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ĐẠI HỌC CẦN THƠ

SỞ NÔNG NGHIỆP VÀ PHÁT TRIỂN NÔNG THÔN TỈNH BẾN TRE

Rapid Integrated & Ecosystem-Based Assessment of Climate Change Vulnerability & Adaptation for Ben Tre Province, Vietnam

Đánh giá nhanh tổng hợp tính tổn thương và khả năng thích ứng với biến đổi khí hậu tại ba huyện ven biển, tỉnh Bến Tre

2012

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Cover image	Saline intrusion and erosion cause serious damages in the coastal areas of Ben Tre province (Photo: Le Anh Tuan, 2011)

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This report was conducted as a joint effort of Department of Agriculture and Rural Development (DARD) of Ben Tre province, DRAGON institute of Can Tho University, and WWF-Vietnam. The ongoing involvement and support of DARD has made the wider project, of which this report is a part, a success.

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We also would like to thank Tristan Skinner for his great work editing the report in English as well as for his many valuable technical contributions.

During the field tests in Ben Tre province, invaluable contributions were made by other partner organizations, and community members in Thua Duc commune, Binh Dai district; An Thuy commune, Ba Tri district; and Thanh Phu Natural Reserve, Thanh Phu district, all on the coast in Ben Tre province. These contributors are too numerous to mention by name, but we are hopeful that this final product reflects their views and meets their expectations.

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ABBRIVIATIONS

CCAP	:	Climate Change Action Plan (provincial)
CDM	:	Clean Development Mechanism
CTU	:	Can Tho University
DARD	:	Department of Agriculture and Rural Development
Danida	:	Danish International Development Agency
DONRE	:	Department of Natural Resources and Environment (provincial)
DRAGON	:	Delta Research And Global Observation Network
EBA	:	Ecosystem Based Adaptation
EIA-3D	:	Three-dimensional (3D) model based on rectangular grid representation, developed by Environmental Impact Assessment Centre of Finland Ltd (EIA Ltd.)
GoV	:	Government of the Socialist Republic of Vietnam
IPCC	:	Intergovernment Panel on Climate Change
ICZM	:	Integrated Coastal Zone Management
MARD	:	Ministry of Agriculture and Rural Development
MONRE	:	Ministry of Natural Resources and Environment
NTP	:	National Target Program
NTP-RCC	:	National Target Program to Respond to Climate Change
PPC	:	Provincial People's Committee
RIVAA	:	Rapid Integrated Vulnerability and Adaptation Assessment
SEDP	:	Social-Economic Development Plan

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EXECUTIVE SUMMARY

The Mekong Delta, including the Ben Tre province, has been identified as one of the most sensitive and exposed regions of the world to sea level rise (SLR) and seawater intrusion (IPCC 2001, IPCC 2007). SLR of 1.0 m is projected to occur by 2100, which would inundate more than 38% of the Mekong Delta. It is estimated that by 2050, as many as one million people will be at risk of being displaced from the Mekong delta (MONRE 2009; IMHEN 2010).

WWF has undertaken a project to strengthen the resilience of Ben Tre province to climate change through ecosystem-based adaptation. This rapid integrated vulnerability and adaptation assessment (RIVAA) is a first step toward that end. Its specific objectives are to: i) assess the climate change vulnerability of ecosystems, ecosystem-dependent communities and development-related activities in three Ben Tre communes; ii) develop a set of prioritized integrated adaptation strategies at the ecosystem and community levels, that draw on ecological, social and institutional linkages; and iii) identify potential adaptation actions to recommend for integration into both the provincial Climate Change Action Plans and the Socio-Economic Development Plan of Ben Tre province.

Ben Tre is a coastal province in the Mekong Delta covering 2,287 km^2 and has a total population of 1.2 million, with a density of 532 ppl/km^2 (BTSO, 2010). People in Ben Tre Province depend heavily on the services of natural ecosystems for their income and livelihoods. Adaptation measures to increase the resistance of ecosystems and thus the human ability to adapt to climate change will play an important role in Ben Tre province and the Mekong Delta. Ecosystem-based Adaptation (EbA) is directly related to the management, protection and restoration of ecosystems to enhance human resistance to the hazards of climate change.

Summarised below are the method and results from the RIVAA to climate change and development of Thua Duc commune, Binh Dai district; An Thuy commune, Ba Tri district; and Thanh Phu Natural Reserve, Thanh Phu district, all on the coast in Ben Tre province, see figure 1.1.

Approach: In this study, 'ecosystem-based approach to climate change adaptation' is understood as promoting the conservation and restoration of ecological processes and habitats that build both ecosystem and community resilience to climate changes by maintaining ecosystem services that protect and support livelihoods and infrastructure. In this report, 'ecosystem-dependent activities' refers to community activities that depend on ecosystems and the services they provide. This study assesses the vulnerability of ecosystems and local livelihoods to the combined risks of climate change and unsustainable development. This study includes the following elements:

Data collection (Chapters 3 & 4):

- **Bottom-up** climate and non-climate hazard assessments of key ecosystems and their livelihood-dependent activities. Workshops, meetings and 71 interviews were conducted in the three communes to: i) identify key ecosystems and their environmental and socio-economic services; ii) discuss and rate the dependence of communities' livelihoods on these ecosystems; and iii) identify the current climate and non-climate pressures on the ecosystems and their ecosystem-dependent livelihood activities.

- **Top-down** assessment of development targets and climate change projections. A literature review was conducted to review and assess: i) the current institutional and policy arrangements for climate change adaptation; and ii) projected climate trends for Ben Tre province and the key potential development targets at three selected communes in the province.

Vulnerability assessment (Chapter 5):

- **Risk Assessment:** synthesis of the bottom-up and top-down assessments. This combined the potential climate and development related hazards with the hazard assessment of the ecosystems and their livelihood-dependent services.

- **Adaptive capacity assessment:** Adaptive capacity was assessed by looking at three variables: i) a rapid ecological adaptive capacity assessment; ii) the local communities' current coping mechanisms and how they're positioned to continue to adapt to climate change; and ii) institutional adaptive capacity – the current strengths and weaknesses of provincial and district government institutions to adapt to climate change
- **Vulnerability assessment:** based on an analysis of the above listed risk assessment and the adaptive capacity assessment.

Adaptation options (Chapter 6):

- **Adaptation options**: outlines and describes key adaptation strategies for ecosystems and communities. In addition, the potential adaptation linkages to the provincial Climate Change Action Plans and Socio-Economic Development Plan of Ben Tre province are provided.

Bottom-up/Top-Down Assessment Results: The bottom-up assessment identified the following ecosystems and their dependent livelihood activities in the study area:

i) **coastal mangroves** and the associated intensive/extensive **shrimp farming** (black tiger prawn and white-legged shrimp);

ii) **intertidal alluvial mud flats and sandbars** and the **blood cockles** (*Anadata granosa*) and **farming of clams** (*Meretrix lyrata*) which they support,

iii) **open water estuaries** support an extensive and important **capture fisheries** industry;

iv) **sand dunes** and the **vegetable plantations** that the dune ecosystem supports.

This study reviewed several climate change assessments of the Mekong delta. The impacts of **climate-related hazards** on livelihoods in Ben Tre local communities can be summarized as:

- erratic rainfall, including unseasonal rainfall during the dry season;
- increased intensity of rainfall events during the wet season;
- prolonged hot weather (air temperature consistently above 35°C);
- increased inundation and saline intrusion due to sea level rise and increased flooding from the up-stream catchment;
- increased coastal erosion due to increased storm and wave activity, monsoon winds and sea level rise; and
- increased number and intensity of tropical storms.

The above climate change hazards vary among the three communities, depending on the characteristics of each ecosystem and their respective livelihood activities. In addition to climate-related hazards, ecosystems and communities are also facing pressures from un-sustainable development and economic activity including:

- expanding and increasing intensity of agriculture and aquaculture practices, particularly the expansion of prawn and shrimp farming, and the increasing use of fertilizers and pesticides;
- over-exploitation of fisheries and forests;
- changes in hydrology and sedimentation due to the construction of the Ba Lai sluice-dam;
- water quality pollution from sewerage and industrial waste;
- sand and gravel extraction; and
- urban encroachment.

Risk Rating Results: The bottom-up and top-down 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 below.

Coastal mangroves: 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 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 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 flats and sandbars: the mudflat 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 estuaries: the 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 dunes: the 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 - more detail is presented in Chapter 3. A delayed wet season will also threaten the current agricultural crops and production cycle.

Adaptive Capacity Results: 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. The table below summarises the results from the adaptive capacity assessment.

***Vulnerability Assessment Results*:** The vulnerability assessment was undertaken by combining the climate change and development hazard assessment with the ecosystem and dependent livelihood activity risk rating and adaptive capacity assessment (see summary in Table 5-5). The vulnerability to climate change and development for the four ecosystems can be summarized as follows: i) **estuarine areas** are at **high** vulnerability; ii) **mangroves** are at **moderate to high** vulnerability; iii) **mudflats** and **sandbars** are at **moderate** vulnerability; and iv) **sand dunes** are at **low to moderate** vulnerability level.

***Adaptation Options*:** Adaptation options have been developed through community consultation and using the results of the vulnerability assessment (presented in this report). The recommended adaptation actions for Ben Tre are:

i) **climate-smartmangrove restoration**;
ii) **revised zoning and land-use planning** in coastal areas;
iii) improved **freshwater resource management**;

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

iv) **climate change policy mainstreaming**; and
v) **monitoring, evaluation and improving.**

Mangrove restoration was initially implemented in 1998 in Ba Tri and Binh Dai districts and should be closely monitored and expanded in the Thanh Phu Natural Reserve. Mangroves have a vital role to play in reducing the impacts of climate change and extreme weather events, they also have huge potential to store carbon in their root systems. However, mangroves are at a high risk of impact by climate change therefore it is important that any mangrove restoration should be 'climate-smart'.

Revised zoning and land-use planning in coastal areas is a critical step in climate change adaptation. Shrimp farms, roads and other infrastructure are planned for exposed areas of the coastline. Avoiding exposure is an easy and cost-effective form of climate change adaptation. "Climate-smart" land-use planning is critical and may require the reallocation of some assets and infrastructure such as schools, hospitals and community houses.

Freshwater resources (both ground and surface) for communities and ecosystems are scarce in the coastal communes of Ben Tre. **Freshwater resource management** must be improved.This could include: i) analysis of the provincial hydrology including mapping of surface and groundwater; ii) protection and/or restoration of riparian wetlands that protect freshwater resources; iii) coordination with upstream uses to secure freshwater for downstream uses and ecosystems; and iv) development of a conservation strategy for natural sources.

While "hard" engineering solutions have typically been favoured, the communities and the report recommend 'climate-smart' **ecosystem restoration and conservation**, and **institutional actions**. These adaptation recommendations were designed to be implemented and **mainstreamed** through short- and long-term planning processes such as the annual Climate Change Action Plan (CCAP) of Ben Tre province in the 2011 to 2015 period, following the National Target Program to Respond to Climate Change (NTP-RCC). It is recommended that CCAP's and NTP-RCC's should be mainstreamed into the national and provincial Social and Economic Development Plan's (SEDP).

Monitoring of adaptation planning and implementation is recommended to ensure mal-adaptation is avoided, lessons are learned, and successes maximized and replicated. It will be important to **monitor the healthy ecosystem for climate change impacts**. For example, Thanh Phu district has outstanding and intact ecosystems and it will be important to understand: what is surviving? and what are we losing due to extreme events?

These adaptation recommendations are at a broader district and provincial level. A further study is required to develop an 'adaptation action plan' for each coastal district that would use this RIVAA as a starting point.

> "The current large-scale of clam death in coastal areas of Ben Tre province"

1 INTRODUCTION

The Mekong Delta, including Ben Tre province, has been identified as one of the most sensitive and exposed regions of the world to climate change Hazards such as sea level rise (SLR) and seawater intrusion (IPCC 2001, IPCC 2007). SLR of 1.0 m is predicted by 2100, which would inundate approximately one-third of the Mekong Delta. It is estimated that by 2050, as many as one million people will be at risk of being displaced (MONRE 2009; IMHEN 2010). It is therefore the overall purpose of this assessment and report to strengthen the resilience of Ben Tre province to the hazards of climate change through ecosystem-based adaptation.

This assessment and report have been completed by the Department of Agriculture and Rural Development (DARD) and the Department of Natural Resources and Environment (DoNRE) of Ben Tre province, in partnership with the DRAGON institute of Can Tho University (CTU) and WWF-Vietnam. Danida, through the Capacity Building and Sustainable Production Programme and Coca-Cola through the Ecosystem-based Climate Change Adaptation in Ben Tre Province, Vietnam, funded this study.

1.1 Study objectives

The objectives of this Rapid Integrated Vulnerability and Adaptation Assessment (RIVAA) is to:

- Assess the vulnerability of ecosystems and ecosystem-dependent communities within three project areas to climate change and development-related hazards;
- Develop a set of prioritized integrated adaptation strategies at ecosystem and community scales that draw on ecological, social and institutional linkages; and
- Identify potential linkages to the provincial Climate Change Action Plans and Socio-Economic Development Plan of Ben Tre province.

A key objective is to inform and recommend to Ben Tre province the priority recommended ecosystem based adaptation options from this RIVAA to integrate into the Ben Tre province Climate Change Action Plan (CCAP). Therefore the target audience of this report is primarily DARD and DONRE and key stakeholders engaged in management and protection of biodiversity and natural resources in the province; this includes other NGOs working on climate change adaptation including IUCN and Oxfam. In addition, this RIVAA aims to highlight possible adaptation options for various scales: household, community, commune, and ecosystem scale, allowing for holistic and integrated adaptation options.

1.2 Study approach

This RIVAA was a **rapid** assessment (conducted in a short time frame) and was based on the ecosystem and water resource focused vulnerability assessment methodology 'Flowing Forward' developed by WWF (Le Quesne et al 2012). The '**Flowing Forward**' methodology is a risk-based approach to assessing the vulnerability of ecosystems and local livelihoods to the combined risks of climate change and development. This RIVAA methodology is presented in more detail in section 2 and summarized in.

This study applies a **risk-based**, **participatory**, and **qualitative** combined with **quantitative** approach inspired by the 'Flowing Forward' methodology which has, however, been modified significantly to fit with the specific context of the Ben Tre project and province.

In this RIVAA, an **ecosystems-based approach** is understood as promoting the conservation and restoration of ecological processes and habitats that build resilience to climate changes by maintaining ecosystem services that protect and support livelihoods and infrastructure. The term **integrated**

assessment refers to a cohesive analysis of both natural and social systems, as well as climate change and development hazards.

Study Limitation

The assessment didn't have the capacity to identify the levels and margins of exposure and sensitivity of the livelihoods and ecosystems to climate change and therefore could not develop prioritized adaptation options. As a consequence the adaptation options could not be down scaled or specified for a specific ecosystem or group of communities. And it was impossible to identify prioritized options. Instead broader district and provincial options and key recommendations are presented and discussed in chapter 6. Further study is required to develop an 'adaptation action plan' for each coastal district that would use this RIVAA as a starting point.

The rapid methodology did not allow for suitable investigation of the *ecological adaptive* capacity of Ben Tre coastal provinces. Analysis on institutional setting was used to derive an 'ecological adaptive capacity rating', however, it is important to acknowledge additional resources and time is required to increase the level of confidence in this rating.

The limited resources meant that the climate change trends, 'top-down' assessment was limited to a current literature review and experiences reported by the communities – no primary data or modelling were completed.The following climate change threats have had limited analysis:

- There is no in depth sea level rise assessment: a GIS analysis of the province is required to see what, where and by how much each ecosystem and livelihood activity (landcover/use) will be inundated.
- River flooding from increased surface water is an important hazard due to the increased precipitation in the upper catchment of the Mekong basin. However this was not considered in this assessment. There is also potential that the Mekong's upstream flow will be impacted by increased intensity and frequency of storms and dam operations.

1.3 Study site description

This RIVAA focuses on three coastal communes in three districts of Ben Tre province: Thua Duc commune (Binh Dai district), An Thuy commune (Ba Tri district) and Thanh Phu Natural Reserve (Thanh Phu district), Figure 1-1. The 'triangle' shaped Ben Tre province is located within the Mekong delta and has 65 km of coastline with 4 rivers (Dai, Ba Lai, Ham Luong and Co Chien) running into the East Sea from the northeast to southwest. In the north, Ben Tre province shares a border with Tien Giang province (the Tien river separating the two provinces; Vinh Long province to the west and southwest and Tra Vinh to the south, the Co Chien river separates Ben Tre and Tra Vinh).

The coastline consists of alluvial and sandy intertidal zone with mangroves, mudflats and open water estuaries. The mangroves consist mainly of *Rhizophora sp.*, which inhabit many of the province's estuaries and coastal areas. The intertidal zones are flanked by sand dunes. There are some woodlands and stretches of dense mangroves along the coastline. Ben Tre has many islets and islands resulting from upstream alluvial deposition. Chapter 3 of this report describes the ecology of the three focus communes in more detail.

Marine, estuarine & freshwater water bodies dominate the landscape in Ben Tre. Ben Tre has 65 km of coastline, a total inland water surface area 23,000 km^2 and more than 2367 km of river and waterways – including 4 of the 8 deltaic Mekong branches (My Tho River, Ba Lai River, Ham Luong River, Co Chien River) and 103 small streams or canals (both natural and man-made). Due to the high level of agriculture, industry and transport activities on the estuary, water quality has declined greatly and varies over the year.

Hydrology: The total discharge of the Tien River in the wet season (the major Mekong river channel) is up to 80% of the annual flow. The following text describes the key riverine estuaries and their hydrology:

- **My Tho river:** My Tho River flows down from the north of Binh Dai district, the river widens from 50 – 60 m in Binh Dai up to 1km at Dai river mouth. The depth of the river is between 3 and 4 m and it is 83 km in length, traversing the length of the province. During the wet season, the average river flow is approximately 6,480 m^3/s, whilst in the dry season it is approximately 1,598 m^3/s.
- **Ba Lai river**: Ba Lai River flows 71 kilometres from the west to the east, arriving at Cua Ba Lai.

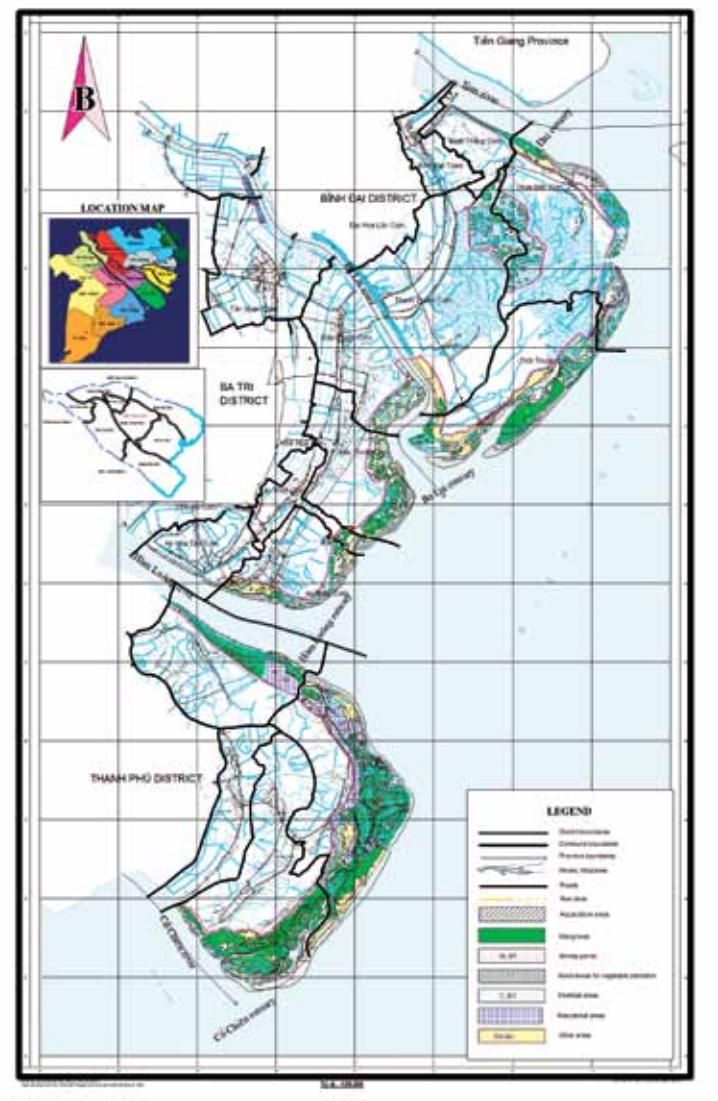


Figure 1-1: Map of Ben Tre province and study areas: Thua Duc commune (Binh Dai district), An Thuy commune (Ba Tri district) and Thanh Phu natural reserve (Thanh Phu district).

Ba Lai River is 3 - 4 metres deep, 25 – 50 metres wide and it opens into the sea at the width of 1km. The flow volume is 50 – 60 m^3/s in the dry season and five times that in the rainy season. Ba Lai Dam built in 2003 has changed the ecosystem in Ba Tri from forests to farming as the natural flow has been controlled artificially. The Ba Lai area, flooded seashore land, is quite famous for a dense population of its Vam Ho birds.

- **Ham Luong river**: Ham Luong River, 72 kilometres long, flows through the center of Ben Tre Province. Ham Luong River begins in Chau Thanh and opens into the sea. It is the natural border between Ba Tri District and Thanh Phu District, The flow volume is 800 – 850 m^3/s in the dry season and 3,300 – 3,400 m^3/s in the rainy season.

- **Co Chien river**: Co Chien, in the southeast, is the largest river mouth in Ben Tre Province. It is formed by Co Chien River, which is 82 kilometres long and opens into the sea; Co Chien River is the natural border between Ben Tre Province and Tra Vinh Province. The flow volume at Co Chien is 700 -750 m^3/s in the dry season and 2,800 - 2,900 m^3/s in the rainy season. (BRPC website, 2012).

Topography: The topography of the three coastal districts is very flat, with an average elevation of 1-2 meters above sea level (BTDARD, 2009). There are several sand dunes systems that reach a maximum of 5 metres above sea level. The coastal areas of Ben Tre can be divided into three main types of eco-elevations classes:

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

Salinity and tides: The boundaries of saline, brackish and freshwater areas change over time depending on the tide, season and upstream hydrology. Salinity levels within the river mouth fluctuate between 3-17%, especially in 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 2^{nd} – 3^{rd} and 17^{th}- 18^{th} of the lunar calendar) and two low-tide periods (the 7^{th}– 8^{th} and 21^{st} – 23^{rd} 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 deposition the Mekong delta can extend by 40-60m 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, with erosion and alluvial deposition due to the natural interaction of current flows.

Climate: 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%, with an average evaporation is 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% 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.

The wind direction during the wet season is from the West to Southwest with an average speed of 1.6 to 5.4 m/s. From October to February the wind changes to come from the Northeast and is reducing

its speed, to 1.6 – 3.3m/s. In February and March, the prevailing wind is from the North East to South East and from East to Ssouth East in April.

Population: The population of Ben Tre province in 2010 is 1,256,738 people (ppl); and a population density of 532 ppl/km^2 (ASP, 2010). The population of Ben Tre in 2010 decreased 0.3% from 2005 (1,273,184 ppl), while the average growth rate of Vietnam was 1.2%. The lower population growth 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. The Binh Dai district population increased by 0.4 % (190,635 ppl in 2005 and 132,315 ppl in 2010), which is thought to be due to the booming aquaculture industry. Between 2005-2010, however, employment within aquaculture in the whole Ben Tre province decreased from 47,570 persons in 2005 to 46,058 persons in 2010 (BTSO, 2011). 90.3% of Ben Tre's people live in rural areas, however, the urban population is slowly increasing with the move from agriculture to industry and commercial business. More people are moving into urban areas (SEDP report, 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 Châu Thành, Cho Lách, North Mo Cay and South Mo Cày. This assessment focuses on the 3 coastal districts (Binh Dai district, Ba Tri district, 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 already under pressure and are over exploited (Figure 1-2).

Land Use: Agriculture and aquaculture are the key livelihood activities of most of Ben Tre residents. The total 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 the three communes are saline soils (68-79 %) and sandy soils (12-21%),Table 1-1. Saline soils are suitable for salt and brackish aquaculture and are impossible for agriculture cultivation activities.

Figure 1-3 shows the land use in the Ben Tre province. It can be seen that the dominant land uses are: 1 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.

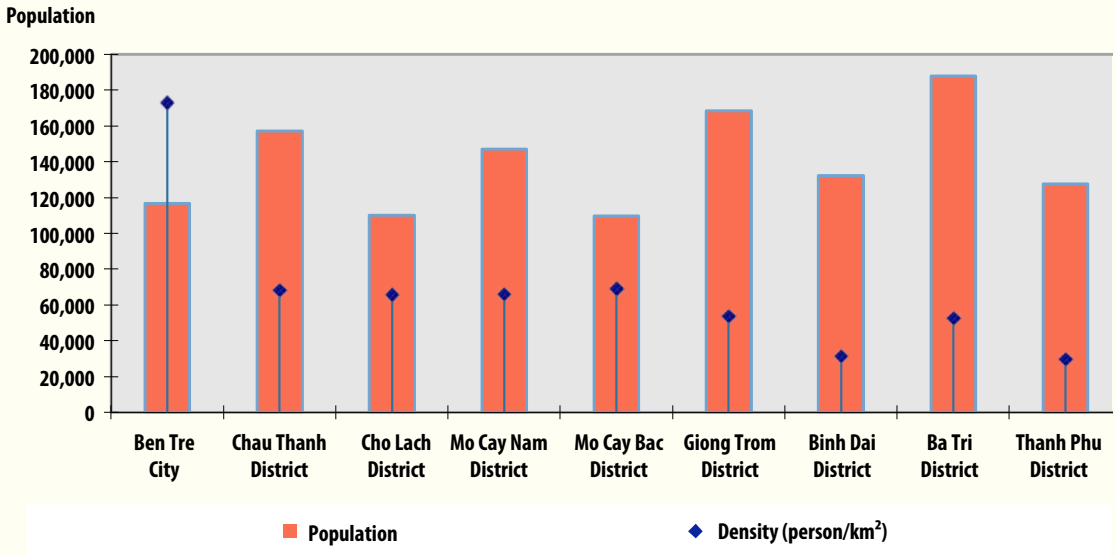


Figure 1-2: District population and population density of Ben Tre province (BTSO, 2011).

Table 1-1: Land characteristics of 03 coastal districts in Ben Tre Land and solid characteristics.

District Commune	Soil type							
	Alluvial soil		Alkaline soil		Saline soil		Sandy soil	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Binh Dai	2,460.48	9.75	2,129.44	8.44	17,328.57	68.69	3,310.53	13.12
Ba Tri	5,739.39	0.31	804.71	4.40	13,426.66	73.43	3,997.14	21.86
Thanh Phu	484.33	0.02	2,176.64	7.19	24,036.48	79.43	4,042.26	13.36
Characteristics	Located in fresh water area. Rice, crops, and some perennial plants (coconuts, fruit trees, etc.) Light to heavy physical composition Good irrigation Rich organic nutrients in the upper layer The deeper layer includes iron which can become alum, poisoning plants, if droughts are prolonged.		In low land area Rice (small area), water-lily, grasses, ect. Heavy physical composition Bad irrigation and drainage, low pH in water Rich in organic, accumulating poisoning element of alum, some area are heavily alkalized		In most of coastal communes Rice (1 harvest), forest (berembang, Rhizophora, water coconut…) Suitable for fresh and brackish aquaculture Physical composition is sand mixed with clay or sand mixed with clay and mud Bad irrigation and drainage and high salinity in water Rich in organic, accumulating poisoning element of alum, some areas are heavily alkalized.		In sand dunes, running parallel to coastline. Crops (vegetable, ..), fruit trees, long-term harvesting trees Abundant freshwater in lower layers Main soil element is sand (more than 80%), loose structure Good irrigation and drainage but poor nutrients due to poor ability to retain fertilizer. Intertidal zones also have soil that is sand or sand mixed with mud. These zones are changing frequently. Main plants are mangrove forest. These areas are good for farming clam, cockle.

(Source: Ben Tre Department of Science and Technology, 2004)

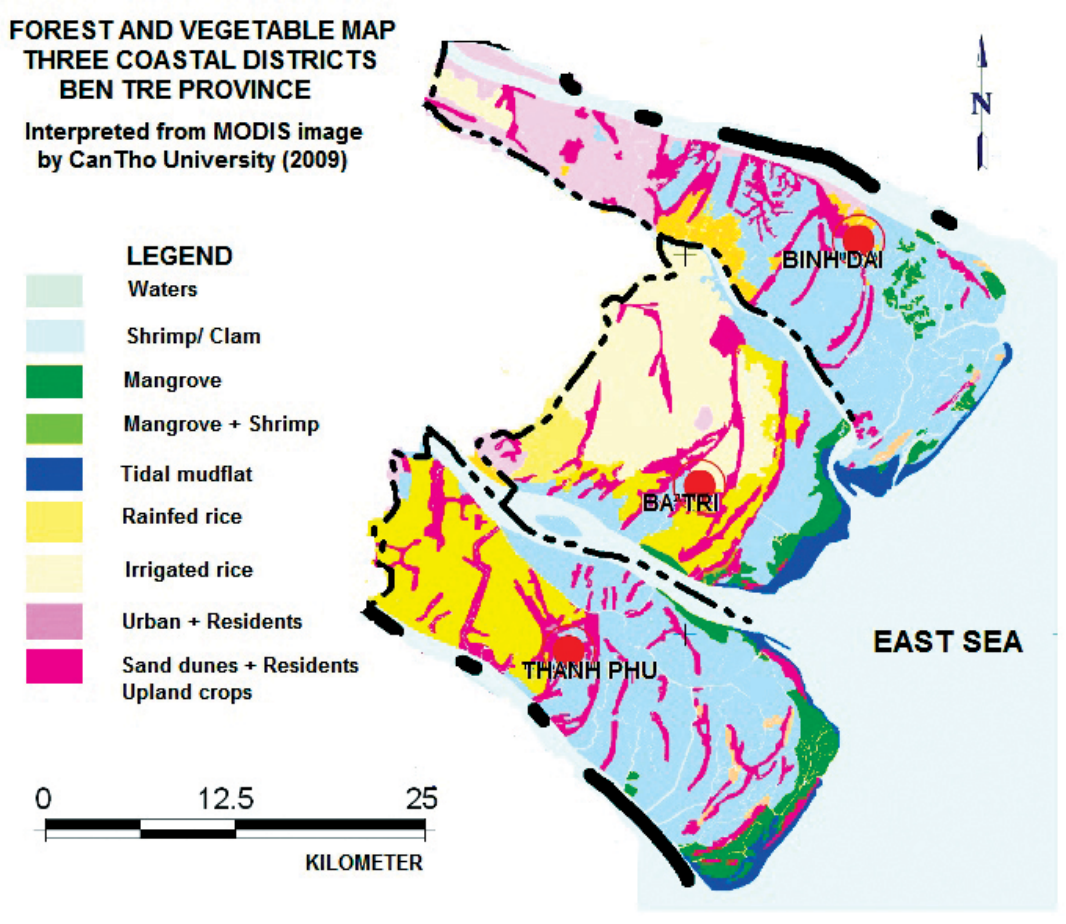


Figure 1-3:Landuse of Binh Dai district, Ba Tri district, Thanh Phu district, Ben Tre province

Table 1-2: Statistics of key agricultural and aquatic productions of 3 Ben Tre coastal districts in 2010.

No.	Production	Binh Dai 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

> Increased drought events during dry season has caused negative impacts on agriculture activities

2 METHODOLOGY

This RIVAA combines a risk-based, participatory and qualitative approach based on the 'Flowing Forward' methodology (Le Quesne et al. 2010[1]), which was considered suitable as it explicitly addresses ecosystems and the critical services they provide for both humans and biodiversity at the basin and sub-basin scales. For a country like Vietnam, and Ben Tre province in particular, where a high percentage of the population is directly dependent on such services for generating subsistence based local livelihoods, analysing these linkages in this assessment framework is critical.

This *rapid* assessment used current literature and provincial, district and village surveys as its primary sources of information. There were no resources or scope to undertake in depth primary climate change or hydrological analysis or modelling. The advantages of this type of assessment are that it can be completed in a short timeframe, engage the community and increase results uptake and can be easily duplicated. Using participatory method, however, has an element of risk, as the approach is broad in nature and highly subjective.

This study assesses the vulnerability of ecosystems and local livelihoods to the combined risks of climate change and development. This study includes the following elements which are summarised in the flow diagram, Figure 2-1:

1. **Top-down assessment of development targets & climate change projections:** a literature review was undertaken to review and 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 at three selected communes in the province.

2. **Bottom-up assessment of climate and non-climate pressures on key ecosystems & their livelihood-dependent activities:** workshops, meetings and 71 interviews[2] were undertaken in the three communes to: i) identify key ecosystems and their environmental and socio-economic services; ii) discuss and rate the dependence of communities' livelihoods on these ecosystems; and iii) identify the current climate and non-climate pressures on the ecosystems and their ecosystem-dependent livelihood activities.

3. **Risk Rating: Synthesis of the bottom-up and top-down assessments:** a combination of potential climate and development related impacts (top-down) with the hazard assessment of the ecosystems and their livelihood-dependent services (bottom-up).

4. **Assessment of the adaptive capacity of the communes:** an assessment of: i) the ecological ability to adapt to climate and development threats; i) the communities' adaptive capacity – local communities' current coping mechanisms and how they're positioned to continue to adapt to climate change; and iii) institutional adaptive capacity – the current strengths and weaknesses of provincial and district government institutions to adapt to climate change.

5. **Vulnerability assessment:** based on a comparison of the risk assessment and the institutional and commune adaptive capacity.

6. **Adaptation options:** outlines, describes and prioritises the key adaptation strategies at the ecosystem and community level. In addition, the potential adaptation linkages to the provincial Climate Change Action Plans and Socio-Economic Development Plan of Ben Tre province are provide.

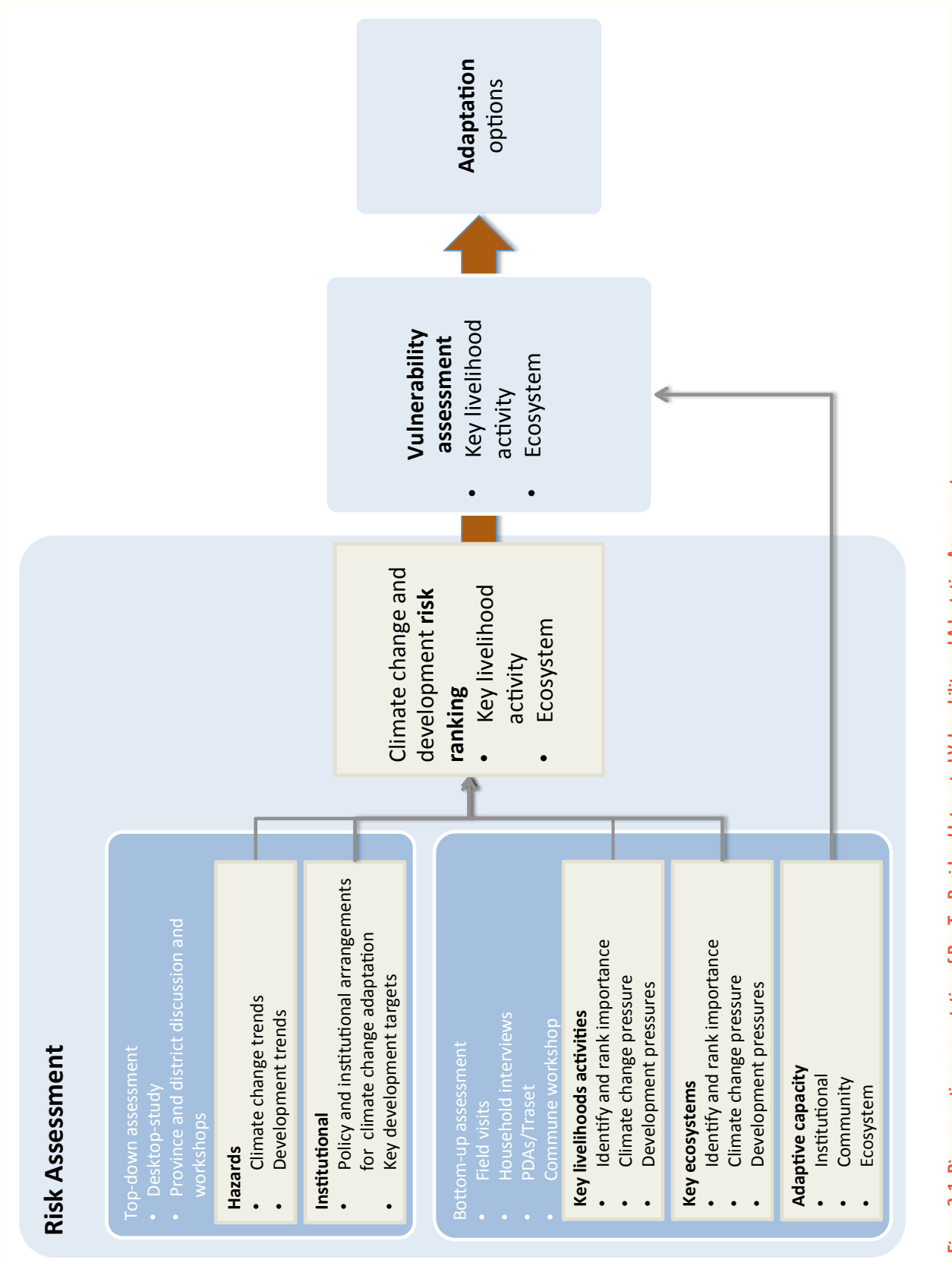


Figure 2-1: Diagrammatic representation of Ben Tre Rapid and Integrated Vulnerability and Adaptation Assessment.

> Sea level rise and saline intrusion have been impacted to the three coastal districts of Ben Tre province. These events are projected to increase in the future.

3 BOTTOM-UP ASSESSMENT

The Can Tho University and WWF-Vietnam assessment team conducted field visits to each commune Thua Duc (Binh Dai district); An Thuy (Ba Tri district); and Thanh Phu natural reserve (Thanh Phu district) to survey[3] individual households. Workshops were undertaken in January and May 2012. Field visits to three coastal communes were completed. In addition participatory rural appraisals (PRA) were undertaken in three coastal districts from 6th Sep. to 8th Sep. 201. The purpose of this bottom-up assessment was to:

i. Gather information on key ecosystems and their environmental and socio-economic services;

ii. Discuss and rate the dependence of communities' livelihoods on these ecosystems; and

iii. Identify the current climate and non-climate pressures on the ecosystems and their ecosystem-dependent livelihood activities.

Information on community adaptive capacity was also collected during the 'bottom-up' field visit assessments.

3.1 Key ecosystems and their dependent livelihood activities

The interviews of technical officers at district and provincial levels, combined with the field surveys and workshops identified four key ecosystems and their associated livelihood dependent activities. These four ecosystems are presented in detail in this section. The Ecosystems and their livelihood dependent activities are:

1. **Estuarine** ecosystem and **captured 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**.

This section describes the key local livelihood activities throughout the year and provides an overview of the timeframe of each activity through a 'season calendar'. The seasonal calendar demonstrates how weather events and climatic conditions affect livelihood activities. This section also highlights some recent changes to the seasonal calendar. The PRA tool was applied to get an understanding of the specific time schedule for each livelihood activity in three communes, and the impacts and pressures from these livelihoods on natural resources. Information was collected through surveys and interviews in three communes to produce the three seasonal calendars. Table 3-1, Table 3-2 & Table 3-3 below, outlines the seasonal calendar of the three coastal communes - these calendars will be important information when developing agriculture/aquaculture and livelihood adaption options.

The seasonal calendars for individual fishing and aquaculture activities are different (Table 3-1). The extensive shrimp farming calendar is different within each of the communes, but the yearly timeframe is similar. In Thanh Hai commune, 'crab intercropping farming' is undertaken during the period when shrimp is not farmed. Similar to black tiger shrimp farming in Thanh Hai commune, residents of An Thuy commune gain more income from farming White-leg Prawn, which use natural shrimp feed. Conversely, Blood cockle intercropping faming in shrimp ponds or just blood cockle farming are preferable in Thua Duc commune. This demonstrates that differences in livelihood activities in different communes depend on the environmental conditions in the three communes (seed, water quality, and soil).

Table 3-1: Seasonal calendar of Thua Duc commune, Binh Dai district. In general, the seasonal calendars of the three communes are similar; the differences are mostly due to the different soil conditions and ecological characteristics within each commune.

Events		J	F	M	A	M	J	J	A	S	O	N	D
Weather and Climate	Hot season												
	Raining season												
	Low pressure & Storms												
	Dry season												
	Spring tide												
Capture fisheries and aquaculture	Offshore fishing												
	Extensive black tiger shrimp famring												
	Oyster farming in shrimp farming												
	Oyster seed nursery												
	Intensive black tiger shrimp farming												
	Whiteleg shrimp farming												
	Clam farming												
Agriculture	Watermelon												
	White roots												
	Sugar cane												
	Peanut												

Table 3-2: Seasonal calendar of An Thuy commune, Ba Tri district

Events		J	F	M	A	M	J	J	A	S	O	N	D
Weather and Climate	Hot season												
	Raining season												
	Low pressure & Storms												
	Dry season												
	Spring tide												
Capture fisheries and aquaculture	Offshore fishing												
	Extensive black tiger shrimp famring												
	Crab intercropping in shrimp ponds												
	White Banana Prawn												
	Intensive black tiger shrimp farming												
	Whiteleg shrimp farming												
Agriculture	Watermelon												
	White roots												
	Cattle farm												

Table 3-3: Seasonal calendar of Thanh Hai commune, Thanh Phu district

	Events	J	F	M	A	M	J	J	A	S	O	N	D
Weather and Climate	Hot season												
	Raining season												
	Low pressure & Storms												
	Dry season												
	Spring tide												
Capture fisheries and aquaculture	Advanced extensive shrimp farming												
	Crab intercropping in shrimp ponds												
	Intensive black tiger shrimp farming												
	Whiteleg shrimp farming												
Agriculture	Watermelon												
	White roots												

3.1.1 Open water estuarine ecosystem | Capture fisheries

In Ben Tre province, there are four main estuaries: Dai, Ba Lai, Ham Luong, and Co Chien (Figure 3-1). These esturaies are defined by the mix and stratification of freshwater from the upstream Mekong river basin and the marine water driven by the semi-dual tide regime, wind, and current. The water here is a mixture of fresh water which comes from upper streams, brackish water and saline water.The open estuary systems are influenced by the East Sea tides, which are 2-3m and run semi-diurnally. The salt concentration in the estuaries ranges from 25 to 40‰ and is diluted by the Mekong river upstream flow - freshwater in Ben Tre can only be found in the groundwater aquifers.
Open water estuaries provide the following ecosystem services:

- Reducing salinity penetration;
- Reducing impacts of wave and wind erosion on the coastal areas;
- Providing river nutrition for coastal creatures;
- Providing breeding grounds and habitat for clam, cockle, birds, reptiles, crab and other aquatic species;
- Water traffic and transportation particularly with the new fishing port development;
- Providing shelter for ships and boats during storms; and
- Developing tourism and scientific research.

The estuaries in Ben Tre support a diversity of both freshwater and marine aquatic species. Open water estuarine habitats provide such benefits as food, refuge, passage for migration and shelter to a variety of fish, birds, molluscs and crustaceans as well as algae and many species of flora. Estuaries also provide a nursery for many forms of marine fish species at different stages of their lifecycle. The key estuarine species include Plankton of which the Silic algae (*Bacillariophyta* account for 65.1%), protozoa and invertebrates, including a variety of Molluscs.

The **open water estuaries** support highly important **capture fisheries** or wild fisheries. Capture fisheries exist primarily in the offshore, coasts and river estuaries. Capture fisheries are extremely important in the Ba Tri district. (CEE-CESC, 2010).The key estuarine capture fisheries technique used is the natural clam seedling cultivation, which is one of the key capture fisheries in the three coastal communes; this is primarily due to the high quantities of planktonic algae species that feed young clam. Other key offshore fisheries include herrings (*Clupeidae sp.*), anchovies (*Engraulida sp.e*) and *Carangidae sp.* Offshore fishing is also a year-round activity. In addition, the estuarine fisheries also include the puffer fish (*Tetraodontidae sp.*) and the seabass. These are year-round activities but are not key livelihood activities in the three coastal Ben Tre communes.

The fishing techniques used for the capture fisheries include: nets, boats, trawlers, wading, sediment filtering and fish traps. The annual captured fishing yield in the **coastal** areas of Ben Tre is approximately 19,000 – 24,000 tons and the annual captured fishing yield for **offshore** areas is between 1 mill – 1.2 mill tons. There is a potential to increase the captured fisheries by 540,000 – 630,000 tons/year (Phong N.T, 2012).

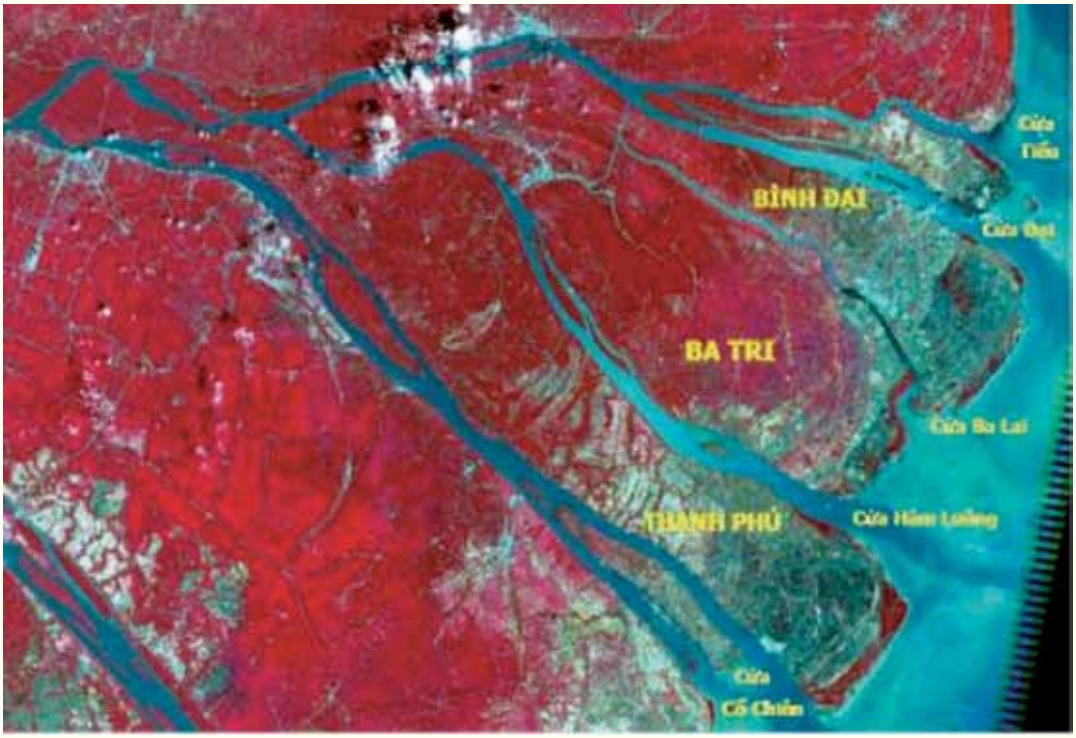


Figure 3-1: The satellite image above shows the open water estuaries and captured fisheries environments (dark blue) in Ben Tre Province (Source: CEE-CESC, 2010).

3.1.2 Mangrove ecosystem | extensive/intensive shrimp farming

Mangroves are a typical wetland ecosystem for the coastal areas of tropical countries. Mangroves appear in all 3 coastal districts in Ben Tre, especially in Thanh Phu and Binh Dai districts. Overall, Ben Tre has 3,900 ha of mangroves, which mainly grow within the three coastal districts. The width of the mangrove forests can vary from 50m to 2km. The extent of mangroves in Ben Tre is considered small and under pressure from the encroachment of aquaculture farms (Figure 3-3). Only Thanh Phu Nature Reserve, Thanh Phu district, maintains a large area of mangroves (2,584 ha).

Mangroves play a fundamental role in providing habitat for various kinds of aquatic and terrestrial species – particularly for many estuarine and marine fish species. Mangrove forests provide input of nutrients to aquatic ecosystems as well as shelter and nurseries for aquatic species. The main food source for aquatic organisms in mangrove areas is in the form of particles of organic material (detritus) resulting from the decomposition of mangrove litter (such as leaves, twigs and flowers). During the process of decomposition, mangrove litter increases the levels of protein and serves as a source of food for a variety of deposit-eating organisms such as molluscs, crabs and polychaete worms. These primary consumers become food for large predators and are important input for the mangrove estuarine and marine ecosystem.

The coastal river mouths in Ben Tre are home to 145 flora species within 56 flora families. 30 species are mangrove species and approximately 39 species have been introduced due to the process of importing breeding seed from other places (CEECES, 2009). The key Ben Tre mangrove ecosystems species include *Rhizophora sp*; *Avicennia sp* or grey mangrove (Figure 3 2) *Sonneratia sp.*, *Aegiceras sp.*, Nipa palm and *Bruguiera sp*. A list of the dominant flora species in the mangrove ecosystems can be seen in table Table 3-4.

Fauna within mangrove forests are also diverse and abundant. At the Thanh Phu Wetlands Reserve, 8 amphibians, 27 reptiles, 16 mammals and 60 species of birds have been recorded. Tens of thousands of the Intermediate Egret, Little Egret, Black-crowned Night Heron, and Grey Heron have been sighted in the mangrove ecosystems. They gathered mostly in Vam Ho bird-ground, Tan My commune, Ba Tri district. Endangered species such as *Lutra perspicilata*, King cobra, *Pelecanus philipensis*, *Mycteria cinerea* have also been sighted in the Vam Ho Bird-ground.

Mangroves play an important role in regulating the micro-climates of the coast. Mangrove regulates temperature of the water surface under its canopy as well as the DO, salinity and pH which are strictly depending on mangrove foliage coverage. In addition, a 45-65% mangrove canopy cover provides the nutritive composition that supports an ecological stable for shrimp farming(Le Ba Toan, 2006).

Figure 3-2: Grey mangroves (*Avicennia officinalis*), Above; and Rhizophora forest, Below. (Photo: Le Anh Tuan, 2011).

Table 3-4: Specific species of mangrove forest in Ben Tre river mouths (source: BTDST, 2008)

No.	Species (Latin name)	Species (Local name)
1	*Aegiceras corniculatum* (L) Blanco	Sú
2	*Avicennia alba* Blume	Mắm trắng, mắm lưỡi đồng
3	*Avicennia officinalis*	Mắm đen
4	*Avicennia latana* Ridl	Mắm
5	*Avicennia marina* Vierh	Mắm biển
6	*Bruguiera cylindrical* (L.) Blume	Vẹt trụ
7	*Bruguiera parviflora* (Roxb) W.Arn	Vẹt tách
8	*Ceriops tagal* (Perr) C.B.Robin	Dà vôi
9	*Lumnitzera racemosa* Will	Cóc trắng
10	*Nipa fruitacans* Wurmb	Dừa nước
11	*Rhizopora apiculata* Blume	Đước, đước vôi
12	*Rhizopora mucronata* lamk	Đước, đước bột
13	*Sonneratia alba* J.Smith	Bần trắng
14	*Sonneratia caeseolaris* L.Engl	Bần sẻ, bần chua
15	*Sonneratia ovata* Baker	Bần ổi
16	*Xylocarpus granatum* Koenig	Su ổi

The existence of mangrove increases the values of coastal and marine resources by increasing productivity, supporting a wide biological diversity and helping to protect the coastline from erosion. Moreover, the mangrove also supports offshore and deep-sea fisheries by playing a significant role as nursery grounds. Therefore, mangrove forests not only directly support the shrimp farming in three coastal districts but also provide good conditions for other livelihood activities such as clam and blood cockle farming.

Ariizumi et *al*. in 2005 showed the change in land cover, specifically mangroves and shrimp ponds in the three coastal districts of Ben Tre, from 1989 – 2004 (Figure 3-3) Using Terra/ASTER data sets (2004) and a Landsat/TM image (1989) it was found that the area of mangroves has decreased by 50% 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% of land cover in 1989 to 36.5% in 2004, while the area of mangrove decreased sharply from 61.6% to 26.2% over the same period. **This is the greatest threat to the mangrove ecosystems and coastal communities 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 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.

Mangroves provide the following ecosystem services:

- Protecting the coast, minimizing erosion and the impacts of tsunamis and storms
- Providing good conditions for the deposition of alluvia to prevent/reduce sea encroachment
- Regulating micro-climate
- Minimizing the iron and aluminium in coastal soil and land,
- Providing habitat for wildlife (birds, animals, fish, reptiles, etc.)
- Purifying air and absorbing carbon

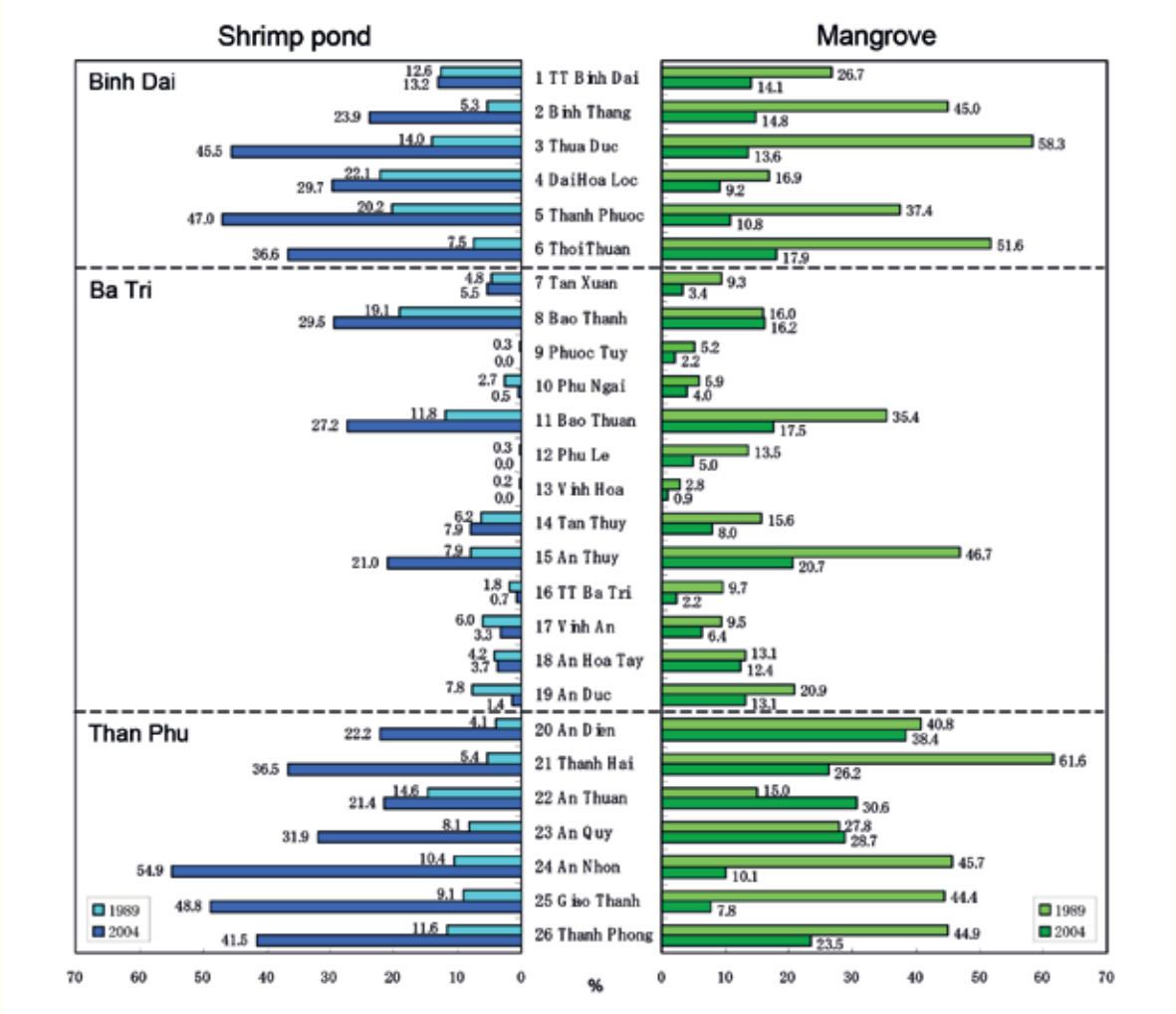


Figure 3-3: Areas of mangroves and shrimp ponds in 1989, 2004 (Source: Ariizumi et al., 2005)

- Treating waste water from rivers, canals and human activities
- Providing nutrients for shrimp, fish and other aquatic species
- Providing wood for construction, firewood, etc.
- *Rhizophora* leaves contain tannins which can be used for dying garments.
- *Rhizophora* can be used to make medicines eg. bark can be used to treat diarrhoea, dysentery, leprosy and its gum can be used to repel mosquitoes.
- Attractive areas for tourism and scientific research.

Mangrove forests support **extensive/intensive shrimp farming**. 'Extensive' shrimp farming uses mostly natural tides and feed to farm shrimp. Shrimp seed are trapped from wild stocks by making use of tides, however, farmers may supplement wild stock from hatcheries. This results in a low stocking density and no additional feed is required in this system as shrimp use natural feed. This type of farming gets less profit than intensive farming.

In 'intensive' shrimp farming, industrial shrimp food is used and water is oxygenated by machinery. The shrimp seeds are brought from local hatcheries and the origin of brood stock is typically unknown. This type of farming normally brings better economic values in the short term but at the same time, causes many environmental problems such as chemical wastes; waste water poisons; more disease outbreaks, spread and requires the destruction of mangroves for shrimp pond development.

In this assessment both *intensive* and *extensive* shrimp farming is categorised into one group, which results in them receiving the same ranking of risk but in reality the impact of 'extensive' is different from 'intensive'. Farming in more condensed mangroves and extensively is considered to have less risk than in cleared areas and high intensity.

In recent years, Thanh Hai commune was able to produce three crops of intensive black tiger and white-leg shrimp farming in one year. The first crop from Feb to Jun, the second crop was from Jul to Oct and the last crop was from Oct until Jan the next year (Table 3 1).The traditional crop calendar, however, shows each crop cycle was approximately 2.5 months long, with a two-week break between crop cycles to assist in pond cleanness. Local people call this the "unseasonal white-leg shrimp crop" because it coincides with the beginning of wet season when salt concentration is low, which is not appropriate for white-leg shrimp farming.

White legged shrimp farming is shorter in time of crop, which means an increase in yearly total crops and demands for more use of pesticides and veterinary medicines. Moreover, the current practice shows that farmers have been buying baby shrimp without clear origins so their quality is low due to shortage of high quality breeders. This has led to outbreaks of disease among shrimp.

3.1.3 Intertidal mudflat and sandbar ecosystem | Bivalve farming

Intertidal areas are formed when the alluvial and marine sediments from rivers and the ocean are deposited (Figure 3-4). Intertidal zones are dynamic environments - formed and eroding on an annual to seasonal basis. For example the alluvial deposition - responsible for the development of intertidal mudflats in the Ben Tre estuary - built-up at a rate of 90-100 ha/year (CEECESC, 2009). The sediment intertidal zones to 0.5 m include 'small grit' (under 10%) and mostly 'fine sand' (80 – 90%) and the rest is made up of 'clay mud/mudflats'. The geomorphologic change is rather complicated as it is affected by many factors such as river and ocean hydrology; hanging and flowing solid materials; river-bottom and sea-side topography; wind characteristics and human activities.

These intertidal zones are found on the edge of more stable ground such as mangrove forests and the coastal areas. The Dai, Ba Lai, Ham Luong and Co Chien estuaries all have intertidal zones. There are well developed and stable intertidal zones between Binh Thang to Thoi Thuan, from Tan Thuy to An Thuy, from Bung islet to Khau Bang canal, and from Cu canal to Vam Giong canal.

Intertidal zones provide suitable habitat for bivalve organisms (clam, cockle, mussel), invertebrates and mangroves. The fine sandbars are ideal habitat for the clams while the blood cockle find habitat in the mudflats.Within the Ben Tre intertidal estuaries 120 fish species have been identified, of which the *Perciformes, Clupeiformes* and *Pleuronetiformes* families dominate (CEECESC 2009).

Figure 3-4: Intertidal zone in Thanh Phu.
(Photo: Le Anh Tuan, 2011)

The intertidal mudflats and sandbars ecosystems provide the following ecosystem services:

- Providing areas for growing crops (watermelon, jicama, bean, etc.);
- Providing a place for breeding seed clam;
- Providing habitat for wild flora such as sea spinach (*Ipomoea pes-caprae*), casuarinas and sea nut grass;
- Providing an area where rain water can be collected for provision of water during the dry seasons;
- Potential areas for the recharging of deep groundwater;
- Providing sand for construction and in-fill; and
- Reducing the impacts of storms.

Intertidal sandbar and mudflats areas support extensive **farming of clams** (***Meretrix lyrata* – sandbars) and blood cockle (*Anadata granosa* - mudflats)**. The bivalve species can only survive in the intertidal areas due to their limited ability to travel and find foods. The intertidal areas are very rich in their food sources. The unusual changes in saline concentration from tides, SLR, unusual rains or strong waves highly impact on clam and cockle lives – having been known to cause mass deaths.

Clam farming occurs in all three communes; however, the clam farm in An Thuy commune is the largest with a big clam seed nursery area (Figure 3-5).Clam farming takes in all seasons and harvesting can take place at any time of the year. Clam seed is concentrated in shallow water areas. By March the clams have grown enough to be placed into deeper water areas.

Figure 3-5: Clam nursery (left) and blood cockle nursery farms (right)

Figure 3-6: Farmers grow watermelon on Ho sand dune, Ba Tri district. (Photo: Le Anh Tuan, 2011)

3.1.4 Sand dune ecosystem | Vegetable plantation

Sand dunes are typically found between 1.0 – 1.5 m above surface water level and lie parallel with the coastal shoreline. Sand dunes are formed after many years of alluvium and coastal sediments build up. Sand dunes provide shelter for coastal communities to live within, and grow crops such as watermelon, corn, bean, and other vegetables including beet, tomato, pumpkin and sugar-cane. In addition aquaculture such as breeding seed clam is undertaken in the sand dunes (Figure 3 6)

Sand dunes provide the following ecosystem services:

- Providing areas for human domestic residences, where tidal floods can be avoided;
- Providing areas for growing crops (watermelon, jicama, bean);
- Providing a place for breeding seed clam;
- Providing habitat for wild flora such as sea spinach, casuarinas, sea nut grass;
- Providing an area where rain water can be collected for provision of water during the dry seasons;
- Potential area for the recharging of deep groundwater;
- Providing sand for construction and in-fill; and
- Reducing the impacts of storms.

Sand dunes contain deep under-ground freshwater reserves. Aquifers running from Ben Tre city to north of Chau Thanh district (at depths of 290 – 350m and 410 – 440m) and could potentially provide 32.640 m^3/day of fresh water. Underground freshwater at shallower depths (30-50m and 60-90m) is distributed mainly in the south of Thanh Phu, part of Ba Tri (An Thuy commune), and north of Chau Thanh and Cho Lach. This water can be used for agricultural production and daily household activities.

Sand dune areas support important **vegetable plantations** for the local communities in three selected communes. Due to its topography character of higher position than intertidal areas, sand dune is the only ecosystem among the four that can maintain freshwater source and is the only place for vegetable plantation, livestock farming and irrigation system development – only on a small scale. The dominant crop on the sand dune is watermelon, which prefer the sandy soil and sunshine. Soy, green bean, peanut, jicama are also cultivated on the sand dune.

3.1.5 Ecosystem and livelihood community importance ranking

This section describes the communes' survey results of i) the importance of each livelihood activity to each commune ii) the key livelihood activities on each ecosystem; iii) the importance of each ecosystem to each commune.

Table 3-5 summarises the relationship of ecosystems and their dependent livelihood activities. Each livelihood activity depends on no one single ecosystem. For example shrimp farming is highly dependent not only on mangroves but intertidal mudflats and the open water estuaries. The communes identified the following livelihood activities to be dependent on the following ecosystems:

- **Extensive/intensive shrimp farming** is highly dependent on the **mangrove forests**. It also has a moderately high dependence on open water estuaries and the intertidal mudflats and sandbars. As could be assumed, shrimp farming has no direct dependence on sand dunes;
- **Clam and blood cockle farming is** highly dependent on the **intertidal mudflats and sandbars**. It also has a moderately high dependency on the mangroves and open water estuaries;
- **Vegetable plantation** is highly dependent on the **sand dune ecosystems**. It also has a moderately high dependency on the intertidal mudflats and sandbars and to a lesser extent open water estuaries and mangroves; and
- **Inshore/inland capture fisheries** are highly dependent on the **open water estuaries.** They also have a moderate dependency on the intertidal mudflats and sandbars and mangroves. As

could be assumed, captured fisheries have no direct dependence on sand dune ecosystems.

The most important livelihood activity for each commune can be seen in Table 3-6. The reason for this ranking is the livelihood's economic value – the income from these activities to local community. The more money it brings, the higher ranking it gets.These livelihood activities are vulnerable to changes in climate and some large-scale development activities:

- **Thanh Hai** commune ranked **Extensive/intensive shrimp farming** as their most important livelihood activity;
- **Thua Duc** commune ranked **planting vegetables** as their most important livelihood activity; and
- **An Thuy** commune ranked c**apture fisheries** as their most important livelihood activity.

Table 3-5: Key livelihood activities and ranking of dependence on the key ecosystems for the three focus communes.

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*

The communities in the three focal communes ranked the importance on each ecosystem to their community (Table 3-6). This ranking is based on the result from community workshops. Local communities look at how each ecosystem provides/enables livelihood activities to cultivate. Local perspective works on the economic value of income generation from the activities.The ranking results concluded that:

- **Thanh Hai** commune ranked the **intertidal mudflats, sandbars and mangroves** as the most important ecosystem to their community. **Openwater estuarine** ecosystem and **sand dunes** were ranked as of moderate importance to the commune;
- **Thua Duc** commune ranked **Sand dunes** as the most important ecosystem to their community. **Openwater estuarine** ecosystem was ranked as of low importance and **Intertidal mudflats, sandbars and mangrove** as of moderate importance to the commune; and
- **An Thuy** commune ranked the **openwater estuarine** as the most important ecosystem to their community. **Intertidal mudflats, sandbars and mangroves** ecosystem was ranked as moderately highly important and **sand dunes** as of moderate importance to the commune.

Table 3-6: Key ecosystems importance within three communes. These rankings are based on the survey results of the local communities.

Ecosystem/Livelihood activity	Thua Duc commune	An Thuy commune	Thanh Hai commune
Open water estuarine	★	★★★★	★★
Capture fisheries	n/a	★★★★	n/a
Intertidal mudflats, sandbars and mangrove	★★	★	★★★★
Extensive/intensive shrimp farming	n/a	★★★★	★★★★
Sand dune	★★★★	★★	★★
Planting vegetables	★★★★	n/a	n/a

Notes:

★★★★	*Highest level of importance*
★★★	*Moderately high level*
★★	*Moderate level*
★	*Low level*
n/a	*Not assessed*

3.2 Community perceived climate and non-climate related pressures

This section presents the climate and non-climate pressures and hazards that have been observed by the communities in the 3 coastal communes. Workshops, meetings, and household surveys were used to collect this information.

3.2.1 Climate pressures and hazards

A community survey was completed in relation to climate pressures and hazards. The results are presented in Figure 3-7, Figure 3-8 and Figure 3-9 below. The questionnaire in the three communes used three impact levels including 'Increased', 'Stable' and 'Decreased'. However, during the survey, the surveyed communities came up with 'no concern' or 'does not matter' answers.

In general, weather and climate events impact all areas of the three coastal communes. High temperatures, sea level rise and saline intrusion have been highlighted by the communities as the key current climate-related concerns that have strong impact on local livelihoods and ecosystems.

All three communes observed that the temperature has increased: 92% of people in Thanh Hai commune observed an increase in temperature, 47% in An Thuy and 71% in Thua Duc commune. SLR (observed through the increase in spring tide) and saline intrusion have also been noted by the community as increasing. 54% and 71% of Thanh Hai commune noted that SRL and saline intrusion had increased respectively, 33% and 33% in An Thuy commune and 67% and 57% in Thua Duc commune. It can be recognized that An Thuy commune is less impacted by spring tide and saline intrusion. This could be due to a more effective dike system.

3.2.2 Development pressures and hazards

There are many development related pressures and hazards that currently threaten the integrity of ecosystems and the well-being of communities who depend on them. Many of these development pressures pose greater threats in the short term than the long-term climate change impacts. Moreover, in many cases these development threats create barriers and inhibit the communities and the ecological ability to adapt to climate change. It is now well recognised that the first step to climate change adaptation is to reduce the '**adaptation deficit**' (Carew-Reid J.E., et al. 2011). That is, we need to reduce the current

environmental and development pressures and hazards to assist in building ecosystem and community resilience and producing effective adaptation. These hazards include:

- On-going **population growth** within each of the communes has led to increasing pressure on coastal ecosystems and habitats, particularly through the extraction and use of natural resources such as fish, forests for construction materials and fuel.
- **Intensive and expanding agriculture and aquaculture** have lead to the extensive destruction of the mangrove and other ecosystems (see section 3.1.2 for more details). Farming practices have led to the use of and increased dependence on fertilizers, pesticides, herbicides and fungicides. These chemicals pollute the environment, poisoning ecosystems, food and water.
- Water infrastructure projects, such as **Ba Lai dam**, have diverted and altered the flow regime. This has caused a change in the hydrological and geomorphic process on the downstream Ba Lai river and with its estuary.
- The disposal of **sludge/mud wastes from shrimp ponds** to mangrove forests covers mangrove roots, which limits the plants' ability for oxygen intake, ultimately resulting in the mangroves' death.
- Industrial and domestic wastewater has caused **water quality** in the coastal estuaries and rivers to decline.
- The **extraction of sand and gravel** from sand dunes and riverbeds will alter the geomorphic process. Erosion leads to the loss and decline in quality of water-bodies and natural forests, which are critical for the key ecosystems and dependent livelihood activities.
- The right bank of Ba Lai river mouth and the left bank of Ham Luong river mouth have experienced frequent **erosion** due to the increased **frequency and intensity of wave action**.

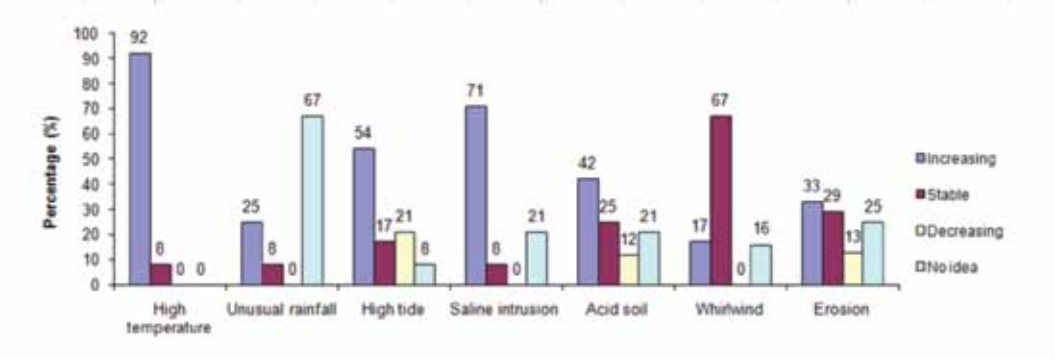


Figure 3-7: Percentage of households' opinions about trends and fluctuations of weather conditions in recent 10 years in Thua Duc commune

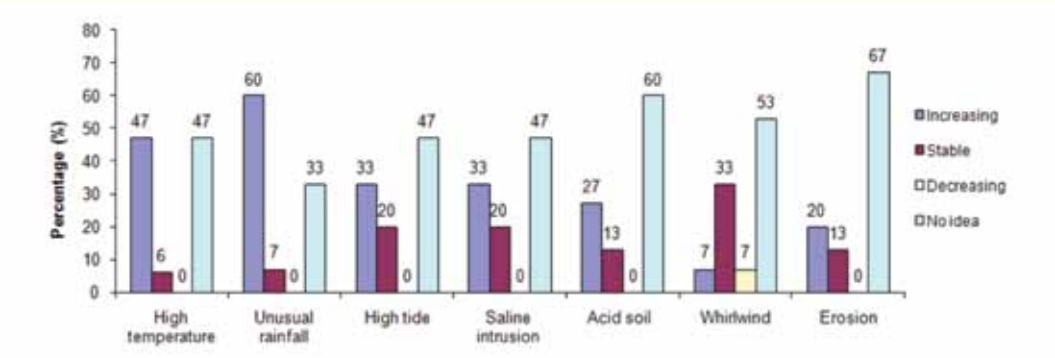


Figure 3-8: Percentage of households' opinions about trends and fluctuations of weather conditions in recent 10 years in An Thuy commune

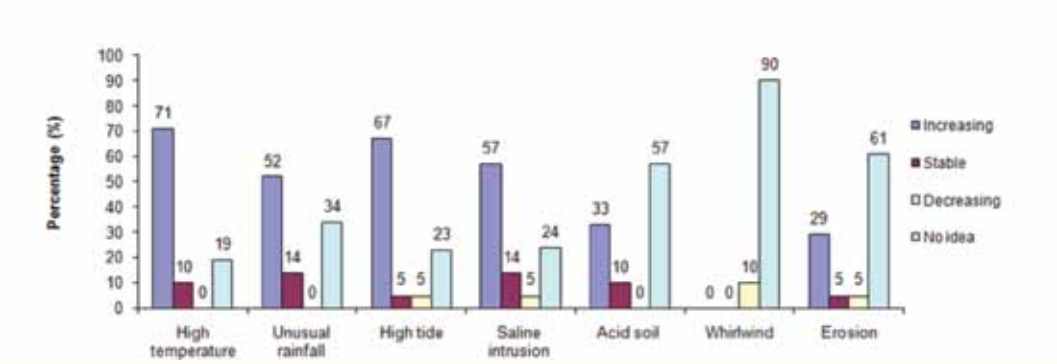


Figure 3-9: Percentage of households' opinions about trends and fluctuations of weather conditions in recent 10 years in Thanh Hai commune

Each year, during strong wave events and in the spring high tides, these areas experience sea encroachment of 20 to 30 m inland. Here costal and upstream sediment deposition occurs resulting in zones of intertidal mudflats and sandbars and coastal sand dunes. Additionally, sand abstraction, river navigation and the removal of trees are also contributing to land erosion. Sand extraction leads to a lowering of the riverbed and sediment load in the water column. Ships and boats create waves, progressively causing riverbank erosion. The removal of trees decreases the bank stability.

- The further **coastal development** for transportation infrastructure, boat shelters and other fishing services has led to a reduction in mangrove forests and has led to further water quality and forestry pollution issues due to the inappropriate disposal of oil and construction material. Once complete the on-going use of these services will lead to further degradation of the mangrove and estuarine ecosystems.

- Farmed black tiger prawns regularly suffered losses due to **disease outbreaks**. These outbreaks have caused many farmers to switch to growing white-leg shrimp.

- Furthermore they have resulted in **less sediment being deposited** into the Mekong river delta at Ben Tre. Consequentially, this has led to the erosion of riverbanks, riverbeds and coastal mudflats. In the last two years, the upstream flows were reduced, leading to a change in river and coastal currents, and a reduction in the silt inflow to the downstream area. The proposed hydropower dams on the mainstream of the Mekong will worsen this situation.

"Water melon plantation on sanddune is one of the key vegetable plantation and has been under many threats from the changing climate."

4 TOP-DOWN ASSESSMENT

The aim of the top-down assessment is to review and assess the:
i.Future **climate trends** and hazards for the Ben Tre province;
ii. Current **institutional and policy** arrangements for climate change adaptation; and
iii. Key potential **development targets** at three selected communes in the province.

The purpose of completing this review is to understand the future climate trends for the studied three focal coastal communes of Ben Tre; to understand the potential institutional and political 'hooks' and integration for ecological climate change adaptation; and to look at the interrelationship between the SEDP development targets and how climate change will impact on these. Climate change projection downscaling to provincial scale was not possible for this study - the results from this section are based on current available literature.

4.1 Climate change trends

Table 4 -1: Projected climatic trends in the Mekong Delta in the next three decades (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
Whirlwind – strong wind - thunderbolt Abnormal heavy rain (> 100 mm/day)	↗	Coastal areas, islands of the delta
Abnormal heavy rain (> 100 mm/day)	↗	Coastal areas of Ca Mau peninsula, areas between Tien and Hau rivers.
Tropical low pressure and coastal storm	↗	Coastal areas of Ca Mau peninsula, areas between Tien and Hau rivers.
Floods (flooded areas and days)[4] (impacts from upper stream project were not taken into consideration)	↗	Long Xuyen – Ha Tien quadrangular area, Dong Thap Muoi, area between Tien and Hau rivers.
Sea level rise – salt-water invasion	↗	Coastal provinces
Sliding	↗	Coastal provinces, area between Tien and Hau rivers
Flood-tidal impacts	↗	The whole delta
Changes in underground water level	↘	The whole delta

The following is a summary of the expected climatic projections. These are based on 3 IPCC greenhouse gas emission scenarios: A1, B1 and A2.

- ***Temperature:*** An increase in the highest average temperature in the dry season by 1-2°C in 2020-2040 and approximately 2-3°C in 2050 – 2090 (Tuan & Sapparkorn, 2009; Stewart et al, 2011).

- ***Precipitation:***
  - A decrease in annual rainfall in 2020 – 2040, but then increasing gradually toward the end of the 21st century.
  - During the 2030s, monthly rainfall is expected to decrease at the beginning and the middle of Summer-Autumn but increase slightly at the end of the rainy season.
  - Annual rainfall in Ben Tre is projected to decrease by about 20%, and the rainy season is expected to commence about 2 weeks later (Tuan & Sapparkorn, 2009; Stewart et al, 2011). Rainfall is expected to be less predictable (MoNRE 2008).
  - Decreased rainfall in dry seasons and early rainy seasons but an increase in both the intensity and the number of rainy days in both dry and wet seasons (MoNRE 2008).

- ***Sea level rise:*** An increase in the area of inundated land - the EIA-3D model for the Mekong delta shows that between 2030-2040, flooded areas in the delta will expand out to Soc Trang, Bac Lieu and Ca Mau (Tuan & Sapparkorn, 2009 & Stewart et al, 2011).

A summary of the climate trends for Mekong delta was developed and presented in Table 4-1. Ben Tre province is expected to experience the same trends.

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 hazard of sea level rise. In the dry season, Ben Tre already experiences frequent, and often severe, increases in saline intrusion due to droughts and sea level rise. The following section outlines the direct and indirect impacts of each climate change hazard – temperature, precipitation and sea level rise.

4.1.1 Temperature trends

Temperature data from 1977 – 2010 show that average temperatures in Ben Tre have increased by 0.5 °C in 35 years (Figure 4-1). The average temperature was unusually high in 2010, reaching 29.6 °C. Based on three greenhouse gas emission scenarios developed by IPCC the annual average temperature is expected to be 27.9 in 2050 and between 28.3 and 29.3 by 2100 (Table 4-2). This equates to a change in temperature of 1.0 to 2.2 °C. It is interesting to note that the 2010 annual temperature will be similar to the predicted temperature for 2100 – looking at the impacts and responses to the extreme heat in 2010 will help adaptation planning.

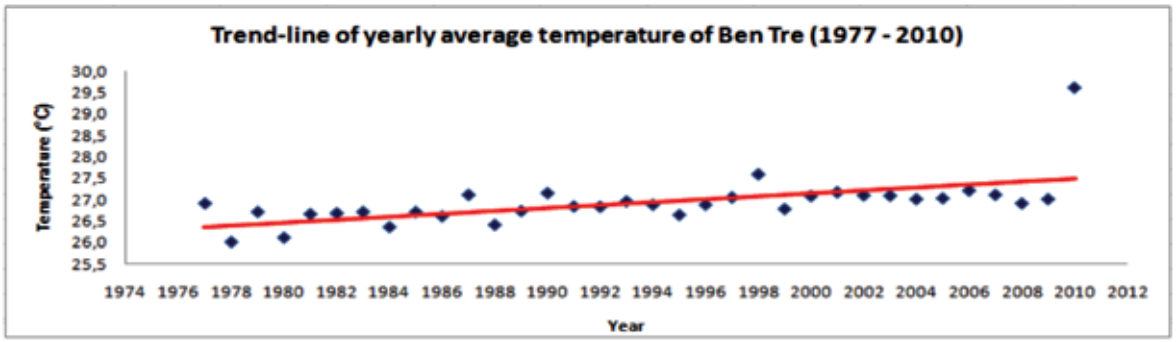


Figure 4-1: Yearly temperature change in Ben Tre from 1977 - 2010 (data collection from yearly record of Ben Tre Hydrology and Meteorology station and has been analyzed by the consultant)

Table 4-2:Future mean annual temperature of Ben Tre for A1, B1 and A2 IPCC scenarios (source:Phung K. N., et al., 2010)

		YEAR								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
Temp. (°C)	High	27.3	27.5	27.7	27.9	28.2	28.5	28.8	29.2	29.5
	Low	27.3	27.5	27.7	27.9	28.0	28.2	28.2	28.3	28.3

4.1.2 Rainfall trends

Data from 1998 to 2010 indicated a slight increase in rainfall (Figure 4-2). Based on three IPCC scenarios - B1, B2 and A2 - rainfall trend from 2020 toward the end of 21st century is projected to increase by 11 – 25 mm (Table 4-3). This change in trend of total annual rainfall is not significant. What is expected to have a significant impact, however, is the change in the starting time of the wet season. This is projected to commence two weeks later than it currently does (Tuan, L. A., 2010). Furthermore, the peak wet season, when most of the rain will fall, will be delayed to the end of the wet season.

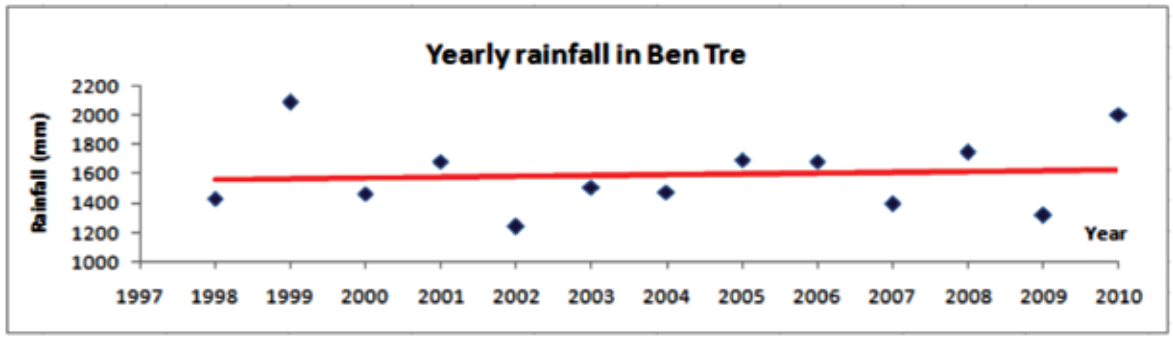


Figure 4-2:Yearly rainfall change in Ben Tre from 1998 – 2010

Table 4-3: Future annual rainfall range in Ben Tre according to A1, B1 and A2 IPCC greenhouse gas emission scenarios (MONRE, 2009).

		YEAR								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
Precipitation	Min	1575.2	1576.7	1579.9	1581.4	1583.0	1584.6	1586.2	1586.2	1586.2
	Max	1575.2	1576.7	1579.9	1583.0	1586.2	1589.3	1592.4	1595.6	1600.3

4.1.3 Sea level rise trends

Ben Tre province is highly exposed to sea level rise because it i) has a low elevation; ii) is close to the East Sea and iii) is surrounded by a web of connected waterways. MoNRE in 2009 predicted the sea level rise will be between 65 – 100 cm by 2100.

A moderate sea level rise of 75 cm will mean that (MoNRE 2009, Phung K. N., et al., 2010, Figure 4-3):

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

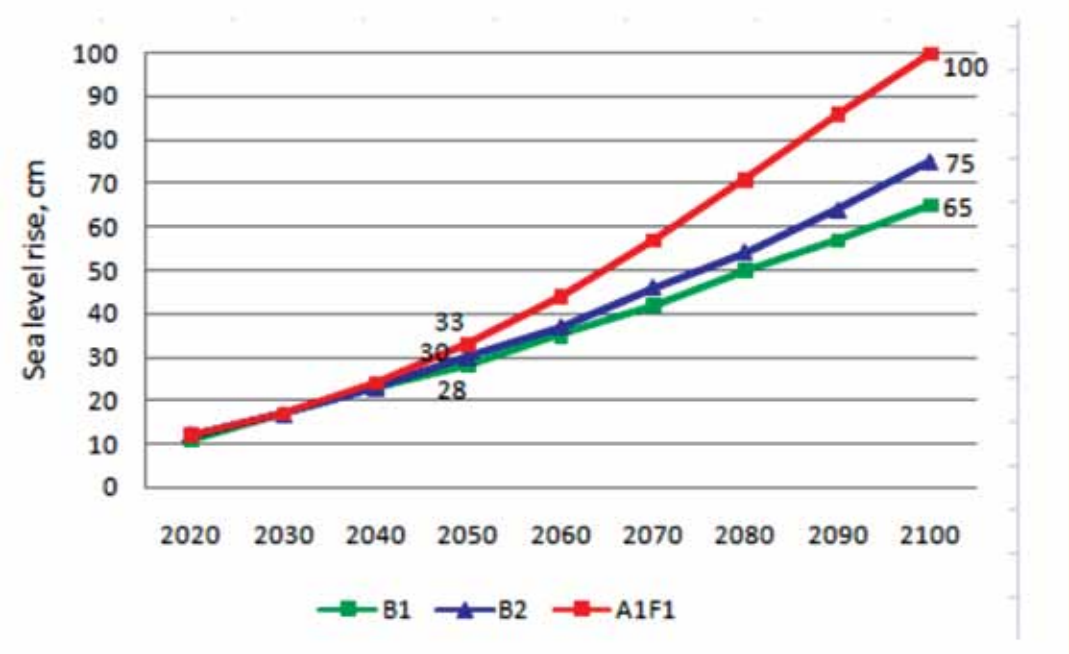


Figure 4-3:Sea level rise projection in coastal areas of the Mekong delta according to 03 greenhouse gas emission scenarios: B1, B2& A1F1, (Source: MoNRE, 2009)

Table 4-4: The percentage of inundation areas in Ben Tre province bases on B2 scenario (Moderate scenario). (Source: MoNRE, 2009)

District	Total area	SLR									
		12 cm		17 cm		30 cm		46 cm		75 cm	
		S(km²)	%	S(km²)	%	S(km²)	%	S(km²)	%	S(km²)	%
Ba Tri	331.25	35.94	10.85	39.24	11.85	47.43	14.32	67.66	20.43	169.92	51.30
Binh Dai	371.41	31.35	8.44	37.69	10.15	60.27	16.23	89.87	24.20	171.32	46.13
Thanh Phu	384.39	57.82	15.04	58.17	15.13	60.01	15.61	62.70	16.31	89.07	23.17
Total Ben Tre	2,223.06	272.09	12.24	290.45	13.07	342.08	15.39	425.67	19.15	725.25	32.62

The three coastal districts will be highly affected by SLR, especially Ba Tri and Binh Dai districts. The scenario of SLR up to 75 cm, 50% of the total area of both districts will be inundated, which means the two coastal communes will be totally inundated (Table 4-4). It is not clear from this rapid assessment and literature review which areas, livelihood activities and ecosystems will be impacted by the SLR.

4.1.4 Sea level rise and saline intrusion

As sea level rise and drought worsen saline water will enter both the ground and surface waters. Figure 4-5 and Figure 4-6 below outline the projections of the saline intrusion up to years 2020 and 2050. In 2020, the salinity concentration 4 ‰ will cover almost all of Thanh Phu district and Ba Tri, while approximately half of Binh Dai district will be affected. In 2050 the projections indicate that all three coastal districts of Ben Tre province will be covered by the 4 ‰ saline area, a large proportion will be covered by 10 ‰ and much will be covered by 20 ‰. Saline intrusion and SLR will strongly impact on agriculture activities and natural coastal ecosystems.

In October 2011, many communes lost hundreds of hectares of land due to the encroachment and increase of sea level (Figure 4-7 and Figure 4-8). In recent years, the intrusion of salt water inland into rice paddies and aquaculture ponds within Ben Tre has become more severe in the dry season due to the reduced flows from upper Mekong River, the appearance of northeast wind, and sea level rise in the East Sea. Between 2002 and 2010 salinity was recorded at 4‰ (April S max) in Ben Tre city and up to Phu Tuc, Phu Duc communes on the at Dai river and to Cai Mon on the Co Chien river about 60 km from the coastline. In 2004, 2005 and 2010 salinity levels of 4‰ occurred in Vam Mon, 60 km away from Ham Luong River. Furthermore salinity levels of 1 ‰ were recorded in almost all places

in Ben Tre province. The increases in sea level and the impacts of saline intrusion are closely linked and have been observed by communities, particularly in the negative impact of saline intrusion on the black-tiger prawn farms.

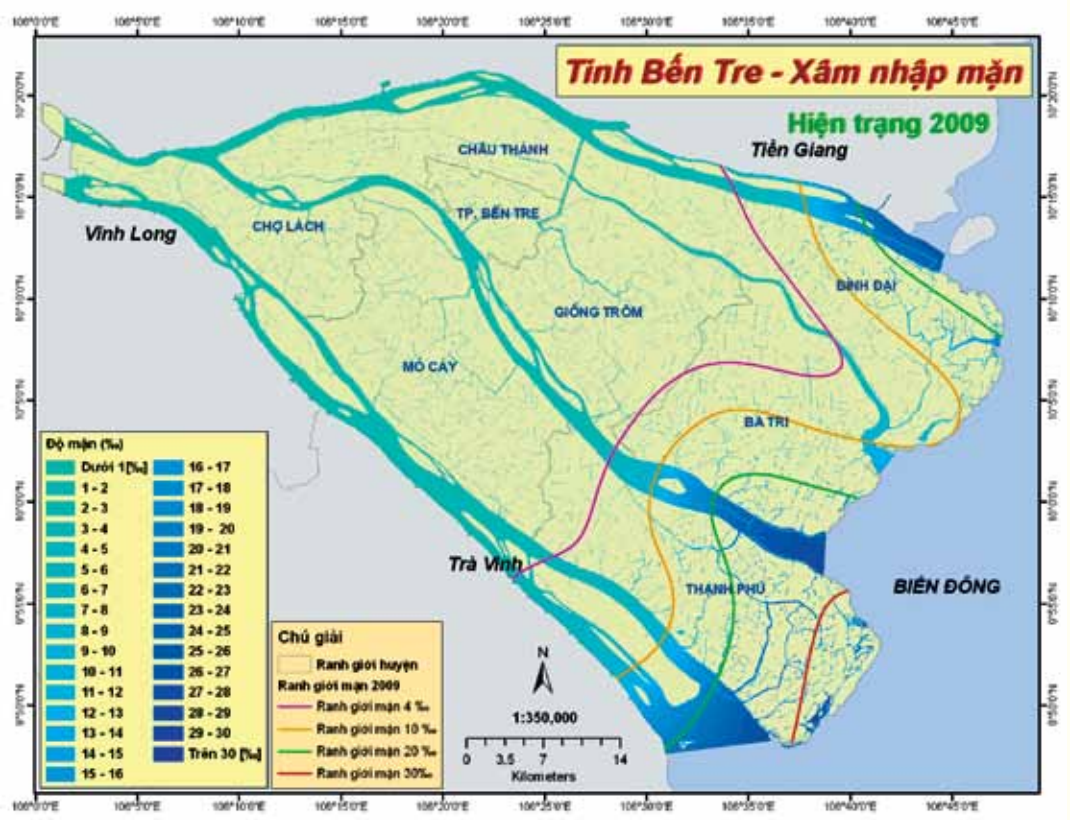


Figure 4-4: Saline intrusion in Ben Tre in 2009 (Source: SIMHE, 2010)

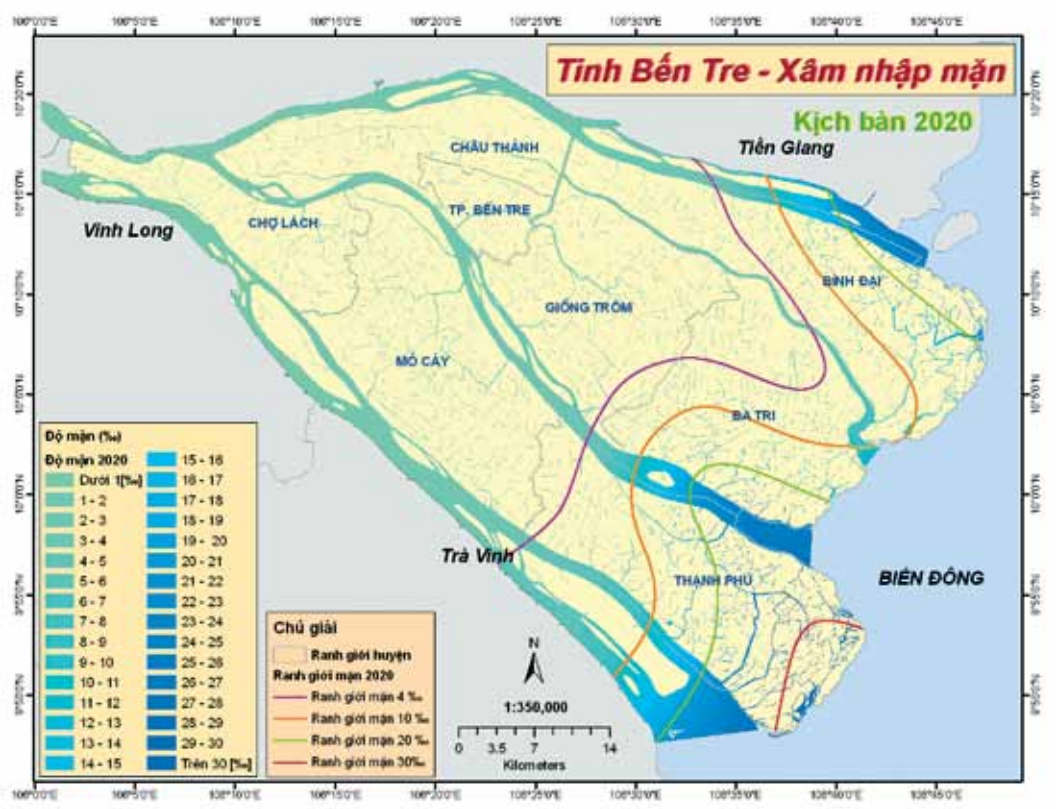


Figure 4-5:Saline intrusion projection in Ben Tre province in 2020, (Source: SIMHE, 2010)

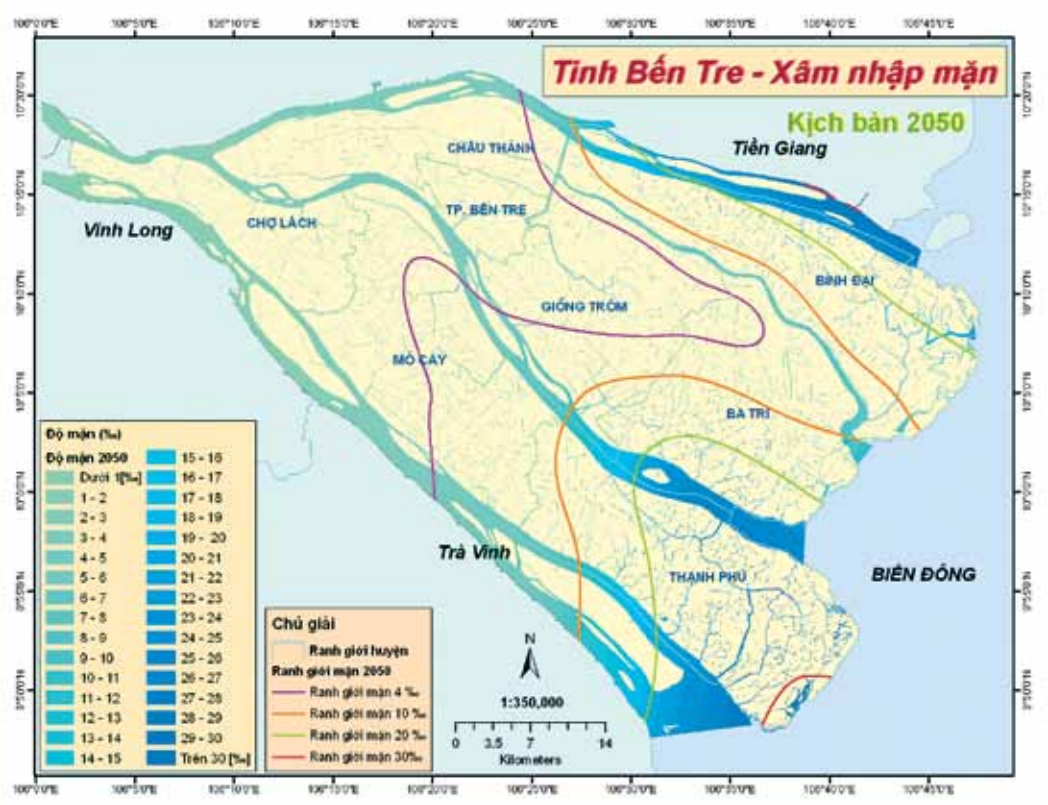


Figure 4-6: Saline intrusion projection in Ben Tre province in 2050, (Source: SIMHE, 2010)

Figure 4-8: Loss of land and crop in An Thuy commune due to sea encroachment (Photo: Hoang Viet, 2011)

Figure 4-7: Eroded sea dikes and loss of land in Thua Duc commune (Photo: Hoang Viet, 2011)

4.1.5 High temperatures and drought

Along with saline intrusion drought is believed to be having the greatest impact on the Ben Tre province. In 2010 drought and salinity alone are estimated to have caused a total loss of 198 billion VND. From 1995 – 2008, drought and salt-water intrusion are believed to have caused a loss of 672.3 billion VND (BTDARD, 2011). The damages and the losses were due to changes in upstream flows, which led to:

- water shortages for 132,823 households;
- reduced or destroyed productivity of 15,782 ha of rice fields;
- damage to 857,000 seeds;
- destruction of 445,000 seeds;
- up to 13,700 ha of destroyed young coconut trees;
- reduced productivity of 8,495 ha of sugar cane, and 25,019 ha of fruit trees; and
- failure of 360 ha of shrimp farms, equivalent to the loss of 5,289 tons of shrimp and fish.

Communities have observed and believed that the increased temperatures in recent years, particularly in 2010, led to the decline in clam yield. It is thought to be due to higher temperatures, increased evaporation, which leads to a higher salinity and causes clam deaths. The impacts of higher temperatures are felt mostly by the seeds of clams, and by shrimp farms. Prolonged higher temperatures cause an increase in salinity levels through high evaporation rates. The hot weather also caused clam deaths in mudflat bar areas due to temperature 'shock', and the deaths of black tiger shrimp were also due to sudden changes in temperature and rainfall.

4.1.6 Typhoons and storms

Typhoons and erosion cause serious hazard to local coastal communities (Table 4-5). On average, Ben Tre receives six to nine typhoons every year from the East Sea, resulting in heavy rain throughout the whole region and coastal erosion. During the five decades between 1940 and 1990, there were **no records of storm directly impacting Ben Tre Province**-this was not due to the lack of reporting and

Table 4-5: Damage data by storms to Ben Tre in recent years
(Source: Ben Tre provincial Department of Agriculture and Rural Development, 2011)

No.	Time occurred and name	Casualty	Infrastructure damage and material loss	Total loss (estimated)
1	Nov. 2nd, 1997 Storm no. 5 (Linda)	• 116 died • 57 injured	• 570 houses destroyed • 2.141 house roofs damaged • 322 classrooms damaged • 27 buildings and clinic station damaged • A lots of roads, stores and irrigation systems damaged	336 billion VND
2	Dec. 10th,1998 Storm no. 7 (Dawn)	• N/A	• N/A • 281 houses destroyed • 14 classrooms damaged • A lots of roads, electric stations and irrigation systems damaged	40.5 billion VND
3	Dec. 5th, 2006 Storm no.9 (Durian)	• 18 died • 671 injured	• 26.476 houses destroyed • 93.488 house roofs damaged • 89 classrooms completely destroyed • 1.633 classrooms' roof damaged • 250 buildings' roof lost • 59 dispensary damaged • 12.043 electric posts felt • 17,075 ha of rice; 989 ha of crops; 20,148 ha of fruit trees; 8,686 ha of sugar canes; 21,984 ha of coconut damaged • 114 ha of coastal mangrove forests collapsed • A lots of irrigation systems; road damaged	3,182 billion VND

recodes but because there simply were no significant storms. However, after 1990, the province received several storms, causing severe damage within coastal areas. Local communities regularly remembered the Linda storm in 1997, and Durian in 2006 and the biggest typhoon in 2007, which destroyed many local houses. Local government officers reported that storm impact on coastal erosion is a highly critical issue. These coastal areas experienced no storm prior to 1990 and the traditional way of living does not consider storms. This will make it extremely difficult for adaption planning.

4.2 National legal and institutional framework to respond to climate change

The following section summarises the relevant climate change adaptation Vietnam Government's policies. In recognizing potential hazards of climate change for Vietnam, the Government has developed the following national legal policies:

- Instruction No. 35/2005/CT-TTg, dated October 17th, 2005 of the Prime Minister on **Implementing in Vietnam the Kyoto Protocol**: under the UN Convention Framework on Climate Change in Vietnam this instruction is for the implementation of Kyoto Protocol under the United Nations Framework Convention on Climate Change. It provides a legal framework for clean development mechanism activities in the country.

- Decision No. 47/2007/QĐ-TTg, dated April 6th, 2007 of Prime Minister: Mandates the Ministry of Natural Resources and Environment and other related ministries, agencies and provincial

government to **implement the Kyoto Protocol and clean development mechanism**;

• Resolution No. 60/2007/NQ-CP dated December 3rd, 2007 of the Government on **Developing National Targets Programme on Responding to Global Climate Change**: this resolution assigned MONRE to take the lead in developing National Target Program to Respond to Climate Change (NTP-RCCC); and

• Decision No. 158/2008/QĐ-TTg, dated December 2nd, 2008 of the Prime Minister: This decision approved the **National Target Programme on Climate Change** (NTPCC) of Vietnam;

• Decision No. 2179/QĐBTNMT, dated November 16th, 2010 of the Minister of MONRE: This decision approved the **Supporting Program to Respond to Climate change** (SPRCC);

• Decision No. 2139/QĐ-TTg, dated December 5th, 2011 of the Prime Minister: This decision approved the **National Climate change Strategy** of Vietnam.

Legal policies relevant to climate change adaptation in Ben Tre province

• On May 27th, 2011, Ben Tre People Committee signed Decision No, 1224/QĐ-UBND: this decision enforces the **Action Plan Framework of Ben Tre Province on Responding to Climate Change and Sea Level Rise**;

• On October 1st, 2009 Ben Tre provincial People Committee signed Decision No, 2369/QĐ-UBND: This decision established a **Steering Committee for Responding to Climate Change** and this committee has reformed on February 15th, 2011 under the Decision No, 302/QĐ-UBND. Institutional settings related to Climate Change are represented in the following official structure as Figure 16.

• On May 23rd, 2011, Ben Tre People Committee signed Decision No, 1143/QĐ-UBND: this decision declares the project "Impacts assessment, detailed climate change scenarios in Ben Tre and proposed adaptation solutions".

• On Sep 6th, Ben Tre People's Committee signed Decision No, 1983 /QĐ-UBND: This decision of the provincial People's Committee declares the Project "Responding to climate change and sea level rise of Ben Tre province in 2011-2015 and vision to 2020".

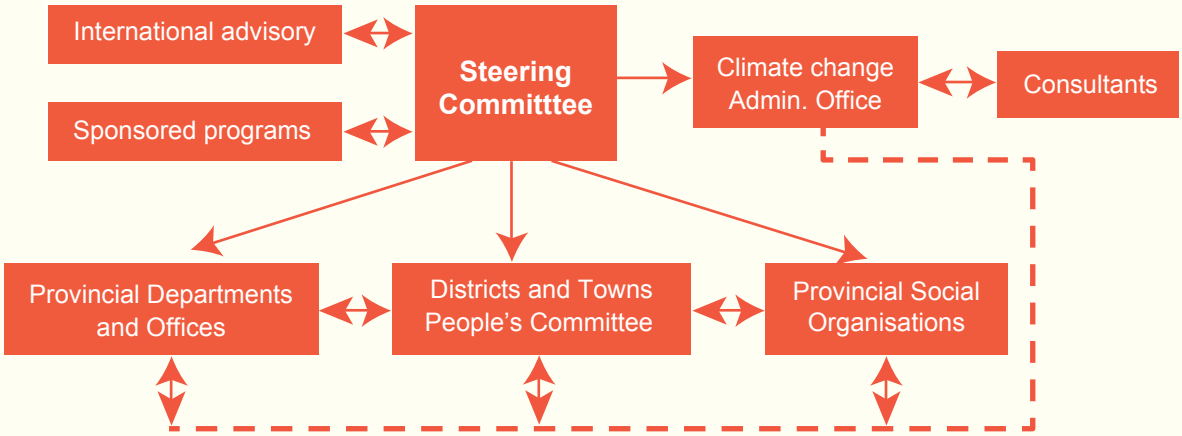


Figure 4-9: Diagram of the Steering Committee to Respond to Climate Change in Ben Tre province

Socio-economic development targets, 2011 - 2015 and vision to 2020

The Socio-economic Development Plan of Ben Tre up to year 2020 has long-term development targets to:

i. Promote Ben Tre province by strengthening the marine-based economy so it is in a strong position within the southern economy.

ii. Gradually improve and develop i) infrastructure, ii) culture – society and iii) human resources, with the aim to reach international standards; and

iii. Strengthen links with the most developed provinces in the Mekong River Delta and the key southern economic sectors.

Below is a summary of the socio-economic development targets for Ben Tre province.

Target 1: Economic development

- Economic growth will be at an average 13.8% per year over the next 10 years. From 2011 to 2015 economic growth will be 13% per year and from 2016 to 2020 economic growth will reach 14.5% per year.
- The economic income will shift by increasing the proportion of income from industry, construction, and services and reducing the proportion of income from agriculture. It is expected that in 2015, the rate structure of the 'agricultural sector - industry, construction – service' will shift from: '30.3% - 27.4% - 42.3%' to '19.2% - 32.6% - 48.2%' by 2020.
- Export turnover will reached 575 million USD by 2015 and $ 1.4 billion USD in 2020, an average increase of 20% per year.
- The industry, small industry & handicraft sectors will increase. Foreign investment of food processing for export and technology based production will be prioritized.

Target 2: Infrastructure and public works

- Infrastructure and public works will be invested in rural areas throughout the province.
- Ben Tre city will be up-scaled by 2020 and three more urban centres will be developed in Mo Cay, Ba Tri and Binh Dai.
- Expansion of river transportation to make use of the three major rivers and bridges including: Rach Mieu bridge – in Chau Thanh district, connects Ben Tre to Tien Giang province (Highway 60); Ham Luong bridge (Highway 60) and Co Chien bridge.
- Construction of Giao Long port as a transport hub for industrial areas and port services.
- Upgrade the current Rach Mieu ferry to be a cargo and travel terminal.
- Construction of river cargo port in Tan Thanh Binh (Mo Cay district).
- Complete the fishery ports of Binh Thang (Binh Dai district), An Thuy (Ba Tri district), An Nhon (Thanh Phu district) and fishery market.
- Construction and completion of key roads include national highway 60, 57 and May provincial highways; as well as upgrade some of district highways to provincial level quality.
- Construct the industrial zones including different levels of a market.
- Completion of residential areas to support the rural industrialization and urbanization.
- Speed up the completion of the irrigation systems in the north of Ben Tre
- Conduct a study on the possible freshwater sources for large-scale irrigation system in the South of Ben Tre;
- **Complete sea dikes and residential zoning for the development of a 'marine economy' and to assist with the response to climate change and sea level rise;**
- Speed up freshwater supply from Cho Lach and Chau Thanh for domestic, industrial and commercial use.

Target 3: Industries, tourism, trade, and services (including transport services)

- Upgrade the industrial zone of Giao Long (Chau Thanh district) and other industry areas.
- Investment in and construction of market chain, export production services.

- Investment in eco-tourism opportunities and services.
- Development of wholesale and retail markets in urban centres.

Target 4: Social Development

- By 2015 the growth rate will average 0.4%/year and 25% of the population will live in the urban cities; this will grow to 30% in 2020;
- By 2020, 99% of household. will use electricity, 100% will have water supplied and 95% of urban and rural households will be using hygienic water;
- Completion of general secondary education by around 2015. The healthcare system will be expanded in residential areas by the modernization of traditional medicine hospitals and building more specialized and updated health clinics. By 2020 there will be 10.3 doctor/10 000 population and 30.7 thousand beds / 10 000 people;
- Complete a Provincial Culture House and 'Stadium Sports City'. By 2020, 95% of communes, wards and towns will have a completed 'social and cultural centre'; this centre will have traditional home, a gallery, broadcasting and sports facilities; and
- By 2020, poverty will be less than 3% by new standards, employment underworking-age will be at 77.5%, unemployment will be less than 1%.

Target 5: Agricultural sector

- Conserving and preserving breeding plants, local cattle and applying innovative technology to cross-breed new varieties;
- Improving and creating new breeds that give higher productivity and are able to adapt to the dry and salty environment in Ben Tre; altering crops and cattle to adapt with climate change;
- Improving the irrigation and drainage capacity of the delta, coastal areas and lowland along the river;
- Improving the alerting and forecasting system on weather, climate, oceans and agriculture;
- Using water-saving irrigation technology;
- Applying farming methods that improve productivity and reduce greenhouse gas emission;
- Giving priority for land-use projects that are related to irrigating constructions in order to increase agriculture land use, intensive farming, productivity and to change planting and husbandry patterns to improve land usage;
- Strengthening science and technology transfer, improving skills for agriculture labour to gradually move forward to industrial and service sector;

Target 6: Forestry sector

- Amending policies and socializing afforestation, forest protection and management in consideration with social policies such as: handing over land and forest; settling agriculture and housing; etc.
- Improving forest and fragmented tree plantation;
- Protecting mangroves in wetland areas: enhancing and protecting them and preventing fire; and
- Creating areas that provide forestry seeds.

Target 7: Fishery sector

- Studying and breeding aquatic species that are sustainable in the environment;
- Importing and breeding marine aquatic species that have high economic value and can tolerate high temperature and salinity;

- Deepening ponds to create suitable temperature and to reduce bad impacts resulting from higher temperature and fast vaporization;
- Increasing aquaculture breeding capacity and developing commercial fishery;
- Establishing natural ecosystem protection areas;
- Enhancing the capacity to predict fish movements and changes in fishing grounds;
- Transforming agricultural production in inundated areas from purely rice growing to rotational cultivation;
- Developing freshwater fisheries; keeping freshwater fishes in dam, lake, lagoon as the agriculture-forestry-fishery model;
- Constructing systems that can prevent storms, wave and water rise.

Target 8: Land-use planning

- Optimizing land use for projects or programmes which were included in the socio-economic development master plan, and for sectoral projects;
- Amending projects when necessary with consideration of climate change;
- Carrying out studies especially on preventing land degradation and pollution and on exploiting and using natural resources toward sustainable development;
- Studying land programmes for urban and resident areas especially areas that are potentially affected by flood, landslide and sea level rise.

Target 9: Science and Technology Development

Up to 2020, technology industry will contribute an increased 20% to the provincial GDP, with a 20% per year target for technology innovation.

Target 10: Environmental protection

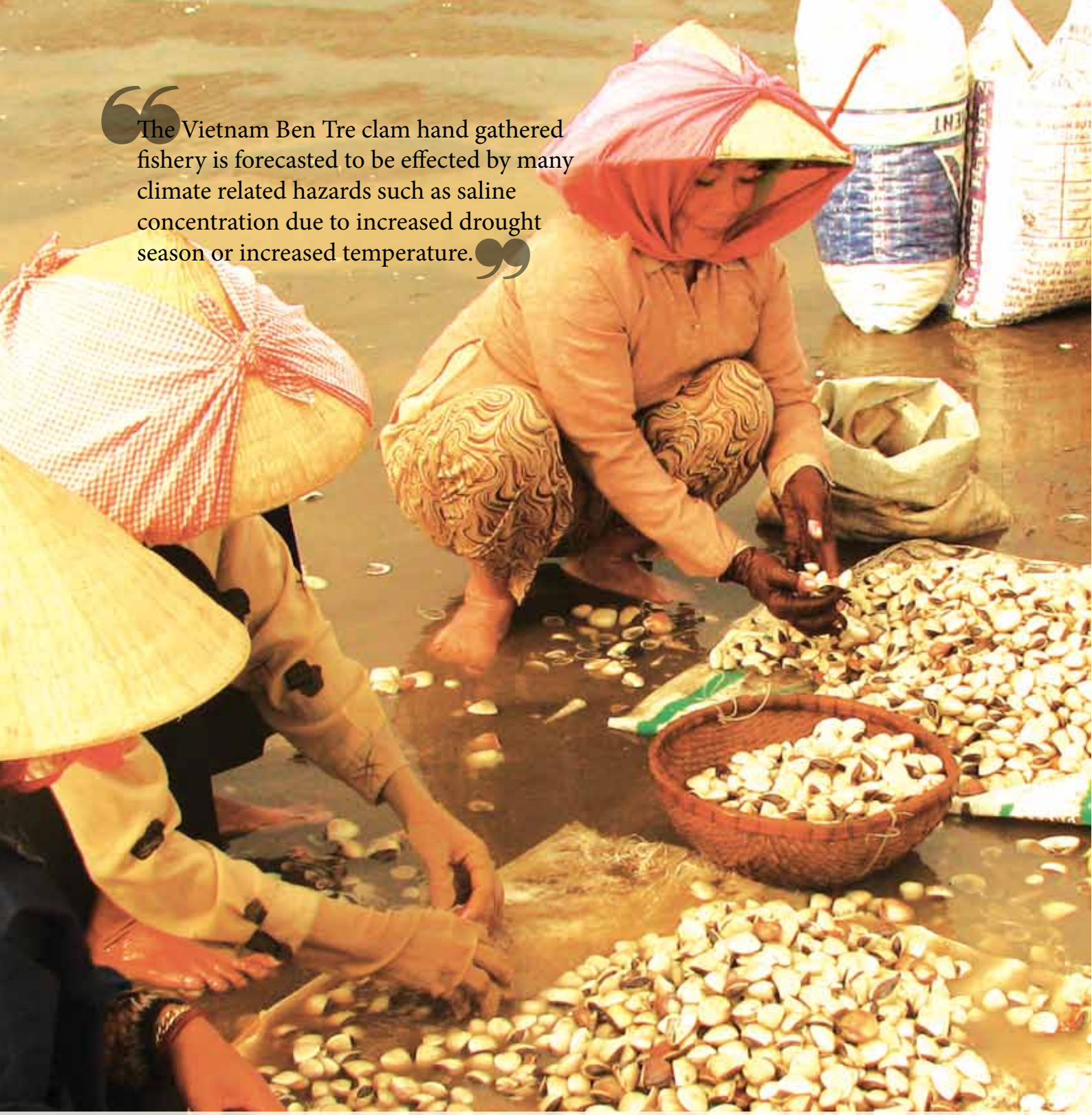
- Protect and improve the environment in urban, rural, industrial and agricultural zones, especially the mangroves and intertidal ecosystems; and
- Build new urban and industrial zones with built-in basic water and waste collection systems, over 65% of which waste is processed.

Socio-economic development plans relating to selected *communes and districts*

- **Economic development programme for coastal areas:** The three eastern districts (Binh Dai, Ba Tri, Thanh Phu) and Ben Tre city have been categorized under the coastal development programme and will be one of three target programmes of the province.
- To form four large **commercial centres** in Ben Tre city, Mo Cay, Ba Tri & Binh Dai districts. This will include modernisation of trade and service activities including: i) construction of ports and wholesale markets for agriculture and fishery products at Giao Long (Chau Thanh district), improvement of ii) The Binh Thang harbour (Binh Dai), iii) An Nhon fishing port (Thanh Phu district), iv) An Thuy–An Hoa Tay Complex area (Ba Tri district), v) agricultural product markets in Tan Thanh Binh (North Mo Cay district), vi) Tan Phu (Chau Thanh district), vii) Luong Quoi (Giong Trom district).
- **An Thuy commune will be developed into the central town of Ba Tri district** as a commercial, industrial and service centre as well as a marine economic centre of the district which connects with An Thuy market, Ba Tri fishing port, An Hoa Tay fishing village and Binh Thang fishing port.
- **Ba Tri district is expected to upgrade to provincial town and become an economy-commerce-socio-culture centre** of the east coast of Ben Tre province;

- **Thanh Phu district is also in line to become a centre of the economy-commerce-socio-culture development plan.**
- The total area of **rice plantation will decreased to make way for rotational rice-aquaculture farming**. This will occur mainly in Ba Tri, Thanh Phu districts and partly in Giong Trom and Binh Dai districts.
- **Development of processing industry:** the processing industry will be encouraged through the development of the industrial zone in Giao Long (Chau Thanh district), An Hiep industrial zone and 4 new industrial zones in Giao Hòa (Châu Thành, Binh Dai district). Additionally there is a possibility of a new industrial zone at the current An Nhon industrial zone (Thanh Phu).
- Construction of the **Ham Luong bridge** connecting Ba Tri and Thanh Phu district;
- Construction of **provincial road ĐT.885** (Ba Tri province).
- Construction of the **coastal road** connecting Binh Dai-Ba Tri-Thanh Phu, which is around 38.6 km in length.
- Construction of **provincial road** Thanh Hai-My An connectiong Ba Tri-Thanh Phu, which is estimated 16,5km in length.
- Construction of important **district roads** including DH.173 (East-West) connecting Châu Thành-Giong Trom-Ba Tri district (around 58.3 km); ĐH.16 connecting Binh Dai-Ba Tri-Thanh Phu districts, is considered a coastal prevention route (38,5 km).
- Dike construction projects in 3 districts: Binh Dai, Ba Tri, Thanh Phu districts (no details are available regarding this project).

Most of these above development targets are more focused on physical construction. It can be recognized that environment plans have not yet been clarified on the detail of scope, scale, timeframe, expected outcomes and management issues (land-use plan, forestry or fishery). It shows the fact that these areas are not the top priorities of the province in the coming 10 years. Moreover, all of the above mentioned development targets have not taken into account analyses of climate change hazards, vulnerability assessments and plans to respond to projected climate change impacts for each target. This raises the concern regarding the projected increased intensity and severity of SLR and erosion events. These events are expected to strongly impact on the whole province particularly three coastal districts, which consequently will impact on road/dike and coastal constructions. How much it will impact depends heavily on how well they are planned for.



"The Vietnam Ben Tre clam hand gathered fishery is forecasted to be effected by many climate related hazards such as saline concentration due to increased drought season or increased temperature."

5 VULNERABILITY ASSESSMENT | CLIMATE CHANGE AND DEVELOPMENT

The bottom-up and top-down assessments of the ecosystems and their dependent livelihood activities have been synthesized to produce the following vulnerability assessment. The vulnerability assessment was made up of three steps: i) risk rating (section 5.1) and ii) adaptive capacity (section 5.2), which were combined to produce iii) the final vulnerability assessment (section 5.3). The results are discussed in detail below and the final vulnerability assessment is summarised in Table 5-5.

5.1 Risk rating

This section identifies and rates the climate change and development risks for each selected key ecosystem and their respective ecosystem dependent livelihood activities. Table 5.2 summarises the aggregate risk facing the four key ecosystemsand their dependent livelihoods. The risk rating assessment is qualitative base.The criteria for each risk rating is different for livelihood activity and ecosystem and is described in the relevant sections below. The risk rating is based on the following climate change and development projection and hazards, which have been summarised here:

Climate change pressures and hazards:

- erratic rainfall, including unseasonal rainfall during the dry season;
- increased intensity of rainfall events during the wet season;
- prolonged hot weather (air temperature consistently above 35°C);
- increased inundation and saline intrusion due to sea level rise and increased flooding from the up-stream catchment;
- increased coastal erosion due to increased storm and wave activity, monsoon winds and sea level rise; and
- increased frequency and intensity of tropical storms.

Development pressures and hazards:

- expanding and increasing intensity of agriculture and aquaculture practices, particularly the expansion of prawn and shrimp farming, and the increasing use of fertilizers and pesticides, particularly the loss of mangroves due to the expansion of prawn and shrimp farms;
- over-exploitation of fisheries and forests;
- changes in hydrology and sedimentation due to the construction of the Ba Lai sluice-dam;
- water quality pollution from sewage and industrial waste;
- sand and gravel extraction; and
- urban encroachment.

5.1.1 Integrated risk assessment of key ecosystems

This risk rating looks at both the *current climate and non-climate* related hazards and *projected* risks from potential *climate change and development* impacts. Table 5.1 below shows the final risk rating for the four selected key ecosystems in the coastal regions of the Ben Tre province.

Coastal mangroves: coastal mangrove ecosystems are at ***moderately high*** risk from the impacts of current development and climate change. (ANNEX 3 , Table 5-1). 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 highly exposed and sensitive to inundation and erosion caused by SLR and increased storm activity.

In Binh Dai and Ba Tri, many of the mangrove forests are thin strips interspersed with shrimp ponds and have very low biodiversity. In Thanh Phu, there are some areas of single species mangrove reforestation and plantations. In these cases the mangrove forests are at higher risk, as they are not resilient to storm and wave action.

The risk for mangroves has increased due to many factors such as wood exploitation, water pollution, erosion, and expansion of aquaculture. There are currently, however, on-going projects by local government and NGOs to restore mangrove ecosystems that are resilient to future climate change projections.

Intertidal alluvial mud flats and sandbars: the mudflat and sandbar ecosystems are at ***moderate risk*** from current and future climatic and development pressures (ANNEX 3 ; Table 5-1). These include being permanently inundated by SLR, and experiencing an increase in annual maximum temperature, leaving many benthic bivalves at risk of death. In addition, port and dike construction planned for Ben Tre will have significant impacts on these important and exposed ecosystems.

Intertidal habitats (mudflat bars and sandbars) are dynamic environments and the ecological communities in the intertidal habitats are used to living in a dynamic environment and are adapted to the regular challenges that arise. However, the current rapid pace and extent of both development and climate change may be too fast and drastic for many species.

Open water estuarine: the estuarine ecosystem is also at ***moderately high*** *risk* from development and climate change hazards (ANNEX 3 ; Table 5-1). The estuary is exposed and sensitive to coastal erosion caused by SLR, an increase in storm events, and a projected increase in seasonal inflow, flood pulse and sediment loads. Moreover, planned dike and port development will create additional hazards linked to changes in hydrology and sediment, and habitat alteration.

Current human activities in estuarine areas are leading to a rapid change in coastal ecosystem resources. In the future, projected changes in climate and sea level rise will be likely to increase the risk of estuarine areas, with even further changes in coastal ecosystem resources.

Sand dunes: the sand dune system in Ben Tre has a ***moderate risk*** of further climate and development hazards (ANNEX 3; Table 5-1). 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 the sand dune dry season aquifers. Increased precipitation during the wet season and in the upstream catchment of the Mekong River will both negatively and positively impact as it may assist in the reduction of saline intrusion during the dry season, however the extent of the reduction is unknown.

The increased average dry season temperature and prolonged and intense rainfall late in the wet season will impact biodiversity and ecological processes in coastal areas. It has been caused widespread death of the Ben Tre hard clam, introduce alien species (e.g. a freshwater mussel and increase of parasites on local gastropod species) and increase of disease outbreak. The predicted increase of unseasonal events will likely make the situation more serious. In previous wet seasons communities have seen alterations to the river hydrological regime and an increase in the high tides which have caused flooding and washed-out farming areas in Tron and Ho dunes, An Thuy commune.

Table 5-1: Final risk rating of key ecosystems/habitats of three coastal communes in Ben Tre province. Risk here refers both to the likelihood that current hazards and future changes will impact the listed ecosystems as well as the perceived severity of impacts on livelihoods based on community perceptions and expert opinion.
* Please refer to Annex 3 (Risk Ranking of Key Ecosystems/Habitats Matrix) for how the rankings have been 'averaged out'.

Ecosystems	Current hazards (climate and non-climate related)		Projected future changes and impacts		Final risk
	Description	Impact Severity	Description	Risk	
Estuarine areas	Water pollution, due to lack of proper treatment of sewage, as well as industrial activities, including dams. Trans-boundary impacts (hydropower, water pathway, irrigation projects in the upstream countries such as China, Laos, Thailand and Cambodia) that reduces sediment and nutrients in the water flows, causing low water quality	Moderate -High	If dams are constructed, altered hydrology will affect both quality and quantity of flows, particularly those planned up-stream. Unpredictable changes in upstream flows will strongly influence alluvial and sediment loads and affect estuarine hydrology. Stronger tropical monsoons, accompanied by stronger winds and bigger waves, will cause more extensive damage. Higher frequency and greater severity of tropical storms will likely cause damages to estuarine system	High	High
Mangroves	Expansion of agriculture and aquaculture results in clearance of mangrove forests, an increased use of chemicals, which are harmful to mangrove ecosystems. Increased SLR, accompanied with high spring tide, causes saline concentration, which also damages mangrove areas. Deforestation and weak law-enforcement of illegal logging also cause mangrove degradation.	High	The provincial plan of aquaculture expansion will highly threaten current mangrove areas. The projected increase in SLR, together with spring tide, will increase the possibility of forest land erosion. A projected increase in saline concentration and SLR could negatively impact the health of the mangroves. Projected increased storms and typhoons will also wreak extensive damage to mangroves . The province, however, is planning and implementing several strategies/action plans for mangrove restoration and plantation in the coming years.	Moderate	Moderate -High

Ecosystems	Current hazards (climate and non-climate related)		Projected future changes and impacts		Final risk
	Description	Impact Severity	Description	Risk	
Intertidal areas	Increased storm surges and stronger winds cause erosion, which results in losses of some intertidal areas but also the establishment of new alluvial areas.	Low-Moderate	The high projected increase of SLR, together with spring tide events, will greatly increase the saline concentration, which in turn could change alluvial composition and salt level. The planned construction of new harbors will likely disturb the integrity of intertidal zones and decrease their overall area.	Moderate-High	Moderate
Sand dunes	Population growth in associated settlements and increased exploitation of surface water are putting pressure on the sand dunes. Increased drought seasons and the accompanying increase in saline concentration impacts sand composition.	Low-Moderate	Projected increase in temperature and changes in rainfall distribution could extremely affect sand dune ecosystems and those living nearby. Possible limitation of fresh water access due to prolonged hot periods.	Moderate	Moderate

BOX 1: CRITERIA FOR ECOSYSTEM RISK RATING

High level: According to local communities, these hazards have the potential to cause the most damage to the integrity and resilience of the ecosystem and its ability to deliver key services for sustainable livelihoods, These are current and projected climate and non-climate related hazards.

Moderate level: According to local communities,these are severe hazards, which harm the integrity and resilience of the ecosystem and its capacity to sustain delivery of key services for sustainable livelihoods.These are current and projected climate and non-climate related hazards.

Low level: According to local communities, these activities are less harmfulthan the above categories, causing less damage to the integrity and resilience of the ecosystem. Again, these are current and projected climate and non-climate related hazards.

5.1.2 Integrated risk rating of ecosystem dependent livelihood activities

This section presents the assessment of the climate change and development risks facing the four key ecosystem dependent livelihood activities. This assessment comprises a holistic accumulation of risks including the degree of impact of livelihood activities on ecosystems (as assessed in the above chapter – chapter 3, the bottom up assessment); the risk level of each ecosystem service (also analyzed in the bottom-up assessment); the final compiled risk rating from current and expected climate change and development impacts. (Table 5-2,ANNEX 3).

Extensive/intensive shrimp farming (black tiger prawn and white-legged shrimp) has a ***medium high*** risk of impacts from development and climate change. Inadequate 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 the saline intolerant black tiger prawn farms) and further increase the risk of disease.

Clam (*Meretrix lyrata*) and blood cockle (*Anadata granosa*) farming is at ***medium high*** risk from climate change and development hazards. An increase in intensity and frequency of droughts, 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 estuarine **capture fisheries** are at ***medium risk*** from climate change and development hazards. There is an on-going investment in capture fisheries - development of ports, wholesale markets, boat shelters and seafood canning facilities. This continued unsustainable investment and development has the potential to cause unsustainable fishing practices and a collapse in the industry.

Vegetable plantations (watermelon, rice, jicama and beans) and have a ***medium 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 the currentagricultural crops and cropping cycle. 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 dunes are used to living in a 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 unsustainable development combined with the increased frequency and intensity of extreme hydro-meteorological events poses much greater risk to ecosystems and livelihoods than long-term climate change trends. Much of the development is to produce short-term economic gain that will quickly exploit the natural resource base. 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 dunes, intertidal and estuarine ecosystems), whichsupport the communities, communes and provinces. If these ecosystems are not sustainably managed the economic and social gain from development activities will be short lived. It is also worth noting that each ecosystem depends on other ecosystems and the loss or degradation of one increases the risk to the others.

5.2 Adaptive capacity

This section presents the analysis of three important areas of adaptive capacity, including:

i. **Community adaptive capacity** – The starting point for this assessment was to learn about the strategies and actions that local communities employ to cope with current climate and non-

Table 5-2: Risk rating of key ecosystem-dependent livelihood activities. The risk rating pertains to the severity of the activities' impacts on regional livelihoods. Ratings (3rd column) come from Table 5-1.

Ecosystem-dependent livelihood activities	Final risk ranking of supporting ecosystems		Final risk rating of potential future combined impacts	Final accumulated risk
	Ecosystems affected	Final projected risk		
Extensive/intensive shrimp farming	Estuarine areas Mangroves	High Moderate	Moderate/High	**Moderate/ High**
Clam farming	Mudflat bar Sandbars	Moderate/High Moderate/High	Moderate/High	**Moderate/ High**
Capture & offshore fisheries	Estuarine areas	High	Low/Moderate	**Moderate**
Vegetable plantation on sand dunes	**Sand dunes**	**Moderate**	**High**	**Moderate/ High**

climate related hazards in order to sustain their dependent livelihoods. Based on community inputs, we then evaluated whether these coping actions would be viable in the future and suffice to meet future trends.

ii. **Institutional adaptive capacity** – We assessed the current capacity of provincial and district government institutions to protect natural resources and prevent impacts or reduce risks of hazards. We also evaluated the capacity of these institutions to take advantage of opportunities to improve their management, and to take actions to reduce possible threats that will impact on management policies and actions for sustainable livelihood development and ecosystem conservation.

Table 5-3: Summary of ecosystem and livelihoods adaptive capacity - ecological, community and institutional - for the 3 coastal Ben Tre districts.

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

5.2.1 Community adaptive capacity: spontaneous adaptation strategies

In response to climate change and development risk, the community's adaptive capacity plays an important role. These coping actions come out as practical experiences of the local communities after years of facing climate related hazards. These actions are very effective in current weather conditions, however, they may not be sufficient in the future given the climate changes and development pressures. The 4 key dependent livelihoods activities were assessed to have the following adaptive capacity:

- **Extensive/intensive shrimp** farming: *Low to Moderate*;
- **Clam farming on intertidal:** *Moderate*;
- **Capture/offshore fishery:** *Low*; and
- **Vegetable plantation** on sand dunes: *High*

CRITERIA FOR ECOSYSTEM ADAPTIVE CAPACITY

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.

Institutional adaptive capacity

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

- There is strong support from the provincial authority leaders for climate change adaptation capacity building and application; however, human resources available for climate change adaptation are limited in both quantity and quality, particularly at the local level. Raising awareness for and leading adaptation strategies are challenging. Natural resource protection to reduce impacts of climate related disasters has not been a priority.
- Current institutional policies encourage unsustainable agricultural development through the over-exploitation of natural resources (land, water, forests and fisheries). This is leading to the exhaustion of these resources and the overall degradation of the environment. These practices further increase risks associated with climate change and reduce communities' ability to adapt to climate change
- Among the four selected ecosystems, the province of Ben Tre stands out as having started to invest in mangrove rehabilitation and replantation on degraded areas in recent years. In 2008 a review of mangrove forest allocation in the entire province was conducted, and the results from this research have been used to develop the provincial forest protection and development planning through 2020. These plans were submitted to Ministry of Natural Resource and Environment, which will soon approve them.

- The second important project related to mangrove forests is a 2012 economic report on coastal forest plantation in Ben Tre province, approved by the Department of Natural Resource and Environment. Under the provincial climate change adaptation and SLR action plans, mangrove rehabilitation and replantation is also a priority; however, no funds have yet been allocated to these initiatives. Lack of awareness of of the threats of climate change at all levels, from policy makers to the community residents, is an obstacle. Furthermore, the lack of communication and coordination between government departments and institutes on strategies and policy may reduce the efficiency and effectiveness of implementing adaptation strategies. However a standing office of National Target Plan for the Response to climate change (NTP-RCC) in Ben Tre province is working with both DONRE & DARD on climate change action plans. Climate change adaptation strategies will be incorporated into sectorial integration plans in Ben Tre province, after which more opportunities for strengthening communication and collaboration among relevant departments, particularly DONRE and DARD, will exist.

- Various research institutions and NGOs have begun to invest, conduct studies, and provide technical support for projects in preparation for climate change. These will help strengthen institutional capacity and build resilience in local communities.

Institutional adaptive capacity in Ben Tre coastal districts has been rated as *low* based on the above discussion. While mangrove restoration is a top priority, funds have still not been allocated to this work—and the total area of mangroves of the province continues to decrease. Investment in capacity building does continue to grow, however, which is promising for future institutional adaptation.

Figure 5-1: Coping strategy: nylon net to cover cockle nursery areas to avoid sun in Binh Dai district. (Photo: Lê Anh Tuấn, 2011)

Figure 5-2: Coping strategy: dike system in Thanh Phu district to protect local communities and production areas. Outside of the dike is the mangrove area. (Photo by:Lê Anh Tuấn, 2011)

Current Coping Strategies

Table 5-4 summarizes the current coping strategies of local communities, taken from field surveys and workshops.

Local **communities** have implemented many initiatives to adapt to changes in climate and the coastal environment. These include the establishment of cooperatives for sustainable clam management and production; using nets to cover cockle nurseries against the sun (Figure 5-2); farming clams 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.

Current **government** adaptive strategies include: the development of coastal dikes (Figure 5 -3); 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 goverment 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 short term results, these constructions can damage natural systems, often leading to maladaptation in the long term.

Construction and climate change severely threaten shrimp farming, one of the most important subsistence activities in the region. One adaptation strategy has been to switch from raising black tiger prawns to white-leg shrimp. , which has reduced overall fisheries losses and increased the income for local communities; however, according to many aquaculture scientists, this is not a sustainable solution, due to of the low-quality seed, which breeds diseases and leaves antibiotic residue in the marine ecosystems.

5.2.2 Institutional adaptive capacity

Figure 5-3: A Well for getting freshwater for watermelon (left) and tanks to store drinking water for drought (right)

Table 5-4: List of the current coping strategies of local people and government

Climate change hazards	Coping actions
Unseasonal rainfall	No reaction
Prolonged hot weather, drought	Using nets to shield cockle nurseries from the sun. Scattering clam farms at lower elevations for 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 the project 661 from 1998 – 2010)
Erosion and monsoon 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 the 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.

5.3 Final vulnerability assessment results

The vulnerability is the combination of the risks and overall adaptive capacity. Table 5-5 shows the vulnerability assessment of each key ecosystem and their dependent livelihood activity of the three coastal districts of Ben Tre province. The vulnerability to climate change and development for the four ecosystems can be summarized as follows.

i. **Open Water Estuarine** has a *high* vulnerability;

ii. **Mangroves** have a *moderate to high* vulnerability;

iii. **Mudflats and sandbars** have a *moderate* vulnerability; and

iv. **Sand dunes** have a *low to moderate* vulnerability level.

The vulnerability to climate change and development for the four livelihood dependent ecosystems can be summarized as follows:

i. **Extensive/intensive shrimp farming** has a *Moderate to High* vulnerability;

ii. **Clam farming on intertidal** has a *Moderate* vulnerability;

iii. **Capture/offshore fishery** has a *Moderate to High* vulnerability; and

iv. **Vegetable plantations** have a *Moderate* vulnerability.

Table 5-5: Summary of the vulnerability (hazard, risk - sensitivity and exposure, adaptive capacity) assessment for the ecosystem and key ecosystem-dependent livelihood activities in three communes of Ben Tre province.

		Level of importance to community	Current hazards	Future potential climate and development hazards	Risk ranking[8]	Adaptive capacity[9]	Vulnerability[6]
Ecosystem	Coastal mangroves	Med – high, most important for Thua Duc and Thanh Hai communes	Dramatic loss of mangrove habitats, due to expanding areas of shrimp farming aquaculture; Deforestation and weak forest management; Trans-boundary impacts (hydropower, water pathway, irrigation projects in the upstream countries such as China, Laos, Thailand and Cambodia); reduction of sediment and nutrient loading.	Permanent-regular inundation from SLR with little migration options for many species; Increased erosion from increased storm activity and monsoonal winds; Uncertain change to the alluvial dynamic of the mudflats and sandbars due to increased flow and increased sedimentation from upstream catchments. SLR and spring tide inundation; Dike construction – flow, sediment and habitat alteration; Continued (unsustainable) investment and development of shrimp farming under the provincial SEDP; Port and wholesale market development will increase the demand for shrimp.	Moderate/ High	Low	High
Key EDLA[10]	shrimp farming	Med – High, most important to Thanh Hai commune		Continued (unsustainable) investment and development of shrimp farming under the provincial SEDP (boom and bust); SLR increasing salt concentration; Increased temperatures causing disease and sudden changes in salt concentration; Increased erosion and mangrove destruction leading to a loss of natural habitat and food.	Moderate/ High	Low/ Moderate	Moderate/ High
Ecosystem	Intertidal alluvial mud flats and sandbars	Med – High, most important for the An Thuy commune	Over-exploitation of aquaculture mudflat and sandbar resources, Increased erosion process Trans-boundary impacts reducing sediment and flows Polluted water from storms, water run-off, sewerage, industrial contaminates from the port and shrimp farms.	Permanent inundation from SLR with little migration options for many species; Uncertain change to the alluvial dynamic of the mudflats and sandbars due to increased flow and increased sedimentation from upstream catchments; Changes to sediment dynamics and suspension from increased annual flood discharge through the estuary; Dike construction – flow, sediment and habitat alteration; Port, bridge, industrial zone and associated infastructre expansion and development reducing and degrading the area of intertidal ecosystems;	Moderate	Low	Moderate-High
Key EDLA	Clam farming	Low – Med		Increased annual maximum temperature could cause increase in mass, simultaneous death of clams; Increased recurrence of SLR and saline intrusion will be likely cause death of clams; Increase in insect disease (mosquito fly) due to increased rainfall in the wet season rainfall.	Moderate/ High	Moderate	Moderate

		Level of importance to community	Current hazards	Future potential climate and development hazards	Risk ranking[5]	Adaptive capacity[6]	Vulnerability[6]
Ecosystem	Open water estuarine	Med – high, most important for Thua Duc and Thanh Hai communes	Polluted water from storm water run-off, sewerage, industrial contaminates from the port and shrimp farms Water infrastructure on river such as dams & harbours including transboundary impacts (hydropower and irrigation projects in upstream countries) that reduces sediment and flow.	Increased coastal erosion, due to increased storm activity, monsoonal winds and SLR; Increase in annual flow, flood pulse and flooding, due to the increase in precipitation in the upper Mekong Basin; Uncertain change in the alluvial dynamic of the mudflats and sandbars due to increased flow and increased sedimentation from upstream catchments; SLR and spring tide inundation; Increased estuarine/marine aquatic habitats due to increased upstream flow and SLR; Dike construction – flow, sediment and habitat alteration; Increased temperature impacting the shrimp farms and ecology.	Moderate/ High	Low	High
Key EDLA	Capture fisheries	Low – Med, most important to An Thuy commune and less important to Thanh Hai commune		Continued (unsustainable) investment and development of shrimp farming under the provincial SEDP – boom and bust; SLR causing increase in salt concentration; Increased temperature causing disease and sudden changes in salt concentration; Increased erosion and mangrove destruction leading to a loss of natural habitat and food.	Moderate/ High	Low/ Moderate	Moderate/ High
Ecosystem	**Sand dunes**	Med	Population growth coupled with increasing agricultural and industrial demand; Increasingly polluted water and soil due to a new harbor and other land constructions, as well as sewage from water transportations; Residents simultaneously exploit, destroy and adjust and recover natural resources; Increased road/ infrastructure construction and infrastructure cut the connectivity of dune ecosystems.	Increased storm, rainfall events and monsoonal wind impact the dynamic nature of the sand dunes, reducing access to shelter and flood refuge areas as well as agricultural land. Increased SLR could possibly limit freshwater access, causing saltwater intrusion and reduction in access to shelter and flood refuge areas.	Moderate	High	Low/ Moderate
Key EDLA	Vegetable plantation	Low – Med, Most important to Thua Duc commune		Unseasonal rainfall may have serious negative impact on watermelon crops. Increased duration and intensity of rainfall events may cause poisonous levels of alum concentration. Delay in the start of the wet season will change the shrimp crop calendar.	Moderate/ High	High	Moderate

[5] The Risk Ranking and Vulnerability score for the key ecosystem dependent livelihood activity combines both the risk assessment of the ecosystems and the dependent livelihood activity. For activities that happen in more than one ecosystem, for example shrimp farming, which is in both mangroves and intertidal areas, this combines both the ecosystem risk ranking for mangroves and intertidal areas.

[6] Adaptive capacity of an ecosystem is based on the institutional arrangements for the management and protection of those ecosystems. It was not possible to assess the adaptive capacity of each ecosystem under this report study.

[7] Ecosystem-dependent livelihood activities

* Please refer to the Annex 3 (Vulnerability Matrix) for the calculation of how the rankings have been 'averaged out'.

> Mangrove restoration and rehabilitation has been and should be more invested to strengthen the resilience against projected increased sea level rise and changes in climate

6 ADAPTATION OPTIONS & RECOMMENDATIONS

Climate change adaptation aims to reduce vulnerabilities to climate-related hazards by i) decreasing exposure and sensitivity to these hazards and ii) by increasing the adaptive capacity and resilience of communities, provinces and the national government to climate change pressures (Figure 6-1). Multiple mechanisms and approaches should be integrated when developing adaptation strategies and actions. This should include: natural systems adaptation; land-use planning; community and social adaptation; economic instruments; policies and plans; institutional mechanisms; and engineering solutions. It is now widely recognized that adaptation should:

- Promote long-term local solutions for people and nature
- Start to adapt NOW with optimal or *no-regrets*[8] actions and reduce the adaptation deficit; this includes focusing on reducing non-climate stresses;
- Involve local communities and address governance and justice issues;
- Develop multi-partner, multi-sector, multi-scale strategies;
- Build upon existing NRM good practices and recognize that the climate is not static;
- Adopt adaptive management approaches and support local innovation;
- Integrate Ecosystem-based Adaptation with wider climate adaptation strategies; and
- Promote communication and education, sharing and exchange.

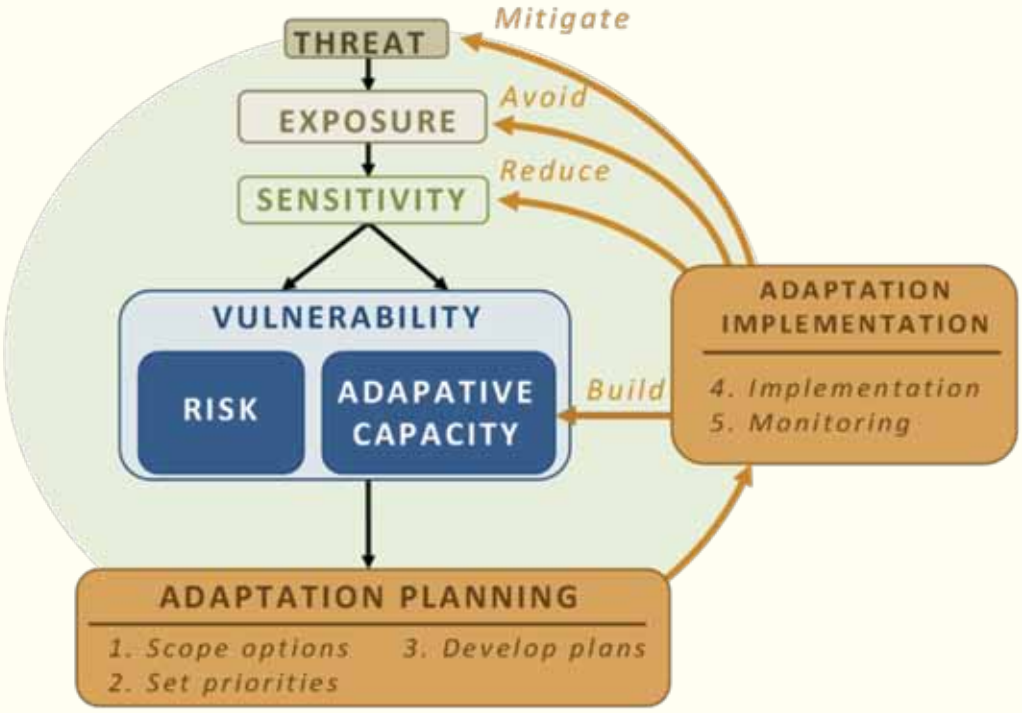


Figure 6-1: Adaptation planning and implementation cycle (ICEM, 2012)

[8] '*No-regrets*' describes those 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*'.

There is a critical need for immediate reduction in non-climatic pressures on ecosystems and livelihoods - this is an important element of climate change adaptation for coastal areas. This should aim to help people improve their key livelihoods while maintaining and restoring the key supporting ecosystem services.

Adaptation options have been developed through community consultation with consideration of the results of the vulnerability assessment (presented in section 5 of this report). These adaptation options have been designed to use a multiple approach to climate change adaptation and have integrated the *climate deficit, community & ecosystem* based approach.

The above findings of RIVAA show that all four selected ecosystems and their dependent livelihood activities are at a medium to high vulnerability to climate change. These findings provide us with the evidence needed to promote and develop adaptation plans to protect the four key selected ecosystems and maintain their services for sustainable dependent livelihood development. In order to provide ecosystem services for livelihood activities, we recommend the following key areas of concern. The prioritized recommended adaptation actions for Ben Tre provinces are:

i. **Climate smart mangrove restoration**;

ii. **Revised zoning and land-use planning** in coastal areas;

iii**. Freshwater resource management;**

iv. Climate change **policy mainstreaming**; and

v. **Monitoring** climate change adaptation and development.

These adaptation options are complementary with the community-level interventions already being implemented or are being proposed by the province and individual districts.
These go along with a large climate change awareness and education program coinciding with other adaptation actions.

6.1 Climate smart mangrove restoration

Mangrove restoration was first initiated in 1998 in the districts of Ba Tri and Binh Dai. WWF and the Ben Tre government are currently continuing mangrove restoration activities. WWF is assisting to set up a 2.2 ha mangrove nursery in Ba Tri district that will produce one million seedlings per year for mangrove restoration efforts across the Mekong Delta. WWF is working with government partners in Binh Dai district to plan the restoration of *Avicennia* and *Sonneratia* in a 3 to 4 ha coastal strip that used to contain *Rhizophora* that were killed by wave and sand action. They will plant blocks with different mixes of species, surrounded by natural fences, and monitor their progress over time.

Mangrove restoration and rehabilitation have been invested in by Ben Tre province for more than 10 years. However, the investments in mangrove restoration are at a small scale and short-term. Under the Action plan to respond to Climate change and SLR of Ben Tre province (2011 to 2015), there have been no funds allocated to mangrove rehabilitation and plantation in 2012. There is an expectation, however, of 800 million Vietnam Dongs fund allocation for mangrove plantation in 2013 but not in future years. Moreover, climate related hazards have not been taken into consideration in provincial mangrove restoration design plans.

It is recommended that (climate smart) mangrove restoration projects are expanded to, and focus on Thanh Phu NR and Binh Dai districts. In addition the management board of Thanh Phu Nature Reserve should receive further investments in high technology equipment and training in climate-smart mangrove restoration.

These projects should be closely monitored and expanded. There is a need of longer-term monitoring of mangrove survivorship and project effectiveness in climate change adaptation. **It is highly recommended that local people be more involved with planting, monitoring, and enforcement processes**.

This report refers to climate-smart mangrove restoration as: Increasing the resilience of the mangroves to more severe extreme weather events especially storms and climate change impacts such as SLR, erosion and storm surges. This is fundamental to the success of future mangrove restoration projects. Climate-smart mangrove restoration includes:

- Mangrove restoration project design effectively integrates the projected impacts of the future climate trends.
- The use of varying species and support structures in mangrove restoration so it is designed to withstand future climate change hazards.
- Process of mangrove seedling selection and plantation has developed since the introduction of traditional practices. The nurseries can provide better quality of seedlings for plantation. Good quality mangrove seedlings, particularly the *Avicennia, Sonneratia* and *Rhizophora*, which are the dominant species in the coastal districts of Ben Tre province, provide stronger young mangroves.
- Following the correct timetable for mangrove sowing which means in the season of less strong waves and winds. This increases the survival of the mangroves.

Investment in mangrove nurseries is required from the local and central government to improve the conditions of the mangrove seedlings and to expand the mangrove nursery network across the Mekong delta. In addition, **all mangrove restoration projects should be 'climate-smart'.**

Shrimp farming increased from 5.4% of land cover in 1989 to 36.5% in 2004, while the area of mangrove decreased sharply from 61.6% to 26.2% over the same period. **This is the greatest threat to the ecosystems and community of the Ben Tre province.** 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 mangrove forests.

In the SEDP there are conflicting goals between shrimp farm growth and development and mangrove restoration and conservation. It **is therefore recommended that new developments, including shrimp farms, require an environmental impact assessment and social impact assessment to be completed. It is also recommended that a strategic environmental assessment is complete for the SEDP**, which would assess the combined environmental impact of the multiple faceted SEDP. In addition **all new developments should undertake a climate change vulnerability assessment to ensure they are 'climate-smart'.**

It is also **highly recommended that the other conservation and restoration projects are implemented for the other 3 key ecosystems in the area – intertidal mudflats and sandbars, open water estuaries, sand dunes**. This would require an assessment of the most ecologically significant and important as well as the most vulnerable areas (both to climate change and development). The conservation plan to be developed would be see not only important habitats and species preserved but would be a significant step in the reduction of vulnerability to climate change through the reduction of the *climate change deficit*.

6.2 Revised zoning of coastal development

Revised zoning and **land-use planning** in coastal areas is a critical step to climate change adaptation. Shrimp farms, roads and other infrastructure are planned for exposed areas of the coastline. Avoiding exposure is an easy and cost-efficient form of climate change adaptation. *Climate-smart* land-use planning is critical and may require the reallocation of some assets and planning infrastructure to alternative sites. In Ben Tre, the local communities identified shrimp ponds, farms, roads, infrastructure, and other human activities in vulnerable coastal areas as clear concerns.

There are many infrastructure developments outlined in the Ben Tre SEDP for the next 10-20 years: ports and wholesale markets, upstream dams and irrigation as well as road and other infrastructure

that supports industrial development. Additionally, the coastal ecosystems and the livelihoods that depend on them are under pressure due to population growth and increasing demand for agricultural production and fisheries. Dam and dike development targets are also in line with the Action plan to respond to Climate change and SLR (2011-2015). However, **it is strongly recommended that the province be more careful in preparation for constructing this infrastructure by integrating the SLR scenarios and making appropriate adjustments**. Land-use planning needs to achieve a sustainable balance between development, food security and environmental conservation.

Zoning and land-use planning needs to include the conservation and protection of all sensitive coastal ecosystems. This would assist in climate change adaptation and build long term, sustainable fisheries including: clam, shrimp and captured fisheries. Additionally and importantly, land use planning needs to be integrated with the SEDP plan to ensure it avoids conflicting priorities and mal-adaptation.

Climate change mainstreaming into regional and provincial land-use plans is critically important. Approaches to reducing coastal vulnerability through the (climate-smart) restoration of natural ecosystems and the rationalization of land zoning are highly recommended for discussion and input in the future land-use planning process in Ben Tre province and Mekong delta.

The beginning description of Thanh Phu district shows that this area has outstanding, intact ecosystems. The recent unusual climate related hazards such as storms show that the district received less damage than the two others. Both local communities and government say that it is because of the healthy mangroves. The Thanh Phu natural resources have been sustainably used and not yet over-exploited. There are many opportunities for Thanh Phu to maintain and conserve its intertidal, mangrove, estuary and sand dunes ecosystems. **It is recommended that land use planning and zoning be implemented in each district to ensure that ecosystems can play their important role in supporting the development of each district.**

Binh Dai district has exploited much of their natural ecosystem but there are still possibilities to maintain and preserve a part of the mangrove ecosystem and establish other key ecosystem functions. Ba Tri district consists of many livelihoods and has a complex combination of pressures, including population growth and natural resource exploitation. Its coastal ecosystems are thought to be becoming increasingly vulnerable due to these increasing pressures. Both these districts will be highly vulnerable to SLR. **Zoning and land-use planning for the period from 2011-2025 should take into consideration the SLR scenarios to ensure the physical constructions will be adaptive to the projected increased severe inundation and saline intrusion. The land-use planning should also recognise the importance of conservation of natural resources.**

There has been a large expanse of intensive watermelon farms along the banks of an estuary in Ba Tri district. This area had been severely affected by recent flooding, unseasonal rainfalls with considerable damage to some of the farms. Such flooding and erosion events are likely to increase. Even in the case of the 3,000 ha Thanh Phu mangrove reserve, GIS shows agricultural development taking place on the seaward edge outside the mangrove belt.

One of the very important first adaptation actions is to plan and promote the relocation of vulnerable agriculture, aquaculture, infrastructure, and human settlements behind coastal vegetation, then further inland if possible. This would make those activities less vulnerable to intense storms and sea level rise, allow for a more dynamic coastline (with a reduced need for hard infrastructure), and provide additional opportunities for coastal re-vegetation and ecosystem conservation.

6.3 Freshwater conservation

Freshwater resources (both ground and surface) for the community and ecosystems are scarce in the coastal communes of Ben Tre. This situation is likely to continue and predicted to become more serious over the next 50 -100 years. More frequent and intense storms, floods, and droughts are likely for Ben Tre province, altering the quality and quantity of freshwater resources. Currently there is little known about freshwater resources in Ben Tre province.

Both the SEDP and action plans to respond to climate change and SLR mention the need for freshwater conservation. However, these two planning documents have not come up with a long -term and detailed process of how to conserve freshwater resources (both ground and surface) sustainably. The projected greater severe saline intrusion, drought and hot period events along with expected increases in aquaculture activities, particularly shrimp farm expansion, will strongly impact freshwater resources. **Freshwater resource management should be of the highest priority in the coming years and strongly required at these three coastal communes;** this could include:

i. Analysis of the provincial **hydrology including mapping of surface and groundwater**; particularly important for the three coastal communes under this report assessment

ii. Investigation of **freshwater pollutants** (industrial, domestic sewage, storm-water, shrimp farms) and plans for improving water quality;

iii. **Protection and/or restoration of riparian wetlands** that protect freshwater resources;

iv. **Coordination with upstream uses** to secure freshwater for downstream uses and ecosystems. Managing river flows and sediment delivery is required. Upstream dams are and will be a major issue; and

v. The development of a **conservation and management strategy** for freshwater resources in Ben Tre province. This is required to a. protect springs, other water sources and storage areas, b. restore riparian wetlands that can help to buffer human settlements and agricultural areas from seasonal flooding and c. look at the opportunities to remove existing water impoundment infrastructure and restore natural flows (Tram Chim Wetland is a good example).

6.4 Policy and climate change mainstreaming

While "hard" engineering solutions have been favoured previously, the communities and this assessment have recommended ecosystem restoration and conservation, and institutional adaptation as alternatives. These adaptation recommendations have been designed to be implemented and **mainstreamed** into short- and long-term planning processes such as the annual Climate Change Action Plan (CCAP) of Ben Tre province and the National Target Program to Respond to Climate Change (NTP-RCC).

The Ben Tre government and communities will continue to develop and update adaptation strategies to protect people and their livelihoods. Many adaptation strategies are described in the five-year Framework Action Plan of Ben Tre province to respond to Climate Change (FAP-RCC 2011-2015). Some are ecosystem-based (such as protecting mangroves and managing water resources), but in many cases, hard infrastructure is favoured. In addition, there are considerable uncertainties about how to integrate climate-adaptive approaches into the province's development plans and targets.

There are updated climate change related policies in Ben Tre province, the Action plan to respond to Climate change and SLR, the CCA and SLR framework and detailed Climate change and SLR scenarios as well as the SEDP (all in period 2011-2015 and vision to 2020). Each of these policies has pointed out prioritized activities in the coming five years. This report highlights, however, that there is a lack of synchronization and connection among them. The prioritized activities currently are often isolated and scattered. **There should be a follow up and coordination between the detailed Climate change & SLR scenarios for Ben Tre province and the action plan and the framework.**

The action plan and framework should design adaptation strategies based on key significant findings in the detailed climate change & SLR scenarios for Ben Tre province. SLR and its consequences of increased inundation and saline intrusion are the most adverse and intense hazards to the three selected coastal communes and districts.

The scenarios of 75 cm increase of SLR will inundate around 50% total areas of Ba Tri and Binh Dai districts and one third of Thanh Phu district. These figures show the urgent need of a really comprehensive master plan to reduce and minimize the adverse impacts. Climate change and sea level rise effects on natural ecosystems, particularly mangrove forests and local livelihoods. are complex matters. **Long-term**

monitoring of changes to the coastal systems at the three coastal districts is required.

Observations can then be incorporated into future planning and policy development. It is **recommended that a climate change and development monitoring system be integrated and implemented through the district policies and institutes.**

It is highly recommended that there should be a vulnerability assessment of climate change impacts to ecosystems and more studies of consequences of climate change impacts on ecosystems services, livelihood activities and dependent communities.

Many of the activities under the SEDP (2011-2015) promote more intensive resource use or inappropriate development in sensitive areas. Some significant plans are improvement of aquaculture activities, particularly shrimp farming and white-leg shrimp farm promotion. The continuity of dam construction both new and expansion plans to get freshwater also threaten the healthy development of brackish and salty species in the long-term. These can change ecosystems and potentially become maladaptation strategies that will increase the risk and vulnerability of the ecosystems, the communities and their livelihoods. This assessment's climate change adaptation **recommendation should be incorporated into the Ben Tre CCAP and NTP-RCC. Furthermore, the Ben Tre action plan and response to climate change should be mainstreamed into the national and provincial SEDP.**

Integrated climate change adaptation strategies and plans should align with local socio-economical development projects and current livelihood activities. The future planned climate change adaptation actions should build on current spontaneous adaptation measures. However, there will be a need for monitoring and evaluation of the successes of these measures against climate change effects. At the same time, it also requires buy-in and support from governments (both central and provincial) as well as support from scientific research programmes and civil society and NGO projects. **New adaptation innovation should be integrated and led by the communities with the approval and support of the government.**

6.5 Monitoring and evaluation

Monitoring of adaptation planning and implementation is recommended to ensure mal-adaptation is avoided, lessons are learned and successes maximized. Monitoring and evaluation will be critical to the CCAP and NTP-RCC strategies. Monitoring needs to be long term and targeted if it is to show climate change and adaptation progress. It is recommended that monitoring and evaluation should focus on monitoring the ecosystems themselves (their health and condition), the livelihood dependent activities and climate change trends.

It will be **important to monitor this healthy ecosystem for climate change impacts**. For example, Thanh Phu district has outstanding and intact ecosystems and it will be important to understand what is surviving? What are we losing due to extreme events? etc. This will help us better understand how ecosystems are responding to changes in climate and will be useful for future planning. And if we can show that an intact ecosystem type is resilient to change, then we can be more confident in saying protection and restoration are good adaptation strategies.

Next Steps:

The assessment didn't have the capacity to identify the levels and margins of exposure and sensitivity of the livelihoods and ecosystems to climate change and therefore could not develop prioritized adaptation options. As consequence, the adaptation options could not be down scaled or specified for a specific ecosystem or group of community. And it is impossible to identify prioritized options. Instead broader district and provincial options and key recommendations are presented and discussed in chapter 6. Further study is required to develop an 'adaptation action plan' for each coastal district that would use this RIVAA as a starting point.

ANNEX 1. Household questionnaire

RAPID ASSESSMENT OF THE VULNERABILITY AND ADAPTION TO CLIMATE CHANGE BASED ON ECOSYSTEM

QUESTIONNAIRE CODE[9]	INTERVIEWEE NAME	INTERVIEWED DATE
		____/____/2011

A. HOUSEHOLD INFORMATION

1. Name of interviewee:_____[ ] Male [ ] Female

2. Household address (Full detail: no./street/hamlet/commune/ward/district/province):

No_____Street/hamlet_____Commune/ward_____

District:_____Province: _____

3. Population:

3,1 Total number:_____ No, of male _____ No, of female _____

3,2 Laborer:_____ No, of male _____ No, of female_____

4. Level of Education:

No, of people	Illiterate	Primary school	Secondary school	High school	Higher education
Household head					
Wife/husband of household head					

Other household members (children, daughter/son-in-law, etc,), *please list*

Kindergarten	Primary school	Secondary school	High school	Undergraduate	Graduate

B. CULTIVATION MODEL (PRODUCTION ACTIVITIES) OF YOUR FAMILY (KEY NATURAL DEPENDENT LIVELIHOOD ACTIVITIES)

5. What is your family's main source of income? (What is your family's key livelihood?)

---

6. Could you please list the other sources of income, in order of importance?

Aiding livelihood/job of your family (what poultry, plants, jobs)	Cultivation area (where in the map)	Rating

7. Calendar of livelihood activities (labouring, trading, aiding job):

Livelihood activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec

8. Please rate the importance (value) of natural resources in your residential and production areas (agricultural land, forest, alluvial ground, river, ocean, etc,) to your livelihood and daily life:

Natural resources	Rating

9. Changes (e.g., Total area, location and quality) of natural resources (forest, alluvial ground, river, ocean, ect,) that relate to your livelihood from 2000 up to now,

Natural resources	Changes in 2000 - 2011		
	Area	Location	Quality

C. NATURAL HAZARD RISKS, HUMAN IMPACTS AND RESPONSE

10. Do you remember, in the past 10 years, that your local community experienced any natural hazards or unusual weather conditions (please mark X on the months that it happened)?

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
High temperature (warm)												
Droughts												
Alkalized												
Nhiễm mặn												
Flood												
Lốc xoáy												
Storm												
Tidal flood												
Thunderbolt												
Low temperature (cold)												
Erosion or land slide												
Other unusual hazards (please list below)												

11. Compared to the past 10 years, how have the usual weather conditions changed?

	Increased	Stable	Reduced	Your own experience
High temperature (warm)				
Droughts				
Alkalized				
Increased Salt				
Flood				
Whirlwind				
Storm				
Tidal flood				
Thunderbolt				
Low temperature (cold)				
Erosion or land slide				
Other unusual hazards (please list below)				
High temperature (warm)				

_____

_____

12. In the past 10 years, did your community experience any difficulties resulting from government regulations on land/crops/hydro-construction or were there any spontaneous activities of local residents that affected the area's livelihood (please list in the table below)?

Factors/causes	Livelihood/agricultural production model	Damage

Please explain damage causes?

_____

_____

13. Loss in production and daily life due to unusual weather conditions in the past 10 years,

Productivity reduced	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Poor crops												
Lack of drinking water												
Cattle die												
Diseases in plant												
Disease in human												
House damage												
Losing job												

Productivity reduced	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Immigration												
Work interruption												
Losing capital												
Other loss												
(please explain below)												

Please explain damage causes?

_____

_____

14. Loss in production and daily life due to currently unusual weather conditions?

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Productivity reduced												
Poor crops												
Lack of drinking water												
Cattle die												
Diseases in plant												
Disease in human												
House damage												
Loosing job												
Immigration												
Work interruption												
Loosing capital												
Other loss												
(please explain below)												

Please explain damage causes?

_____

_____

15. In your experience, what are the impacts from climate change? Please list the impacts in order importance to your daily life and your key livelihood activities (agricultural production),

Types of natural hazards/weather patterns	Rating

Please explain?

_____

_____

16. Are there any methods implemented in your community (hamlet, commune, etc,) to respond to climate change's impacts? Please rate them in order of participated numbers, from those that have the same key livelihood as yours

17. If you have to change growing season and vegetation and cattle, how will you change them according to the following timetable:

Adaptation methods to climate change at hamlet (commune) level		Rating
Happen in your area	Participate?	

Please explain why you choose or do not choose the methods?

_____

_____

18. Do you have any suggestion to reduce the impacts of or take advantages of positive effects from climate/weather change? (please give details)

Vegetation/cattle/ aquaculture/ other	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec

Please explain your choice,

_____

_____

19. Has any member of your family taken part in a training course on preventing natural hazards or on related issues?
Yes [ ] No [ ] if yes, please give more details:

Course title	Main content	Time	Who organized?	Who participated?

20. Is your family aware of natural hazards and climate change in the future?
Yes [ ] No [ ]
If yes, please choose sources of information:
Press [ ] Radio [ ] Television [ ] Authority [ ]
Internet [ ] other [ ]

21. Do you want to enlarge the shrimp farming area??

Yes [ ] No [ ] If yes, please choose:

- Using residential area or unused land around the house [ ]
- Encroaching on the mangrove land [ ]
- Buy/hire other shrimp farming areas near yours [ ]
- Buy/hire other shrimp farming areas further away from yours [ ]
- If not, please tell if you:
- Transform shrimp farming area for other purposes [ ]
- Are satisfied with the current area [ ]

Please give more explanation

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NOTES

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ANNEX 2: List of Interviewees

List of Ben Tre provincial and district authorities took part in RIVAA survey

No.	Full name	Organization/Agencies
1	Đoàn Văn Phúc	Ben Tre city Environmental Protection Agency
2	Tiết Kim Chiêu	Science and technology office, Department of Agriculture and Rural Development
3	Đặng Thị Hồng	Binh Dai Agriculture Office
4	Phan Thanh Dũng	Binh Dai Environment Office
5	Võ Văn Việt	Binh Dai Environment Office
6	Hồ Văn Thương	Ba Tri Forestry Office
7	Lê Văn Tài	Thanh Phu Forestry Office
8	Lê Văn Hải	Thanh Phu Environment Office
9	Phạm Văn Trường	Thanh Phu Protected and Special Purpose Forest Management Board

Interviewee list in Thua Duc commune, Binh Dai district

No.	Full name	Gender	Address
1	Trần Văn Của	Male	Thua Trung hamlet
2	Nguyễn Thị Hoa	Female	Thua Trung hamlet
3	Nguyễn Hoàng Nam	Male	Thua Trung hamlet
4	Huỳnh Văn Hận	Male	Thua Trung hamlet
5	Châu Văn Đoan	Male	Thua Trung hamlet
6	Lưu Hữu Nghĩa	Male	Thua Trung hamlet
7	Phan Thị Chài Chị	Female	Thua Trung hamlet
8	Trần Văn Phùng	Male	Thua Trung hamlet
9	Hồ Hồng Huyền	Female	Thua Thanh hamlet
10	Lê Thanh Long	Male	Thua Trung hamlet
11	Nguyễn Văn Đức	Male	Thua Tien hamlet
12	Nguyễn Thị Kim Xuyến	Female	Thua Trung hamlet
13	Nguyễn Ngọc Hạnh	Female	Thua Trung hamlet
14	Trương Thị Bé	Male	Thua Trung hamlet
15	Trần Văn Hai	Male	Thua Trung hamlet
16	Phạm Thị Điều	Female	Thua Trung hamlet
17	Dương Thị Sửu	Female	Thua Trung hamlet
18	Ngô Thị Nhã	Female	Thua Trung hamlet
19	Phan Văn Dựt	Male	Thua Trung hamlet
20	Mai Thị Yến Nhi	Female	Thua Trung hamlet
21	Nguyễn Thị Tuyết Thu	Female	Thua Trung hamlet
22	Lưu Văn Tài	Male	Thua Trung hamlet
23	Lê Văn Cường	Male	Thua Trung hamlet
24	Nguyễn Văn Quang	Male	Thua Trung hamlet

List of Ben Tre communal authorities took part in RIVAA survey

No.	Full name	Organization/Agencies
1	Hà Văn Voi	Thanh Hai commune, Thanh Phu district
2	Nguyễn Minh Thơ	Thừa Đức commnue, Binh Dai district
3	Trần Văn Phấn	An Thuy commune, Ba Tri district

Interviewees list in Thanh Hai commune, Thanh Phu district

No.	Full name	Gender	Address
1	Huỳnh Văn Ngọc	Male	No, 8 hamlet
2	Nguyễn Hữu Phước	Male	No, 8 hamlet
3	Phạm Văn Dạn	Male	No, 8 hamlet
4	Dương Thị Thùy Linh	Female	No, 8 hamlet
5	Lưu Thị Cuộn	Female	No, 8 hamlet
6	Bùi Văn Tiến	Male	No, 8 hamlet
7	Huỳnh Văn Lướt	Male	No, 8 hamlet
8	Nguyễn Văn Cương	Male	Thạnh Hưng B hamlet
9	Phạm Văn Thuận	Male	No, 8 hamlet
10	Nguyễn Văn Phương	Male	No, 8 hamlet
11	Trần Thị Nga	Female	Thạnh Hưng B hamlet
12	Phạm Văn Chim	Male	No, 8 hamlet
13	Nguyễn Văn Đoàn	Male	No, 2 B hamlet
14	Ngô Văn Hồng	Male	No, 8 hamlet
15	Phạm Văn Sắt	Male	No, 8 hamlet
16	Phạm Thị Mai	Female	No, 8 hamlet
17	Nguyễn Văn Nghĩa	Male	No, 8 hamlet
18	Phạm Văn Tâm	Male	Hamlet 8
19	Phạm Thị Mộng Thúy	Female	Hamlet 8
20	Đinh Văn Nhánh	Male	Hamlet 8

Interviewee list in An Thuy commune, Ba Tri district

No.	Full name	Gender	Address
1	Nguyễn Tườn Quang	Male	No, 3 hamlet
2	Nguyễn Văn Nhỏ	Male	An Thới hamlet
3	Lê Văn Nhị	Male	No, 7 hamlet
4	Nguyễn Thị Hồng Thủy	Female	An Thới hamlet
5	Lưu Văn Hải	Male	An Thới hamlet
6	Đỗ Văn Bằng	Male	An Thới hamlet
7	Huỳnh Văn Thì	Male	No, 7 hamlet
8	Lý Phương Dung	Female	An Thới hamlet
9	Lâm Văn Hà	Male	An Thới hamlet
10	Huỳnh Văn Nguyên	Male	An Thới hamlet
11	Võ Văn Đông	Male	An Thới hamlet
12	Phạm Văn Tường	Male	An Thới hamlet
13	Trương Văn Lái	Male	An Thới hamlet
14	Huỳnh Văn Trọn	Male	An Thới hamlet
15	Huỳnh Văn Chiến	Male	An Thới hamlet

ANNEX 3. Risk rating matrix and ranking calculation

Final risk rating of key ecosystems/habitats of three coastal communes in Ben Tre province

Ecosys-tems	Potential impacts from climate change		Potential impacts from key development targets		Overlay of compiled potential impacts	Risk rating
	Negative	Positive	Negative	Positive		
Estuarine ecosystem	Projected increased erosion events could damage protection corridors (from waves and winds, etc) Projected increased severity of storms will potentially increase the variability of flows; change in aquatic species composition.	*More diverse fish species likely* *Increase in inland capture fisheries*	Increased water pollution/ concentration of contaminants due to runoff of untreated wastewater, sewage and chemicals from future planned shrimp farms; port constructions Potential dike construction projects will strongly change the river sediment; water flow will be altered, negatively affecting watershed habitats and ecosystems.	Improvement in living conditions (infrastructure and freshwater access) for local community Increase in safety for farmers	Estuarine delta ecosystems will be highly impacted. River sediments and water flow will likely be disturbed, aquatic composition will possibly be changed and watershed habitats will be negatively impacted due to more frequent and severe storms and erosion events as well as water construction plans especially the dike projects.	High
Mangroves ecosystem	Increased high spring tide and sea level rise will likely degrade and kill mangroves due to saline intrusion, concentration and high level of saline water Mangroves will potentially die more easily (especially grey mangrove or white mangrove) and retreat inland due to increased saline concentrations as a result of increased spring tides and sea level rise events as well as more storms More severe erosion will destroy forests and habitats of species living in mangroves.	The greater levels of unusual/unseasonal rain in dry season will contribute to reduce forest fires risk.	Dike construction projects may destroy nearby mangroves and interfere with mangrove growth due to changes in sediment, nutrition and saline concentration.		The total area of mangrove in the three coastal communes will likely decrease due to to the expansion of aquaculture production (shrimp ponds in particular), the expansion of industrial zones and future dike construction projects. More extreme weather events, saline intrusion, severe erosion events and storms and storm surges, will likely add to areduction in the total mangrove area.	Moderate

Ecosys-tems	Potential impacts from climate change		Potential impacts from key development targets		Overlay of compiled potential impacts	Risk rating
	Negative	Positive	Negative	Positive		
Intertidal areas (mudflat bare& sandbar) ecosystem	More spring tides and sea level rise events will lead to increased saline intrusion and impact mudflat bars	Increased erosion events may lead to an increase in sedimentation and the formation of new mudflat bars. It may lead the expansion of arable land, aquaculture, and mangroves.	Plans to expand industrial zones, build new bridges and construct a habor/port will result in a reduction in the area of sand bars.		The area of mudflat bars will be greatly reduced due to future development plans. Moreover, the increased saline concentration due to spring tides and sea level rise is likely to affect the mudflat bar ecosystems as it causes changes in alluvial compositions and salt level. However, the increased erosion events will potentially form new mudflat bars as well.	Moderate High
Sand dunes ecosystem	The projected increased unusual/ unseasonal rain in raining, especially increased heavy rains may cause alum concentration & inundation; The projected increased spring tide and SLR can cause change in saltwater / freshwater balance	If there will be Increased spring tide and SLR, they may provide good conditions to vegetable plantation on the high areas of sand dunes because when the spring tide happened, the water level get raised which reduces fresh water penetration, keep the soil moisture stable. The projected increased unusual/unseasonal rain in dry season will possibly create better land condition (less salty and more available freshwater)			Changes of projected climate phenomenon such as unseasonal rainfalls, increased spring tide with SLR totally affect the sand dune ecosystem. There will be negative impacts obviously such as inundation and shock in saltwater / freshwater balance such as more unseasonal rains in dry season will make the sand dune land better or more spring tide and SLR at some levels will make the land at better condition	Moderate

Key ecosystem dependent livelihood activities	Direct potential impacts from CC scenarios		Direct potential impacts from Development targets		Compiled potential consequences	Risk rating
	Negative	Positive	Negative	Positive		
Extensive/ intensive shrimp farming	The more serious erosion events could cause loss of mangroves, natural foods for shrimps and reduce shrimp farms. Potential impacts on intensive shrimp farming due to sudden decrease of salt concentration due to unseasonal rains in dry season as climate change projection The projected prolonged hot period likely Impact on improved extensive shrimp farming due to increased salt concentration because of increased evaporation If there will be more frequent and severe spring tide and SLR, it then highly impact on extensive shrimp farming due to increased salt concentration because the high spring tide limite water run-off from river mounths to the sea	The Projection of more prolonged rains will be likely good for extensive shrimp farming, enhance the level of water exchange between the ponds / dams and the outside, stimulating the shrimp growth	The future dike construction plans will strongly impact on the offshore fishing.	Land use planning will provide more areas for shrimp ponds/ farming construction of ports, wholesale markets of agriculture and fishery products provide potential markets for shrimp & clam Development of seafood processing industry also provide good conditions for fishery, shrimp and clam farming	Shrimp farming will be invested for development under the provincial SEDP, however, the projected changes in Climate will strongly affect the productivity of farming. They key impacts include spring tide with SLR that causes salt concentration; disease outbreak and sudden changes in salt concentration because of prolonged hot period or unseasonal rainfalls.	Moderate High
Clam farming on intertidal areas	The more projected prolonged hot period: Natural clams on mudflat barand sand dune areas can easily get simultaneous death due to the heat or virus attack. Outbreaks of insect disease (mosquito, fly) after the projected unseasonal rains			Construction of ports, wholesale markets of agriculture and fishery products provide potential markets for shrimp & clam	Similar to shrimp farming, Clam farming will be provided good conditions for development but the climate change scenarios especially sudden and unexpected changes in temperature, rainfalls will highly impact on clam farming.	Moderate High

Key ecosystem dependent livelihood activities	Direct potential impacts from CC scenarios		Direct potential impacts from Development targets		Compiled potential consequences	Risk rating
	Negative	Positive	Negative	Positive		
Capture/ offshore fishery			The future dike construction plans will strongly impact on the offshore fishing	Construction of ports, wholesale markets of agriculture and fishery products provide potential markets for fishery products	The construction of fishing ports and storm shelters for fishermen to help develop off-shore fishing of Ben Tre. The natural ecosystem may be more or less disturbed.	Low moderate
Vegetable plantation on sand dunes	The projection of more unusual/seasonal rains may destroy Water melon fields. The projection of more heavy rains may cause increased alum concentration which can poison vegetables. Projected of prolonged and intensed rainfall in the late raining season will likely change the crop calendar. The likely of outbreaks of insect desease (mosquito, fly) after the unseasonal rains as projection Heavy rains in the beginning of the raining season can be able to cause flooding crops and bring alum into cultivation lands Projected of prolonged hot season also may cause disease breaks on vegetables	The more likely of unusual rains also provide a necessary quantity of fresh water to vegetables and trees in dry season (reduce water shortage and saline instrusion) The projection of increase intensity and severity of Spring tide and SLR provide good conditions to vegetable plantation on the high areas of sand dunes because when the spring tide happened, the water level get raised which reduces fresh water penetration, keep the soil moisture stable.	The total area of rice plantation will decreased and be developed as areas of additional rice crops and rotational rice-aquaculture farming The toal area of vegetables will possibly reduced due to many road construction plans		Vegetable plantation seems to be the most vulnerable livelihood activity in the future. While vegetable plantation will not be in the key target of agriculture sector, the total land area for vegetables will be reduced. Moreover, future potential changes in climate effecting the coastal areas of Ben Tre province will seriously impact on vegetable plantation. The key climate risks include unseasonal rainfalls, prolonged and intense rainfalls or hot periods, changes in season calendar which will directly change the cultivation habit and circle.	High

Risk Ranking of Key Ecosystems/Habitats Matrix						
Current Hazards	High	M	MH	MH	H	H
	Moderate High	LM	M	MH	MH	H
	Moderate	LM	LM	M	MH	MH
	Low Moderate	L	LM	LM	M	MH
	Low	L	L	LM	LM	M
		Low	Low-Mod	Moderate	Mod - High	High
Compiled Projected Future Impacts						

Vulnerability Matrix						
Risk Ranking	High	M	MH	MH	H	H
	Moderate High	LM	M	MH	MH	H
	Moderate	LM	LM	M	MH	MH
	Low Moderate	L	LM	LM	M	MH
	Low	L	L	LM	LM	M
		High	Mod - High	Moderate	Low-Mod	Low
Adaptive Capacity						

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