 1.

The population in Ben Tre in 2010 decreased by 0.3 percent if compared to 2005 (1,273,184 people), while the average growth rate of Viet Nam was 1.2 percent. The decrease in population in Ben Tre is thought to be due to people migrating to bigger cities such as Ho Chi Minh, My Tho and Can Tho for living, working and running small businesses. Generally, between 2005-2010, employment within aquaculture in the whole Ben Tre province decreased from 47,570 persons in 2005 to 46,058 persons in 2010 (Ben Tre Statistic office 2011).

Of Ben Tre's population, 93.3 percent live in rural areas. However, the urban population is slowly increasing with the move from agriculture to industry and commercial business. More people move into urban areas (Ben Tre SEDP 2011).

The population distribution in Ben Tre province is uneven. The coastal districts have relatively low population density with the majority of the population concentrated in Ben Tre city and the inland, freshwater districts of Chau Thanh, Cho Lach, North Mo Cay and South Mo Cay. This assessment focuses on the three coastal districts (Binh Dai, Ba Tri, and Thanh Phu district), which have a combined area of 1,194.5 ha and a population of 447,812. Ba Tri district is the smallest but most dense; therefore many of its natural resources are under pressure and/or over exploited.

2. METHODOLOGY

2.1. Conceptual Framework

This case study is the result of the application of the draft EbA framework prepared prior to the field-testing. The framework provides detailed guidance for 3 major stages and their component steps:

- ***Stage 1***: Assessment of vulnerability of ecosystems, ecosystem services and dependent communities/selected sector(s).
- ***Stage 2***: Identification and prioritization of ecosystem based adaptation options.
- ***Stage 3***: Recommendations for implementation and iterative monitoring and evaluation.

The framework also provides guidelines for mainstreaming EbA.

Stages 1 and 2 were field tested to develop this case study. This case study represents a rapid vulnerability assessment as a way of field-testing the EbA framework.

Figure 1 displays the key elements of Stages 1-2: understanding the local context, assessing communities' vulnerability to both climate change and development impacts, and developing effective adaptation strategies.

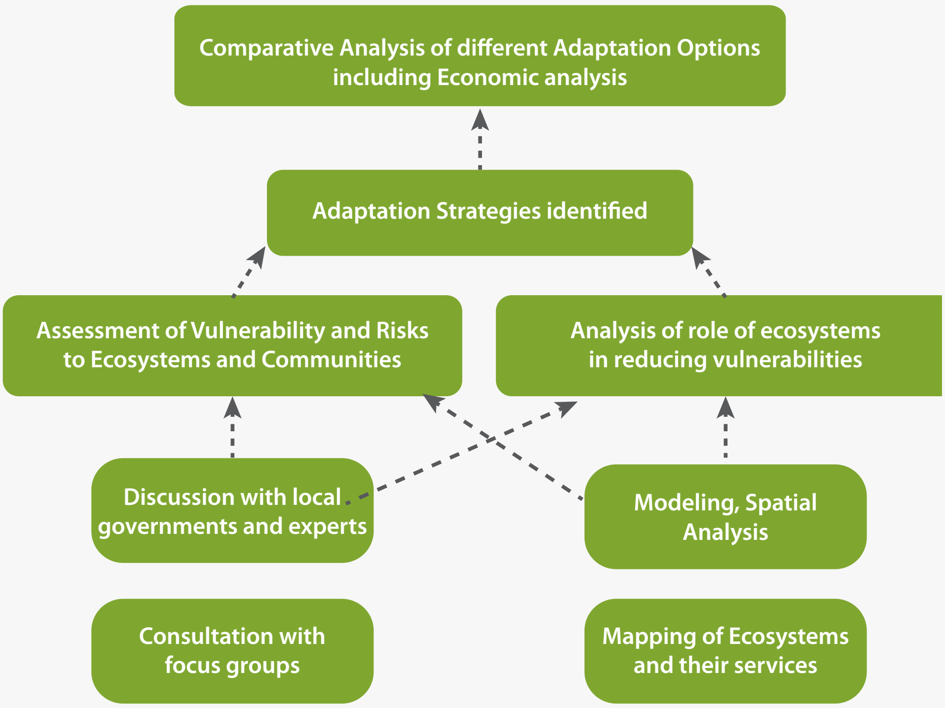


Figure 1. Process Diagram of the Process Defined by the Draft EbA Framework

The table below summarizes the first three steps of the framework and how they were operationalized for field-testing.

Table 1. Field-Testing the Steps of the Framework

Stages and steps in the framework	Tools and Methods	Revisions made and associated justifications
1. Vulnerability Analysis		
1.1. Understanding the context of communities, their demographic, socioeconomic conditions, key sources of livelihood and how it is supported by the ecosystem services	Secondary data collection (population demographic, livelihood sources etc. Focus group discussions, Household survey; Resource mapping.	The existing Rapid Integrated Vulnerability and Adaptation to CC Assessment in Ben Tre is an important reference. Field data collection was carried out in-line with the framework.
1.2. Understanding and mapping ecosystem and ecosystem services in the study area	Field transects, expert judgment, consultation with stakeholders, community resource mapping, InVEST.	Understanding of the ecosystems and ecosystem services came primarily from existing project information, and also from community consultation through exercises such as resource mapping, ecosystem services identification. It was not possible to use InVEST prior to the analysis.
1.3. Understanding current threats or risks from climate change to the communities	Focus group discussion, Participatory hazard mapping, creating historical timeline.	Carried out in-line with the framework.
1.4. Understanding threats from non-climate risks and different socio economic dynamics including potential development plans to the communities	Policy review, key informant interviews, focus group discussion, household interviews, etc.	Carried out primarily through community discussions, secondary data, and policy review (SEDP; CC Action Plan of Ben Tre province) with additional information from project documents.
1.5. Understanding threats from current climate and non-climate risks to the ecosystems and ecosystem services	Secondary research, focus group discussion, expert judgment.	Dealt with as a full matrix of interactions between climate and non-climate risks, people and the ecosystems. There were few ecosystem services analyzed.
1.6. Creating Future Scenarios to identify future vulnerabilities to Climate and non-climate change	Expert judgment, focus group discussion. InVEST and Marxan for spatial scenario analysis, land-change modeling.	Future scenarios have been developed in consultation with the local communities, governments, and governmental plan. InVEST and land-change modeling has been used to run the scenarios.
1.7 Assessing exposure, sensitivity and adaptive capacity	Data analysis, focus group discussion, expert judgment.	This could not be done very properly for this field-testing.A SWOT analysis of institutions was carried out to understand institutional adaptive capacity and support to EbA.
1.8. Summarizing the information and creating vulnerability matrix	Data analysis, focus group discussion, expert judgment.	The development of different scenarios and quantifying changes in some ecosystem services produce findings on vulnerability.
2. Developing adaptation Strategies		

Stages and steps in the framework	Tools and Methods	Revisions made and associated justifications
2.1. Identifying existing coping strategies and strategies for adaptation	Focus group discussion; key informants' interviews.	Carried out in-line with the framework. This activity was done through exercises during community consultation as well.
2.2.Multi-criteria analysis including spatial analysis	Participatory stakeholder consultations, land change modeler, InVEST, Marxan with Zones.	This was not done due to time limitation and priority for cost-effectiveness analysis.
2.3 Cost effectiveness analysis	Research; data analysis and expert judgement.	Carried out based on the framework.

The following chapters describe the field-testing teams' experiences when implementing the draft framework.

2.2. Methods

2.2.1 Secondary research and analysis

Before starting work in the field/site, it is important to collect the secondary data available at both national and subnational level. Any secondary data available on scientific information on climate change, types of ecosystems in the study area (such as forest type, information on topography, geography etc.) would be useful. Similarly demographic and socioeconomic data of communities such as male/female ratio, major sources of livelihoods in the area etc. can be collected beforehand.

2.2.2. Stakeholder Consultation including community representatives

Stakeholder consultation process for EbA includes identifying and engaging key people and organizations that can either impact or are impacted by any part of EbA assessment. It is necessary to do a preliminary stakeholder assessment to identify key stakeholders that can help in initiating the discussion about the adaptation objective. At a subnational level it may involve:

(a) National and subnational governmental agencies, such as ministries of natural resources and their provincial and district level offices, ministries of planning and investment and their subnational offices, sectoral ministries such as agriculture, forestry, water, land-use and their subnational offices.

(b) Technical experts in climate change and different sectors.

(c) Non governmental agencies that are engaged in climate change and adaptation related activities

(d) Community representatives.

2.2.3. Focus Group Discussion

Focus group discussion (FGD) is one of the most commonly used participatory methods to understand concerns and perceptions of the communities. A focus group is a small group of six to ten people led through an open discussion by a moderator. The moderator/researcher should establish a focus group based on some shared characteristics, so that the group is more or less homogenous, everyone feels equal and no member feels inhibited to speak. Focus group can be formed based on gender, livelihood groups, or other similarities to facilitate the discussion on common and individual concerns and perceptions.

Prepare a predetermined questionnaire to conduct a focus group discussion, but the discussion should be open-ended and semi-structured. The questionnaires should not be too long and the FGD should ideally be under two hours. To make analysis easier, the same questionnaire should be used with different focus groups where possible. Other Participatory Rural Appraisal (PRA) tools such as a seasonal calendar, historical timeline, or community mapping can also be included as a part of FGD.

2.2.4. Seasonal Calendar

The purpose of generating a seasonal calendar is to identify the seasonality of the (a) weather patterns, i.e. summer months, rainy season, winter etc.; (b) the community's livelihood activities, which are often connected to resource use and resource abundance; and (c) seasonality of hazards. Communities identify different activities (agriculture, aquaculture, seasonal migration) that occur throughout a year and the guided discussion will seek to identify how the climate change will affect overall activities and whether it will alter the seasonality of community's livelihood activities. The discussion will also seek to understand historical changes in seasonality that the community has already experienced, and the social mechanisms that the community has employed to mitigate their effects.

2.2.5. Historic Climate Trend Analysis

Understanding the history of past extreme events and a community's reaction to these events can serve as very important information for an adaptation plan. The historical trend analysis will give insight into past climate hazards, their trends, intensity, and impacts to ecosystem services and communities. The trend analysis can be done either just through discussion or by drawing a line to mark the passage of time (10-20-30 years based on the available data).

2.2.6. Participatory mapping

Participatory mapping can be done either on a piece of paper, through actual maps of the study area, or as direct inputs in digital maps depending on the context. Participatory mapping can help in EbA by identifying: (a) key ecosystems, and ecosystem services and their location in the study area; (b) climate hazards showing the locations more prone to hazards; and (c) location of populations that are most vulnerable if applicable, or populations with different livelihoods.

2.2.7. Scenario Analysis

A scenario analysis is a process of analyzing possible future events by considering alternative possible outcomes or alternate future developments. For EbA and/or other adaptation planning, the scenario analysis can provide useful insight on the future risks and vulnerability to both societies and ecosystems. Scenarios are developed based on certain criteria or assumptions about the future, for example, the level of infrastructure development, with or without climate change pressures among others. These criteria can either be collectively agreed upon or taken from existing and future development plans/policies.

2.2.8. Scenario analysis involving modeling tools for future vulnerability assessment

The assessment of the impact of climate change on the ecosystem services can be done through scenario analysis using tools such as InVEST, land change modeler, or hydrological models, for example. Data layers that reflect climate change scenarios (e.g. sea level rise, change in precipitation) will be used as input parameters in the models. WWF uses InVEST, mostly in large-scale assessments for valuation of ecosystem services.

InVEST is designed to inform decisions about natural resource management. Decision-makers, from governments to non-profits to corporations, often manage lands and waters for multiple uses and inevitably must evaluate trade-offs among these uses; InVEST's multi-service, modular design provides an effective tool for evaluating these trade-offs.

The InVEST toolset includes models for quantifying, mapping, and valuing the benefits provided by terrestrial, freshwater and marine systems. Specifically it includes models for:

- Wave Energy
- Coastal Vulnerability
- Coastal Protection
- Marine Fish Aquaculture
- Marine Aesthetic Quality
- Marine Overlap Analysis Model: Fisheries and Recreation
- Marine Habitat Risk Assessment
- Terrestrial Biodiversity: Habitat Quality and Rarity
- Carbon Storage and Sequestration
- Reservoir Hydropower Production
- Water Purification: Nutrient Retention
- Sediment Retention Model: Avoided Dredging and Water Quality Regulation
- Manage Timber Production
- Crop Pollination
- Wave Energy
- Coastal Vulnerability
- Coastal Protection
- Marine Fish Aquaculture
- Marine Aesthetic Quality
- Marine Overlap Analysis Model: Fisheries and Recreation
- Marine Habitat Risk Assessment
- Terrestrial Biodiversity: Habitat Quality and

In this field test, only three models were used to quantify the most important services of coastal ecosystems: Coastal Vulnerability, Coastal Protection and Erosion, and Carbon Storage and Sequestration.

2.2.9. Expert Judgment

Expert judgment is an approach for soliciting inputs from individuals with particular expertise on concepts related to EbA. Considering the complexity involved in EbA especially with regards to uncertainties and the impact of climate change on ecosystems, expert judgment can be used for rapid assessment and analysis of different aspects of vulnerability and adaptation prioritization of adaptation options. Expert judgment can be used in a variety of ways including a panel format for aggregating opinions, meetings, and workshops. It is important to realize that specific expertise may be necessary at different phases. Expert consultation may be needed in designing the project, deciding the data to be included, and for analyzing the data rigorously to come to scientific and experience-based conclusions.

The experts needed may include: climate change and adaptation specialists, hydrologists, ecologists (foresters, marine biologists, etc.), species specialist for particular species, sociologists/socio economic specialists, economists, and others that may be identified.

2.2.10 Vulnerability Matrix

Creating a vulnerability matrix is one way of presenting the vulnerability analysis. The ultimate objective of the user should be to understand current and future risks and impacts from climate and non-climate risks in order to come up with effective adaptation strategies.

It is good to keep in mind that the "vulnerability of a system" is best understood by looking not only at individual pressures and impacts but also the altered interactions within the system—in this case, interactions between ecosystem and communities.

2.2.11. Multi-Criteria Analysis

Multi-Criteria Analysis (MCA) is a decision-making tool for complex problems where multiple criteria are involved. Since it is important to consider many social, economic, environmental criteria in selecting the final adaptation measure, MCA can be used to compare and make a decision on the best possible adaptation measure. The multi criteria decision support system will help in structuring the available information in a clear and concise way so as to support the identification of the most suitable alternative; with this approach the choices made will be participatory, explicit, and justified. MCAcan be done with or without the use of any software/computer based tools. In both cases, stakeholder participation is extremely important to define the criteria used in analysis.

Process:

1) Collectively agree on the main categories of effects of the adaptation strategies to be considered: environmental, social, economic, etc.;

2) Identify the criteria/indicators to be used to measure those effects (decrease in the amount of some ecosystem services, loss of natural habitats, decrease in agricultural areas, opportunity costs, capacity requirements, etc.).

3) Together with stakeholders, set targets for the different indicators and assign weightage/penalty factors: how much agriculture areas, natural forest or other habitat types, etc.?

4) Follow the previous steps for each adaptation strategy;

5) Based on targets, penalty factors and costs the outcome will be maps showing the best arrangement of the zones identified at the minimal cost for the adaptation alternatives;

The MCA can also be done qualitatively without the use of any spatial tools, if needed, by collectively deciding on different criteria, giving weightage and ranking the adaptation strategies. This assessment is qualitative in nature but should be informed by interviews with local experts as well as published performance of these measures against current climate hazards. The table below provides an example of a simple multi-criteria analysis.

2.2.12. Cost Effectiveness Analysis

Cost effectiveness analysis (CEA) is an economic decision-making tool. It is used to compare two or more options for achieving the same (or similar) outcome, the benefits of which are not easily measured in monetary terms.

A classic cost-effectiveness analysis starts by stating a specific goal, such as reducing the incidence of a disease in a town by 50 percent in four years, presents data on the expected cost of two or more methods of achieving this goal and then selects the least-cost alternative (World Bank 2010).

An important aspect of CEA is that the main benefits of projects and interventions are not evaluated in monetary terms. These benefits are presented in non-monetary measures of effectiveness, such as numbers of lives saved or years without major flooding. By comparing the ratio of costs to the measure of effectiveness, options for interventions can be ranked. Avoiding having to estimate a monetary value for an aspect of project benefit is a key attraction of CEA.

3. UNDERSTANDING THE LOCAL CONTEXT

3.1. Framing and Setting the Context for Analysis

3.1.1. Setting up a social ecological system

Ben Tre was chosen for the case study as it is considered to be at high-risk due to its topography and geomorphology. Since the coasts were predicted to be highly vulnerable to climate change, three coastal areas were considered for the case study. Communities in these three coastal districts depended on mangroves, estuaries, and sand dunes in the area. The site was selected based on discussion with the national stakeholder group consisting of different ministries and departments. The administrative boundary of these districts was taken as the boundary of the site area for case study.

The national stakeholder-working group provided overall guidance to developing the case study. The **multidisciplinary team** that worked in field-testing and data analysis consisted of experts in: (i) climate change, (ii) ecosystems, (iii) social research methodology and community facilitation, and (iv) local government officials with knowledge of the study areas and proposed development plan in these areas. In addition, consultants were hired for specific analysis that included GIS-based modeling and cost-effectiveness analysis. The field-testing team, led by WWF also included experts from ISPONRE, DONRE and DARD to build in the aspect of adaptive learning.

3.1.2. Geographic context

Topography: The topography of Binh Dai, Ba Tri, and Thanh Phu districts is very flat, with an average elevation of 1-2 meters above sea level (Ben TreDARD, 2009). There are several sand dune systems that reach a maximum of 5 meters above sea level. Ben Tre can be divided into three main types of eco-elevation classes:

- *Low-lying mangrove and alluvial flats*: land elevation in these areas is less than 1 m in height and flooded at high tide, representing 6.7 percent of the total area;
- *Moderately higher semi-tidal flats:* elevation in these areas averages 1-2 m and are only submerged during periods of high tide from September to November, including areas of garden land and rice land, accounting for 87.5 percent of the total area;
- *Dunes systems:* land elevation in these areas is 2-5 m and is generally composed of sand dunes, accounting for 5.8 percent of the area of coastal districts.

Salinity and tides: The boundaries of saline, brackish, and freshwater areas change over time. This depends on the tide, season, and upstream hydrology. Salinity levels within the river mouth fluctuate between 3-17 percent, especially in the dry season. Salinity levels have a significant effect on the estuary ecosystem. Coastal areas of Ben Tre are greatly affected by the uneven dual tides of the East Sea. The tide rises and falls twice each day (every six hours) and has a tidal range of 2.5-3.0 m. Each month, there are two high-tide periods (the 2nd - 3rd and 17th - 18th of the lunar calendar) and two low-tide periods (the 7th- 8th and 21st - 23rd of the lunar calendar).

Geomorphology: A large amount of alluvia is deposited into the sea from the rivers. The average suspended substances in river water are approximately 0.3-0.8 g/liter. Due to this deposit the Mekong Delta can extend 40-60 m into the sea each year, forming islets and islands near the river mouth. However, there has also been an increase in riverbank and coastal erosion. The coast in Ben Tre receives silt and other sediments from the Mekong River via its tributaries. The coast's morphological features are strongly influenced by changes within the river and the sea from erosion and alluvial deposits due to the natural interaction of current flows.

3.1.3. Socio-Economic Context

Population: The focal districts have relatively low population densities with the majority of the population concentrated in Ben Tre city and the inland freshwater districts.

Agriculture and aquaculture are the two primary livelihood activities of most of Ben Tre residents.

In sand dune areas, vegetable production (watermelon, white roots, bean, etc,) is the key livelihood activity. In

Table 2. Administrative characteristics of Binh Dai, Ba Tri, and Thanh Phu districts of Ben Tre province, Viet Nam

Name of District – City	No. of town and ward/commune	Area (km^2)	Population	Density (people/km^2)
Binh Dai district	**1 town and 19 communes**	**410,5**	**132.315 (129,125)***	**315**
Ba Tri district	1 town and 23 communes	358,4	187.835 (190,632)*	524
Thanh Phu district	1 town and 17 communes	425,6	127.662 (129,372)*	300

** Population data from 2005 (Source: Ben Tre Department of Statistics 2011)* intertidal areas, clam (*Meretrix lyrata*) farming and collecting provide the majority of household income. Blood cockle (*Anadata granosa*) forms the main commodity farmed in mud flats.

The total salt field area in Ben Tre is 1,500 ha and is mostly (>1000 ha) situated in Binh Dai District (with 650 ha in Bao Thanh commune and 384 ha in Bao Thuan commune).

Land Use: Agriculture and aquaculture are the key livelihood activities of most of Ben Tre residents. The total

Table 3. Agricultural and fishery production in Binh Dai, Ba Tri, and Thanh Phu districts of Ben Tre province, Viet Nam.

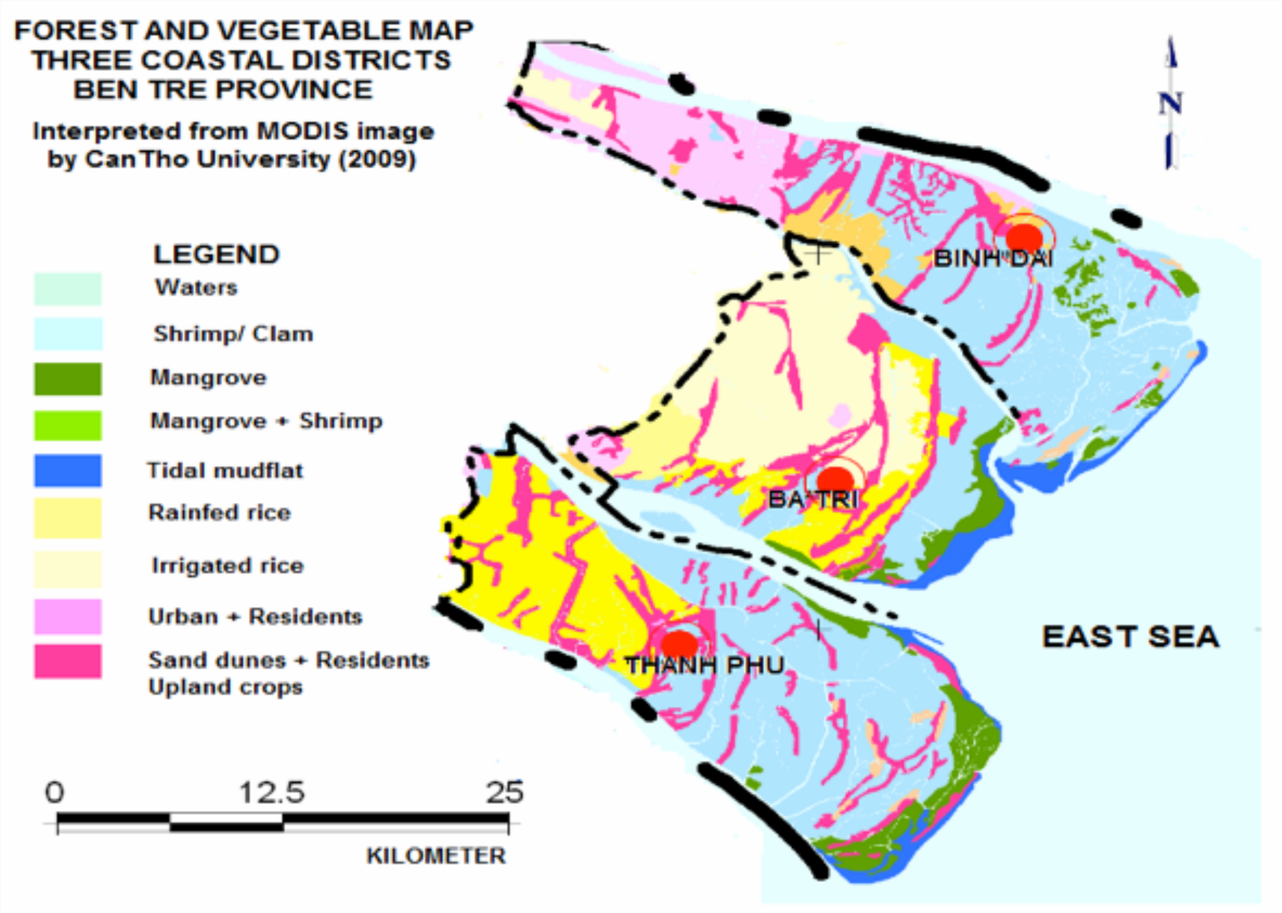
No	Product	Binh Đai district	Ba Tri district	Thanh Phu district
1	Rice:			
	- Area (ha)	6,180	39,332	15,175
	- Productivity (quintal/ha)	45,11	48,74	32,65
	- Yield (ton)	27,879	191,687	49,550
2	Vegetable production			
	- Area (ha)	783	1,314	1,093
	- Yield (ton)	14,045	23,824	25,183
3	Coconut			
	- Area (ha)	5,840	1,413	3,315
	- Yield (thousand ton)	44,7	10,5	23,2
4	Cow breeding (number)	6,121	68,924	25,365
5	Pig breading (number)	14,813	19,683	17,153
6	Fishery			
	- Capture fisheries (ton)	54,379	53,108	7,640
	- Off-shore fishing boats	649	865	18
	- Aquaculture yield (ton)	46,408	13,707	12,420
	- Aquaculture area (ha)	16,803	5,001	16,377

Source: Ben Tre Statistics Department, 2011

agricultural area in Ben Tre is more than 178,000 ha, which includes: 80,900 ha of rice; 5,300 ha of vegetable products; 5,900 ha of sugar cane and 32,000 ha of water surface areas that are suitable for aquaculture (Ben Tre DARD, 2010). In addition, there is a total area of 1,500 ha salt fields in Ben Tre of which over 1,000 ha are in Ba Tri district.

The majority of the soil types in Ben Tre are saline soils (68-79 percent) and sandy soils (12-21percent). Saline soils are suitable for salt and brackish aquaculture and are impossible for agriculture cultivation activities. Figure 2 shows the land use in the Ben Tre province. It can be seen that the dominant land uses are one-season clam/shrimp farming, followed by rain-fed rice crops, mangrove forests, and sand dunes. This information is important to note when looking at agriculture development and climate change adaptation options.

Figure 2: Land use in Ben Tre province Viet Nam



3.2. Recent and Historic Climate Change Patterns

Ben Tre has a tropical monsoon climate. Similar to other Mekong delta provinces, Ben Tre has two distinguishable seasons: the wet season (early May until the end of October or early November) and the dry season.

There's very little fluctuation of the average temperature throughout the year. The provincial temperature average is 27°C. April and May are the hottest months of the year with average daily temperatures up to 29°C, December is the coolest with an average temperature around 25°C. There is a large difference, however, between day and night time temperatures: in the dry season, the difference is around 14°C and around 11°C in rainy season. Yearly average humidity in Ben Tre is about 83 percent, with an average evaporation of 1,187 mm/year. Yearly average rainfall ranges from 1,200-1,500 mm with an average of 110 days of rain. Ben Tre city receives higher rainfall than the coastal areas, ranging from 1,400-1,500 mm on average. The yearly average rainfall in Binh Dai district is 1,244 mm, 1,371.5 mm in Ba Tri district, and 1,454 mm in Thanh Phu district (CEE-CESC 2009). Rainfall distribution is seasonally unequal with 75-95 percent of the total rain falling during the wet season, from early May to end of Oct. August, September and October receive the highest amount of rainfall, and January, February and March the lowest.

Ben Tre province is already experiencing climate change. Average temperature has risen by an estimated 0.05 - 0.15°C in each decade of the 20th century; between 1990 and 2005, the annual average temperatures increased by an average of 0.3°. The trend in rainfall in Ben Tre has been inconsistent between 1990 and 2006, and can be divided into two main phases: (1) from 1990 to 1998, average annual rainfall increased by 319.28 mm total, for an average annual increase of 35.5 mm/year; and (2) from 1998 to 2006, average annual rainfall decreased

to 161.2 mm total, for an average annual decrease of 17.9 mm/year[3]. The period of hurricane activity affecting the southern coast of Viet Nam is later than other areas in the country and is concentrated in November and December. The first months of the rainy season (April-May), or even earlier (January to March) may also see oceanic storm activity in the region. From 1961 to 2006, 12 hurricanes hit this southern coast.

In recent years, communities in the area have reported that they experience the effects of a changing climate. There has been an increase of adverse droughts, which cause a lack of fresh water and increased saltwater intrusion. The increase in salinity strongly impacts aquaculture activities often causing massive deaths in shrimp and clam farms. Additionally, more unseasonable rainfall has been observed in the coastal districts that were the focus of this study. More rain may be welcome in dry parts of the year but it can have negative impacts on vegetable production (particularly watermelon production).

3.3. Ecosystem Services and their Importance to Local Livelihoods

The field survey, interviews with stakeholders, and reference to prior work in the study area identified four key ecosystems and their associated livelihood dependent activities. These ecosystems and their livelihood dependent activities are:

1. **Estuarine** ecosystem and c**aptured fisheries**;
2. **Mangrove** ecosystem and **extensive/intensive shrimp farming**;
3. **Intertidal mudflats and sandbars** ecosystem and **bivalve farming**; and
4. **Sand dune** ecosystem and **vegetable plantation**.

A general significance ranking of local ecosystem services was done via two different methods: (i) consultations with representative community groups in focus group discussion, and (ii) interviews with technical officers.

Figure 3 shows the significance ranking of ecosystem services in Binh Dai, Ba Tri, and Thanh Phu districts of Ben Tre Province as assessed via semi-structured ranking exercises conducted during consultations with government officials and local residents.

[3] Nguyen Ky Phung et al. 2010. Building action plan to respond to climate change in Ben Tre province as part of the national target.

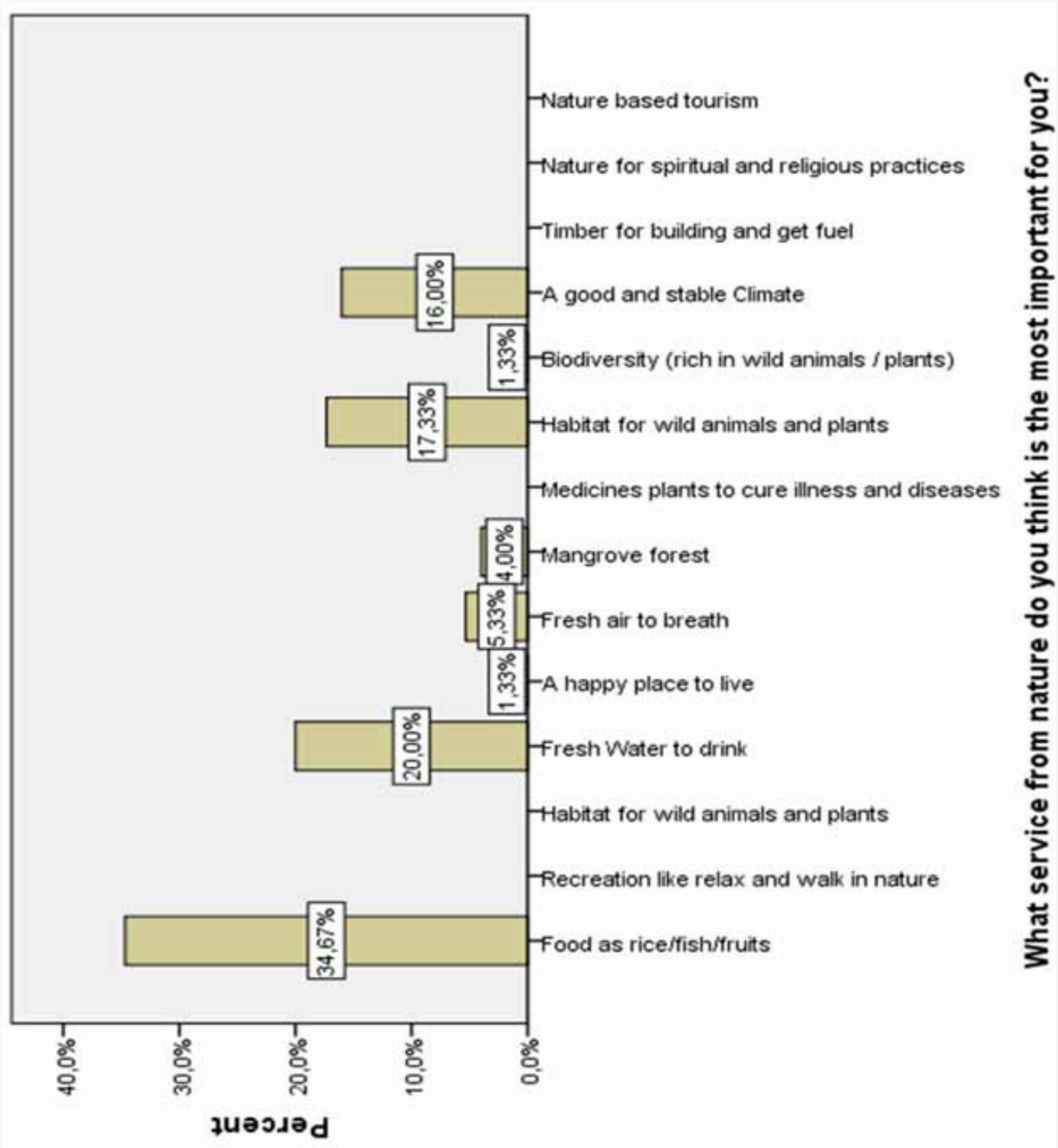


Figure 3: Ranking of ecosystem services in Ba Tri, Binh Dai and Thanh Phu district of Ben Tre province.

Different livelihoods are dependent on a variety of overlapping ecosystems. For example, shrimp farming is highly dependent on not only mangroves but also intertidal mudflats and the open water estuaries. Food such as rice, fruit, fish, and fresh water to drink are the most important services that the communities use from the ecosystems. However, habitats for wild animals are important for rice farmers and the mangrove forest is used for protection and is important for mangrove rangers.

Table 4. Key livelihood activities and ranking of dependence on the key ecosystems

Key Livelihood activities	Dependence level on ecosystems			
	Open water estuarine	Mangrove	Intertidal mudflats and sandbars	Sand dunes
Extensive/intensive shrimp farming	+ + +	+ + + +	+ + +	-
Clam and blood cockle farming	+ + +	+ + +	+ + + +	-
Vegetable plantation	+ +	+	+ + +	+ + + +
Inshore/inland capture fisheries	+ + + +	+ +	+ +	-

++++ *Highest level of dependence*
+++ *Moderate high level*
++ *Moderate level*
+ *Low level*
- *No dependence on ecosystem*

4. RESULTS OF VULNERABILITY ANALYSIS

Prior to field activities, a literature review was conducted to assess: (i) the current institutional and policy arrangements for climate change adaptation; (ii) the future climate trends for Ben Tre province, and (iii) the key potential development targets in the three focal districts. The results discussed in this section are based on both this literature review and work conducted in the field.

4.1. Current climate and development pressures to communities and ecosystems

4.1.1. Current climate pressures to communities and ecosystems

The study team conducted several stakeholders' consultation workshops and interviews with key informants including government departments in Ben Tre. They were used to identify threats to communities, especially to local livelihoods from current climate and non-climate pressures.

The identification of hazards to local communities was undertaken via an approach where community representatives assembled an historical timeline and indicated when a particular hazard impacted commodity production or other revenue of a given community.

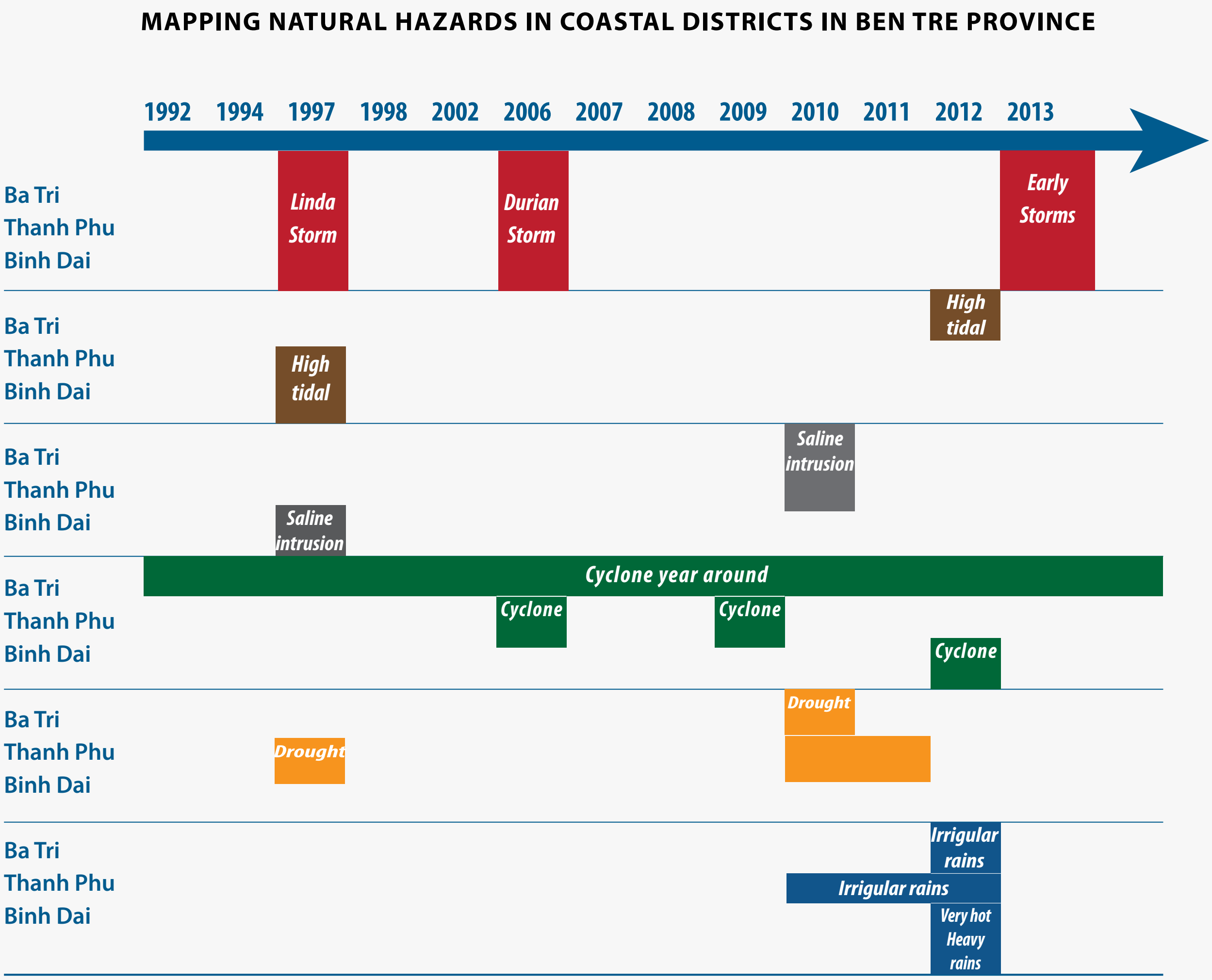


Figure 4. Historical hazards in Ben Tre (Source: WWF field data, 2013)

Five climate-related hazards and associated events that significantly affect the study districts are:

i) Storms/storm surges;
ii) Cyclones;
iii) Rising sea levels;
iv) Drought;
v) Irregular rainfall patterns.

Among these, storms are considered the worst events for local communities. Storms affect multiple aspects of life at a very large scale. Communities directly on the coast are clearly the most vulnerable to storms. Two major storms in 1997 and 2006 caused extensive damage to public infrastructure and household assets. The most serious storm impacts occurred after storms subsided and included a lack of food and fresh water and disease outbreak. Given damages to infrastructure, communities often had to face these challenges with limited assistance from the government or other communities. Responses consisted of (1) temporarily moving (both people and assets) to sturdier houses and/or inland and (2) permanent migration to other areas.

Higher spring tides and saline intrusion have also seriously impacted local communities and livelihoods. These impacts are particularly felt during the long dry season.

The increased drought periods in the dry season are also a big concern to the coastal communities. The shortage of freshwater for crops and other daily uses, and increased saline intrusion are significant consequences. Aquaculture, particularly shrimp farming, is the most impacted area by increased drought periods.

Table 5. Rating the impacts of climate-related hazards to the ecosystems and its dependent livelihoods by communities (Binh Dai/Ba Tri/Thanh Phu)

Hazards	Mangroves	Sand dune	Intertidal area	Coastal sand dunes	Estuarine water	Brackish water ponds	Fresh water, crop
Storm	**-2/-2/-1**	**-1/-2/0**	**-2/-1/0**	**-1/-2/0**	**-1/-1/0**	**-2/-1/-1**	**-/-2/-**
Tornado	-1/-1/-1	0/-1/-1	0/0/0	0/0/0	0/0/0	0/0/0	-/-1/-
High tide/ sea level rise	-1/+2/-1	-2/-2/-2	0/-1/0	0/-1/0	-1/-2/-1	-2/-2/-2	-/-2/-
The average annual rainfall is reduced	0/0/0	-1/-2/-1	0/0/0	0/-2/0	0/0/0	-1/-1/-1	-/-2/-
Unseasonal rain	0/0/0	-2/-1/-2	0/0/0	0/-1/0	0/0/0	-1/+1/-1	-/-1/-
Templature increase	0/-1/0	-1/-2/-1	-1/-1/-1	-1/-2/-1	0/-1/0	-1/-1/-1	-/-2/-
Drought (prolonged)	-1/-1/-1	-2/-2/-2	-2/2/-2	-2/-2/-2	-1/-1/-1	-2/-1/-2	-/-2/-

Rating score:
- 2: Very serious negative impacts *-1: Moderate negative impacts* *0: No impacts*
1: Positive impacts *2: Very positive impacts*

4.1.2. Current development pressures on communities and ecosystems[4]

i. Ba Lai sluice gate-dam constructed in 2000-2002 to make the Ba Lai river become a freshwater reservoir. Its gates open twice per month at the low tide period and stand open in the flood season. The dam has also been used for transportation between Ba Tri and Binh Dai districts, but it has caused many negative impacts on the two district communities. This big construction was built from 2000 to 2002. The sluice gate-dam stops saline intrusion and regulates the freshwater flows, which is important for freshwater vegetable plantation and freshwater aquaculture. However, since the sluice gate acts as a barrier to the natural flows of the river, it caused changes in the coastal ecosystems and coastal erosion due to reduction of sediment and river flows. It also had an effect on brackish water aquaculture. Many people living in this area have been forced to shift their livelihood from aquaculture to freshwater farming.

ii. Construction of sea and river dikes: Sea and river dikes are also important development activities in the coastal area. Dikes are used to prevent wave energy; high tides and saltwater intrusion and improve road transportation. Those constructions resulted in resettlement of the farms and households on the sand dunes.

iii. Extensive aquaculture farming and changes in land use: Another significant development activity in the coastal area is land-use development from rice fields to aquaculture farms. Recently, the local farmers have been experiencing an increase of disease outbreak and massive death of shrimp. The higher intensive shrimp and other aquaculture farming are under many threats, including increased use of pesticide and fertilizers.

Literatures also show a change in land cover, from 1989 – 2004, specifically mangroves and shrimp ponds in the three coastal districts of Ben Tre. Using Terra/ASTER data sets (2004) and a Landsat/TM image (1989) it was found that the area of mangroves has decreased by 50 percent and the area of shrimp ponds has increased three fold within the Ben Tre Province. Thanh Hai commune of Thanh Phu Nature Reserve had the most significant mangrove destruction. Shrimp farming increased from 5.4 percent of land cover in 1989 to 36.5 percent in 2004, while the area of mangrove decreased sharply from 61.6 percent to 26.2 percent over the same period. This is the greatest threat to the ecosystems and community of the Ben Tre province.

The short- and long-term effects of mangrove destruction to make way for shrimp farming will outweigh the long-term impact of climate change. Further the loss of mangroves will make it increasingly difficult to adapt to and mitigate climatic and development pressure. Adding further complication, the SEDP 2011-2015 outlines plans for the afforestation of mangrove ecosystems, however, the SEDP also outlines the further development of large shrimp aquaculture farms, which conflicts with the re-establishment of mangrove forests.

iv. Dredging canals and sand excavation: These activities are aimed to improve waterway transportation and provide construction material for construction. However, water pollution has been observed increasingly as a consequence of these activities.

[4] Impacts from upper stream project were not taken into consideration

4.2. Threats from Future Climate and Development Pressures to Communities and Ecosystems

4.2.1. Climate Change

Ben Tre is one of the Mekong Delta provinces, it, therefore, has a same climate trends with the whole Delta, the table below is showing the expected climate trends in the Mekong Delta in next three decades.

Table 6. Projected climatic trends in the Mekong Delta in the next three decades (Source: Le Anh Tuan, 2010)

Climate phenomenon	Trend	Main affected areas
Max, min, average temperature in dry season	↗	**An Giang, Dong Thap, Long An, Can Tho, Soc Trang, Kien Giang**
Number of days that temperature is above 35°C in dry season	↗	Areas border with Cambodia, West of Hau river.
Rainfall at the beginning of the season (May, June, July)	↘	The whole delta
Rainfall at the end of the season (August, September, October)	↗	Coastal area of the delta
Frequency and duration of whirlwind – strong wind - thunderbolt	↗	Coastal areas, islands of the delta
Abnormal heavy rain (> 100 mm/day)	↗	Coastal areas of Ca Mau peninsula, areas between Tien and Hau rivers.
Frequency and intensity of tropical low pressure and coastal storm	↗	Coastal areas of the Mekong Delta
Floods (flooded areas and days)[4]	↗	Long Xuyen – Ha Tien quadrangular area, Dong ThapMuoi, area between Tien and Hau rivers.
Sea level rise – salt-water intrusion	↗	Coastal provinces
Riverbank land sliding and erosion	↗	Coastal provinces, area between Tien and Hau rivers
Flood-tidal impacts	↗	The whole delta

The impacts of these changes on Ben Tre will be significant, greatly affecting ecosystems and agricultural productivity, as well as creating challenges for socio-economic development within the region. Ben Tre province will be most impacted by sea level rise. In the wet season, tides, floods, storms and tropical low-pressure systems contribute to frequent storm surges, adding to the impact of seas level rise. In the dry season, Ben Tre already experiences frequent, and often severe, increased saline intrusion due to droughts and sea level rise. The following section outlines the direct and indirect impacts of each climate change projection – temperature, precipitation and sea level rise.

According to the provincial climate change scenarios (Ben Tre DONRE, 2011[5]), the climate conditions for Ben Tre are projected to be as follows:

- Temperature in Ben Tre are predicted to increase by 1.1°C by 2050 and by up to 1.5°C by 2070.
- Sea level rise by 30cm by 2050, 46cm by 2070 and 75 cm by 2100 in the medium scenarios (B2) and 33cm by 2050, 57 cm by 2070 and 100cm by 2100 in the high scenarios (A1F1[6]) ;
- Slight increase in frequency of storms and tropical depressions/cyclones and higher intensity

[5] Bentre DONRE, 2011. Climate change action action plan, sub-topic report : Climate change scenarios in the priod 2010 – 2100.
[6] Intergovernmental Panel of Climate Change (IPCC) emission scenarios https://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf

According to Nguyen Ky Phung et al. (2010) long heavy rain will tend to increase in late October and early November, when denatured cold air with high intensity combines with the activities of tropical cyclones or ranges of tropical convergence.

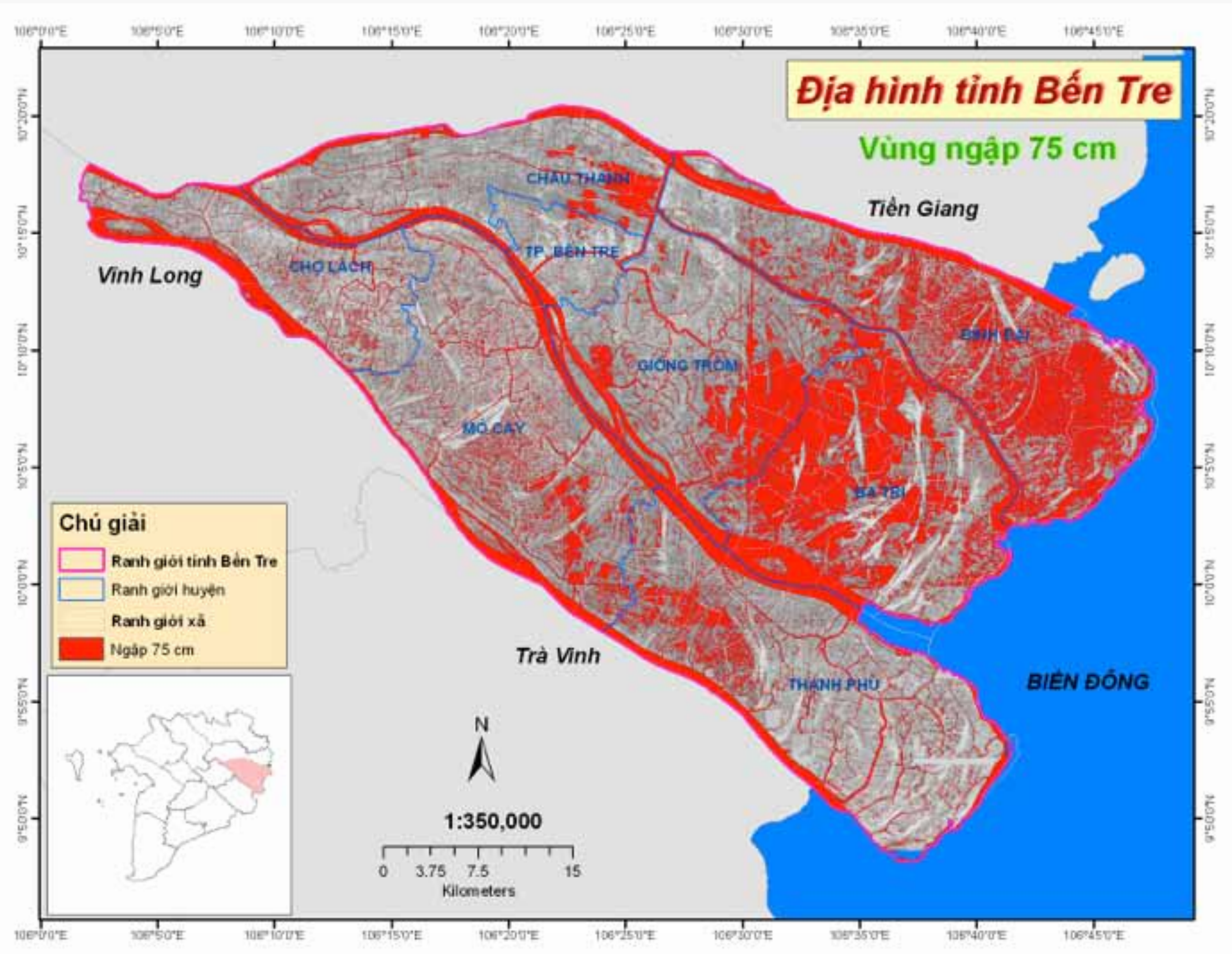
Storms do not often happen but will occur with strong intensity and inflict heavy damage, whereas droughts tend to occur more frequently and lead to deeper salinization in dry seasons.

Cited in the report, a moderate sea level rise (under B2 scenario) of 75 cm will mean that:

- 90 km^2 or 23 percent of Thanh Phu district will be permanently inundated by sea water;
- 170 km^2 or 46 percent of Binh Dai district will be permanently inundated by sea water;
- 175 km^2 or 51 percent of Ba Tri district will be permanently inundated by sea water; and
- 725 km^2 or 33 percent of the total Ben Tre province will be permanently inundated by sea water.

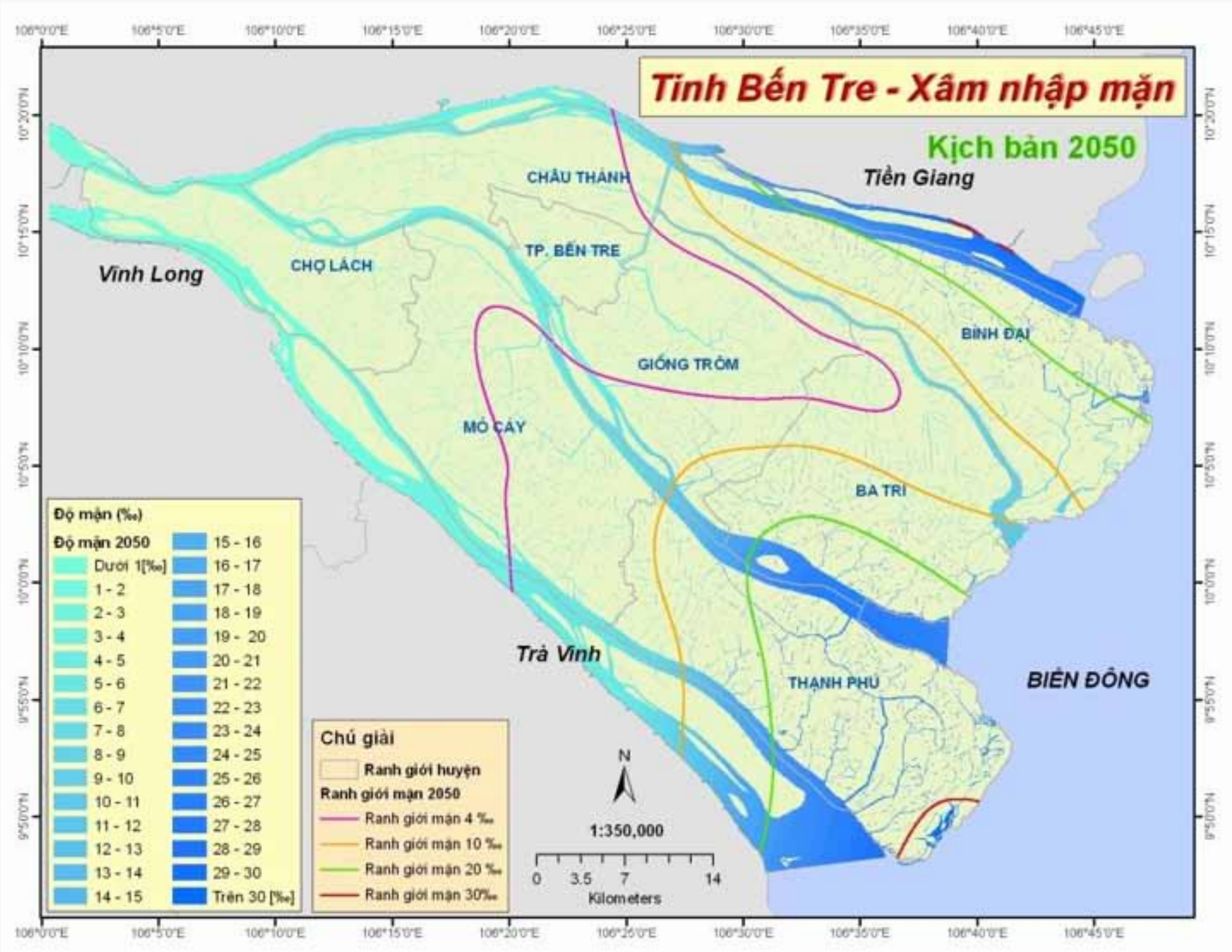
The three coastal districts will be highly affected by the sea level rise (SLR) especially Ba Tri and Binh Dai districts. The scenario of SLR up to 75 cm, 50 percent of the total area of both districts will be inundated, which means that the two coastal communes will be totally inundated. It is not clear from this rapid assessment and literature review which areas, livelihood activities, and ecosystems will be impacted by the SLR.

As sea levels rise and droughts worsen, saline water will enter both the ground and surface waters. In 2020, a



Map 2. Inundation areas if sea level raise at 75cm by 2100, (Bentre DONRE, 2011)

salinity concentration of four percent will cover almost all of Thanh Phu district and Ba Tri, while approximately half of Binh Dai district will be affected. The projections indicate that a four percent saline area will cover all three coastal districts of Ben Tre province, a large proportion will be covered by 10 percent, and much will be covered by 20 percent by 2050. Saline intrusion and SLR will strongly impact the inland agriculture activities, freshwater availability for different usages, and the natural coastal ecosystems in general. Map 3 outlines the projections of saline intrusions up to years 2020 and 2050.



Map 3. Saline intrusion projection in Ben Tre province in 2050 (Source: SIMHE, 2010)

The following sectors are most vulnerable due to the influence of climate change impacts:

- Aquaculture sectors mostly Binh Dai town and most of the rice areas in Ba Tri district, a part of Thanh Phu, (Giong Trom district); land with fruit trees and other plants (Chau Thanh, Mo Cay district, a part of Giong Trom district);
- Forestry sector (Binh Dai, Ba Tri district).

4.2.2. Development activities

According to the socio-economic development plan of Ben Tre province up to the year 2020[7], there are important development targets at the three coastal districts:

- The total area of rice plantation will be decreased to make way for rotational rice-aquaculture farming. This will occur mainly in Ba Tri, Thanh Phu district and partly in Giong Trom and Binh Dai district;
- Development of processing industries: four new industrial zones in Giao Hoa (Chau Thanh, Binh Dai district). Additionally there is a possibility of a new industrial zone at the current An Nhon industrial zone (Thanh Phu district);
- Construction of the Ham Luong ferry connecting Ba Tri and Thanh Phu district and continuance of sluice gates construction in the Ba Lai sluice dam;
- Construction of provincial road ĐT.885 (Ba Tri district);
- Construction of the coastal road connecting Binh Dai-Ba Tri-Thanh Phu district, which is around 38.6 km in length;
- Construction of provincial road Thanh Hai-My An connecting Ba Tri-Thanh Phu district, which is estimated to be 16.5 km in length;
- Construction of important district roads including DH.173 (East-West) connecting Chau Thanh-Giong Trom-Ba Tri district (around 58.3 km); DH.16 connecting Binh Dai-Ba Tri-Thanh Phu district, is considered a coastal prevention route (38.5 km);
- Dike construction projects in three districts: complete the system with freshwater dikes in Phu Long, Binh Dai district; Dike construction between Hoa Loi and My Hung communes of Thạnh Phu district.

The communities in general expect positive benefits from the proposed development activities but predict negative impacts on ecosystems due to pollution and defragmentation.

Table 7. Rating of coastal communities in 3 districts (Binh Dai/Ba Tri/Thanh Phu) on impacts of development activities on ecosystems and their livelihoods. (Binh Dai/Ba Tri/Thanh Phu)

Hazards	Mangroves	Sand dune	Intertidal area	Coastal sand dunes	Estuarine water	Brackish water ponds	Fresh water, crop
Road	**0/+1/-1**	**0/+2/-1**	**0/+1/-1**	**0/+1/0**	**0/+1/0**	**+1/+1/0**	**+1/+2**
Bridge,	0/+1/0	0/+2/+2	+2/+1/+1	0/+1/0	+2/+1/0	+2/+2/-+1	+2/+2
Dike	-1/+1/0	-1/+2/+2	0/0/+1	0/0/0	+2/0/+1	+2/+2/-+1	+2/+2
Urban expansion	0/-1/0	0/+1/-1	0/0/+1	+1/0/-1	0/0/-1	0/+1	0/+1
Industrial development	0/-2/0	0/-1/	0/-2/	0/-2/	-2/-1/	-1/-1/-1	-2/-2
Conversion of forest land to Agriculture / Fisheries	-2/-2/-2	-1/-1	0/-2/-1	0/-2/0	0/-1/-1	0/-1/0	0/-2
Tourism	-/-/-1	-/-/-1	-/-/-1	-/-/-1	-/-/0	-/-/0	

Rating score:
- 2: Very serious negative impacts
-1: Moderate negative impacts
0: No impacts
1: Positive impacts
2: Very positive impacts

[7] Ben Tre Provincial People's Committee, 2011. Master plan on Socio-Economic Development of Ben Tre province towards 2020.

4.3. Summary of current and future pressures on communities and ecosystems

The assessments of the ecosystems and their dependent livelihood activities have been synthesized to produce the following risk rating, adaptive capacity, and final vulnerability assessment. Conclusions are summarized in Table 8 and in the balance of this section.

Table 8. Risk ranking of key ecosystems/habitats of three coastal communes in Ben Tre province

Ecosystems	Current hazards (climate and non-climate related)		Compiled projected future impacts		Final risk
	Description	Risk	Description	Risk	
Estuarine areas	• Polluted water resource due to daily life and production activities • Water infrastructure on river such as dams, harbors; • Transboundary impacts (hydropower, water pathway, irrigation projects in the upstream countries as China, Lao, Thai and Cambodia) that reduces sediment and nutrients in the water flows.	Medium -High	• SLR together with spring tide; • Unpredictable changes of upstream flows; • Alluvial change; • Strong tropical monsoon winds; • Big waves; • High risk of tropical depression and storms.	High	Medium -High
Mangroves	• Expansion of agriculture and aquaculture cultivation lands, increase of chemicals in agriculture activities that harm to ecosystems; • Deforestation and weak control and management of forest.	High	• SLR together with spring tide increase forest land erosion possibility; • Change of water salinity; • Reduction of alluvial concentration; • Increased storms and typhoons.	Medium	Medium-High
Intertidal areas	• The exploitation and production of aquaculture and mudflat bars cause changes of flow regime, increased erosion process; • Water transportation vehicles and transboundary impacts reduce sediment and nutrients in the water flows.	Low-Medium	• SLR together with spring tide; • Unpredictable change of lows; • High risk of tropical depression and storms.	Medium-High	Medium
Sand dunes	• Population growth; • Increase of polluted water and soil; • The people at the same time exploit, and destroy, but also adjust and recover the natural resources.	Low-Medium	• CC increases temperature and changes the rainfall distribution, which has an extreme effect on ecosystems and livelihood activities. However, the impacts will be really serious after the next 20 years; • Possible limitation of fresh water access.	Medium	Medium

Coastal mangrove ecosystems are at moderately high risk from pressures of development and climate change. Current serious threats include the continued expansion of shrimp aquaculture as well as weak institutional control over and management of mangrove resources. Additionally, mangroves are both highly exposed and sensitive to inundation and erosion caused by SLR and increased storm activity.

Extensive/intensive shrimp farming (black tiger prawn and white-legged shrimp) have a moderately high risk from pressures related to development and climate change. Unsuitable management and unchecked expansion of shrimp farming will leave little natural food or habitat for shrimp, leaving the industry highly vulnerable to hazards such as disease and typhoons. Sea level rise, increased temperature and the associated increase in salt concentrations will lead to an increased number of white-legged shrimp farms (converted from the saline intolerant black tiger prawn farms), further increasing the risk of spread of disease.

Intertidal alluvial mud flat and sandbar ecosystems have a moderate risk from future climatic and development pressures. These include permanent inundation due to SLR, and an increase in annual maximum temperature, increasing the risk of death to many benthic bivalves. In addition, port and dike construction planned for Ben Tre will have significant impacts on these important, and exposed, ecosystems.

Clam (Meretrix lyrata) and blood cockle (Anadata granosa) farming is at moderately high risk from climate change and development hazards. An increase in maximum annual temperature, increased salinity, changes in upstream hydrology and sediment loads, and SLR inundation, will threaten the existence of the industry. Deeper analysis is needed to predict how the supporting ecosystem will respond to these changes.

Open water estuarine ecosystem is also at moderately high risk from development and climate change hazards. The estuary is exposed and sensitive to the coastal erosion caused by SLR, an increase in storm events, and the projected increase in seasonal inflow, flood pulse and sediment loads. Moreover, planned dike and port development will create additional hazards causing changes in hydrology and sediment and habitat alteration. The estuarine capture fisheries are at moderate risk from climate change and development hazards.

Sand dune system in Ben Tre has a moderate risk from further climate and development hazards. Sand dunes are particularly exposed and sensitive to erosive processes such as the predicted increases in storm activity, monsoonal rains, and the duration and intensity of rainfall. Furthermore, SLR and saline intrusion could contaminate sand dune dry season aquifers.

Increased rainfall will both negatively and positively impact vegetable plantations (watermelon, Jicama, and beans) and have a moderately high risk from climate change hazards. Watermelon crops are sensitive to an increase in rainfall. However, increased rainfall and temperature will allow other crops to flourish. A delayed wet season will also threaten current agricultural crops and production cycles.

4.4. Integrated risk assessment of ecosystem dependent livelihood activities

This assessment comprises a holistic accumulation of risks including the risks to livelihood- activities ; the risk level of each of the ecosystem services; the final compiled risk ranking from current and expected climate change and development impacts.

The criteria for the compiled impact ranking system also is qualitative but based on selected indicators:

> o *High level*: The degree of adverse consequences from current and projected climate change and development activities on the livelihood activity is extremely bad (calculated into economic value based on discussion results from local community workshops and surveys as well as findings from the consultant team);

o Medium level: The degree of adverse consequences from current and projected climate change and development activities on the livelihood activity is high (calculated into economic value based on discussion results from local community workshops and surveys as well as findings from consultant team);

o Low level: The degree of adverse consequences from current and projected climate change and development activities on the livelihood activity is very low or even the projected changes will likely provide positive condition for sustainable livelihood development (calculated into economic value based on discussion results from local community workshops and surveys as well as findings from consultant team).

Table 9. Integrated assessment of climate change and development pressures and hazards on key ecosystem dependent livelihood activities.

Ecosystem dependent livelihoods	Final risk ranking of supporting ecosystems		Final risk ranking of potential compiled impacts	Final accumulated risk
	Key ecosystems supporting the livelihood activity	Final projected risk ranking of each ecosystem		
Improved extensive/ intensive shrimp farming	• Estuarine areas • Mangroves	• High • Medium	• Medium - High	• Medium - High
Clam farming	• Mudflat bar • Sandbars	• Medium - High • Medium - High	• Medium - High	• Medium - High
Capture & offshore fisheries	• Estuarine areas	• High	• Low - Medium	• Medium
Vegetable plantation on sand dunes	• Sand dunes	• Medium	• High	• Medium - High

Improved extensive/intensive shrimp farming (black tiger prawn and white-legged shrimp) have a ***medium-high*** risk of impact from development and climate change. Unsuitable management and unchecked expansion of shrimp farming will leave little natural food or habitat for shrimp, leaving the industry highly exposed and sensitive to impacts such as disease and typhoons. Sea level rise, increased temperature and the associated increase in salt concentrations, will lead to an increased number of white-legged shrimp farms (rather than black tiger prawn farms) and further increase the risk of disease and industry failure.

Clam (Meretrix lyrata) and blood cockle (Anadata granosa) farming is at ***medium–high*** risk from climate change and development hazards. An increase in maximum annual temperature, increased salinity, changes in upstream hydrology and sediment loads, and SLR inundation, will threaten the existence of the industry. It is hard to predict how the supporting ecosystem will respond to these changes.

The estuary ***capture fisheries*** are at ***medium risk*** of climate change and development hazards. There is an on going investment in captured fisheries. This includes the development of ports, wholesale markets, boat shelters and seafood canning facility and industry. This continued, unsustainable, investment and development has the potential to overstretch the fisheries' populations and cause a collapse in the industry.

Vegetable plantations (watermelon, Jicama and beans) and have a ***medium-high risk*** of climate change hazards. Watermelon crops are sensitive to an increase in rainfall. However, increased rainfall and temperature will allow other crops to flourish. A delayed wet season will also threaten current agricultural crops and cropping

cycles.
Vegetable plantations in the sand dunes regularly face difficulties including drought and flooding. This is expected to increase with planned developments and climate change trends. Like mudflats, the communities in the sand dues are used to living in dynamic environment and are adapted to the regular challenges that arise.

Some projected climatic changes may have benefits. Unusual and unseasonal rain in the dry season can provide needed fresh water for trees, plants and crops, and reduce saline intrusion, as well as helping to reduce the risk of forest fires.

In most cases it can be noted that the risk from development is much greater for both livelihoods and ecosystems than from climate change. Much of the development is seen to be short-term economic gain that will quickly exploit resource to enhance economic development. This includes the rapid development of infrastructure (ports, roads, and transport), industry, and aquaculture. Most of these developments will come at the expense of the environment (mangroves, sand dune, intertidal, and estuarine ecosystems) that is supporting the communities, communes and provinces. If these ecosystems are not sustainably managed the economic and social gain will be short lived. It is also worth noting that each ecosystem depends on the other and the lost or degradation of one increases the risk to the others.

4.5. Community Developed Indicators for Vulnerability/Resilience

The coastal communities have been experiencing particular impacts of an ever-changing climate. They find that habitats for wild animals and plants are decreasing and mangrove loss leads to erosion and salt intrusion, which affects productive land. They are facing a shortage of water, which is caused by increased long hot periods and drought seasons.

The agriculture sector is experiencing more climate change impacts and the local communities see that EbA solutions are highly suitable for the agriculture sector, including aquaculture. Shrimp farmers seem to be a vulnerable group. They are more exposed to climate events such as storms and flooding and increased hot periods. They also experience mangrove loss that leads to erosion and salt for their productive land.

Ecosystem services might value differences between stakeholders depending on perspective on benefits from ecosystem services as economic, social or ecological.

While communities recognized different impacts to different sectors, this case study also tried to assess how different individuals within the community show different vulnerabilities to climate change. For example, the communities discussed that women are more likely to be more vulnerable because they cannot swim as fast in the event of disasters and are also out collecting different services from the ecosystems. The other factors included income, diversity of livelihood, land location etc. Table 10 summarizes resiliency indicators as identified in consultations with residents of the three coastal districts included in this study.

Table 10. List of Resiliency Indicators for Evaluating Vulnerability of Communities.

Indicator	Ranges of evaluation	Vulnerable
Income	<400,000 VND/person/month	High
	400,000-520,000/person/month	Medium
	>520,000/person/month	Low
Livelihood diversity	One livelihood/job	High
	More than 2	Low
Land for cultivation (Aquaculture & agriculture)	Low (None)	High
	Medium (Agriculture land/ <0,5ha / Aquaculture <1 ha)	Medium
	High (Agriculture land >0,5ha /Aquaculture >1 ha)	Low
Land location	High (Inside-dike: Salt & Fresh)	Low
	Low (Out site-dike: None & Forest)	Medium
Freshwater access	Low (Distance to freshwater sources > 2km)	High
	High (Distance to freshwater sources <2km)	Low
Housing condition	Low (Poor constructed house)	High
	Medium (Semi-permanent house)	Medium
	High (Permanent house)	Low
Gender	Female, elders, kids	High
	Male, mature	Low

Source: WWF, 2013. Data from the field.

4.6. Assessing Exposure, Sensitivity and Adaptive Capacity

The community adaptive capacity was determined by assessing the current coping strategies of the community, and the ecological and institutional ability to respond to hazards and risks. Table 11 summarizes the results from the adaptive capacity assessment.

Table 11. Adaptive capacity ranking

Ecosystem | Livelihood activity	Adaptive Capacity		
	Ecological	Community	Institutional
Mudflat/sandbar | **Clam and cockle farming**	Low	Moderate	Low
Mangrove | **extensive/intensive shrimp**	Low /moderate	Low /Moderate	Low
Sand dune | **Vegetable plantation**	High	High	Low
Estuarine | **Capture/offshore fishery**	Low	Low	Low

- High adaptive capacity: Community members can manage the impacts of current climate and non-climate related hazards very well and can adapt their livelihoods quickly when pressures increase. They are familiar with projected climate change scenarios and development plans and their current coping/adaptation strategies are likely to remain viable in the future;
- Moderate adaptive capacity: Community members can manage the impacts of current climate and non-climate related hazards and will recover gradually if pressures increase. They are somewhat familiar with projected climate change scenarios and development plans, and their current coping/adaptation strategies might not be viable for coping with future hazards;
- Low adaptive capacity: Community members are not able to manage the impacts of current climate and non-climate related hazards on their selected livelihoods and will not recover their livelihoods if pressures increase. They are unfamiliar with projected climate change scenarios and development plans, and their current coping/adaptation strategies will not be viable in the future.

The field-testing was done in a short period, so the community's and ecosystem's capacity have not been analyzed in detail. A SWOT analysis was carried out to understand the institutional adaptive capacity to climate change impacts in the coastal areas of Ben Tre.

Strengths • The natural conditions in Ben Tre province are favorable for ecosystem conservation and agro-aquaculture cultivation; • There is a strong support from the provincial authority leaders for climate change adaptation capacity building and application	***Weaknesses*** • Human resources for climate change are weak and limited of both quantity and quality, especially at the local level. Raising awareness to adapt and cope with climate change is a challenging problem; • There is the weak awareness of the whole society, at all levels, from policy makers and those officers in departments and local social organizations as well as the community itself the impact of climate change; • Agricultural development but is mainly based on the exploitation of natural resources-natural (land, water, forests, fisheries.) should easily lead to the risk of exhaustion resources and environmental degradation; • Technical infrastructure in rural coastal areas (roads, electricity, water and sanitation access) has been the recipient of a great deal of investment, but is still at weak state. A lack of synchronization may cause barriers in implementing adaptation strategies to climate changes.
Threats • Economic development depends greatly on natural resources. The future projected increases in salinity, drought, storms, sea level rise etc. will likely strongly impact ecosystems and nature- dependent livelihood exploitations; • The increasing population pressure and environmental pollution are acting badly to the natural coastal environment.	***Opportunities*** • There is a standing office of NTP-RCC in Ben Tre province working with DONRE & DARD on Climate change action plans. Sectoral integration plans will be invested and piloted in the province; • Mekong River Delta has been identified as one of places facing many serious challenges on climate change and sea level rise, in which Ben Tre is the top of ten most vulnerability provinces. This threat may be considered as an opportunity for several studies on climate change impacts for Ben Tre from various research institutions and NGOs as a very specific case study; • In Ben Tre, a number of climate change adaptation related projects are being implemented for developing a systematic and comprehensive understanding of the capacities of regional institutions to formulate and implement strategies of adaptation to climate change risks and the forecasted impacts of climate change on management of natural resources in coastal environments. There will be more financial and technical supports in climate change adaptation for Ben Tre province.

Institutional adaptive capacity is complex including: institutional coordination; financial resources; legal and political power; level of interest and motivation of individual actors; availability and dissemination of knowledge on increased risks from climate change impacts; and openness and responsiveness. An analysis of the institutional adaptive capacity to climate change impacts in the coastal areas of Ben Tre found that:

The Mekong River Delta has been identified as one of places facing many serious challenges on climate change and sea level rise. Ben Tre is one of the top ten most vulnerable provinces. Recognition of this threat brought close attention to Ben Tre province. Several studies, investment, and technical support projects responding to climate change impacts conducted by various research institutions and NGOs have already started. This will help strengthen government and communities as well as policy.

There is a strong support from the provincial authority leaders for climate change adaptation capacity building and application. Human resources, however, for climate change adaptation are weak and limited in both quantity and quality, especially at the local level. Raising awareness and leading adaption and coping strategies are challenging.

Current institutional policies encourage agricultural development based on the exploitation of natural resources (land, water, forests and fisheries), leading to exhausted resources and environmental degradation. This increases the risk of climate change and reduces the effectiveness of communities coping strategies and their ability to adapt to climate change.

There is weak awareness at all levels—from policy makers to the community—regarding the pressures and threats of climate change. Furthermore, there is a lack of communication and coordination between government departments, institutes, strategies and polices. This may cause barriers and reduce the efficient and effectiveness of implementing adaptation strategies to climate changes. There are, however, with the existence of the standing office of National Target Program to Respond to Climate Change (NTP-RCC) in Ben Tre province, which has closely working with both DONRE & DARD on climate change action plans. Moreover, the mainstreaming of climate change adaptation into sectorial integration plans will be invested and piloted in the province; there will be more opportunities for strengthening the communication and collaboration among relevant departments, particularly DONRE and DARD.

4.7. Current Coping Strategies to Climate and Non-Climate Related Hazards

Local communities have implemented many initiatives to adapt to changes in climate and the coastal environment. Local communities agreed that coping strategies also depended on the vulnerability indicators identified above. Shrimp farming, one of the most important subsistence activities in the coastal area, is facing critical problems caused by both climate and non-climate hazards. One coping strategy that has been applied by local communities is to switch from raising black tiger prawns to white-leg shrimp, which has reduced overall fishery losses and increased the income for local communities. However, according to many aquaculture scientists, this is not a sustainable solution due to the low-quality of white-leg shrimp, which breed diseases and leaves antibiotic residue in the marine ecosystems.

There are some good coping strategies that would be effective in the future, which include using nets to cover cockle nurseries from the sun; clam farming at a range of elevations to reduce the risk of loss due to prolonged hot periods, choosing alternative and suitable varieties of vegetables and watermelons for growing in the sand dunes, vegetable diversification to reduce risks of crop failures, and mangrove re-generation and plantation activities. However, these coping activities are not enough and the irregular rainfall patterns or prolonged hot periods currently still cause loss of crops.

Current government adaptation strategies include: the development of coastal dikes; mangrove plantation and restoration; and dredging activities and residential resettlement plans. Governments have implemented these strategies and plan to continue these investments. The scale and scope of government strategies are usually larger than community-driven actions and are often implemented over a longer period of time. While coastal dikes or dredging activities will provide immediate results (particularly the dike system) these constructions can damage natural resources and alter the ecological systems. In the long term, it may lead to maladaptation, therefore reducing the services to support livelihoods and very costly to restore the origin.

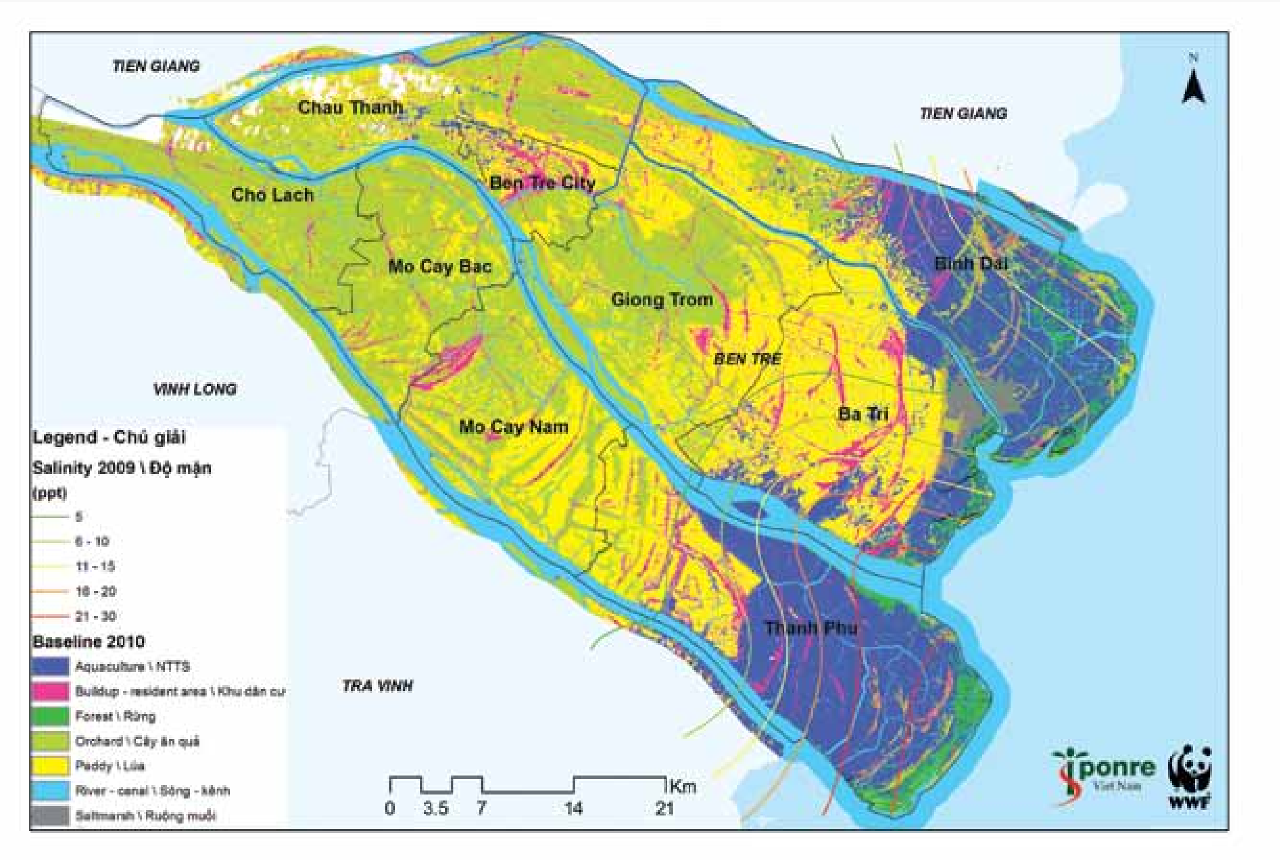
Table 12 summarizes the current coping activities that have been adopted by the local communities and the governments.

Table 12. Current Coping and Adaptation Activities to Climate Change Impacts in Three Coastal Districts, Ben Tre (Source: WWF field data, 2013)

Climate change hazards	Coping actions
Unseasonable rainfall	• No reaction
Prolonged hot weather, drought	• Using nets to shield cockle nurseries from the sun; • Scattering clam farms at lower elevations to reduce population loss from prolonged and concentrated periods of heat; • Avoiding intensive clam farming; • Well-digging to use groundwater for domestic activities (figure 5.4); • Using nylon/plastic to avoid evaporation, weed growth, loss of fertilizers in crops.
Increased SLR and spring tide	• Development of coastal dikes to limit the impact of ocean waves, SLR, winds and storms; • Mangrove plantation and preservation outside of coastal dikes (for example, project 661 from 1998 – 2010).
Erosion and mon-soon winds	• Development of coastal dikes to limit the impact of ocean waves, winds and erosion; • Mangrove plantation and restoration in coastal areas and core zone area of Thanh Phu natural reserve; • Mangrove plantation and preservation outside of coastal dikes (for example,project 661 from 1998 – 2010); • Constructing stone/rock dike systems and concrete pipes; grey or white mangrove plantations to cope with erosion; • Residential resettlement away from coastal areas; • Reduction of industrial activities and construction works (mechanical plants, boat and engine repairing bases) near the mangrove forests and high erosion areas; • Limiting the exploitation of mangroves for construction wood and firewood; • Planting coconuts in sand dunes to limit the impact of heavy winds and storms (and to provide a source for roofing material).
Increased frequency and intensity of tropical storm events	• Development of coastal dikes to limit the impact of ocean waves, winds and storms; • Warning systems of tropical depressions and storms for local people through radio, TV, notice boards; • Dredging activities on the river to make boat shelters for offshore fishermen; • Limiting overexploitation of mangrove trees.

4.8. Scenario Development and Reflection

Scenarios related to the influence of ecosystem status on climate change adaptation are heavily influenced by amounts and configuration of different land uses. Given this, the analysis team established a base map representing today's land cover condition by combining a land use map provided by the Department of Natural Resources and Environment with some refinements taken from classifying 2010 Spot satellite imagery.



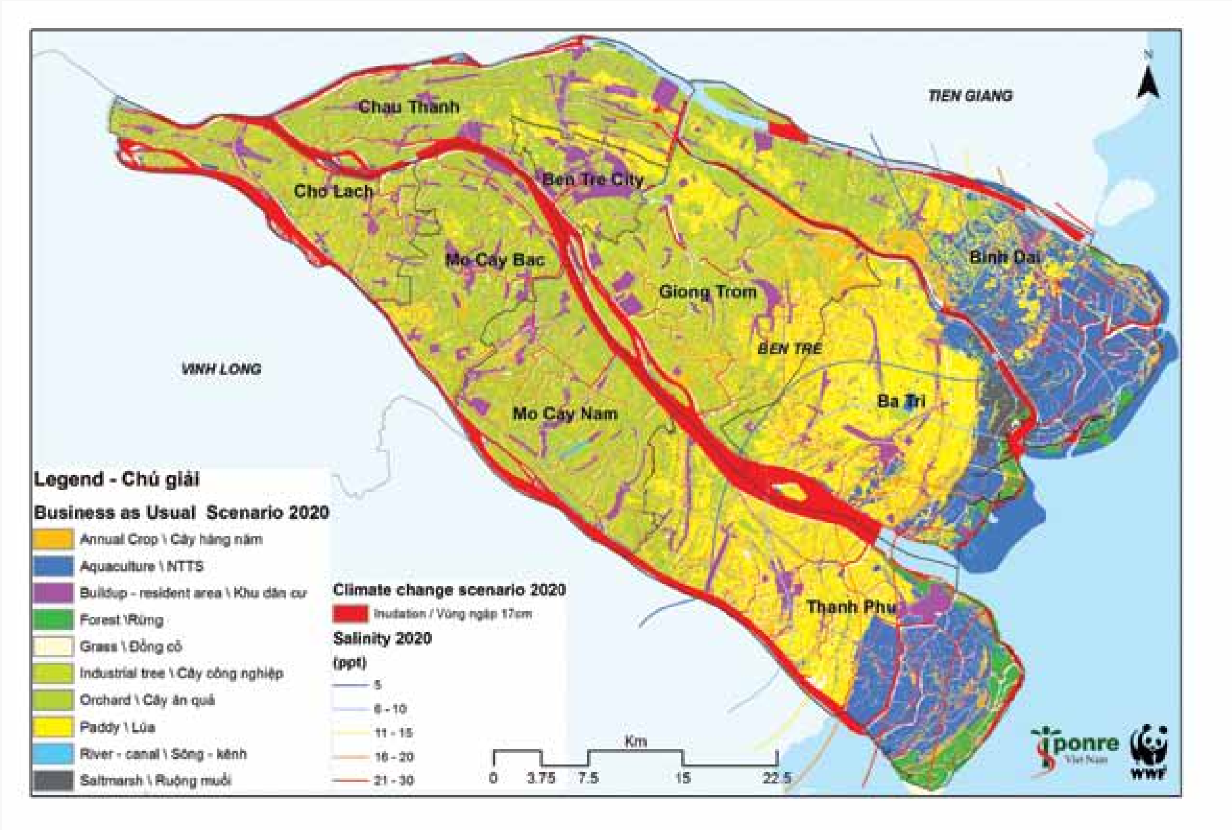
Map 4. Current land use-land cover in Ben Tre provinces

With this map as a starting point, and using the assumptions in the following sections, three scenarios were developed representing what the land use/land cover condition of the area would likely look like in 2020 given various assumptions about agricultural, irrigation, and settlement patterns: business as usual, development, and conservation. Possible climate change-induced changes to the biophysical condition of each of these were held constant to facilitate comparison of factors that are/will be largely in the hands of decision-makers and individual and community behavior and land use on the ground.

4.8.1. Business as Usual Scenario in 2020

Assumptions: Socio-economic development growth is extrapolated from the previous 10-year period; the current provincial land-use plan is fully implemented; and sea level raised at 17 cm.

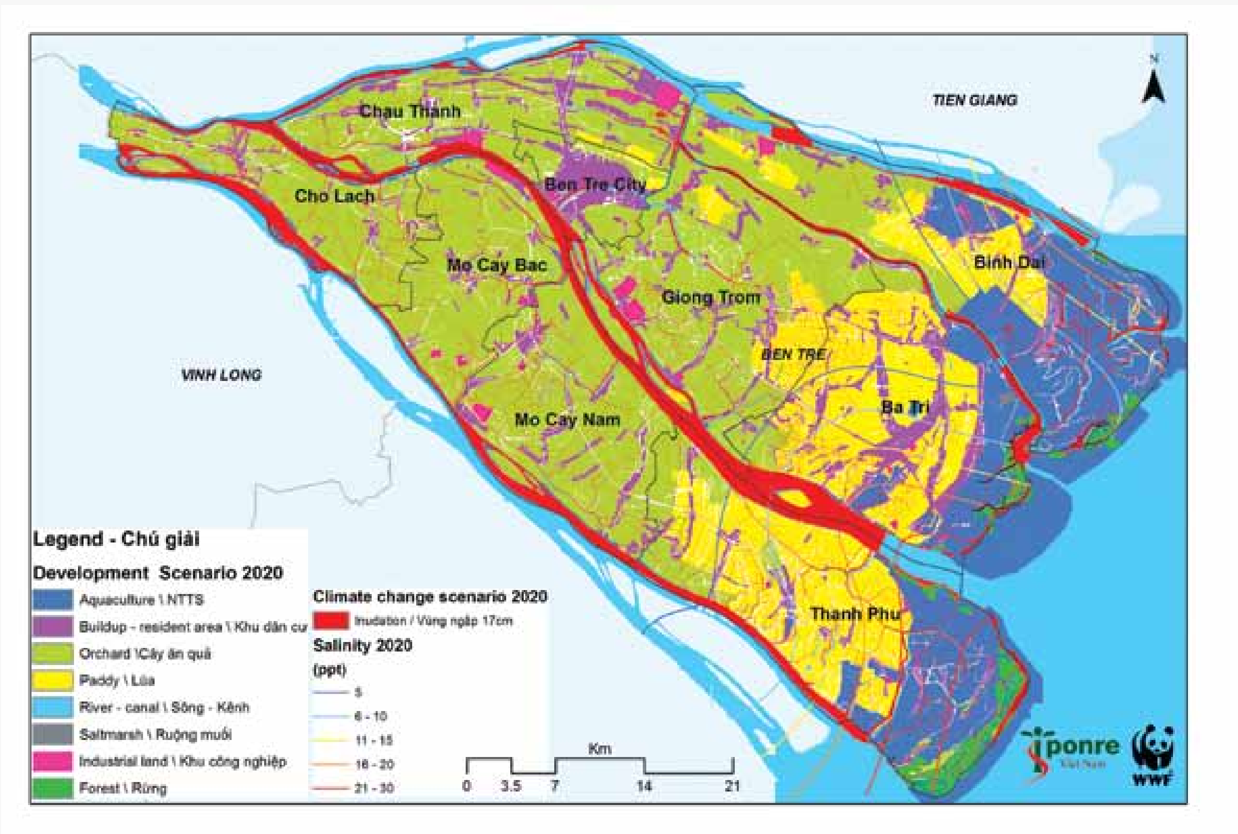
Compared to the baseline scenario, the only two land-use/land-cover types increasing under this scenario are orchard (e.g. fruit trees) (+16 percent) and built-up areas (e.g. settlement, industry, etc.) (+ 31 percent). All other land use/land cover types are decreased in extent—especially areas used for aquaculture (-31 percent), agriculture (-34 percent) and forestry (-44 percent).



Map 5. Business as Usual scenario in 2020 in Ben Tre province

4.8.2. Development Scenario in 2020

Assumptions: Agriculture and aquaculture are expanded and intensified as proposed by the currently proposed agricultural development plan and industry and infrastructure development as proposed by the ministry of industry, and sea level raised at 17cm.

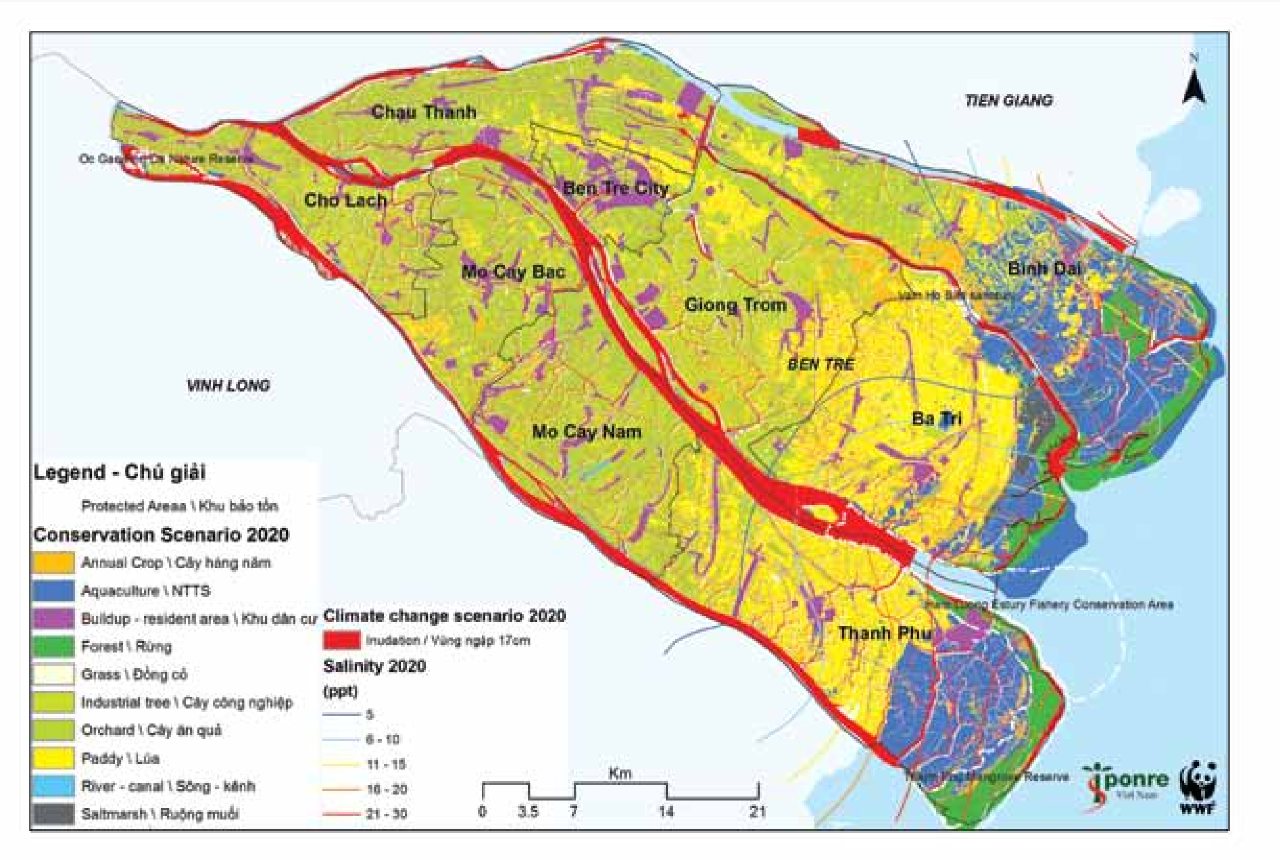


Map 6. Rapid Development scenario in 2020 in Ben Tre province

Compared to the baseline scenario, land-use changes under this scenario follow a similar trend to that of the business as usual scenario (e.g. orchard area +18 percent and built-up area +58 percent), whereas agriculture and aquaculture areas are reduced by 34 percent and 24 percent, respectively. However, in this scenario, salt marsh areas are mostly converted to other land use types (e.g. aquaculture) and the forestry area increases slightly reflecting the forestry department's replantation plans (replanting more than 100ha/year from 2010 to 2020).

4.8.3. Conservation Scenario in 2020

Assumptions: New protected areas are established, mangrove cover is significantly increased as per forest recovery plans, and natural hydrological regimes are maintained, and sea level raised at 17cm.



Map 7. Biodiversity Conservation scenario in 2020 in Ben Tre province

In the conservation scenario, areas of forest, orchard, and built-up areas increase by 44 percent, 16 percent, and 30 percent, respectively. Areas of agriculture, aquaculture, and salt marsh decrease by 23 percent, 38 percent and 16 percent respectively.

The changes in key land cover types of different scenarios are shown in the graph and table below:

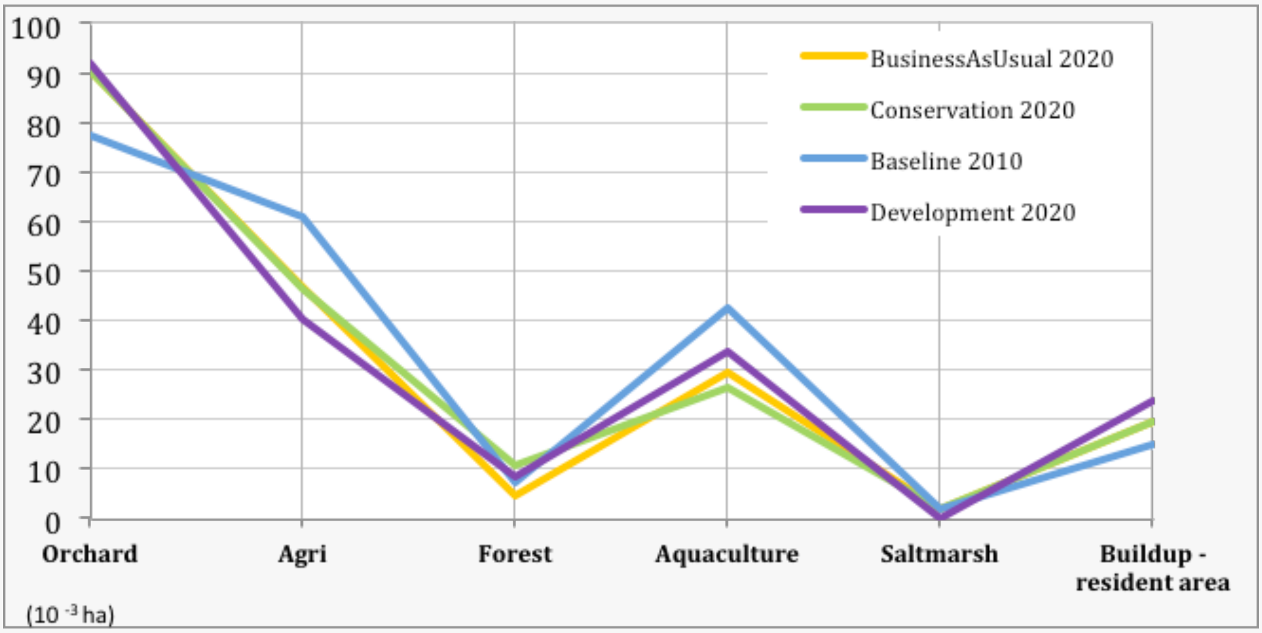


Figure 4. Change in Land-Cover under three future scenarios versus baseline: (1) BAU, (2) Conservation, (3) Development.

Table 13. Area statistics area of main land cover types of 3 scenarios (Unit: Ha)

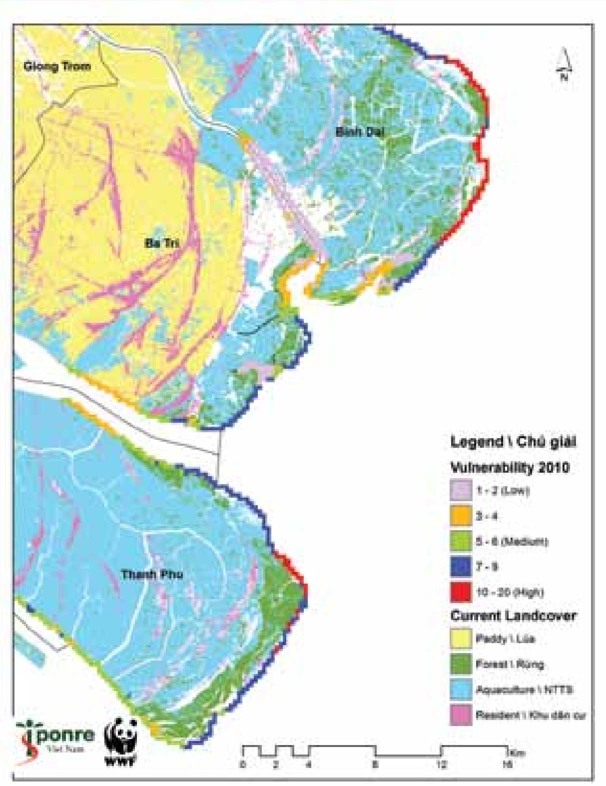
Grouped Land use / land cover classes	Baseline	Business As Usual	Conservation	Development
Orchard	**77,685.25**	**90,644.75**	**90,427.75**	**92,036.50**
Agriculture	61,040.25	47,065.50	46,519.00	40,125.00
Forest	7,400.25	4,858.75	10,715.25	8,341.00
Aquaculture	42,956.75	29,601.50	26,432.25	33,949.50
Salt marsh	2,115.00	1,994.50	1,760.75	111.50
Buildup - resident area	15,037.50	19,741.75	19,669.50	23,780.50

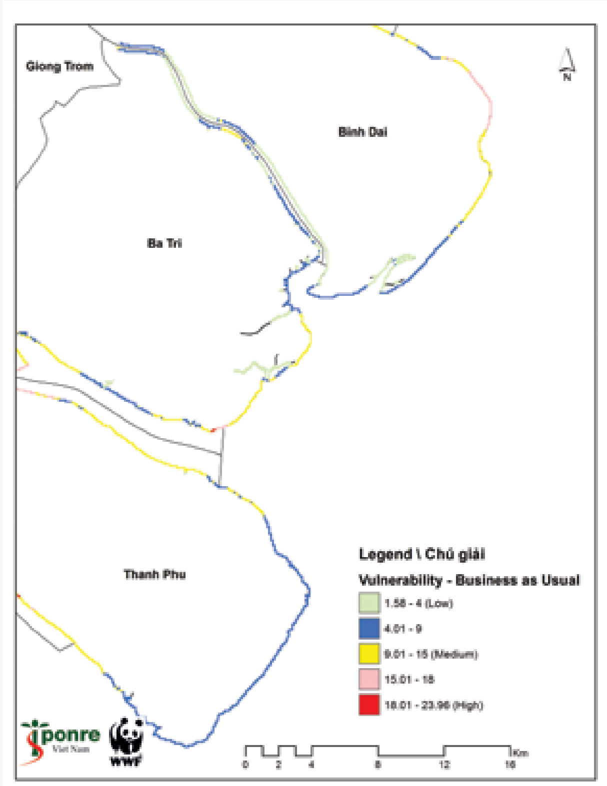
4.9. Future Scenarios and Use of Models to Assess Future Vulnerability

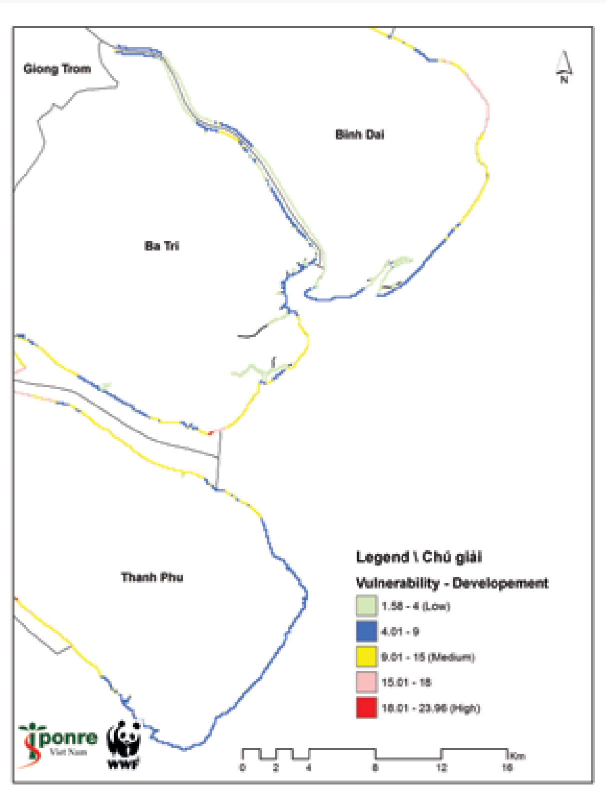
4.9.1. Coastal Vulnerability

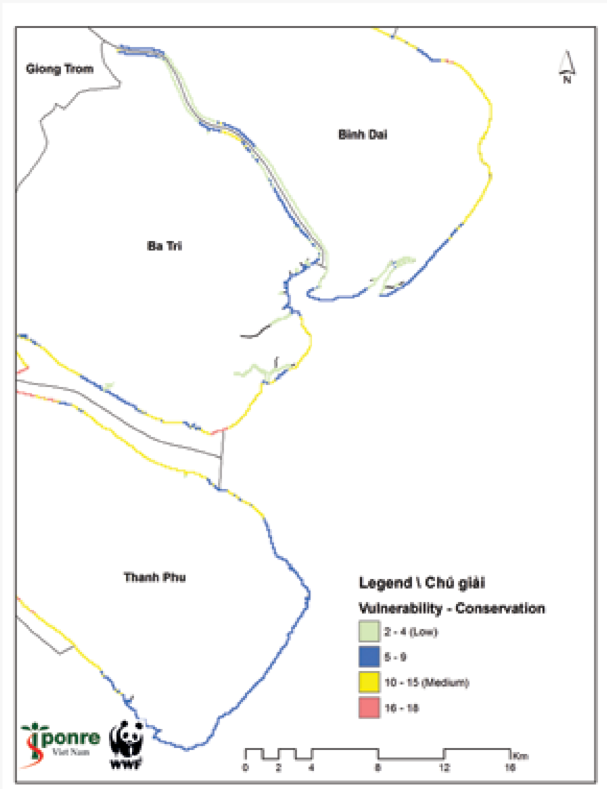
Faced with a changing climate and a growing intensity of human activities and in order to make good choices about what climate change adaptation options will best serve them, coastal communities in Ben Tre province must better understand how modifications of the biological and physical environment (i.e. direct and indirect removal of natural habitats for coastal development) can affect their exposure to storm-induced erosion and flooding (inundation). The InVEST Coastal Vulnerability model produces a qualitative estimate of such exposure in terms of a Vulnerability Index, which differentiates areas with relatively high or low exposure to erosion and inundation during storms. By coupling these results with population information, model outputs show areas along a given coastline where humans are most vulnerable to storm waves and surge. The model does not take into account coastal processes that are unique to a region, nor does it predict long- or short-term changes in shoreline position or configuration.

The InVEST Coastal Vulnerability model was applied to the coastal areas considered in this study. The primary differentiating factor between scenarios was coastal land use under the three scenarios discussed above. The changing of natural habitats under the three scenarios will negatively and positively affect the ability of coastal zones to face climate change and natural disaster. The model generated three scenarios of coastal vulnerability. Risk level is ranking from very low risk to extreme risk. In most cases, the area without mangroves and the estuarial areas have a high value of risk; those areas affected by tide and strong flow of river, and where landslide and erosion occur frequently.







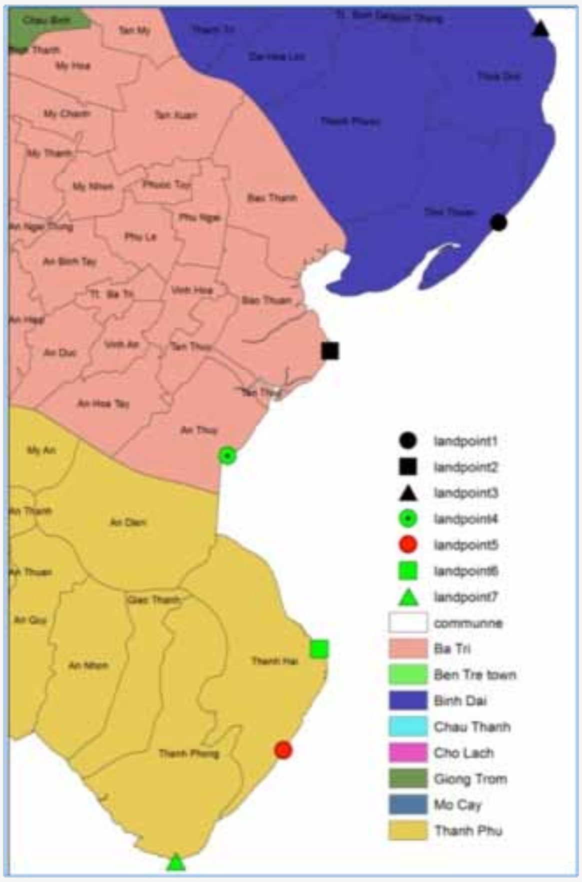


In general, all of scenarios showing that the coastal areas in Binh Dai district (less and thin mangrove belt) are more vulnerable to storm surges and sea level rise than Ba Tri and Thanh Phu district (with more and thick mangrove belt). The river mouths that have mangrove and sea/river dike (Ba Tri river mouth) are more resilient than the areas that do not have either mangroves or sea/river dikes. The coastal areas are more affected by northeast monsoon, especially the areas faced to the northeast, even in Thanh Phu mangrove reserve.

The coastal communities in the development scenario are more vulnerable to weather extreme events than in the business as usual and conservation scenarios in term of lost and damaged community properties and crops due to high population concentration and investment in farming.

4.9.2. Coastal protection – Near-shore wave erosion

Understanding the role that near-shore habitats play in the protection of coastal communities is increasingly important in the face of a changing climate and growing development pressure. The InVEST Erosion Protection model quantifies the protective benefits that natural habitats provide against erosion and inundation (flooding) in near-shore environments. It is composed of two sub-models: a Profile Generator and a Near-Shore Wave and Erosion model. In the absence of local data detailing the profile of the near-shore elevations, the Profile Generator model helps combine information about the local bathymetry and backshore to generate a one-dimensional (1D) cross-shore (perpendicular to the shoreline) beach profile. The Near-Shore Waves and Erosion model uses the cross-shore profile (either uploaded or created using the Profile Generator) to compute summaries of near-shore wave information, and outputs the total water level at the shore, the amount of shoreline erosion, and the amount of avoided damages due to erosion (in local currency) from a given habitat management decision that affects the amount of near-shore marine habitats (e.g., coral or oyster reefs, vegetation, sand dunes) at a given site. This information can help coastal managers, planners, landowners, and other stakeholders understand the coastal protection services provided by near shore habitats, which can in turn inform coastal development strategies and permitting.



Map 9. Land-points observation along the coastline in Ben Tre

In Ben Tre, seven landpoint observations along the coastline were used to make a land-sea profile then estimate the change of wave transmission from 50 km from sea to coastal line.

The coastal protection model is used to simulate the wave transmission based on the information of the tide and storm model integrated with seabed topology, habitat distribution, and biology. In most cases with mangroves existing, wave height and energy were reduced 85-95 percent when it reached the coastal line.

The observation shows that wave height and energy have been reduced 80-98 percent when it approached to the coastline thanks to the mangrove belt and sand dunes/bars, but simulated results are also illustrated that in different scenarios with different type of coastal habitats and management actions reflected to changes of wave height and energy reduction levels.

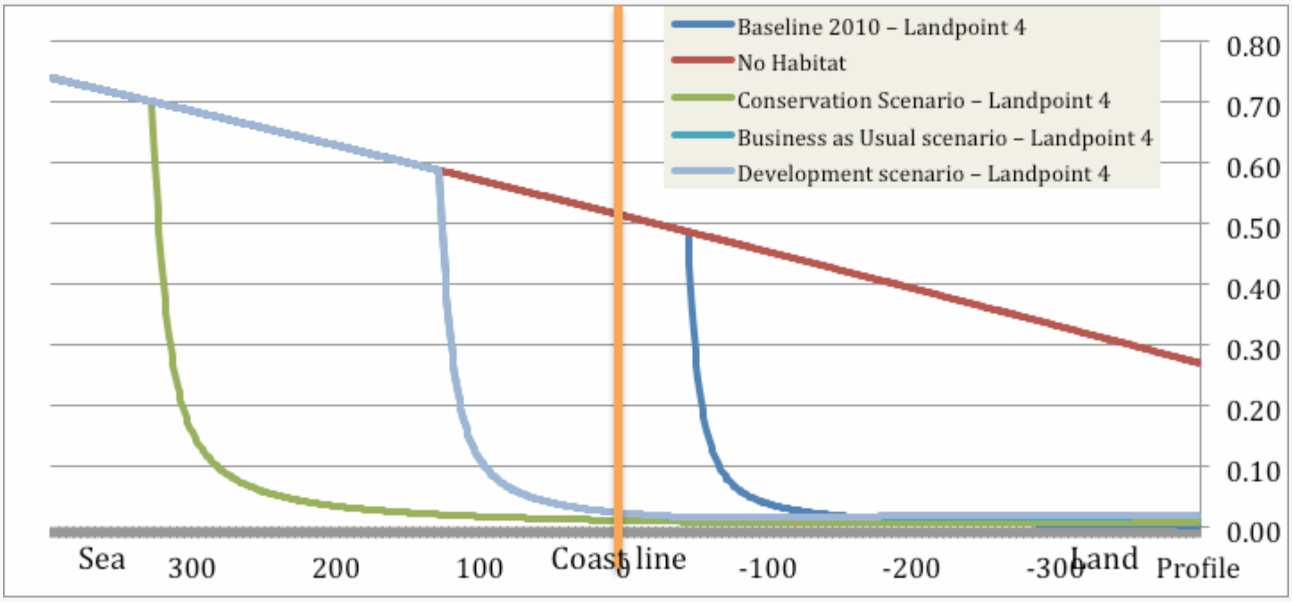


Figure 6. Reduction of Wave Height (m) by coastal habitats at Landpoint 4 under Different Scenarios

This chart is the simulated result from InVEST model at landpoint 4. The red line (no-habitat) means that if there are no mangroves and sand dunes the wave will surge further to 300–400m inland. The current mangrove belt and sand dunes have reduced the wave height from 0.4m to 0.1m when it reached 100m inland. In the business as usual and cevelopment scenarios, the wave height reduced from 0.6m to 0.1m at 100m from the coastline to the sea. In the conservation scenarios, the wave height reduced from 0.7m to 0.1m at 300m from the coastline thanks to mangroves expansion and plantation of the dunes.

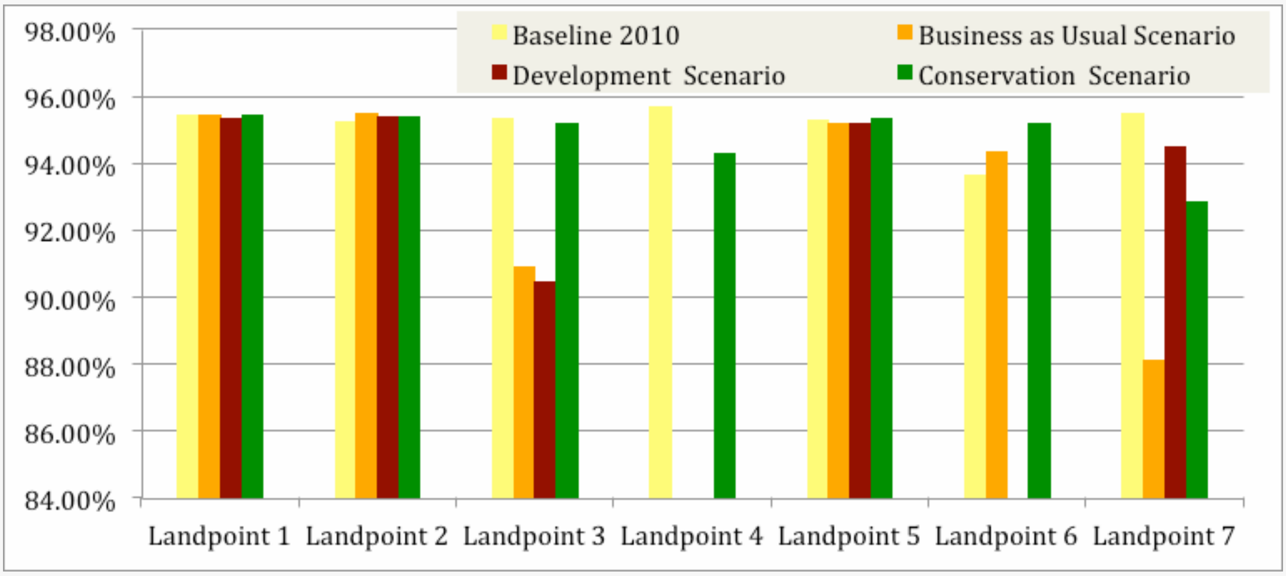
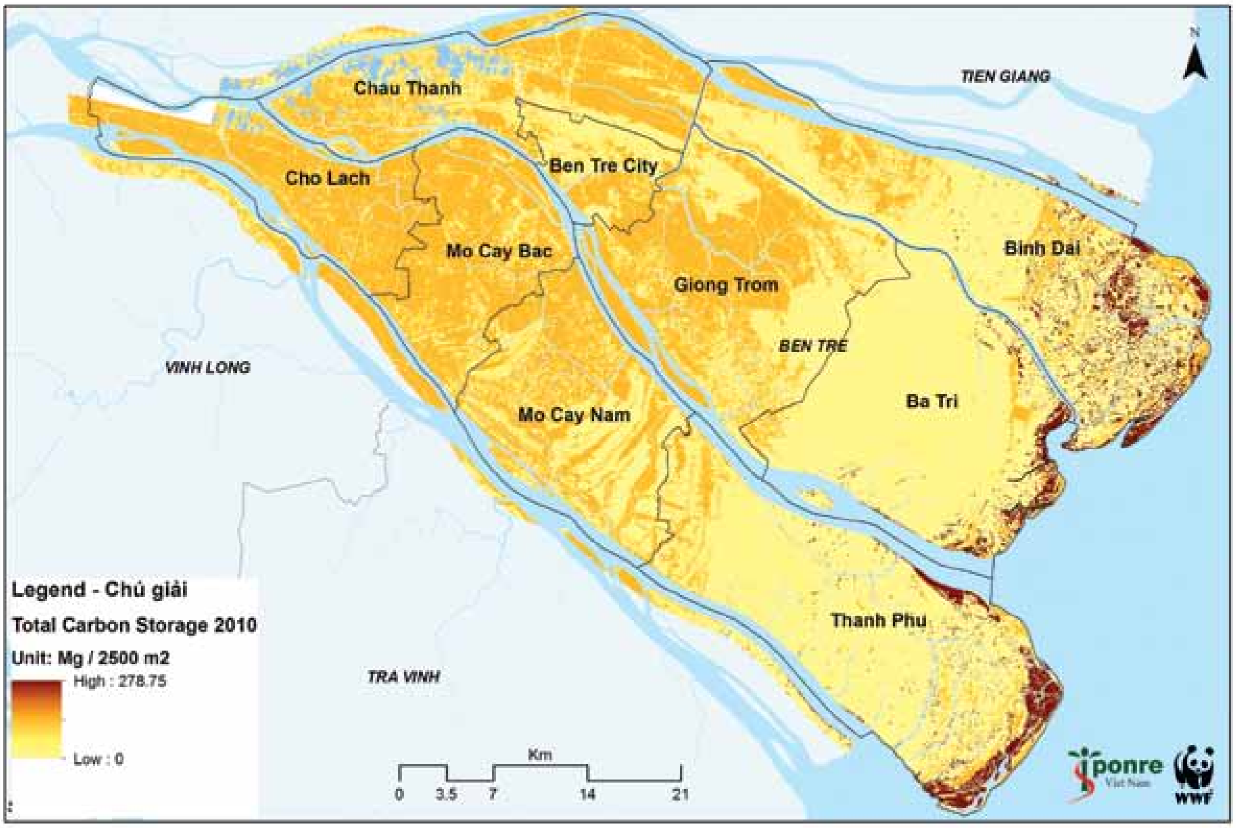


Figure 7. Reduction of Wave Energy (%) by coastal habitats at Landpoints 4 under Different Scenarios

The wave energy is also reduced by 80 percent to 95 percent in different scenarios at seven observation landpoints. In most observation landpoints, wave energy under the conservation scenario is reduced by 92 to 95 percent. In the development scenario, the wave energy is ranging from 80 to 95 percent. Even in landpoint 7 the wave energy reduction is higher than conservation scenario due to building a sea dike behind the mangrove near the Co Chien river mouth.

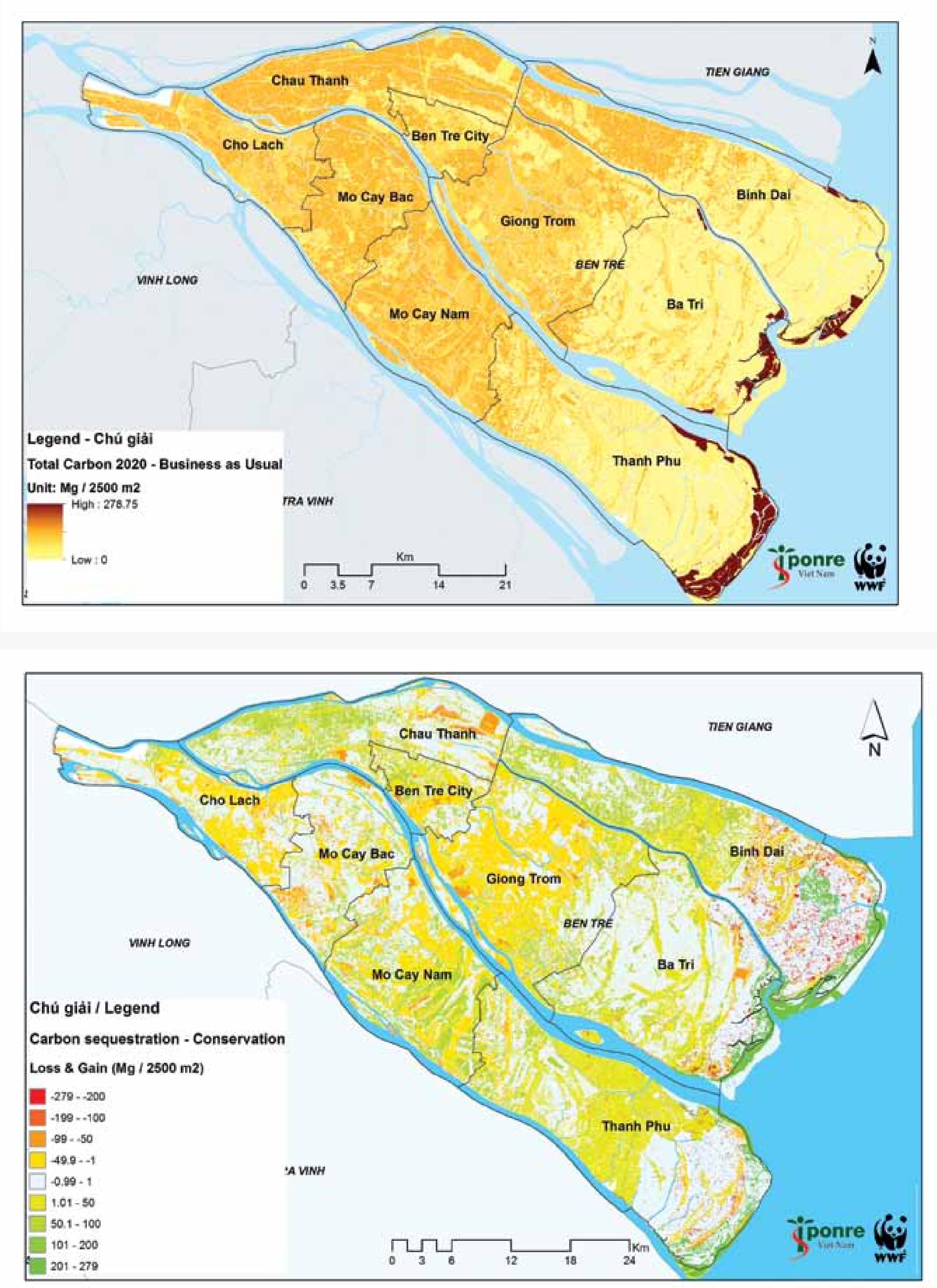
4.9.3. Carbon Storage and Sequestration

Terrestrial ecosystems, which store more carbon than the atmosphere, are vital to influencing carbon dioxide-driven climate change. The InVEST model uses maps of land use and land cover types and data on wood harvest rates, harvested product degradation rates, and stocks in four carbon pools (aboveground biomass, belowground biomass, soil, dead organic matter) to estimate the amount of carbon currently stored in a landscape or the amount of carbon sequestered over time. Additional data on the market or social value of sequestered carbon and its annual rate of change, and a discount rate can be used in an optional model that estimates the value of this environmental service to society. Limitations of the model include an oversimplified carbon cycle, an assumed linear change in carbon sequestration over time, and potentially inaccurate discounting rates. The carbon model was applied to calculate carbon storage from the current land cover map from 2010 and land-use planning maps with three scenarios.

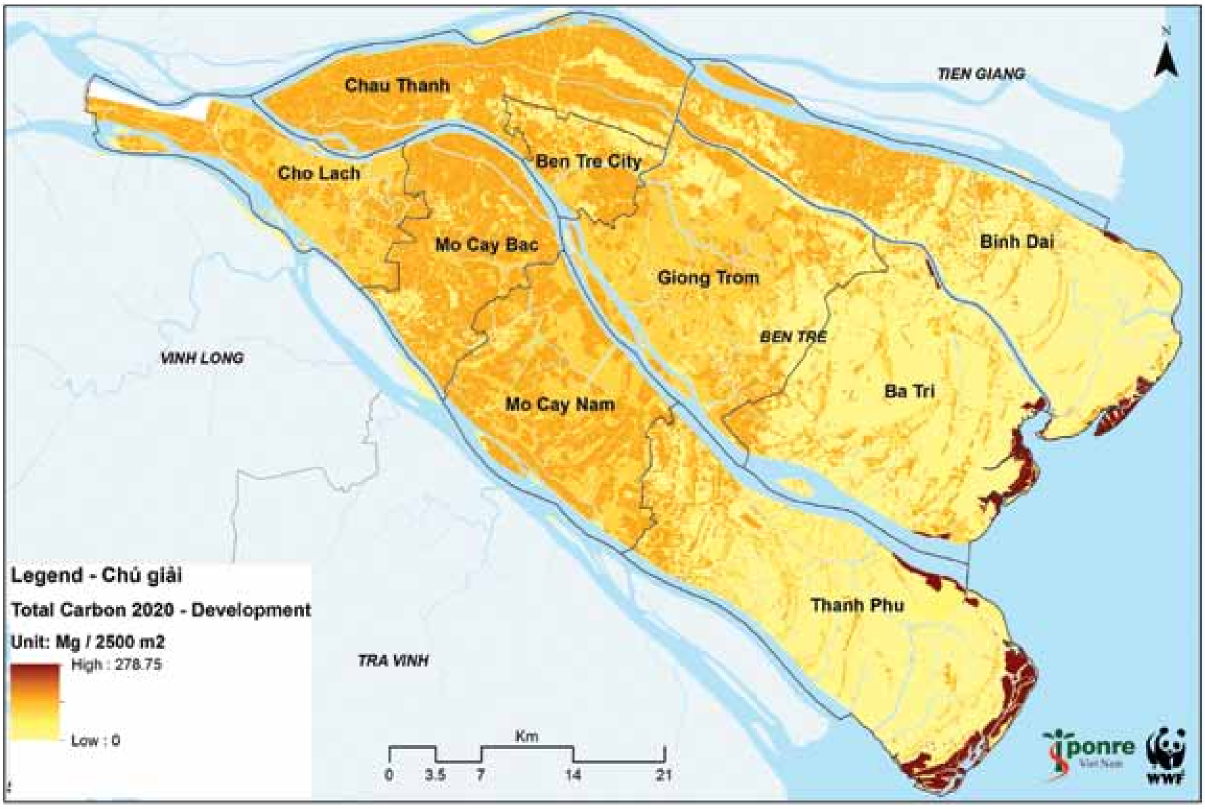


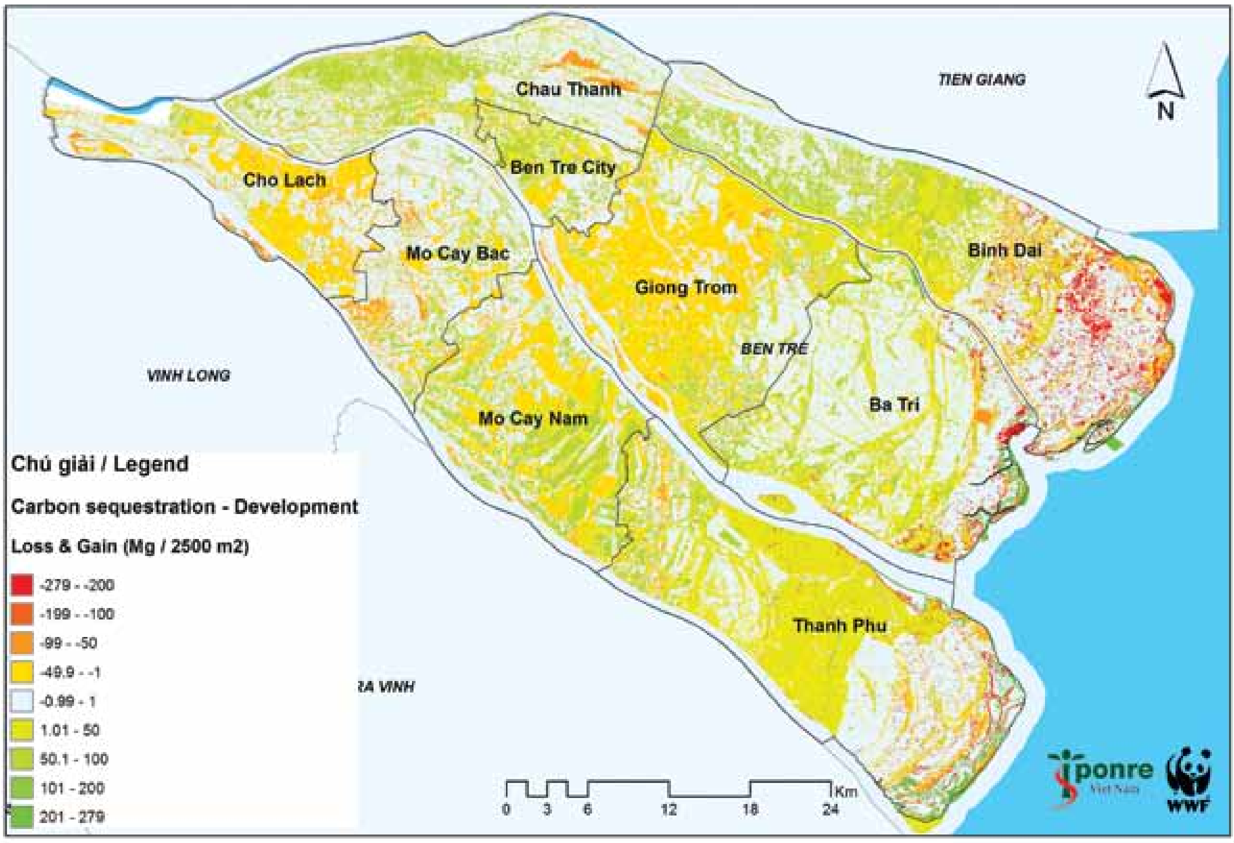
Map 10. Carbon Storage 2010, generated from Current Land-Cover Map

The results of the carbon storage in future scenarios are compared with current carbon storage and calculate sequestration.

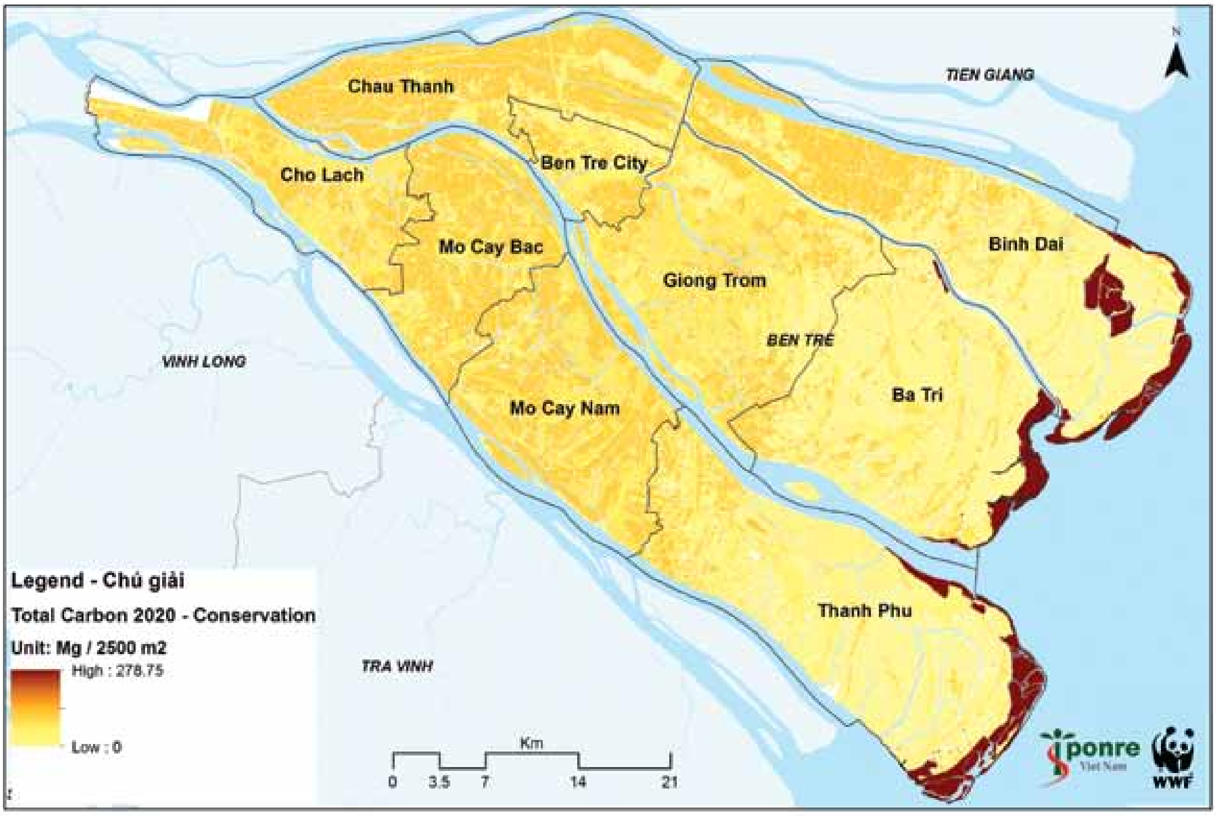


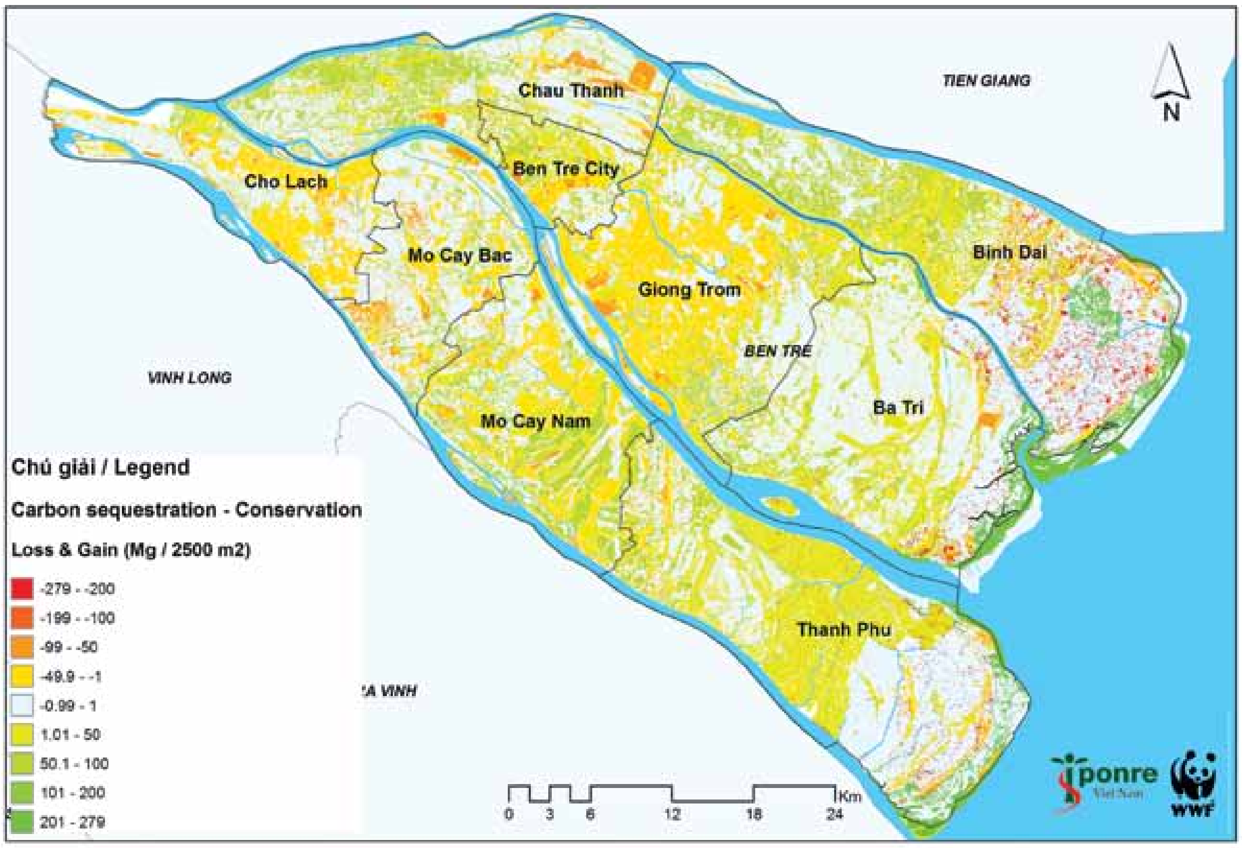
Map 11. Carbon Storage and Sequestration under Business as Usual Scenario in 2020





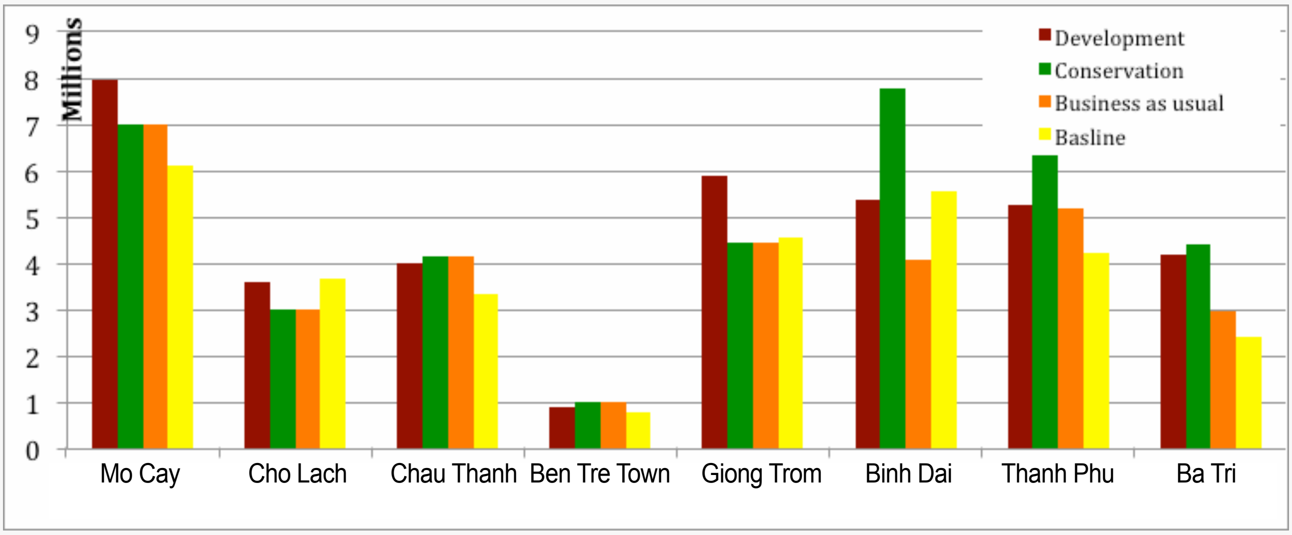
Map 12. Carbon Storage and Sequestration under Rapid Development Scenario in 2020

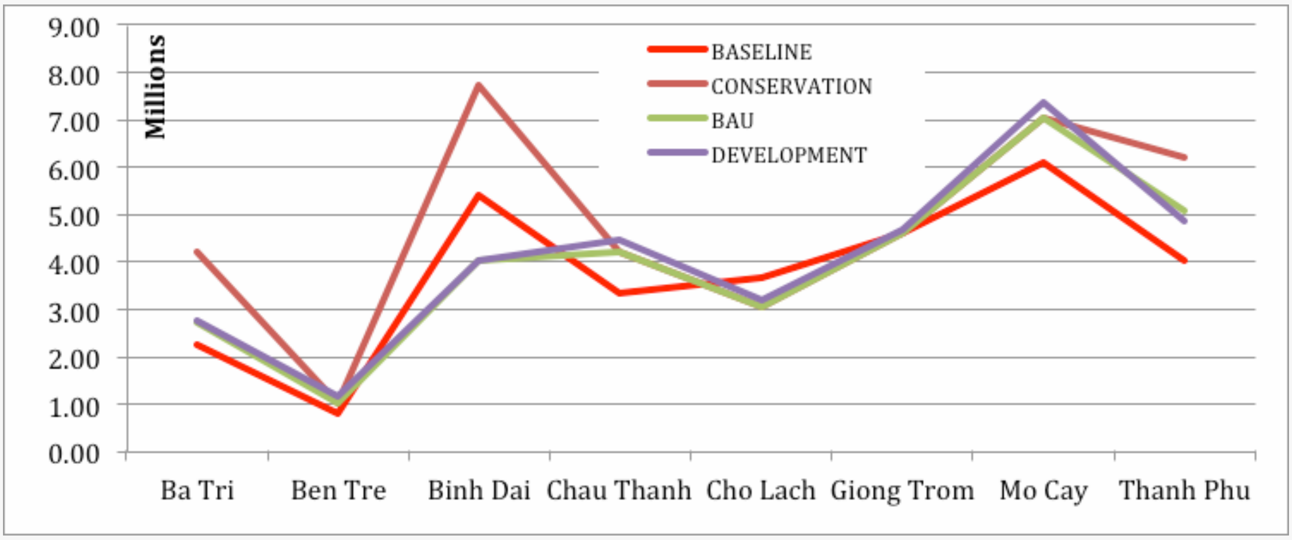




Map 13. Carbon Storage and Sequestration under Conservation Scenario in 2020

Figure 8. Comparison Carbon Storage in Future 2020 with Current Carbon Storage by District





Carbon storage in the conservation scenario is much higher than other scenarios throughout the province. In other scenarios, the carbon storage is also slightly increased in most of the province, except Cho Lach district due to the increased build up areas for industry and settlement; which means the decreased area of fruit garden.

4.9.4. Conclusions

Models developed that predict various future scenarios—a scenario analysis—for the coastal districts in Ben Tre shows that hard structures are not necessarily the most effective measures in reducing vulnerability against coastal erosion and floods. Green infrastructures or EbA measures can work equally well. The scenarios developed and compared include a business as usual scenario (growth at the same rate); high-development scenario (growth at higher rate based on infrastructure development) and conservation scenario (with higher conservation that included plantation of mangroves and other vegetation). The results of the analysis were:

- The coastal vulnerability model showed about 27 percent lower vulnerability index under conservation scenario by 2020. The vulnerability index is a qualitative estimate gained by calculating the exposure of coastal communities to storm surges for each shoreline segments;

• The erosion protection model showed that wave heights in the coastal areas were reduced either at a higher percentage under the conservation scenario (57 percent); or at the same percentage (29 percent). It is also showed that with the different kind of habitats and sea dikes, the wave energies were also reduced by 92-95 percent (in conservation scenario) and 80-95 percent (in development scenario) when it reached the coastline. This indicates that green infrastructure such as mangroves and other vegetation can be as, if not more, effective than hard infrastructure to reduce wave heights. In addition, integrating soft and hard infrastructures (sea-dike behind the mangrove belt) will be more effective in reducing wave energies and coastal erosion;

• Results from the carbon sequestration model showed that if the mangrove cover is increased by 100 percent of the planned forestry areas (mangrove cover is 59 percent currently) as in the conservation scenario, the carbon sequestration is more than 24 percent of the total carbon storage in 2010, equivalent to 7,47 million tons in 10 years. If small mangrove areas are cleared for aquaculture and agriculture as the development scenario, the carbon sequestration is only three percent of the total carbon storage in 2010, equivalent to 1.47 million tons in 10 years.

5. DISCUSSION ON ADAPTATION MEASURES

5.1. Identifying Adaptation Measures

This chapter summarizes the analysis and assessment results from above sections. The long list of adaptation solutions builds upon (i) the current coping actions identified in Chapter 4 (i.e. what are the communities reactions to changes and their feasibility in the future); (ii) looking at future scenarios; what locations will likely be most vulnerable to climate and non-climate negative impacts; how changes in ecosystem services that support the natural health and community property and livelihoods will affect those property and livelihoods; and (iii) discussions with communities on suitable adaptation strategies to mitigate the negative projected impacts and also maintain the ecosystem functions.

Having a long list of suggested adaptation strategies, the next step is to evaluate which strategies are urgently prioritized to immediately reduce projected impacts and also to secure the future sustainability. Conducting a multi criteria analysis helps to come up with a short list of prioritized solutions. In this case study, conducting the cost-effectiveness analysis has been chosen for adaptation solution prioritization.

Table 14 and 15 show the proposed solutions to projected increase extreme weather events caused by climate change and negative impacts caused by development targets from three coastal districts.

Table 14. Recommendation for Future Adaptation Strategies to Projected Climate Related Risks in the Coastal Districts of Ben Tre Province

Hazards	Other proposed solutions
Storms	• Migrate people to shelters; • Immediate support after storms (food & medicine); • Upgrade sea dikes; • Construction of permanent houses (well-constructed houses); • Tanks for freshwater storage; • Timely information; • Increasing area of tree planting; • Invention, replication the kind of safety house.
Tide andsaline intrusion	• Proposed embankment to retain water (tides); • Support for plant and animal seedlings; • Review, build more sluice gates to prevent saline intrusion; • Store freshwater.
Drought	• Strengthen irrigation system; • Investment in pools, freshwater reserves; • Digging internal canals.
Tornado/cyclone	• Building permanent houses; • Support the after hazards reallocation.
Unseasonal rain	• Development of irrigation systems; • Drainage canals.
Disease	• Medicine.
Coastal erosion	• Tree planting; • Construction of embankments.

Source: WWF field data, 2013

Local communities consulted in this process also expressed their proposed adjustments for addressing an increasing amount of development in the areas studied. These adjustments represent social concerns for maintaining and improving living standards and livelihoods in the coastal area.

Table 15. Proposed Adjustments to Behavior and Process to Address increasing Development Pressures in Ben Tre Province (Source: WWF, field data 2013)

Activities	Proposed adjustments
Ba Lai Sluice-dam	• Freshwater treatments (Used Chloramine disinfection) • Intercropping freshwater vegetable plantation • Periodically drain discharge
Sea, and river dikes to prevent saline intrusion (National defend dikes) (1999; upgraded 2012)	
Land use change (spontaneous) from 2002 **Reduction of rice-to more aquaculture area**	• More technical assistance on sustainable aquaculture production • Reproduction financing support • Better management of the farms and breeds • Strengthening the role of agricultural management
Eco-tourism	• Up-scale the investment;provide more jobs
Other sluices (for agriculture)	• Exploiting the correct position
Sand exploitation	• Fair compensation for reallocation • Support for job change
Industrial construction	• Tree planting • Construction of embankments
Residential resettlement	• Fair compensation
Dredging canals	• Keep maintaining the canal dredging

Once the long list of adaptation measures was identified and the future scenarios of vulnerability were generated, there was a follow up discussion with communities and governments for a consolidated list of adaptation measures. This section is the reflection of holistic adaptation measures suggested by both local communities and government agencies that:

i. Addresses programmatic aspects of adaptation including planning, monitoring, etc., as opposed to focusing on individual hazards and pressures;

ii. Is cognizant of the future land-use scenarios and their impacts on vulnerability - for business as usual, added development and conservation;

iii. Underscores the development goal of Ben Tre and is not only limited to the three coastal districts.

Adapting to climate change, which combines the expected changes in socio-ecological systems, is a holistic process of actions and need to be iterative as the projected climate change impacts are still at high uncertainty.

The list below is an indicative list for further analysis and assessments that synthesizes the discussions with the key stakeholders in Ben Tre. These include hard, soft, and EbA strategies:

i. Adjustments of current land-use plans

- Reallocation/setback of construction planning of public works and coastal neighborhoods from high risk areas to climate change.

ii. Integrating climate change issues into provincial strategies and development planning including:

- The Action Program to Respond to Climate Change;
- The Biodiversity Conservation Planning;
- The Socio-Economic Development Plan of the province;
- Communication programs.

iii. Maintenance of dam-dike systems to mitigate coastal and river erosion, impacts of SLR, and controlling saline intrusion:

- Complete the Ba Lai sluice gate-dam to stop infiltration of salt water and preserve fresh water for farmland;
- Complete the Cau Sap irrigation system to preserve freshwater; reduce saline intrusion and improve irrigation system for agriculture production in Ba Tri and Giong Trom districts;
- Upgrade the dike system in Phu Long commune of Binh Dai district;
- In-stream dike and drainage system from Hoa Loi to My Hung commune of Thanh Phu district.

iv. Wise use and management of freshwater resources

- Analysis of hydrological systems in the province, mapping of surface water and groundwater;
- Protection and restoration of wetlands to maintain and protect freshwater resources;
- Collecting and storing rainwater;
- Coordinate with upstream areas to ensure fresh water for use and ecosystems downstream.

v. Conservation and restoration of natural habitats

- Management and protection of riparian vegetation, coastal;
- Plant more mangroves in the coastal areas;
- Restore natural hydrological regime in rivers;
- The establishment of the fisheries management (restoration of aquatic resources).

vi. Increased investment in biodiversity conservation

- Management and strict protection of existing protected areas;
- Propose and upgrade new protected areas;
- Strengthening capacity of conservation areas;
- Communication, increase awareness for local people.

vii. Climate resilient cultivation

a. Growing vegetables:
  - Planting windbreak trees, absorb vapor salt, prevent surges;
  - Rainwater harvesting, water-saving irrigation (drip irrigation);
  - Composting of organic waste.

b. Aquaculture farming:
  - Improved farming practices (pond preparation, seed, animal calendar, harvest care);
  - Forest restoration in coastal;
  - Poly culture (shrimp - crab - fish - oysters).

c. Rice farming:
  - Rotation shrimp - rice / fish - rice;
  - Research / tame the salt-tolerant rice varieties, drought;
  - Increase / improve connectivity to the river to collect water and sediment.

viii. Strengthening Early Warning System

- Build a network of monitoring stations and coastal forecasts;
- Leveraging existing radio systems;
- Send messages to mobile subscribers.

5.2. Prioritizing adaptation strategies - Cost effectiveness analysis (CEA)

In this study, the CEA was applied to assess the effectiveness of EbA in building the resilience of communities in three coastal districts of Ben Tre province to the impacts of climate change, particularly in contrast to hard or engineered solutions with the construction of sea dyke systems.

1. Hard or engineered solution: Construction and upgrade of sea dykes in Thanh Phu, Ba Tri, and Binh Đai district. The sea dike system will prevent flooding caused by tides, typhoons, and sea level rise in favor of local coastal communes;
2. EbA: adaptation measures include the reforestation and conservation of coastal forest ecosystem with a total forest area of 5.000 ha in year 2020 (of which the existing forest area in year 2012 is about 3.947 ha and area to be reforested is about 1.053 ha).

The CEA is conducted to assess the effectiveness of EbA options in both long-term and short-term periods in terms of increasing environmental protection function, return economic values, and beneficiaries' equity. Financial costs for CEA were collected from secondary sources from provincial level government offices.

Specific objectives are:

1. Valuating economic values of major ecosystem services which are related to the EbA options in Ben Tre province;
2. Estimating costs for implementing recommended EbA options on the ground; and
3. Assessing the effectiveness of EbA options in both long-term and short-term periods in terms of increasing environmental protection function and return to economic values.

5.2.1. Financial Cost effectiveness analysis

Sea Dike in Thanh Phu District

The sea dike planned for Thanh Phu district is about 52.4 km length with 16 sewers. It is designed to prevent flooding caused by tides, typhoons, and sea level rise. The total planned investment for this sea dike system is US$144,66 million, with a construction period of six years. This investment is allocated with US$30,116,802 for the 1st and 2nd years, about US$55,134,742 for the 3rd and 4th years and about US$16,045,091 for the 5th and 6th years (Ben Tre DARD 2010). Operating cost begins in the third year of dike construction, which includes the cost for maintenance and miscellaneous costs (Table 16). The sea dike will help protect 37,370 hectares of land from flooding and invasive salt water.

Table 16. Operating Cost of the Sea Dike System in Thanh Phu District

Year	3	4	5	6	7	8	9	10	11-30
Expense (USD)	211,227	316,840	422,454	528,067	633,681	739,294	844,907	950,521	1,056,134

Source: Ben Tre DARD 2010.

Sea Dike in Ba Tri District

The sea dike in Ba Tri district is 31 km long. The dike investment in the first period has an investment cost of 237.181 billion VND (financing sources: WB: 159.773 billion VND; funding from provincial and national fund: 77.408 bill VND). Construction in the first period was completed in December 2012. Operating cost is about 0.5 billion VND/year. The sea dike will help protect 10,728 hectares of land from flooding and invasive salt water.

Sea Dike in Binh Dai District

The sea dike system in Binh Dai district is 47 km in length. The construction in the first period was the completed sea dike in 2003. The dike was approved for investment in the second phase (upgrading) with an investment cost for the period from 2011-2020 of 2,259 billion VND (Investment cost from 2011-2012: 576 billion VND; from 2013-2016: 636 billion VND; from 2017-2020: 1047 billion VND). Operating cost begins is about 0.5 billion VND/year. The sea dike will help protect 4,905 hectares of land.

5.2.2. Estimation of Economic Value of Ecosystems Services

Value of wood and firewood

The value of wood and firewood from mangrove forests was estimated by multiplying the mean annual increment (MAI) with the price of wood. The value of wood and firewood is about 10,50 million VND/ha/year, which was estimated based on MAI of 15 units/ha/year and average price of 700.000 VND/unit.

Value of fishes, crabs, shrimps, clam, blood cockle

The value of fishes, crabs, shrimps, and blood cockle harvested from the mangrove forest was estimated using data generated from group discussion with local by stakeholders and in-deep interview with local farmers involved in shrimp, crab, blood cockle farming and fisher men. This value was estimated by computing the total net value from harvesting of these products and then dividing it by the corresponding mangrove forest area. The estimated value of fishes, crabs, shrimps, and blood cockle harvested from the local mangrove forests is about 27,20 million VND/ha/year.

Recreation Value

Data from the survey of 80 visitors in Con Bung tourist site was used to estimate a simple linear travel cost function. The estimated individual travel cost function is:

$$Vi = 1.35 - 0.0012*TCi + 0.002*INi$$

Where Vi is number of visits made by individual i in a year, TCi is travel cost of individual I, and INi is the annual household's income of individual i.

The survey revealed that the average family income of the visitors is about 70 Mill VND/year and mean travel cost of about 350.000 VND/trip. The estimated consumer surplus is about 477.000 VND/visit. On the average, visitors rated 30 percent of their total satisfaction from the trip for the coastal forests landscape and 70 percent for the beach activities. The total number of visits was estimated based on group discussion with local stakeholders. The total number of visits to the tourist site (119.300 visits/year) was derived based on the estimation on visitor rate for weekend and holidays and for weekdays in the wet and dry season. The mean annual recreational value per hectare of forests is estimated as follow:

Recreational value per hectare of forests = {consumer surplus per visit * total number of visits per year * share (percent) of CS for forest}/ total forest area. Mean annual recreational value of the forest was estimated at 8.41 million VND/ha/year.

Water quality maintenance for supporting commercial shrimp farming

The value of mangrove forest in maintaining water quality for supporting the aquaculture farming is estimated using data collected from the survey of 45 aquaculture farms in Thanh Phong commune in Thanh Phu district. On average, the interviewed farmers would pay about 84.500 VND per year for the conservation and development of the mangrove forest for maintaining water quality for aquaculture farming. The value of 1 ha of mangrove forest in maintaining water quality for supporting the aquaculture farming is estimated as follows: Value per 1 ha of mangrove = (WTP per farm * total number of farms)/total forest area. The estimated value of mangrove forests in maintaining water quality for supporting the aquaculture is about 0.159 million VND/ha/year.

Non-Use Value (historical, cultural, biodiversity)

The historical, cultural, and biodiversity values are non-use values of the local mangrove forests that were also estimated using the contingent valuation method. Results from the CVM survey revealed that the average WTP for the conservation of the historical, cultural, and biodiversity values of the local mangrove forests is about 20 percent of the WTP of the farmers for the conservation and development of the mangrove forest for maintaining water quality for aquaculture farming. On a hectare basis, the historical, cultural, and biodiversity values of the local mangrove forests is about 0.032 million VND/ha/year.

Carbon sequestration

The carbon sequestration value of the forest was computed using benefit transfer method. In this study, results from a study on carbon sequestration conducted by Thoa (2012) in the same study site were used to compute the carbon sequestration value of the local mangrove forests. The estimated total amount of carbon per hectare at age class 3 is about 412.4 tons/ha (Thoa, 2012). Thus the estimated sequestration rates for afforestation/ reforestation, in tons of carbon per hectare per year, are about 18.3 tons/ha/year. With the price of US$5/ton and an exchange rate of 21.000 VND/USD, the value of carbon sequestration per 1 ha of mangrove forest is about 1.92 million VND/ha/year. The values of the ecosystem services of the coastal forest ecosystem are summarized in Table 17.

Table 17. Major economic values of the ecosystem services of one hectare mangrove forest.

Ecosystem products and services from mangrove forest	Economic value of ES (Mill VND/ha/year)
Value of wood and firewood	**10.500**
Value of fishes, crabs, shrimps, clam, blood cockle harvested from mangrove forests	**27.200**
Recreation value	**8.411**
Value of mangrove forests in maintaining water quality for supporting aquaculture farming	**0.159**
Non-use value (historical, cultural, biodiversity values)	**0.032**
Carbon sequestration value.	1.922
Total value*	48.224

** This total value is the value of all benefits from manger ecosystem to be included in the CEA but not the total economic value of one-hectare mangrove forest.*

5.2.3. Cost Effectiveness Analysis (CEA) of CC adaptation options

CEA of the short-term adaptation option (Low CC scenario)

For computing CEA, an discount rate of 10 percent was used in this study. With the low climate change risk scenario, the cost effectiveness ratios were computed for a short-term period of 10 years. Table 4 summarizes the financial and economic cost-effectiveness analysis of the short-term adaptation measures to climate change risk in three coastal districts, namely Thanh Phu, Ba Tri and Binh Dai district, and in Ben Tre province.

Results from the CEA showed very high financial cost ratios for all hard-adaptation measures with the construction of sea dykes in three coastal districts. On average, the cost for a person in the expected flooded area being protected with sea dyke systems in Ben Tre province from climate change risk is about 138.8 Mill VND/person. The cost is much lower the ecosystem based adaptation with coastal forest ecosystems which is about 1.7 mill VND/person.

Table 18. Cost effectiveness analysis for low climate change risk with short-term adaptation options (10 year horizon)

District	Adaptation options	Effectiveness measure (number of affecting residents protected)	Financial costs (mill VND)	Financial cost effectiveness ratio(mill VND / person)	Other economic net benefits/ costs (mill VND)	Total costs (mill VND)	Total economic cost effectiveness ratio(Mill VND / person)
Thanh Phu	Sea dyke	14,806	2,390.5	161.5		2,390.5	161.5
	EbA with mangroves	14,806	21.3	1.4	64.4	-43.1	-2.9
Ba Tri	Sea dyke	10,070	190.3	18.9		190.3	18.9
	EbA with mangroves	10,070	10.5	1.0	58.9	-48.4	-4.8
Binh Dai	Sea dyke	4,714	1,526.6	323.8		1,526.6	323.8
	EbA with mangroves	4,714	17.3	3.7	105.4	-88.1	-18.7
Ben Tre province	Sea dyke	29,590	4,107.3	138.8		4,107.3	138.8
	EbA with mangroves	29,590	49.1	1.7	228.7	-179.6	-6.1

High CC risk and Long-term CEA

For the high climate change risk scenario, the long-term adaptation measures with sea dyke system alone (hard solution) and a combined hard and soft solution with sea dyke systems and coastal forest ecosystems (EbA) were considered in the cost effectiveness analysis.

The cost for protecting a person from the negative impact of climate change risk by using the combined hard and soft adaptation options have a cost saving as compared to the hard adaptation option alone of about 10 percent, 125 percent, and 36 percent for Thanh Phu, Ba Tri, and Binh Dai district, respectively. For Ben Tre province, the combined option would have a cost saving of about 25 percent compared to the sea dyke solution alone. Combining the soft solution (coastal forest ecosystem) with the sea dyke system helps not only reduce the cost per unit of benefit but also increase the security of the dyke system.

Table 19. Cost effectiveness analysis for high climate change risk with long-term adaptation options (30 year horizon)

District	Adaptation options	Effectiveness measure (number of affecting residents protected)	Financial costs (mill VND)	Financial cost effectiveness ratio(mill VND / person)	Other economic net benefits/ costs (mill VND)	Total costs (mill VND)	Total economic cost effectiveness ratio(Mill VND / person)
Thanh Phu	**Sea dyke**	**15,011**	**2,469.8**	**164.5**		**2,469.8**	**164.5**
	Combined Sea dyke with mangroves	15,011	2,500.6	166.6	278.2	2,222.3	148.0
Ba Tri	Sea dyke	12,046	192.1	15.9		192.1	15.9
	Combined Sea dyke with mangroves	12,046	206.4	17.1	253.9	-47.5	-3.9
Binh Dai	Sea dyke	6,050	1,528.4	252.6		1,528.4	252.6
	Combined Sea dyke with mangroves	6,050	1,552.2	256.6	566.6	985.6	162.9
Ben Tre province	Sea dyke	33,107	4,190.2	126.6		4,190.2	126.6
	Combined Sea dyke with mangroves	33,107	4,259.2	128.6	1,098.7	3,160.5	95.5

Sensitivity analysis

A sensitivity analysis was conducted to analyze the impact of changing interest rates on the cost effectiveness of the short and long-term climate change adaptation options. The cost effectiveness ratios of the EbA and hard adaptation options were computed with different interest rates, ranging from 6 percent to 16 percent. The results of the sensitivity analysis conducted for the whole Ben Tre province is summarized in Table 20. The results showed that for all interest rate scenarios, the ecosystem based adaptation options have much lower cost effectiveness ratio than that of the hard adaptation option with sea dyke system. Compared to the hard adaptation option, the EbA has a cost saving of more than 100 percent for the short-term time horizon and more than 24 percent for the long-term time horizon.

5.2.4. Conclusions and Recommendations of CEA

Table 20. Cost effectiveness of short and long-term climate change adaptation options in Ben Tre province under different interest rates.

Adaptation options	Total economic cost effectiveness ratio under different discount rates (Mill VND/person)					
	6%	8%	10%	12%	14%	16%
Short-term (10 year horizon)						
1. Sea dyke	156	147	139	131	125	119
2. EbA (coastal forests)	(8)	(7)	(6)	(5)	(5)	(4)
Cost saving by EbA	105%	105%	104%	104%	104%	104%
Long-term (30 year horizon)						
1. Sea dyke	144	135	127	119	113	107
2. EbA (combined sea dykeand coastal forests)	109	102	95	89	84	79
Cost saving by EbA	24%	24%	25%	25%	26%	27%

Results from the CEA conducted for short-term and long-term adaptation options showed very high financial cost ratios for all hard-adaptation measures with the construction of sea dikes in three coastal districts. The EbA for the short-term adaptation option using coastal forest ecosystems alone and for the long-term adaptation option as a combined adaptation of hard solution (sea dikes system) and soft solution (coastal forest ecosystems) provide the lowest cost adaptation option for dealing with climate change risks. In addition to climate change adaptation, mangrove forests also provide many other goods along with ecosystem services that are crucial to the livelihoods of the local communities. EbA approaches requires an integrated management of the local coastal ecosystems so that they continue to provide these important services to local people and support them better adapt to the impacts of the climate change.

5.2.5. Limitations of the cost effectiveness analysis

Due to the lack of available data needed for the economic valuation and the CEA, there are limitations to this study:

- In this study, the effectiveness is a quantitative measure for flood protection. Social and environmental value is not reflected in the effectiveness measure;
- The value of ecosystem services did not include the value of mangrove forest for supporting near shore fisheries, value for coast erosion protection, and value for nutrient regulation and waste treatment;
- In the CEA of the sea dike system, the indirect benefits such as the benefit from protecting saline intrusion and value for transportation were also not included due to lack of data for computing these values.

6. FINDING CONCLUSIONS AND RECOMMENDATIONS FOR EBA INTEGRATION INTO POLICY DEVELOPMENT PROCESS

Participatory vulnerability assessment is the key to identify current climate and development pressures onto the communities and ecosystems. In Ben Tre province, the assessment results show that:

1. Improved extensive/intensive shrimp farming (black tiger prawn and white-legged shrimp) have a medium-high risk of impacts from development and climate change;
2. Clam (Meretrix lyrata) and blood cockle (Anadata granosa) farming is at medium–high risk of climate change and development hazards. An increase in maximum annual temperature, increased salinity, changes in upstream hydrology and sediment loads, and SLR inundation, will threaten the existence of the industry;
3. Estuary capture fisheries are at medium risk of climate change and development. There is an on going investment in captured fisheries. This includes the development of ports, wholesale markets, boat shelters and seafood canning facility and industry. This continued, unsustainable, investment and development has the potential to over stretch the fisheries' populations sand cause a collapse in the industry; and
4. Vegetable plantations (watermelon, Jicama and beans) and have a medium-high risk of climate change hazards. Watermelon crops are sensitive to an increase in rainfall. However, increased rainfall and temperature will allow other crops to flourish. A delayed wet season will also threaten the current agricultural crops and cropping cycle.

The methods and tools used during the field-testing have effectively analyzed both spatial and non-spatial data and information that has been collected from many different sources to generate high quality and visualized results that can be used to inform decision makers on trade-offs that they have to consider when making any decisions related to investments in climate change adaptation options. However, some new tools (e.g. GIS, environmental economics, etc.) are still complicated or difficult for local government officials or those who do not have background in these subjects.

EbA or any adaptation measures should be coupled with strategies to address "adaptation deficits" by tackling current non-climate related problems that exacerbate vulnerability. One of the major causes for the decline of mangrove forests in Ben Tre is shrimp farming. Similarly population growth and unsustainable land-use for development activities have served to degrade the ecosystems. For example, the construction of sluice dams to prevent salinity intrusion has interfered with ecological flow affecting estuaries and related livelihoods.

While hard engineering based solutions like sea-dykes are traditionally popular in coastal areas, EbA measures can play a significant role in ensuring sustainability of coastal habitats that help people.

The provincial government officials in DONRE, DARD and DPI are identified as the primary target users of the EbA operational framework. 2014 is the right time for implementing the EbA operational framework mainstream into provincial socio-economic development plans for the next planning cycle (2016-2020) and a vision to 2030. The provincial government of Ben Tre was the target user for the draft EbA operational framework while conducting field-testing activities in Ben Tre. As one of the two first piloting provinces of the NTP-RCC program, Ben Tre province has made much advancement in implementing climate change adaptation activities.

In the case of Ben Tre, the province has already produced a Provincial Climate change Action Plan and has conducted many studies and reports on climate change impact assessments. These include climate change impact assessments to the coastal communities and protected areas in 2011 and climate change impact assessment on tourism in Ben Tre province. However, the majority of adaptation solutions are hard/engineering options, which amount to about 90 percent of total investment for adaptation.

Among government agencies, DONRE is assessed as the most relevant in mandate and responsibility for implementation the EbA framework. Currently, DONRE is the focal point of the NTP-RCC program at the provincial level or acting as provincial standing NTP-RCC office. The mandate of this department is to develop, coordinate, and implement the provincial climate change action plan. It is recommended that that:

- The EbA operational framework should be integrated into the next climate change action plan of Ben Tre province;
- The EbA framework should be institutionalized by MONRE and passed to DONRE in different provinces to use a a tool for vulnerability assessment and adaptation planning for climate change action plan at local level;
- DONRE is also responsible for biodiversity conservation plan (BCP) development, where EbA framework can be scaled up and used to strengthen climate change conservation;
- EbA framework should be integrated with the land use development plan, which is also under DONRE;

The provincial SEDP is another suitable policy for EbA framework integration. This policy guides directions for social and economic development. This policy is under the Department of planning and investment (DPI). It is recommended that: EbA framework should be integrated together with the concept of EbA as a part mainstreaming climate change.

Another target user of the EbA framework is the Department of Agriculture and Rural Development (DARD). It is recommended that:

EbA framework is used as a tool to assess adaptation options in:

a. Agriculture sector development plans: There is a national climate change action plan for the agriculture sector at the moment and some provinces are in the process of developing provincial level action plan. Ben Tre province, where the EbA framework was piloted is interested in using the EbA framework to develop the climate change action plan for the agriculture sector of Ben Tre province. It is strongly recommended that the external support from the national level and also technical and financial support from NGOs, institutes, and donors work together with the province fully implement the EbA framework;

b. Forestry development plans;

c. Irrigation development plans; and

d. Aquaculture and fishery aquaculture and fishery development plans.

This EbA operational framework is an important technical guidance for the province at this time, especially the officials of the environment sub-department under DONRE and also the agriculture department, who have already built their capacities by adaptive learning. In order to use and follow this guideline, however, the EbA framework needs to be institutionalized as an official guideline. Additionally, the implementing agencies also expect to receive more technical support during the implementation of the framework for a specific sector.

In addition to the provincial plans, the mainstreaming of EbA is also necessary at the national level. At the national level following agencies are identified for mainstreaming EbA:

- The national focal points working on climate change action plan development and coordination: the National Target Program to Response to Climate Change (NTP-RCC) and the Supporting Program to

Respond to Climate Chanage (SP-RCC);

- Planners and decision makers at central and local government levels, who are developing and approving socio-economic development plan (MPI, DPI), land-use plan (MONRE, DONRE), and sectoral plans (e.g. MARD/DARD, MOT/DOT);

- The technical government and non-government institutions and organizations working in technical support for policy planning and climate change adaptation and mitigation in Viet Nam.

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