IMPACTS OF CLIMATE CHANGE AND ADAPTATION STRATEGY SELECTION UNDER CONSTRAINED CONDITIONS IN BEN TRE PROVICE

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Master Thesis in Fisheries and Aquaculture Management and Economics FSK-3911
(30 ECTS)

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May 2012

ACKNOWLEDGEMENT

To Professor Curits M. Jolly (Auburn University), Dr. Siv Reithe (Tromso University) and Dr. Kim Anh Thi Nguyen (Nha Trang University), I would like to express my heartfelt gratitude for your devotion in directing my study. Your comments were useful in assisting me in the completion of my thesis. The supervision was essential in confidence building and enabled me to complete this study in a timely manner. I am fortunate to have you all as my supervisors.

I also would like to acknowledge and thank the following individuals and institutions that made valuable contributions to my study:

- The provincial government of Ben Tre province, especially the Honorable Chairman of the Provincial People's Committee Nguyen Van Hieu; the local government units of Binh Dai, Ba Tri and Thanh Phu districts for their assistance and hospitality, and for providing valuable information and data necessary for the completion of this study.
- Local residents for enthusiastic participation in the household survey
- Mr. Ho Xuan Huong, Mr. Chau Huu Tri, Mr. Phan Tan Cuong, and Mr. Bui Nguyen Phuc Thien Chuong for their inexhaustible energy supplied during the field work, for their assistance in collecting data and administering the survey.

Finally, I wish to express my sincere appreciation to NOMA-FAME program, University of Tromso and Nha Trang University for giving me the opportunity to study Fisheries and Aquaculture Management and Economics.

May God bless them all.

Nha Trang, May 2012

Le Thi Huyen Trang

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ABSTRACT

It cannot be denied that climate change is now an overriding environmental issue challenging humanity. Scientific research has proven that Vietnam's 10 most vulnerable provinces are among the top 25% most susceptible regions in South East Asia. Eight of those ten provinces including Ben Tre province belong to the Mekong delta. Thus, in this study we aimed at an investigation on the impacts of climatic events, specifically sea level rise, salt water intrusion, typhoon, and erosion, on three coastal communes in Ben Tre, and adaptations to mitigate impacts. Three focus group discussions (FGDs) were carried out to assist in the identification of impacts of climatic events and vulnerable sectors. Results from the FGDs were the hazard mapping, the vulnerability matrix and the historical timeline of climatic hazards. The FGDs was followed by face to face survey of 300 households. Information on the impacts of climate risks, adaptations, awareness and preparedness of climate change was solicited. Cost-effectiveness analysis (CEA) was performed to evaluate two projects: a sea dike and an irrigating system. Findings showed that sea level rise is the most disturbing incident that threatens the future of the province in that it jeopardizes agriculture and aquaculture, the main stay of the local economy as well as it forces households' relocation. Follow-up is salt water intrusion which immensely hinders agriculture and aquaculture as well as troubles households' everyday routines. Total loss from the most recent salt water intrusion mounted to USD 77,151. Devastating typhoon Durian, despite its ephemeral presence, resulted in USD 154,155 loss. Compared to these incidents which relate to climate changes, erosion appears to be least serious. Total loss from the most recent erosion climbed to USD 77,151. In order to cope with climatic risks, households primarily undertook simple precautionary actions that reflect financial and technical limitations at the household level. An assessment of households' awareness and preparedness of climate change revealed that 98% of respondents have no or a little knowledge of climate change; 65% of respondents have not made any adaptive preparations to handle climate change events. Analysis of two preventive measures to protect communities from ravages of climate change using CEA ratios indicated that the irrigating system is more cost effective than the sea dike. The result justified the implementation of the irrigating system ahead of the sea dike even though that the two projects are unaffordable at a time.

CHAPTER 1
INTRODUCTION

1.1. INTRODUCTION

Scientists were long ago aware of the powerful influence of climate on the history of humankind with respect to changes in biology, culture and geography. Nonetheless, research in the last few decades uncovered that humans can generate significant impacts on the climate as well (The New York Times 2012). "*A decade ago, climate change was a conjecture, but now the future is unfolding before our eyes. Canada's Inuit notice it in disappearing Arctic ice and permafrost. The shantytown dwellers of Latin America and Southern Asia see it in lethal storms and floods. Europeans see it in disappearing glaciers, forest fires and fatal heat waves. Scientists see it in tree rings, ancient coral and bubbles trapped in ice cores*" (Pearce 2006). Climate change is now the single most serious environmental challenge of our time, that threatens economic, health, safety, and food security (UNEP – United Nations Environment Programme)[1].

Scientific evidence proved that since 1950 the world's climate has been warming chiefly as a consequence of emissions from increasing fossil fuel burning and the razing of tropical forests (The New York Times 2012). According to the United Nation Environmental Program (UNEP) [2], glaciers and ice sheets have kept on melting, resulting in the second successive year with an ice-free passage through Canada's Arctic islands, and accelerating rates of ice loss from in Greenland and Antarctica. Along with thermal expansion-warm water occupies more volume than cold-the melting of ice sheets and glaciers throughout the world is boosting rates and an ultimate extent of sea level rise which could be far beyond those forecasted in the latest global scientific assessment. A report released by the Intergovernmental Panel on Climate Change (IPCC) in November 2011 predicted that global warming will cause more dangerous and "unprecedented extreme weather" in the future (The New York Times 2012).

Climate change is expected to strike developing countries the hardest according to World Bank. The effects of climate change, such as higher temperatures, changing rainfall patterns, rising sea level, and increasingly frequent weather-related disasters impede agricultural

[1] See at http://www.unep.org/climatechange/Introduction.aspx

[2] See at http://www.unep.org/climatechange/Introduction.aspx

production, threatens food security, and affects water supplies. At stake are recent achievements in the fight against poverty, hunger and disease, and the lives and livelihoods of billions of people in developing countries[3].

Extreme weather events are generally expected to augment in frequency and intensity as a result of global climate change, and their effects significantly attenuate our progress towards the achievement of the Millennium Development Goals (Harmeling 2009). According to the Global Climate Risk Index 2010 (Harmeling 2009), all of the ten countries most affected by climatic risks during 1990-2008 were developing countries in the low-income or lower-middle income country group; Vietnam was the fourth most affected country. The climate risk index indicates a level of exposure and vulnerability to extreme events that countries should see as a warning signal to prepare for more severe events in the future (Harmeling 2009).

Vietnam is one of the most vulnerable countries to climate change in the world. Impressive achievements in pulling millions of people out of poverty are placed in jeopardy due to the possible increasing extreme weather incidents such as severe rainfall and drought, as well as climate change like sea level rise and warming temperatures (OXFAM 2008). According to the Vietnam Assessment Report on Climate Change (ISPONRE 2009), the country has already experienced changes in fundamental climatic elements as well as extreme weather phenomena such as storms, heavy rains, and droughts. Temperature is rising by 0.5-0.7^{0}C per 50 years from the south to the north, and the frequency of cold fronts has reduced by 2.45 events per 50 years. The coastal areas bear the brunt of tropical storms surging from the East Sea with an average of almost seven incidents annually. It has been recorded that tropical cyclone frequency has increased by 2.15 events over 50 years, and sea level has risen 20 cm every 50 years. The overall temperature in Vietnam in 2100, compared with the period of 1980-1999, will probably to experience an increase between 1.1-1.9 ^{0}C and 2.1-2.6^{0}C; annual rainfall is likely to increase as much as 1.6% - 14.6%; and sea level is likely to rise as much as 11.5 cm-68 cm. Among possible impacts of climate change, sea level rise at a rate of 0.5-0.6 cm per year is the most disturbing concern, especially for the Mekong delta in the south of Vietnam.

The Report also emphasizes that impacts of climate change are likely to be worst on the agricultural sector and water supplies, and that flooding and drought likely to be more frequent

[3] See at http://climatechange.worldbank.org/climatechange/overview

because of an increase in rainfall intensity and a drop in the number of rainy days. Mekong and Red River deltas, crucial crop production areas, are likely to be rendered barren by salt water intrusion due to rising sea level. Climate change could furthermore probably engender more biodiversity extinction, especially native plant species and economic value species such as Siadora Vietnamese and textured woods. Sea level rise could lead to a decline in mangrove forests, adversely impact indigo forests and forests produced on the sulfated lands of southern Vietnam, and change the boundary distribution and alignment of primary and secondary forests. The Red River delta and Quang Ninh province, the North Central Coast, South Central Coast and the Mekong River delta were specified as hot spots due to their high vulnerability.

1.2. PROBLEM STATEMENT

Climate change mapping shows that Vietnam's 10 most susceptible provinces are among the top 25% most vulnerable areas in Southeast Asia, and that Ben Tre is one of these (Yusuf and Francisco 2010). Eight of those ten provinces are naturally located in the Mekong River Delta including Ben Tre province. In the arrival of the dry season, Ben Tre often suffers immensely from salt water intrusion that leads to the contamination of fresh water destined for family routine as well as damages to agricultural production. The level of salinity of 1 percent can be detected throughout the entire province while the salinity threshold for drinking water is less than 0.25 percent. Economic damages caused by salt water intrusion from 1995 to 2008 included 15,782 ha of dead or less productive paddy, 13,700 ha of shed unripe coconut, 360 ha of less productive aquaculture and 5,289 tonnes of dead shrimp. The intrusion also put 132,823 households into a situation of continued lack of fresh water (Ben Tre PPC 2011). Climate change as we all know will lead to higher temperatures, longer dry seasons compared to rainy ones, and rising sea level which altogether will extend the affected area as well as the duration and intensity of salt water intrusion. In 2020, when the sea level rises by 11 cm, the 4 percent - salinity boundary will be 15-25 km away from the coastline. The situation will, however, be more serious in 2050 when the sea level rise 30 cm. At that time the 4 percent - salinity boundary will be at the distance of 40 km from the coastline. Areas that are now suffering from salinity of 4 percent will experience 8-10 percent salinity. Such forecasts however do not take into account the effects of droughts, longer dry seasons, and reduced fresh water flow from upstream (Ben Tre PPC 2011).

In addition to salt water contamination, unusual typhoons in recent years served as strong evidence that Ben Tre is no longer a typhoon-free area. In 1997, the typhoon called Linda with wind velocity of 120 km per hour accounted for severe damages of USD 14,467,592. Nine years later, the typhoon named Durian with wind velocity of over 133 km per hour had severely devastated the province, which resulted in 17 deaths, 162 injured persons, and 71,340 collapsed or unroofed houses (Ben Tre PPC 2011).

As segmented by an intricate system of rivers and channels, Ben Tre territory has suffered from erosion which occurs mostly along the riverside due to strong waves and tides Statistics show that riverside erosion during the period 1995 to 2008 had affected 1,826 households, devastated 366,547 ha of land, and severely damaged 501 houses (Ben Tre PPC 2011). As sea level is rising, erosion is likely to occur more frequently.

Climatic events are likely to increase in terms of intensity and frequency as climate is changing. In spite of the evidence that climate change is influencing agricultural productivity and community livelihoods there is no study which documents community awareness, preparation and likely use of effective mitigation strategies to reduce the impacts of climate change on rural areas such as the Ben Tre province where are the impacts are seemingly most noticeable. Hence, a study which investigates the impacts of climate change on residents, and their adaptation strategies is opportune.

1.3. OBJECTIVES OF THE STUDY

In general the study hopes to assess the impacts of most recent climatic events including salt water intrusion, erosion, and typhoon occurrence in Ben Tre province and conduct an economic evaluation of the adaptation strategies planned by the local government to address climate change impacts. Three coastal communes, namely Thua Duc of Binh Dai, An Thuy of Ba Tri, and Giao Thanh of Thanh Phu Districts are chosen as studied sites because they are believed to be most affected in the province. Specifically the study will:

1. Assess households' awareness of climate change;
2. Identify and evaluate the impacts of salt water intrusion, erosion, and typhoon on households along the coasts in the Ben Tre province;
3. Investigate the types and costs of households' autonomous adaptations; and

4. Conduct an economic analysis of at least two adaptation strategies which are currently under consideration of the local government.

CHAPTER 2
THEORY

2.1. THE CONCEPTS OF CLIMATE AND CLIMATE CHANGE

Many people use the words *weather* and *climate* interchangeably. They actually are not. It is important to understand the difference between weather and climate to facilitate the understanding of climate change.

Weather, as we normally know, is the atmospheric behaviors at a given place and time. Weather is identified as a combination of climatic elements, such as wind speed, cloudiness, humidity, atmospheric pressure, air temperature, and rainfall. In many places, there may be changes in the weather among seasons, among months or even among days[4].

Climate, in a narrow sense, is usually considered as the "average weather", or more specifically, as statistical descriptions with respect to the mean and variability of relevant quantities in a given period of a month, a year or thousands or millions of years. The pertinent quantities are most often surface climatic elements such as temperature, precipitation, and wind. Climate, in a broader sense, is the state of the climate system[5] (IPCC 2001). Climate varies from region to region around the world because each area has its own geographic factors like proximity to oceans and altitude and receives varying amounts of sunlight.

As mentioned above, our weather is always changing and now it is discovered by scientists that the climate does not stay the same either. Nonetheless, with respect to weather, changes may be sudden and noticeable whereas changes in the climate are less obvious because of long time demand to settle in. The specific weather we experience may be a bit different from one year to the next, a couple of hotter summers, or a couple of colder winters, may lead people to conclude that the climate is changing. Of course, rapid climate change might cause such climatic shifts, but it is far more likely that these fluctuations are just natural from year-to-year. Nevertheless, because everyone notices such fluctuations, and television and newspapers

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[4] See at http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html

[5] According to IPCC (2001) "*the climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere, and the interactions between them*".

sometimes mention climate change in the same story as they talk about recent unusual weather, it is easy for us to confuse the two.

Climate changes have been recorded throughout the history of our beautiful planet-the earth. On a global scale, any changes in either the amount of heat let into or the amount of heat let out of the system forces the climate changes. For instance, warming climates are due to not only increased amounts of heat released into the earth but also a decrease in the amount of heat that is allowed out of the atmosphere. The heat that enters into the earth system originates from the sun. Sunlight warms up the land surface and the oceans by going through space and the atmosphere. Heat from the heated earth is then sent back into the atmosphere. However, over a long period of thousands of years, accumulative changes in the earth's orbit and the sun's intensity impact the amount of solar energy that reaches the Earth, leading to the varying amount of sunlight released into the system (U.S EPA)[6].

Heat escapes from the earth system as the earth's surface, heated by solar energy, emits heat away. Nevertheless, certain gases in the atmosphere, called greenhouse gases which are "*gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere, and clouds*", defined by IPCC (2001), facilitate the lower atmosphere to absorb the heat released from the earth's surface, capturing heat within the earth's system[7].

The earth's system tends to reach a temperature level at which the amount of coming light is just balanced by the amount of escaping infrared heat energy. This process is usually implied as the greenhouse effect. Made up of such gases as water vapor, ozone, carbon dioxide, methane and nitrous oxide, greenhouse gases play an important role in keeping the earth from becoming an icy sphere, providing a favorable environment for humans, animal and plants to survive (Bilskemper and Leinbaugh).

However, over the past century the rapid increase in burning fossil fuels that releases carbon dioxide into the atmosphere raises the amounts of greenhouse gases within our atmosphere (UNFCCC 2007). Although some of the carbon dioxide released is absorbed into the ocean or taken up by plants, in the short-run about half of it remains in the atmosphere. Industrial

[6] See at http://www.epa.gov/climatechange/science/pastcc.html

[7] See at http://www.eo.ucar.edu/basics/cc_1.html

activities also have been emitting several other greenhouse gases into the atmosphere. As a result, more and more heat has been trapped by increasing amounts of these greenhouse gases, leading to an increase in the global temperature in the past one hundred years. The phrase "Global warming" or "Greenhouse warming" refers to the phenomenon that as more carbon dioxide and/or other greenhouse gases are added to the atmosphere, the temperature of the earth will rise, assuming nothing else changes.

Figure 1 exhibits the combined land-surface air and sea surface temperatures from 1861 to 1998, compared with the average temperature between 1961 and 1990 (15.08°C). The global average surface temperature has increased by some 0.3 to 0.6°C from the late 19th century. Especially, since the early 1990s, the upward trend of average temperature denotes global warming.

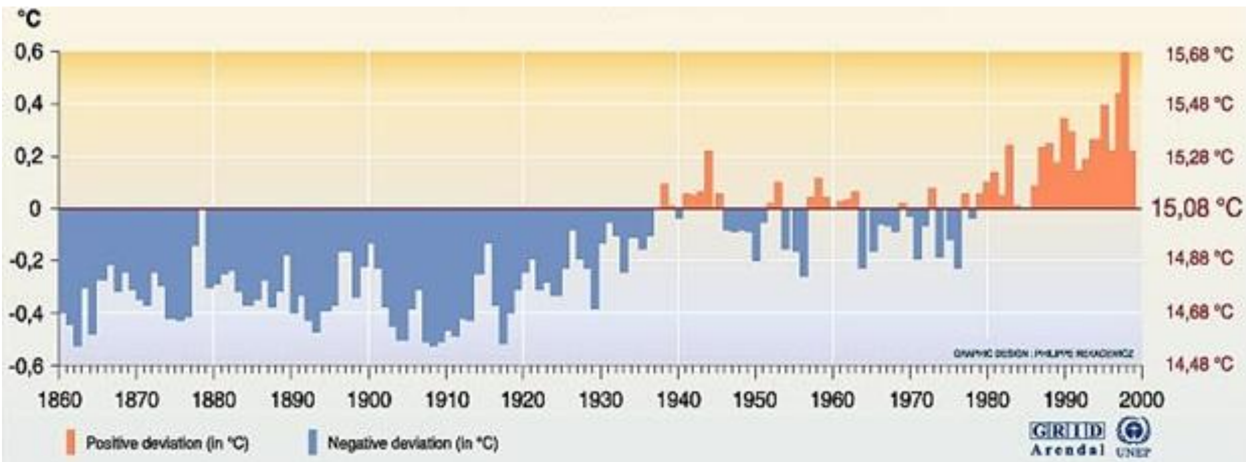

Figure 1. Trend in global average surface temperature

Source: School of environmental sciences, climatic research unit, University of East Anglia, Norwich, UK, 1999[8]

In addition, according to the Surface Temperature Reconstructions for the Last 2000 Years (NRC 2006), it is stated with a high confidence that over the last few decades the global average temperature was warmer than that in any periods during the last 400 years. Present evidence also confirms that many regions around the world had higher average temperatures during the past 25 years in comparison with any periods since 900 A.D.

[8] See at http://www.grida.no/publications/vg/climate/page/3070.aspx

In the above figure, it can be concluded that climate change which occurs today is mainly attributed to human activities which are emitting more and more greenhouse gases, especially carbon dioxide, into the atmosphere. Yet, what is climate change after all? According the IPCC (2007a), climate change refers to "*a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use*".

Another definition of climate change is provided by Wikipedia. Climate change is "*a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions or the distribution of weather events around that average (e.g., more or fewer extreme weather events)*"[9].

Sometimes, the hole in the ozone layer is confused with climate change by many people. However, they are not closely related. The ozone layer prevents harmful ultraviolet light from reaching the earth to protect humans, plants and animals against dangers. Chlorofluorocarbons (CFCs), gases usually used in industrial applications, are the root cause of the hole in the zone layer. CFCs alone cause warming whereas their ozone destruction can bring about cooling. So far there exists an approximate balance between the warming and cooling influences. However, under an international agreement, to protect the ozone layer, the uses of CFCs are now being limited and phased out (U.S GCRIO)[10]

2.2. CAUSES OF CLIMATE CHANGE

The earth's climate has changed throughout mankind's history, and not only in the present decade. From the time when significant portions of the earth were covered by ice - the ice ages to interglacial periods - when ice melted entirely except at the two poles - the climate has continuously changed (U.S EPA)[11]. What scientists are worried about is that the human activity is the primary driver that speeds up the changes in climate in the past

[9] See at http://en.wikipedia.org/wiki/Climate_change

[10] See at http://www.gcrio.org/gwcc/part1.html

[11] See at http://www.epa.gov/climatechange/science/pastcc.html

century. Nevertheless, human activities are not the only factor that can influence climate patterns. As a matter of fact, scientists categorize causes of climate change into natural and human causes.

2.2.1. Natural causes

The following natural factors all have direct influence on earth's climate but in different ways. Some of these facilitate warming while others may slow the process or even bring about both effects. Let's look at them in some more detail.

a. Continental drift

Our earth today consists of seven continents namely Australia, North America, South America, Asia, Africa, Europe and Antarctica. Nonetheless, millions of years ago these seven continents altogether made up one big landmass surrounded by one big ocean. Slowly and steadily the big landmass broke up and took the form as we see it today- seven continents separated by oceans. The process is named continental drift.

After the drift, the physical features and the position of the landmass as well as the position of water bodies changed, thereby impacting on the climate. In addition, the flow of ocean currents and winds that influence the earth's climate were also changed by the separation of the big landmass. Scientists believe that the drift is continuing even today. The Indian landmass is slowly travelling towards the Asian landmass, causing the Himalayan range to be increasing by about 1 mm (millimeter) every year (Shrivastava 2007).

b. Volcanic eruption

A volcanic eruption, although lasting a few days, emits huge amounts of sulfur dioxide (SO_2), water vapor, dust, ash particles and especially carbon dioxide (CO_2) – a greenhouses gas - that can influence climatic patterns for years – into the atmosphere.

Sulfuric gases combine with water vapor to turn into sulfate aerosols, submicron droplets containing about 75 percent sulfuric acid (Wolfe 2000). These sub-micron droplets are efficient reflectors of sunlight to protect the ground from some of the energy coming from the sun. The aerosols are carried around the globe by the stratosphere, the upper level of the atmosphere. This process gives us a notion of why cooling can be brought for a few years after a volcano (Shrivastava 2007). Nonetheless, aerosols do not produce long-term change because they just linger from three to four years in the stratosphere. According to the United States Geological

Survey (USGS)[12], in 1816 New England was describe as “the year without a summer” due to the eruption of the Tambora Volcano in Indonesia in 1815. It was also calculated that the eruption lowered global temperatures by as much as 5ºF.

Volcanic eruptions, however, also release carbon dioxide which, over millions of years, can cause a warming effect. The net benefit of volcanic eruptions is therefore an ongoing debate.

c. Oceans

Oceans are a major component of the climate system. About 71% area of the earth is covered by oceans. They play more significant role in absorbing the sun’s radiation in comparison with the atmosphere and the land surface. Ocean currents can also move the same vast amounts of heat across the planet as the atmosphere does (Shrivastava 2007). Therefore, the oceans help to slow down the process of temperature change in the atmosphere because of the efficiency in absorbing and broadly distributing the sun’s energy through water currents.

d. Clouds

By reflecting sunlight, clouds provide shade to keep the earth’s surface cool. However, clouds hold such a greenhouse gas as water vapor that traps heat within the atmosphere by bouncing energy back towards the earth. Therefore, the net effect of clouds on climate is mysterious to scientists. But thanks to new satellite data and other technologies, there are some emergent clues that may help solve the puzzle. In his article The Effect of Clouds on Climate: a Key Mystery for Researchers (2010), Lemonick stated that *“all of the evidence so far is only suggestive, not definitive, that clouds will accelerate warming. Yet most climate scientists say that the case is getting stronger. And researchers who remain uncertain about the impact of clouds on the climate said that even if clouds have a slight cooling effect, it will not be sufficient to put the brakes on human-caused warming”.*

e. Wildfires

As forest fires occur, carbon dioxide is released into the atmosphere which contributes to the planet’s warming by trapping heat. However, this amount of carbon dioxide can be removed by a forest of similar size that is grown to replace the old one. So, fires affect atmospheric CO_2 in the short term not on long timescales. However, it is worth noting that wildfires are not just the cause but also the result of climate change because climate change will lead to warmer and drier weather.

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[12] See at http://vulcan.wr.usgs.gov/Outreach/AboutVolcanoes/do_volcanoes_affect_weather.html

2.2.2. Human causes

Climate change is attributed mostly to the increased concentrations of greenhouse gases in the atmosphere which is caused by human activities. The extensive uses of natural resources by humans for construction, industries, transport, and consumption throw out our atmosphere vast increasing amounts of greenhouse gases. More and more structures are built on land that was covered with vegetation. Fossil fuels such as oil, coal and natural gas are increasingly burned to power vehicles, industries and households. The energy industry, a vital sector for industrial activities, emits about three-fourths of the total carbon dioxide and one-fifth of the total methane of the world. Moreover, the world population is increasing. All of these intensify the concentration of greenhouse gases, especially carbon dioxide, in the atmosphere.

Carbon dioxide is the most important greenhouse gas in the atmosphere. Carbon, the building block of life, is released as carbon dioxide gas when fossil fuels are used as energy sources. Apart from the combustion of fossil fuels, carbon dioxide is also released from ecosystems that are altered and from vegetation that is either burned or removed. The conjunction of a rocketing increase in agriculture and urban growth and increasing demands for fuel, construction, and paper have fostered deforestation. Currently, changes in land use contribute to one-fourth of the carbon dioxide emitted to the atmosphere (CCIR 2005). According to the co-chair of the Global Carbon Project, CSIRO Marine and Atmospheric Research scientist Dr. Mike Raupach, *"from 2000 to 2005 the growth rate of carbon dioxide emissions was more than 2.5% per year, whereas in the 1990s it was less than 1% per year"*[13]. About half of the carbon dioxide we produce can be absorbed by forests and oceans. Yet, this nature's ability is being extensively used by the soaring accumulation rate of atmospheric CO_2 since 2001 (Pearce 2006).

Methane is another significant greenhouse gas in the atmosphere. Domesticated animals such as dairy cows, goats, buffaloes, and horses are responsible for about one-fourth of all methane emissions. These animals are largely raised due to increasing requirements of growing population. Methane is produced during the process of animal chewing. Moreover, methane is also emitted from rice or paddy fields when they are flooded during the sowing and maturing

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[13] See at http://www.csiro.au/Organisation-Structure/Divisions/Marine--Atmospheric-Research/Increase-in-carbon-dioxide-emissions-accelerating.aspx

periods. Many other activities like oil drilling, coal mining, landfills and other waste dumps also contribute to emit methane (Noorani 2008).

The application of nitrogen fertilizers brings a huge amount of nitrous oxide emission into our atmosphere (Johnston 2005). In past decades, increased food demand, as a result of expanded population, has inevitably led to an increased use of not only synthetic fertilizers but also animal waste that is now applied more widely on agricultural soils. In other words, widespread increase in the use of such nitrogen based fertilizers has been driven by the demand for greater crop yields which require more intensive farming practices. Nonetheless, improper application of nitrogen based fertilizers in many areas has led to excessive proportions of fertilizer which on one hand does not ameliorate crop yield and on the other hand assists higher nitrous oxide emissions[14].

In conclusion, through various activities which emit more greenhouse gases into the atmosphere, humans have been altering the earth's energy balance, contributing to changes in the global climate.

2.3. CONSEQUENCES OF CLIMATE CHANGE

According IPCC Emissions Scenarios (2000), since 1850 average global temperature has been rising by 0.74^{o}C and will be 1^{o}C higher by 2040 if no additional steps are taken to reduce emissions of CO_2 and other greenhouse gases. It is estimated that the temperatures will increase by another 1.5^{o}C by 2100. Even if there were zero greenhouse gas emissions from today on, global average temperatures would still increase to at least 0.5^{o}C before stabilizing in 2050. In the IPCC Synthesis Report (2007b) stated that *"the temperature increase is widespread over the globe and is greater at higher northern latitudes"*. The average temperatures at the Arctic have nearly doubled in comparison with the earthly average rate in the past 100 years. The Land regions have warmed faster than the oceans. Observations since 1961 provided convincing evidence that the global ocean temperature has risen to depths of at least 3000m and that more than 80% of the total heat that are being added to the climate system is absorbed by the ocean. The increasing temperatures will inevitably lead to several consequences as depicted in the following session.

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[14] See at http://www.ghgonline.org/nitrousagri.htm

2.3.1. Sea level rise

Increases in sea level are consistent with melting glacier and thermal expansion of sea water due to global warming. Global average sea level augmented at a rate of 1.8 mm in average per year over 1961 to 2003. The rate was as fast as 3.1 mm per year from 1993 to 2003. It is unclear that such a faster rate reflects a long-term trend or just decadal variability (IPCC 2007b).

Increasing temperatures are believed to melt mountain glaciers, small ice caps and portions of Greenland and the Antarctic ice sheets expand ocean water, expanding ocean water and thereby further raising sea level (U.S *EPA*)[15]. IPCC estimated that the global average sea level will increase from 0.6 to 2 feet (0.18 to 0.59 meters) in the next century (IPCC 2007c).

Rising sea levels inundate wetlands (in the United States, 17-43% of current wetlands could be eliminated if sea level rise about one foot (0.3 m), with more than half the loss in Louisiana)[16], bring about beach erosion, intensify flooding and salt water intrusion, thereby increasing the salinity of rivers, bays, and groundwater tables. Moreover, many adverse effects on the environment and on waterways may be made up of a variety of measures employed by households to protect their own properties from increasing sea level rise. (U.S EPA)[17].

The developing world will experience the most violent impacts of sea level rise. The continued sea level rise may displace hundreds of millions of people within this century. The accompanying economic and ecological losses will be massive and will negatively affect many developing countries already struggling for economic survival. Climate change is likely to retard or wipe out any economic growth experienced in the last decade. For some countries such as Vietnam, A.R. of Egypt, and the Bahamas, the consequences of sea level rise are potentially devastating. The impact may be worst for countries dependent on agricultural exports for economic growth. Climatic change may increase production variability and export volatility. For many others, including some of the largest (e.g., China), the absolute magnitudes of potential impacts are very large (Dasgupta et al. 2007).

The Mekong Delta in Vietnam is highly vulnerable to sea level rise. Stretching from the Gulf of Thailand in the south to the Cambodian border in the west, it is one of the most densely populated regions of Viet Nam and home to more than 17 million people in its 16 provinces. It

[15] See at http://epa.gov/climatechange/science/futureslc.html

[16] See at http://www.koshland-science-museum.org/exhibitgcc/impacts04.jsp

[17] See at http://epa.gov/climatechange/effects/coastal/index.html

produces more than half of the country's rice, and 90 per cent of its rice exports helping to turn Viet Nam into the second largest rice exporter in the world. The Delta is also responsible for an even larger share of total fish and fruit production in the country, a vast amount of which is now exported to China (OXFAM 2008). According to the scenarios for sea level rise in Vietnam (MONRE 2009), by the end of the 21^{st} century, sea level rise could be anywhere between 65 cm to 1 m. As a consequence, inundated areas in the Mekong Delta could lie between 5.100 km^2 (13%) and 15,116 km^2 (33.3%). This will pose a threat to not only farmers but also exports especially rice and even possibly fill the national food security with alarm (Chaudhry and Ruysschaert 2007).

By working on the World Bank data, Hanh and Furukawa, in the study on impact of sea level rise on coastal zone of Vietnam in 2007, figured out that *"If the sea level rises by 1m, around 5.3% of land, 10.8% of population, 10.2% of GDP, 10.9% of urban area, 7.2% of agricultural area, and 28.9% of low ground will be affected"*.

2.3.2. Salt water intrusion

Saltwater intrusion is a natural process that occurs in virtually all coastal freshwater aquifers. The ocean water penetrates into the freshwater aquifer whenever the densities of both the saltwater and freshwater are different from each other. The aggressive encroachments of seawater occupy an area known as the zone of dispersion, through which is formed an interface between the freshwater and saltwater (Spatafora 2008). This interface moves back and forth naturally in consistent with variations in the recharge rate at which freshwater goes back into coastal aquifers (Ranjan 2007). That saltwater intrusion is dependent on the recharge rate of freshwater allows some climatic variables such as precipitation, temperature and carbon dioxide emission to play a role in influencing saltwater intrusion. The warmer temperatures and lower amounts of rainfall slow down the freshwater recharge rate due to lack of groundwater present and foster evaporation (Ranjan 2007). Increasing carbon dioxide emission can directly cause average surface temperatures to rise, indirectly increasing the evaporation rate and for that impacting on the recharge rate of freshwater into the coastal aquifers (Spatafora 2008).

Increasing global population also has something to do with saltwater intrusion because continued growth of population leads to increasing demand for freshwater which is extracted from the underground. The over-extraction, however, may result in an inverse movement of the groundwater flow from the sea to the interior, bringing about saltwater intrusion (Hany et al. 2009).

Sea level rise is believed to accelerate saltwater intrusion, thus slowly exhausting fresh groundwater resource. Ibaraki, an associate professor of earth sciences at Ohio State University stated that *"Most people are probably aware of the damage that rising sea levels can do above ground, but not underground. Climate change is already diminishing fresh water resources with changes in precipitation patterns and the melting of glaciers"* (Ibaraki, 2007).

Saltwater intrusion is a common problem in all coastal regions around the world where people rely on groundwater as their major source of freshwater for several purposes, such as for humans' daily activities , industrial and agricultural purposes. The intrusion of salt water causes water to be unsuitable for human uses, therefore threatening the health and lives of many people in coastal areas.

South Florida's water supply is in jeopardy because of an increasing intrusion of saltwater which steadily penetrates inland from the ocean and causing water supplies to become undrinkable. So far, six out of the eight wells in Hallandale Beach in Florida have been closed as a consequence of saltwater intrusion[18]. Salt water intrusion also threatens crawfish farmers in southwest Louisiana. Crawfish can tolerate small amounts of salt water but it is still dangerous to cultivate crawfish, a freshwater species in Vermilion Parish, Louisiana. That's why Vermilion Parish declared a state of an emergency of salt water intrusion in late November in 2011[19].

As seawater level rise, saline water intrusion in many coastal areas in Viet Nam will worsen. This problem has become more and more serious in recent years due to the rapid extraction of freshwater for irrigation and drinking as well as the construction of canals and upstream dams in the deltas (MHC 1996). A 30 cm increase in sea level (a scenario for 2050) is expected to raise the salinity of the brief branches of the Mekong River as far as 10 km inland (Ratsakulthai 2002). In Soc Trang, a province in the Mekong Delta, saltwater intrusion affected 40,000 ha of rice production (Vien 2011). In Ben Tre, a low - lying province in Mekong Delta, economic damages caused by salt water intrusion from 1995 to 2008 included 15,782 ha of dead or less productive paddy, 13,700 ha of shed unripe coconut, 360 ha of less productive aquaculture and 5,289 tonnes of dead shrimp (Ben Tre PPC 2011).The number of households

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[18] See at http://www.homelandsecuritynewswire.com/saltwater-intrusion-threatens-south-florida-s-water-supplies

[19] See at http://www.louisianaseafoodnews.com/2011/12/09/salt-water-intrusion-threatens-crawfish-farmers/

that lack fresh water for daily use increased up to 110,000, accounting for approximately 40% of the total households in Ben Tre province (OXFAM 2008).

2.3.3. Storm and flooding

Increased temperatures will lead to more evaporation of water, which, as part of the water cycle, eventually causes more precipitation. Heavy rains generally are likely more frequent due to global warming, triggering more potential flooding. Furthermore, rising sea level also raises the vulnerability of coastal regions to flooding during storms because a higher base of water as sea level rises facilitates storms to flood low-lying areas. A report by United Nation Human Settlements Program (UN-HABITAT 2008) stated that *"By 2070 urban populations in cities in river deltas, which already experience high risk of flooding, such as Dhaka, Kolkata, Rangoon, and Hai Phong, will join the group of most exposed populations"*. Besides, several important port cities in Bangladesh, China, Thailand, India , and Vietnam will be among cities whose assets are most exposed.

Climate change also takes much responsibility for an increase in hurricane wind speeds, fosters storm surge levels and brings more extreme wave heights (CCSP 2008). The U.S, for example, already suffered from a direct impact of climate change, that is, hurricane Katrina which devastated the developed city of New Orleans. The storms that are hitting the U.S. could be more frequent and intensive of if temperatures continue to rise (Watson 2010).

2.3.4. Land loss

Wetlands provide habitat for many species, play a key role in nutrient uptake, and serve as the basis for many communities' economic livelihoods, natural products for our use at no cost, for instance. Furthermore, they also provide recreational opportunities and shoreline erosion control, and protect local areas from flooding (U.S EPA)[20]. Wetland ecosystems along coasts, such as salt marshes and mangroves, are generally low-lying within a few feet of sea level and thus particularly prone to sea level rise impacts (IPCC 2007c).

As the sea water rises, the outer boundary of low-lying coastal wetlands will erode. New wetlands will thus form inland which is being flooded because of the higher water levels. The

[20] See at http://water.epa.gov/type/wetlands/people.cfm

newly created wetlands, however, could have much smaller area than the lost ones (U.S EPA)[21]. This generates negative consequences for biodiversity and ecosystem.

The IPCC suggests that by 2080, as a result of higher sea water level, about 33 percent of the coastal wetlands all over the world could be converted into open waters (IPCC 2007c). In addition, an EPA Report to Congress made an estimation that an increase of two feet in sea level could cause 17-43 percent of U.S. wetlands to disappear with more than half of the loss belonging to Louisiana (EPA 1989). These damages are not only environmental but also commercial.

2.3.5. Coastal and riverine erosion

The conjunction of current wave processes is mainly responsible for coastal erosion along the world's coastlines. Areas whose substrates are dominated by such soft substances as sandstone or mudstone are more prone to erosion impacts in comparison with regions of hard substrates (e.g. basalt or granite)[22]. Although erosion rate is varying with areas, in general, the coasts all around the world have witnessed a considerable rise in erosion over the last two decades (Morton et al. 2004). And it is believed that erosion will be intensified as sea level rises (Brown and McLachlan 2002).

In addition to coastal erosion, climate change is likely to accelerate riverine erosion because climate change leads to altered precipitation and sea level rise which are the main causes of changing river flow and river flooding. Evidence on the relation between climate change and riverine erosion could be found in several studies. In the study, Coastal and Riverine Erosion, the North Slope Sciene Initiative (Alaska, U.S) highlighted that increasing sea water level will bring coastal and riverine erosion to the North Slope, thereby reducing amounts of shorefast ice and near shore pack ice, thus accelerating storms[23]. According to the Natural Resource Canada, climate change carries the high potential to cause substantial changes in river flows. Unavoidably

[21] See at http://epa.gov/climatechange/effects/coastal/index.html

[22] See at http://centerforoceansolutions.org/climate/impacts/cumulative-impacts/coastal-erosion/

[23] See at http://quickplace.mtri.org/LotusQuickr/nssi/PageLibrary852570A00051053F.nsf/h_Index/A6D88BBE8558D6D58525768800772A50/?OpenDocument&ResortDescending=14

so, river erosion and floods would be the most direct and violent impacts of climate change[24]. Korn et al. (2010), in their study on the impact of climate change on riverbank erosion in Cambodia, concluded that bank erosion occurs through flooding and quick flow velocity which are being speeded up by climate change.

Regardless of whether erosion occurs along the coast or the river bank, it does cause serious damages socially, economically and ecologically.

2.4. A REVIEW ON ADAPTATIONS TO IMPACTS OF CLIMATE CHANGE

Climate change has resulted in a wide array of environmental and socio-economic effects. It has affected water resources, agriculture, aquaculture, food security, human health, terrestrial ecosystems and biodiversity. Environment and socio-economic effects have triggered actions among households, communities and local governments. These groups have acted concertedly to develop and adapt strategies to react against climatic changes. Thus, adaptations have been indispensably employed to mitigate adverse impacts of climate change.

"Adaptation is a process through which societies make themselves better able to cope with an uncertain future as a result of climate change. Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes" – defined by United Nations Framework Convention on Climate Change (UNFCCC 2007).

Options chosen as adaptations to climate change range from technical options, such as constructions of seawalls, establishment of early warning systems, better water management, and biodiversity conservation, to behavioral changes like reducing water use during droughts, using electricity economically, and reducing burning of fossil fuels.

2.4.1. Review on adaptations to erosion

According to Laos's Ministry of Public Works and Transportation, about 90 percent of Laos's domain constitutes part of the Mekong river basin, so riverbank erosion is one of the most seriously unavoidable damages to the river. The poor will suffer the heaviest losses in riverbank erosion with their houses, community facilities and roads[25]. To cope with this increasingly

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[24] See at http://atlas.nrcan.gc.ca/site/english/maps/climatechange/potentialimpacts/sensitivityriverregions/1

[25] See at http://www.preventionweb.net/english/professional/news/v.php?id=10531

threatening problem, a pilot project of using a soda-mattress (also known as a fascine) made of brushwood, stones and other materials was implemented in 2004 to secure riverbanks from erosion. In the early years of the Meiji period (1868-1912), the soda-mattress system was first introduced and developed in Japan and extensively utilized for groins and dike-foot protection[26]. This project achieved successes in terms of not only protection but also cost effectiveness. It is a cost effective method because building materials used are locally available like tree branches, stones, and manpower.

Like Laos, many coastal cities and municipalities in the Philippines are also being confronted with threats from coastal erosion. The impact of such a coastal hazard is expected to become more widespread as a result of climate change and its accompanying sea level rise as well as the continuing urbanization and development of coastal communities in the country (Bayani et al. 2009). According to Bayani et al. (2009), it is estimated that 283,085 m^2 of land, and 123,033 m^2 of beach and 300 structures along San Fernando Bay will be swallowed up by coastal erosion by the year 2100.

To deal with these serious adverse impacts, three adaptation strategies are proposed, that is, the construction of bulkheads, the combined construction of bulkheads and revetments, and relocation. Because the three options entail large investment and sometimes cause undesirable effects, cost benefit analysis was employed to carefully evaluate and access the feasibility of these adaptations. The method was also picked up by Costa (Costa et al. 2009) to solve a similar problem associated with sea level rise in European Union coastal countries.

With the coastal zone length of 3,260 km, Vietnam cannot avoid being eroded as a result of climate change. Erosions in Vietnam coast had been investigated in several studies like Cat's study (2006) on the status of coastal erosion in Vietnam and the study of Hanh and Furukawa (2007) on impact of sea level rise on coastal zone of Vietnam. Based on these studies, in both the Mekong River Delta and Red River Delta, erosion has occurred along one-fourth of the coastline of each delta. Overall 243 coastal sites, equivalent to 469 km of coastal lines, have been eroded at a rate of 5-10 m/year.

The control of coastal erosion in Red River Delta has been studied for a long time. However, the implementation of solutions has been passive, responded to concrete situations and was in need of definite scientific base (Thanh et al., 2005). In Mekong delta, erosion has

[26] See at http://www.soda.gr.jp/construction-b-eng.html

occurred along numerous parts of the coastline, and in several parts erosion has already destroyed the mangrove forest and harmed the sea dikes. Thus, a model has been developed to diminish erosion and foster sedimentation as a qualification for mangrove rehabilitation in erosion sites. This model combines appropriate sea dikes and wave-breaking barriers which are designed based on computer-based modeling of water current and erosion, and mangrove rehabilitation. The model has been implemented in Soc Trang and Tien Giang, two provinces in the Mekong Dela, and has already achieved a certain amount of success[27].

2.4.2. Review on adaptations to typhoon

Climate change has intensified heat waves, typhoons, droughts and floods in the Philippines, an area of high vulnerability to the negative impacts of a rapid changing climate[28]. As a results from global climate change, typhoons come in more in the north[29]. Typically, in November 1991, Ormoc City in Leyte, Philippines was hit by a destructive flood which was carried by Typhoon Uring. The disaster had done the city enormous damage of 4,922 deaths and 3,000 missing persons, and an estimated loss of more than US$12 million from constructions, agriculture, livestock and fishery production, and commercial establishments. It was one of the greatest natural disasters in the Philippines.

In response to the tragedy, a project was implemented in 1998 to prevent similar future incidents, which aims to reinforce the channel of the two rivers and build three slit dams. In terms of households, the adaptive strategy most preferred to respond to climate-related events was to move temporarily to safer locations, followed by house restructuring so that houses are more flood-resistant (Predo 2010).

In Vietnam, typhoons are also one of the most dreadful types of natural disasters. From 1954 to 1999, Viet Nam had 494 typhoons and tropical depressions. Typhoons are usually accompanied by high tide and heavy rain, thus leading to flooding. About 80-90% of the total Vietnam population will be potentially impacted by typhoons (Dao 2008). In 1997 typhoon Linda which hit Ca Mau, a province in the Mekong Delta, led to 312,456 collapsed and damaged houses; 7,151 damaged schools; 348 flooded and damaged hospitals and health centers; 323,050

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[27] http://www.giz-mnr.org.vn/index.php?option=com_content&task=view&id=192&Itemid=9&lang=vi

[28] http://siteresources.worldbank.org/INTPHILIPPINES/Resources/PhilippineCEACC1July.pdf

[29] http://www.silent-gardens.com/climate.php

damaged ha of rice fields; 57,751 flooded and damaged ha of farmland; 136,334 ha of flooded fish ponds; and 7,753 damaged ships and boats (Chaudhry and Ruysschaert 2007).

There appears to be a shift in the peak month for typhoons' landfall in Viet Nam, from August in the 1950s to November in the 1990s. The path of the typhoons have also moved southwards in recent years (Chaudhry and Ruysschaert 2007).

Consequently, Viet Nam's key responses to cope with serious threats and disasters, resulting from changing climate, are disaster warning and preparedness. Given enthusiastic support from The United Nations Development Programme (UNDP), Viet Nam deployed an early warning system for disasters, collected and reported damage data, and delivered disaster related information more readily and widely through integrating Viet Nam's hydro-meteorological data services and Central Committee for Flood and Storm Control (CCFSC) into the national media (Chaudhry and Ruysschaert 2007).

The early warning system for typhoons in the country delivers a 48 hour warning, broadcast through mass media such as television and radio and in smaller communities through loudspeakers in the streets. In addition, dykes are supervised 24 hours a day during the typhoon season (EU 2006). However, despite recent and ongoing improvements the system is still in need of improvement.

2.4.3. Review on adaptations to saltwater intrusion

Many areas around the world use groundwater as their main source of fresh water supply for industry, agriculture and the domestic sector. The alarming growth rate of the world population has caused continental depletion of the fresh water supply. Thus, salt water intrusion comes as an indispensible consequence in coastal aquifers.

The appearance of saltwater intrusion was detected in early 1845 along Long Island, New York. Seawater intrusion in coastal aquifers emerges as an increasingly serious issue faced by many regions, such as North Africa, the Middle East, the Mediterranean, China, Mexico, and especially the Atlantic and Gulf Coasts of the United States. In the 1950's, three barrier wells were installed in the Los Angeles Basin coastal aquifers in an effort to block the saltwater intrusion. Each barrier is made up of a series of injection wells that shape a subsurface wall of freshwater to prevent saltwater from infiltrating further into coastal aquifers. The barriers were not effective as expected, saltwater keeps penetrating in some areas (USGS 2005).

Before 1980, every year during the dry season, salt water intrusion had done the Mekong Delta of Viet Nam a serious damage, up to 1.7–2.1 million ha out of 3.5 million ha dedicated to agriculture. In the 1980's and 1990's, many salinity management projects, such as closure dams and sluice gates, were installed in the navigation canals that connect the branches of the delta. Consequently, today, Mekong Delta suffered a damage of only 0.8 million ha of agriculture in saltwater intrusion months. Each year, these intakes have to be closed for weeks or even from one to two months to prevent salt water intrusion (Nguyen and Savenije 2006).

However, saltwater intrusion has entered earlier and deeper inland in the Mekong Delta's coastal provinces in recent years[30]. This has resulted in a severe lack of fresh water for 8,000 families and brought about great damage to nearly 20,000 hectares of rice in 2009[31].

In Ben Tre Province, typically, 3,000 hectares of shrimp culture were seriously impacted by increasing salt level in 2010. In addition, higher levels of salinity slowed down growth and even killed farmed tra fish. The loss of the tra fish farming industry is estimated to be as much as VND7.7 billion (USD 385 thousand). The situation is expected to deteriorate in the peak of the dry season. Furthermore, shrimp farming is expected to begin from February 16 but has been delayed because of unusually high salt water level, which is twice as high as the appropriate level for shrimp, according to Nguyen Thanh Cong, head of a shrimp cooperative of Binh Dai District, Ben Tre Province[32].

To cope with the growing saltwater intrusion issue, in 2006, the Ministry of Agricultural and Rural Development facilitated Bac Lieu and Soc Trang provinces to jointly implement a VND 660 billion (US$37 million) irrigation project. Over 60 drainages and dykes have been constructed in an attempt to prevent intrusion of saltwater and secure an adequate supply of freshwater for 150,000 hectares of rice. Leaders of the two provinces said that only one-third of the protection needed is built due to lack of funds and they are still waiting for more funds from government[33].

[30] http://english.thesaigontimes.vn/Home/society/nation/15204/

[31] http://www.saigon-gpdaily.com.vn/National/2009/5/71042/

[32] http://english.thesaigontimes.vn/Home/business/environment/15820/

[33] http://www.saigon-gpdaily.com.vn/National/2009/5/71042/

2.5. COST EFFECTIVENESS ANALYSIS: FORMULATION AND DERIVATION

2.5.1. Comparison between CEA and CBA

Both cost-effectiveness analysis (CEA) and cost-benefit analysis (CBA) are useful tools for program evaluation. Cost-effectiveness analysis refers to the consideration of alternative programs in which both their costs and benefits are taken into account in a systematic way. It is a tool dedicated to decision-making, in that it was born to ascertain which means of attaining particular goals are most efficient (Levin 1995).

Cost-effectiveness analysis is closely related to cost-benefit analysis since both of them are economic evaluations to compare costs against benefits, and they monetize costs in the same way. The only difference between CEA and CBA is the way they measure benefits. In CEA, the benefit of a program is expressed in numeric units, not monetary. For example, in a project to supply freshwater for residents, the benefit could be expressed as the number of households that have access to freshwater. Or in a project in order to prevent lung cancer, the benefit could be measured as the number of lung cancer patients averted the disease. Since the cost is monetized while the benefit is measured in numeric terms, cost effectiveness of a program is expressed as a ratio. Cost-effectiveness ratio (CER) is derived by dividing costs by numeric benefits (Honeycutt et al. 2006; Cellini and Kee 2010).

$$\text{CER} = \frac{\text{Total cost}}{\text{Numeric benefit}}$$

CBA, however, goes a step further to assign dollar value to all (or most) major benefits of a program. Since both the costs and the benefits are monetized, CBA allows us to calculate the net benefit, that is, the difference between the benefit and the cost (Cellini and Kee 2010).

$$\text{Net benefit} = \text{Total benefit} - \text{Total cost}$$

As both costs and benefits of all outcomes are assigned with monetary values, CBA allows us to make comparisons between different programs with different objectives. Meanwhile, by using CEA we have to limit the comparison of programs to those that share similar objectives (Levin 1995). Nonetheless, the advantage of CBA over CEA could be the weakness of CBA because it is not always easy to monetize benefits. Normally the more complicated the program objectives, the more arduous the benefit estimation is, because it often involves various objectives targeted at disparate beneficiary groups (Cellini and Kee 2010).

Furthermore, methods used to quantify benefits could be controversial. In such cases, CEA is more applicable and accurate to use. In addition, CBA is generally used for commercially-motivated programs while CEA is opted for programs in which service motive is prioritized (Shil 2008).

2.5.2. Identify and quantify costs for CEA

In order to classify costs, Cellini and Kee (2010) suggested dividing them into distinct categories: direct versus indirect costs, and tangible versus intangible costs. According to them, direct costs are those that are closely related to the primary objectives of the program such as personnel, facilities, equipment and material, and administration.

According to Cellini and Kee a particular cost could be direct or indirect and tangible or intangible. Indirect costs are unintended costs that occur as a result of program implementation. For example, a dam built in an area for preventing salt water intrusion may cause erosion in another area because it affects river currents. Intangible costs, as its name refers, are implicit and therefore easy to overlook. In contrast, tangible costs are explicit. Thus a particular could be tangible or intangible. For example, construction cost of a dam is direct and tangible cost while damage caused by the dam on another area is considered as indirect and intangible.

Phillips in his paper "What is cost-effectiveness" (2009) employed a somewhat different approach to categorize costs. Phillips classifies costs into three groups: direct, indirect and intangible. Thus, according to him, a specified type of cost could fall into only one of these groups.

In order to quantify costs, Levin (1995) proposed an approach that could be termed "ingredient approach". In this approach, Levin referred to costs as ingredients of the program. The first step is to determine which ingredients are required for an intervention. It is crucial to bear in mind that even donations, for example volunteers or donated building space, must be included since such ingredients chips contributions in the outcome of the program even if they are not taken into account in budgetary expenditures. Identification of ingredients should be done in a meticulous manner to ensure that all resources are included and are described adequately to assign cost values on them. For this reason, Levin suggested that the search for ingredients must be systematic rather than casual. According to him, the primary sources for such data are written reports of the program, observations, and interviews with individuals involved in the program.

Once the ingredients are identified, it is time to assign them with dollar values. By doing this, we assume that all ingredients cost including donations are considered. Ingredients can be divided into those that are purchased in marketplaces, and those that are obtained through other types of transactions. In general, the value of an ingredient for costing purposes is its market value. There exists a variety of techniques for ascertaining the value of ingredients that are not purchased in markets. For example, the value of volunteers could be determined by using the market salary or average salary of a similar job. The value of a donated building space can be estimated from monthly or yearly rental charge of a similar space in the surrounding area.

Honeycutt et al. (2006) also proposed an approach to quantify costs. The method presented is a two-step process: (1) Costs are broken down by each activity the program performs; and (2) Costs within each activity are subdivided into five resource components: labor, contracted services, materials and supplies, buildings and facilities, and donated or on-hand resources. The first step in this costing approach is to determine main activities in the program. Separating costs by activity, known as the activity-based costing, will help point out which activities drive overall costs and how program costs would be altered if particular activities were added or ruled out. Once primary program activities are identified, activity-based costs should be gathered according to the following components: (1) labor, (2) contracted services, (3) materials and supplies, (4) buildings and facilities, and (5) donated resources or those not funded by the program. Labor costs consist of the total compensation for an employee to spend his/her time performing assigned activities. Total compensation includes salaries or wages adding to other benefits. Labor costs could be extracted from accounting documents. Contracted service costs include costs for services provided by outside entities. Keeping records of the bills facilitates service cost estimation. Costs of materials and supplies are expenses on purchases to bolster program activities. Again, keeping track of the bills help estimate material and supplies cost. Costs of buildings and facilities include rent and/or mortgage payments, as well as physical maintenance and operating costs (including utilities, taxes, and insurance). Values of donated resources can be estimated as costs that would have been incurred if these resources had not been donations.

2.5.3. Quantify benefits for CEA

Benefit quantification starts with identification of important benefits which can reflect the success of the program. It is then necessary to decide how to measure effectiveness (benefit) of programs. Measures of effectiveness are idiosyncratic to each program. In all cases they must be connected to the objectives of the program (Cellini and Kee 2010). Therefore, a careful understanding of programs facilitates the selection of effectiveness measures. Table 1 provides examples of effectiveness measures that respond to particular program objectives. With measures of effectiveness in hand, the next task is to count only units of effectiveness that are attributed to the program.

Table 1: Examples of effectiveness measures

Program objective	Measure of effectiveness
Increasing course completion	Number of student completing the course
Reducing dropouts	Number of potential dropouts who graduate
Enhancing employment of graduates	Number of graduates placed in appropriate jobs
Providing freshwater	Numbers of households provided with freshwater
Preventing saltwater intrusion	Number of ha of agricultural land is protected
Reducing traffic accidents	Number of traffic accidents reduced

2.5.4. Discount costs

Since programs might last for several years, a discount rate is necessary to obtain present value of all costs which occur along the lifespan of the program. The underlying idea of discounting is that one dollar spent today is worth more than one dollar spent tomorrow. The present value of costs (PVC) is computed using the following formula.

$$PVC = \sum_{t=0}^{n} \frac{C_t}{(1+i)^t}$$

Where:

C_t stands for cost which occurs at time t,

i stands for discount rate, and

n stands for program's lifespan.

The choice of discount rate is critical in using CEA (and CBA as well). Nonetheless, which discount rate is appropriate is debatable. The Canadian Cost-Benefit Analysis Guide (TBCS 2008) recommends a range of 3 to 7 percent depending on the project and its length. A 2007 study by the Asian Development Bank found that developed nations tended to use real rates between 3 and 7 percent, whereas developing nations used a higher rate of 8 percent or more, reflecting the higher risk and uncertainty of public investments in those nations (Zhuang et al. 2007). However, a World Bank paper has argued for a real rate of 3 to 5 percent (Lopez 2008). In the field of heath and medicine, most health economists agree that a discount rate of 3% should be used (Gold et al. 1996).

2.5.5. Cost-effectiveness ratio

The final step is to bring together the present value of costs and units of effectiveness to compute cost-effectiveness ratios (CERs), where we have a single measure of effectiveness. The CER is expressed as dollars per unit of effectiveness. In a health program, for example, CER might represent dollars per life saves or dollars per lung cancer prevented:

$$\text{CER} = \frac{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}}{\text{Units of effectiveness}}$$

Before calculating CER, distinction must be made between *independent programs* and *mutually exclusive programs* (Phillips 2009; Shil 2008). *Independent programs* means the costs and benefits of one program are not affected by other programs. On the other hand, *mutually exclusive programs* means the implementation of one program will prevent the implementation of other programs, or the application of one program will influence the costs and benefits of other programs.

For independent programs, CERs are calculated for each program using the formula above. Programs are then given priority according to their CERs from the smallest to the largest.

For mutually exclusive programs, it is essential to use incremental cost-effectiveness ratios (ICERs) if the objective is to securing maximum outcomes rather than considering cost (Phillips 2009; Shil 2008). The idea of ICER is how much it costs to generate one additional unit of effectiveness. Programs are placed according to their units of effectiveness, from the smallest to the largest. Afterwards, ICER of each program is computed using the following formula:

$$ICER_t = \frac{PVC_t - PVC_{t-1}}{UE_t - UE_{t-1}}$$

Where:

PVC_t and PVC_{t-1} are present values of costs of program *t* and *t-1* respectively

UE_t and UE_{t-1} are units of effectiveness of program *t* and *t-1* respectively

Here, it is not difficult to realize that ICER of program 1 is equal to its CER (it is compared against the "do-nothing" program which, of course, generates no benefits at no costs).

CHAPTER 3
METHODOLOGY

3.1. FORCUS GROUP DISCUSSION

Television shows, radio broadcasts, newspapers and internet, have altogether concluded that Ben Tre province is one of the areas in Mekong Delta affected the most by climate change. However, there still remains a dearth of specific information, about consequences of climate change; the occurrence of disasters caused by climate change, the impact of climate change on economic activities and livelihoods in communes; which communes in Ben Tre Province have been most affected by climate change; the actions from the local people and local governments to mitigate and adapt to climate change impacts; and sources of funds to assist those affected to cope with climate change.

To provide answer to these above inquiries, three tools were employed, hazard mapping, historical timeline and vulnerability matrix in focus group discussions (FGD). It is expected that focus group discussions in concert with these tools can provide a general picture of the state of climate change impacts on Ben Tre province.

"A hazard map is a map that highlights areas that are affected by or vulnerable to a particular hazard" - Wikipedia[34]. A picture is worth a thousand words. The map is able to provide a comprehensive overview of the community, resources, and livelihoods and to bring together much information in an understandable form.

Hazard mapping was considered as an option to stimulate community participation to involve in vulnerability assessment. The position of resources and hazards were plotted in the map by community members. So, it enables communities to analyze patterns and interrelationships between risks, hazard locations, and resources (Cross et al. 2009). In addition, hazard mapping is used to see how the place is perceived by different groups within the community, to identify important livelihoods resources in the community, and who has access and control over them, to identify areas and resources at risk from climate hazards and to analyze changes in hazards and planning for risk reduction (Morgan 2011). A community based hazard

[34] http://en.wikipedia.org/wiki/Hazard_map

map was employed in a flood control project carried out in Camiguin Island, Philippines (Damo 2007).

Particularly in this study, the hazard map is designed in such a way to highlight geographical features of studied sites, main economic activities, and impacts of typhoons, saltwater intrusion and erosion. The map plays an important role in providing information for the next two tools, say, historical timeline and vulnerability matrix.

Following hazard mapping is the historical timeline of climatic hazards which is meant to display events which have occurred in the province within a specific time period. The timeline, as its name implies, consists of two elements-climatic hazards and times of occurrences. The tool was also employed in several studies. Weart (2008) and Marshall (2009) outlined key climatic events considered as important landmarks throughout the history and they titled their independent works similarly-climate change timeline. Bhandari made use of the tool to accumulate information on climate change and its impacts that have occurred over the past 40 years in Kadampur and Mirtung villages in Nawalparasi district in Nepal (Bhandari 2008). The National Oceanic and Atmospheric Administration (NOAA) views the tool valuable in enabling the understanding climate of the recent past and to provide some background for framing future change in climate[35].

Vulnerability matrix has a wide range of application. Cross, Awuor and Oliver (2009) used vulnerability matrix to determine impacts of climate-related hazards (strong winds, extreme heat and drought) on relevant livelihood resources (natural, physical, financial, human and social resources) that support livelihood activities in order to more effectively analyze concurrent and potential coping strategies (Cross et al. 2009). The matrix is also a tool to help DNS (Domain Name System) operators understand security risks of internet systems[36]. Agencies in Peterborough employed the vulnerability matrix to meet the needs of children and young people. A constitution of consultation and co-operation between agencies and organizations was furnished by the matrix in an effort to foster children's welfare and to identify when a child may be in jeopardy[37].

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[35] http://www.magazine.noaa.gov/stories/mag84.htm

[36] http://www.isc.org/software/bind/security/matrix

[37] http://peterborough.proceduresonline.com/chapters/p_vul_matrix.html

Particularly in this study, the vulnerability matrix serves as a tool to investigate the vulnerable levels (high, medium, low or not vulnerable yet) of vulnerability categories. The vulnerability matrix is provided in the form as shown in table 2. Vulnerability categories are sectors/areas/activities which are most important to local residents' livelihoods and affected by saltwater intrusion, typhoon, erosion and potential sea level rise as well. In terms of scale, H stands for high vulnerability, M stands for medium vulnerability, L stands for low vulnerability and N stands for not vulnerability yet. The vulnerable levels are confirmed by the maximum agreement of participants in focus group discussions.

Table 2: Vulnerability matrix

Scale **H**: High vulnerability **M**: Medium vulnerability **L**: Low vulnerability **N**: Not vulnerable yet ***Vulnerability categories***	***Climatic events***			
	Typhoon	Saltwater intrusion	Erosion	Sea level rise

3.1.1. The first focus group discussion

Upon the agreement and support of the provincial president, the first focus group discussion (FGD) was held with the presence of eight representatives from the Provincial People's Committee, the Province Bureau of the National Target Program to Respond to Climate Change, the Department of Aquaculture and Rural Development, the Department of Natural Resources and Environment, the Department of Science and Technology, the Department of Plan and Investment, and the Department of Finance. With the enthusiastic cooperation of the representatives, the first FGD helped bring to light the following issues: (1) signs of climate change in Ben Tre, (2) impacts of climate changes on Ben Tre, (3) worst affected areas in the province, (4) action plans on mitigating and adapting to climate change impacts, and (5) financial resources to deal with climate change.

3.1.2. The second focus group discussion

The second FGD took place at district level with the presence of 10 government officials of Binh Dai district coming from the People's Committee, the Department of Agriculture and Rural Development, the Department of Natural Resources and Environment, and the Department of Economic Development, as well as authority representatives of Thua Duc-a coastal commune in Binh Dai district. The participants were chosen based on their experience and knowledgeable insights in agriculture, aquaculture and climate change. This FGD served as a platform for people to share their opinions and observations on the signs and impacts of climate change in Binh Dai district and Thua Duc commune in particular. In addition, the second FGD to a certain extent helped verifying results of the first FGD.

3.1.3. The third group discussion

The third FGD took place in three different coastal communes in Binh Dai, Ba Tri and Thanh Phu districts, which are believed to be severely affected by climate change. The participants invited by the authority, were from various professions. The purpose of this FGD is to listen to the voice of local residents which is an important information channel. Besides, during the third FGD, hazard mapping, historical timelines of climate hazards, and vulnerability matrices for each commune were completed thanks to valuable help from participants.

3.2. QUESTIONNAIRE

In order to assess awareness on climate change of local residents, to identify and evaluate types and values of damages caused by typhoon, saltwater intrusion and erosion, and to investigate types and costs of households' autonomous adaptations, a survey instrument was employed as a tool to capture the input of local residents.

3.2.1. Questionnaire development

The questionnaire was designed based on results from three focus group discussions that facilitate the achievement of the research objectives. The questionnaire consisted of six major parts. The first section provides general information about households. The second section addressed occupations of households. The third section identified types and values of damages resulting from typhoon, saltwater intrusion and erosion. The fourth part assessed awareness of households on climate change and its impacts. The fifth section looked into types and costs of autonomous adaptations performed by households. Finally, the last section was designed to capture expectations of households toward local governments.

3.2.2. Questionnaire modification

After completing the questionnaire, a small survey was carried out in order to test whether the questionnaire is understandable and answerable and there are any unnecessary questions. Twenty respondents participated in this pilot-scale face-to-face survey. According to the outcomes of this survey, the questionnaire was modified to provide information to meet the survey objectives. The questionnaire could be seen in appendix A

3.2.3. Household interview

Three hundred households were sampled in a large survey with the modified questionnaire. They were equally divided among three studied coastal districts. In each commune, the survey covered all villages with the hope that the samples represented the population. Respondents were chosen based on the economic structure of the commune in order to involve as many occupations as possible, including agriculture, aquaculture and fishing. Respondents were invited with the help of local officials.

3.2.4. Data entry and process

Data collected from the household interview were encoded using Microsoft Access. Processed data demonstrate how harmful each climatic event is in terms of types and values of damages, and the percentage of affected households. In addition, types and costs of autonomous adaptations of households as well as expectations of communities towards local governments were also displayed. Microsoft Excel was employed to process and analyze the data.

3.3. ECONOMIC EVALUATION OF PLANNED ADAPTATION STRATEGIES

When projects with different cost structures are not expected to produce the same outcomes, cost-effectiveness analysis, whereby the costs are compared with outcomes measured in natural units, is appropriate for project selection. Cost-effectiveness analysis assumes that a certain benefit or outcome is desired, and that there are several alternative ways to achieve it.

CEA is comparative and asks which of the alternative is the cheapest for providing the service. In this study, CEA was employed as the tool for evaluating the two adaptations under consideration of the provincial government: building a sea dike and an irrigating system. The two projects share common objectives, that is, preventing flooding and attenuating salt water intrusion.

The discount rate of 10% was used based on a study of the Asian Development Bank (ADB). The study found that developed nations tended to use real rates between 3 and 7 percent, whereas developing nations used a higher rate of 8 percent or more, reflecting the higher risk and uncertainty of public investments in those nations (Zhuang et al. 2007). Actually, the choice of a discount rate is not quite important because regardless of what discount rate is chosen, it is applied simultaneously to both projects. It therefore does not affect the comparison.

3.4. SECONDARY DATA COLLECTION

The study also made use of secondary data which were kindly provided by the Department of Agriculture and Rural Development, the Province Bureau of the National Target Program to Respond to Climate Change, and the provincial Bureau of Statistic. Specifically, the secondary data are significantly important in conducting cost-effectiveness analysis of planned adaptations.

CHAPTER 4

FINDINGS

4.1. GENERAL INFORMATION

Ben Tre province is located in the Mekong Delta, a low-lying plain serving as the major agricultural production area in Vietnam. The province which is comprised of eight districts covers an area of about 2,300 km^2 with an intricate system of internal rivers and canals. There are four big rivers, Tien Giang, Ba Lai, Ham Luong and Co Chien, which surround and divide Ben Tre into three separate land areas (figure 2). Branches of these internal rivers originate from the Mekong River system and follow the eastern direction to the East Sea at four big estuaries.

It borders Tien Giang province in the north, Vinh Long province and Tra Vinh province in the west, and in the south Co Chien river. Accompanying this system is fertile lands, bordering 65 km of the coastline and a privileged sea area of approximately 20,000 km^2 which is part of the exclusive economic zone.

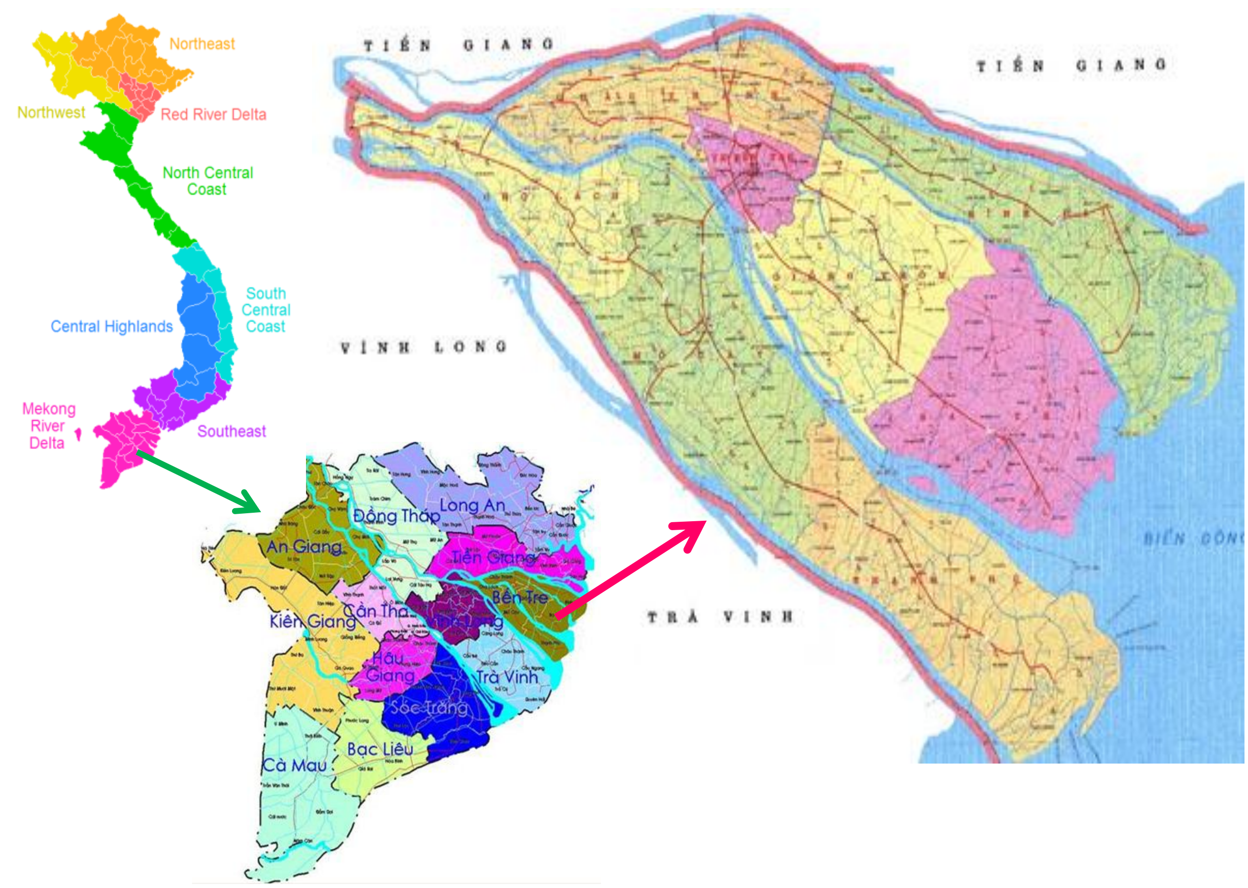

Figure 2. Vietnam, Mekong Delta and Ben Tre province

In terms of climate, there are two main seasons: rainy and dry. The rainy season lasts from May to November and the dry season from December to April of the next year. The rainy season coincides with the southwest monsoon. Average annual rainfall ranges between 1,300 mm to 1,700 mm. Coastal areas receive the lowest amount of rainfall compared to other areas within the province. The temperature of the province is relatively high, which is favorable for the production of certain crops such as watermelon and rice. The average temperature recorded is about 27^oC. The hottest months are April and May, when the average temperature is up to about 29^oC. The coolest is December with average temperature as low as 25^oC.

The total population of Ben Tre (2009) is 1,255,946 with households numbering 358,691. The average household size is four. About 90% of the population lives in rural areas. The average monthly income per capita (2008) is VND 891,440 (USD 43)[38] and VND 1,165,390 (USD 56) in rural and urban areas, respectively. The unemployment rate (2009) is about 11.7%. Most residents have little formal education. The primary occupations are farming, fishing, labor required for manufacturing, labor for construction, petty trade and motorcycle repairing. Approximately 50% of all employed residents are working in agriculture. Gross output of agriculture in 2010 was VND 12,017,951 million (USD 579,569,396) of which approximately 59% was attributed to cultivation. Of the 178,000 ha cultivated in 2010, paddy accounted for 80,900 ha, with the total production of 363,000 tonnes. The production of fisheries amounted to 290,585 tonnes in 2010 with the gross output of VND 7,478,813 million (USD 360,668,065) of which 67.5% was supplied by aquaculture. The industrial output value reached VND 9,575,873 million (USD 461,799,430) in 2010 of which 93.6% came from the manufacturing.

4.2. FOCUS GROUP DISCUSSION FINDINGS

4.2.1. The first focus group discussion

a. Impacts of climate change in Ben Tre province

a.1. Sea level rise

As located right next to the East Sea, Ben Tre is very likely to be flooded as sea level rises. In order to foresee what will happen in the future, the province has already sketched its own scenarios of sea level rise based on that for the entire Vietnam compiled by the Ministry of Natural Resources and Environment. The area which is likely to be inundated is depicted in

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[38] Exchange rate used in this entire study is 20,736 VND/USD

figure 3 in terms of percentage in accordance with various sea level rises. In case no preventive measures are performed, 50 percent of the province area will be under the sea as the sea level rises 1.0 meter in 2100.

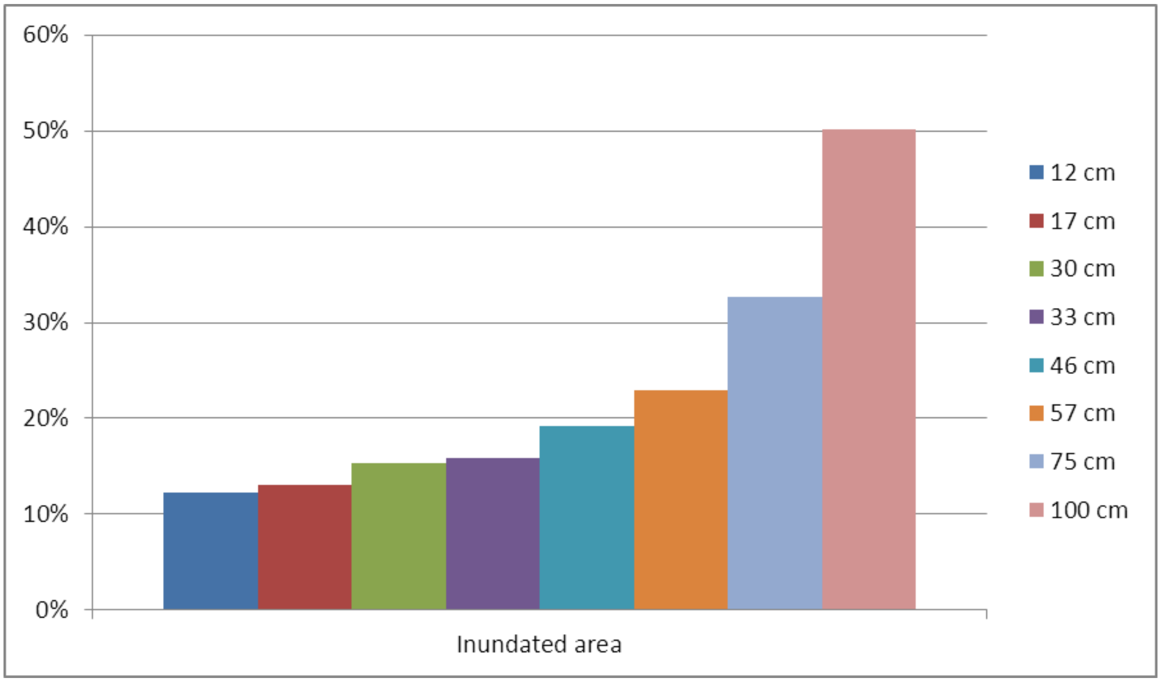

Figure 3: Inundated area (%) by various rises of sea level

Source: Ben Tre PPC 2011

Figure 4 and 5 make a step further to illustrate the land uses of the potentially flooded area. As indicated in the two figures, agriculture and aquaculture will be most affected due to rising sea level; paddy will be most flooded, followed by perennial industrial crops, aquaculture and fruits. As sea level rises 1.0 m, almost 80% of paddy area will suffer from permanent flooding. This is truly worrying since rice is the irreplaceable element in everyday meals. The figures also display another important feature, that is, rural residential area will be more inundated than urban residential area.

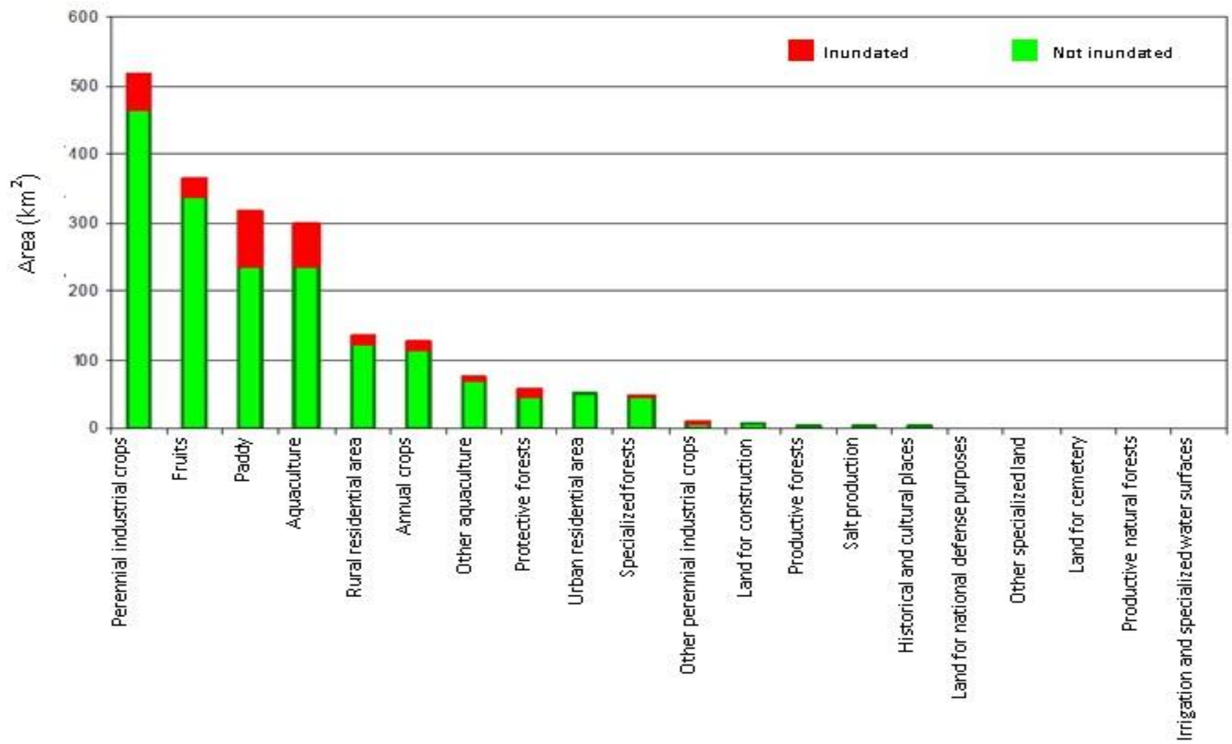

Figure 4: Land uses of potentially inundated area as sea level rise 57 cm

Source: Ben Tre PPC 2011

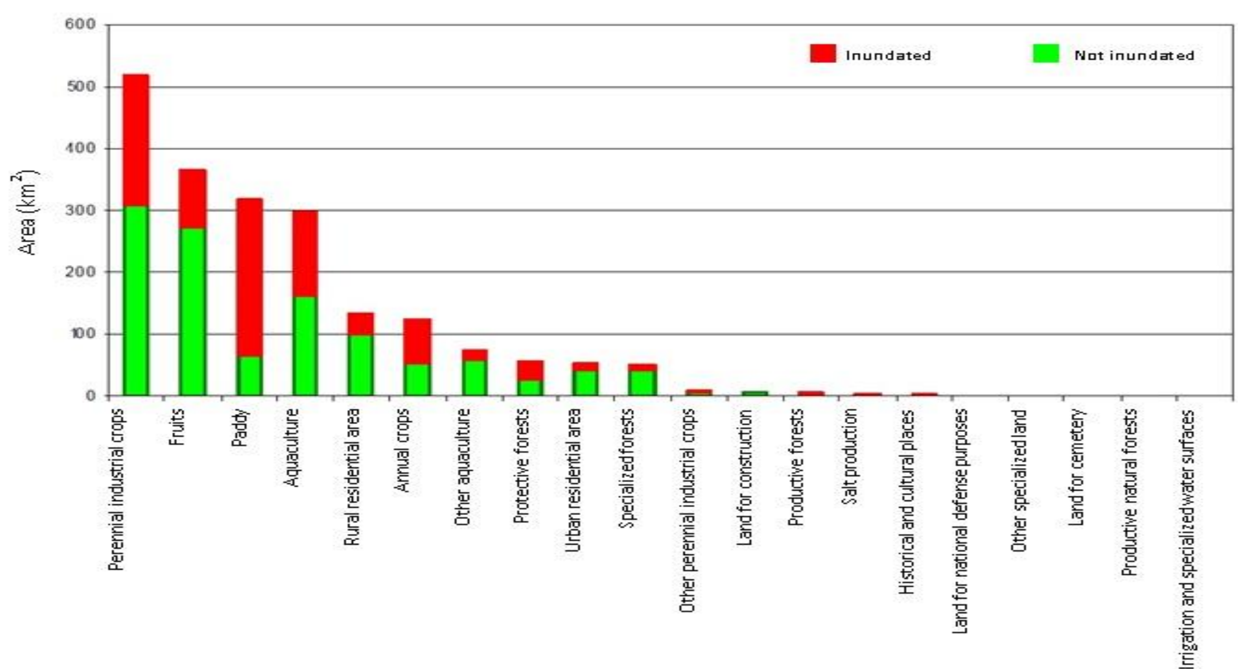

Figure 5: Land uses of potentially inundated area as sea level rise 100 cm

Source: Ben Tre PPC 2011

As a consequence of rising sea level, residents who live on low-lying land will be put in jeopardy and forced to relocate if there are no preventive structures implemented. The following figure specifies the number of residents who live in the potentially inundated area.

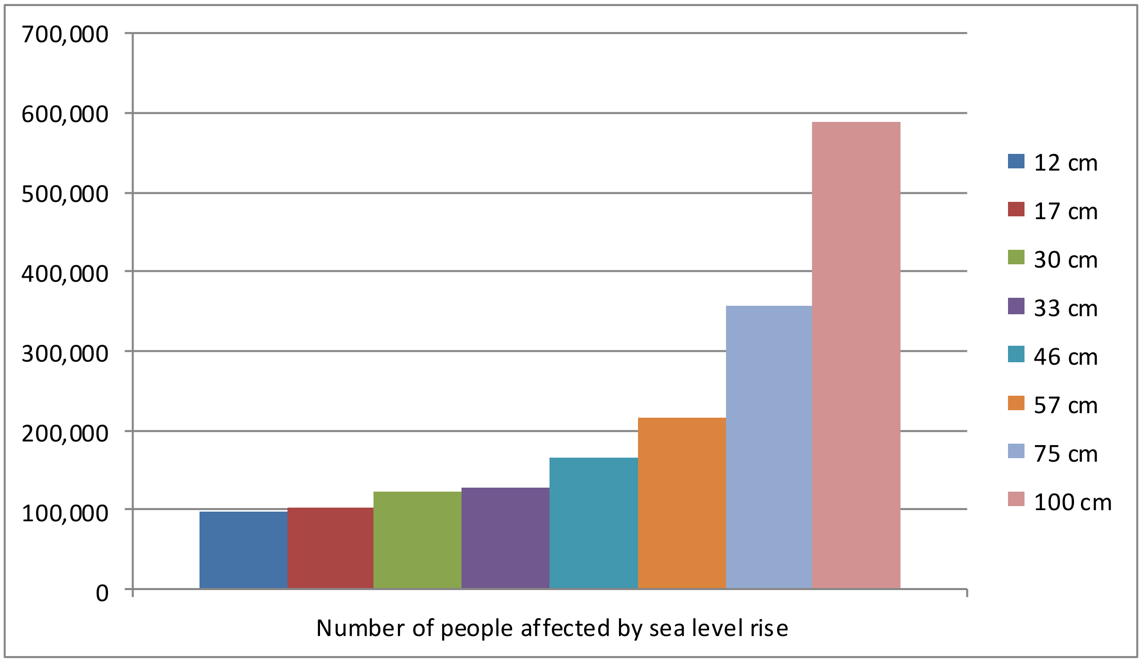

Figure 6: Number of residents living in potentially inundated area

Source: Ben Tre PPC 2011

a.2. Salt water intrusion

As dry seasons approach, salt water intrusion occurs in almost every area of the province causing severe fresh water shortages destined for family routines as well as agricultural production. The salinity of 1 ppm can be detected throughout the entire province while the salinity threshold for drinking water is less than 0.25 ppm. It is estimated that as the sea level rises by 11 cm, the 4.0 ppm salinity boundary will be 15-25 km away from the coastline. The situation will, however, be more serious in 2050 when the sea level rises 30 cm (figure 7). At that time the 4.0 ppm salinity boundary will be at the distance of 40 km from the coastline. Areas that are now suffering 4.0 ppm salinity will experience 8-10 ppm salinity. (Such forecasts do not take into account the effects of droughts, longer dry seasons, and less water flow from upstream).

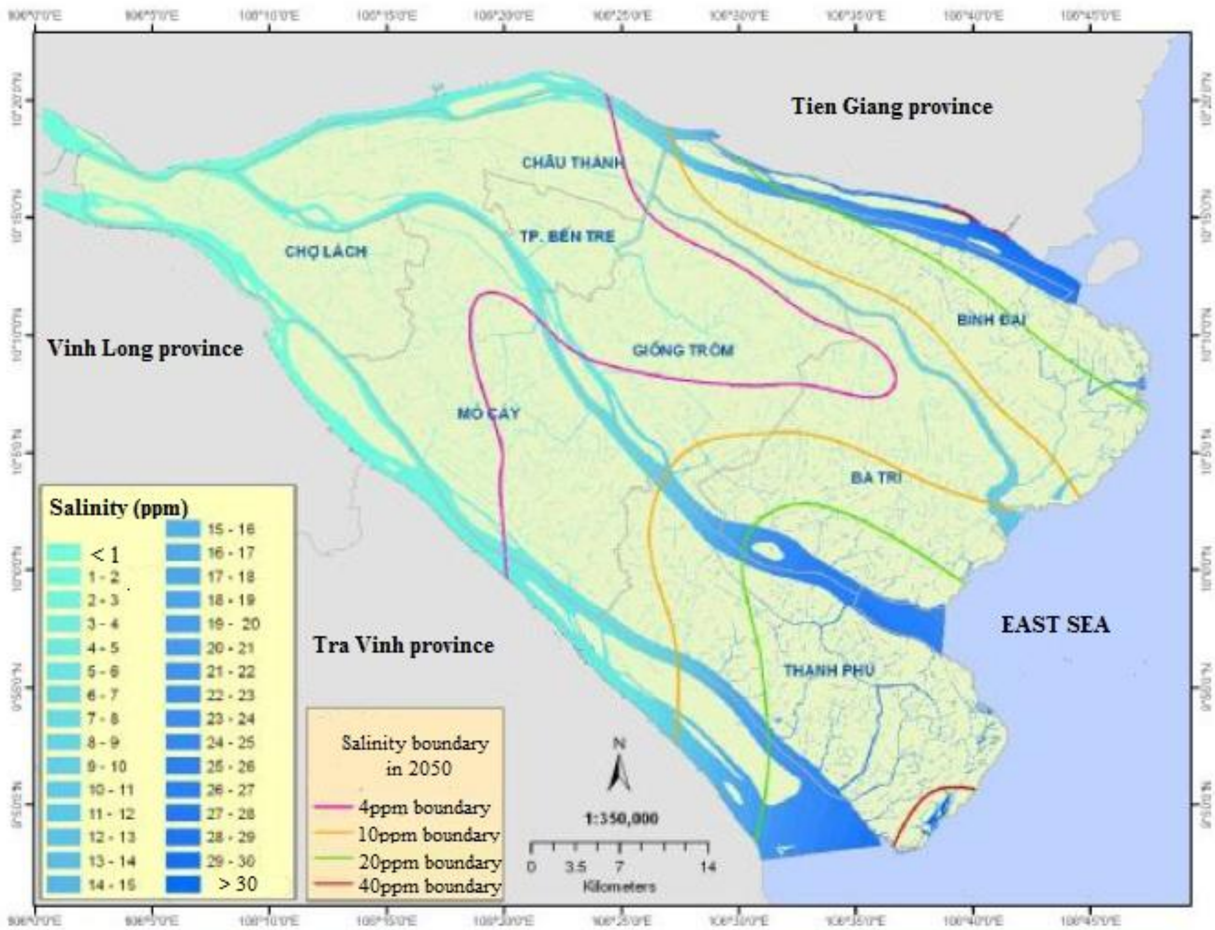

Figure 7. Salt water intrusion forecasts for 2050

Source: Ben Tre PPC 2011

Salt water intrusion in Ben Tre is made possible by the following factors:

1. Ben Tre terrain is pretty flat with a system of abundant rivers and channels. Approximately 90% of the provincial area is located at 1 to 2 m latitudes, and affected by the East Sea tidal regime which carries salt water. Besides, a large number of inland rivers and channels have relatively large width and the four main estuaries are as large as 2 to 3 km. These enable salt water accompanying tides to travel inland.
2. In dry seasons, due to decreased upstream water levels and low precipitation, water levels and velocity of rivers and channels are not strong enough to counter salt water which flows in the opposite direction.

3. The recent fast increase of aquaculture activities has resulted in the reduction of mangrove forests which in turn provides favorable conditions for sea waves and tides carrying salt water deeper inland.
4. Population growth as well as economic activities, has led to an exhausted usage of groundwater which helps worsen the situation.

Economic losses caused by salt water intrusion from 1995 to 2008 amounted to VND 672,325 billion (USD 32,423,080,632) including 15,782 ha of dead or less productive paddy, 13,700 ha of shed unripe coconut, 360 ha of less productive aquaculture and 5,289 tons of dead shrimp. The intrusion also put 132,823 households into a situation of continued lack of fresh water.

According to the Head of Aquaculture Department, Ben Tre Department of Agriculture and Rural Development, salt water intrusion in 2010 caused quite heavy damages to the aquaculture sector of the province, especially to marine shrimp farming with total affected area of over 3,000 hectares, including pangasius farming areas. The loss was up to over 7.7 billion VND (USD 371,335).

As reported by the head of the shrimp management board in Thanh Phuoc commune, Binh Dai district – one of the three districts most affected by salt water intrusion in the province - a few years ago, the extensive farming took about four months to harvest shrimps, but now it takes up to six months due to saltwater intrusion. As farming time is prolonged, cost burden for shrimp farmers is increased.

a.3. Typhoons and flooding

Throughout its early history, Ben Tre suffered so few typhoons that it used to be known as a typhoon-free land. This perception was attached so deeply to residents' mind that they employed coconut leaves and wood as main materials to build their houses. Even after the deadly typhoon in 1997 with wind velocity of 120 km per hour which accounted for severe devastation, residents remained surprised when they were notified about a typhoon which was able to affect the province.

In 2006, the sudden typhoon named Durian with wind velocity of over 133 km per hour had severely devastated the province, which resulted in 17 deaths, 162 injuries, and 71,340 collapsed or unroofed houses. Since then, residents begin believing that typhoons are not unlikely occurrences in the province.

Regarding flooding, the climatic event is mainly attributed to flood water flowing down from upstream since Ben Tre is located at the downstream of the Mekong river. Therefore, upper districts of the province are those which suffer most from flooding. Total damages resulted from flooding from 1996 to 2008 were recoded as VND 365,635 billion (USD 17,632,860,725).

a.4. Erosion

Ben Tre territory is segmented by an intricate system of rivers and channels. Therefore, erosion occurs mostly along the riverside due to strong waves, tides as well as indirect causes such as sand mine, structures on the banks and heavy traffic of vessels. It is recorded that riverside erosion during the period 1995 to 2008 had affected 1,826 households, devastated 366,547 ha of land, and severely damaged 501 houses. Total loss was estimated at VND 73,341 billion (USD 3,536,892,361).

a.5. Other impacts

Climate change has caused fluctuation in weather conditions. Typical examples of such fluctuation are average annual temperature has taken increased by approximately $0.3^{O}C$ from 1990 to 2005 and the gap between daytime and nighttime temperature has also expanded. The amount and frequency of precipitation has varied considerably; from 1990 to 2006, the average amount of rainfall increased by approximately 7.5 mm, which means an annual increase of 0.5 mm in precipitation. Changes in climate have also affected the coastal ecosystem and distorted the fisheries resources, which directly affects the coastal fishing communities. Moreover, fishing activities are often hindered by the risk of typhoons and tropical depression.

b. Areas with worst climate change impact

It was illustrated from the first focus group discussion that the three coastal districts, Binh Dai, Ba Tri and Thanh Phu witnessed the worst damage from climate change impacts. According to the B2 emission scheme (figure 8), for instance, if the sea level rises by 30 cm by 2050, 16.23% (60.27 km^2) of the area of Binh Dai district will have been covered in water, those of Thanh Phu and Ba Tri will be 15.61% (60.01 km^2) and 13.23% (47.43 km^2) respectively.

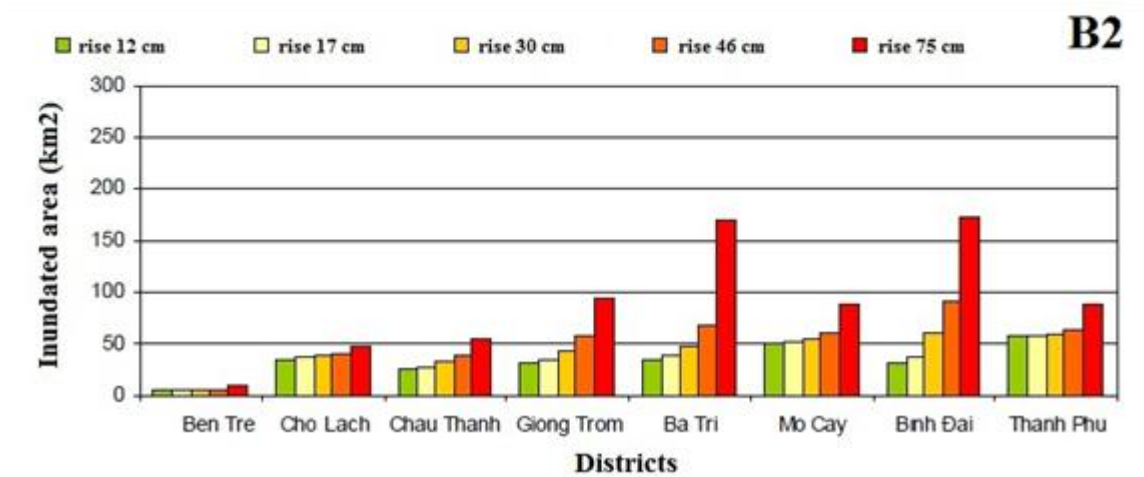

Figure 8. Inundated area by district according to B2 emission scheme

Source: Ben Tre PPC 2011

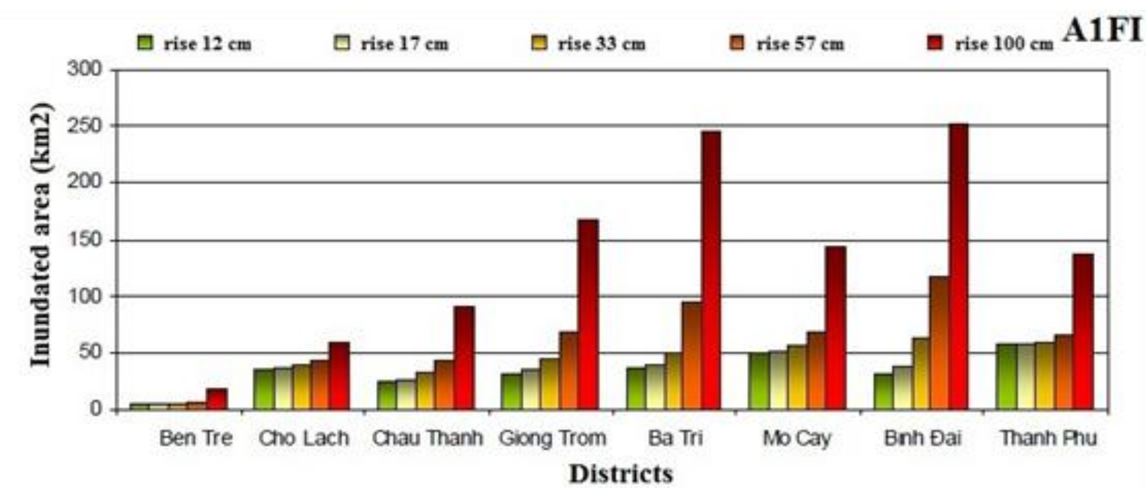

Figure 9. Inundated area by district according to A1FI emission scheme

Source: Ben Tre PPC 2011

These districts also have encountered increasing land loss and salt water intrusion due to sea level rises since they are located right next to the East Sea. This can be seen more clearly by referring back to figure 8 and 9 above. Almost every piece of their territories will suffer from salinity from 10 ppm to 20 ppm in 2050. Particularly a small area of Thanh Phu district will experience 40 ppm salinity.

c. Action plans on mitigating and adapting to climate change impacts

Major action plans such as a 5-year plan (2011-2015) for climate change and sea level rise adaptation were sketched. The plan included building: (1) irrigation to serve agricultural production, such as the Quoi Dien, Cau Sap irrigation systems, Ham Luong salt water-preventing dam; (2) sea walls to bound Binh Dai, Ba Tri and Thanh Phu coastal districts have been constructed. The province also promoted the mangrove swamps planting project along the sea walls. The chosen species are mainly mangroves, cypress and other fruit bearing trees; (3) water supply factories to provide piped water for coastal residence; and (4) enhancing the awareness of the communities on climate change, its impact and response techniques.

In 2010, the office of climate change program made a huge effort in awareness propaganda through two consultative courses designed for the communities, three districts conferences and one provincial conference. The internet as well as the mass media was also utilized to assist the people to obtain knowledge for dealing with climate change. Twice each month, the website www.baodongkhoi.com.vn, is updated with climate change information and once every month, the Ben Tre Television Station Broadcast diffuses news regarding the climate change situation.

d. Financial resources to deal with climate change

Along with the government budget (the central government budget and additional budget from the province), Ben Tre province activities are funded by the following non-governmental organizations (NGOs): Oxfam (2009-2011), financial support of about USD 25,000, assists to improve the capability for managing risks from climate change by diversifying livelihoods; WWF project (2011-2012), financial support of about USD 150,000, assists in applying ecosystem based adaptation to climate change; and DANIDA with financial support of USD 8 million in five years (from 1 January, 2009 to 31 December, 2013).

4.2.2. The second focus group discussion

Changeable weather phenomenon, increasing temperature and salinity, together with the larger gap between day and night time temperatures and sea level rise are consequences of climate change prevailing in Binh Dai district. Alternation in seasonal wind direction also causes variation in currents on river valleys, thus influencing soil erosion.

In Thua Duc commune, productivity of extensive shrimp farming within mangrove forest decreased noticeably (from VND 7-10 million per crop prior to 2007 to only VND 5 million per crop after 2007). Increases in temperature and salinity thickens the exoskeleton of black tiger and white leg shrimp; hence slowing their growth. Such harsh conditions also lengthen the culture period by an average of one month. Fishing productivity, similarly, experiences major declines.

In 2010, massive clam deaths (up to 90%) inflicted enormous losses on farmers. The clam culturing areas are assessed to be highly vulnerable to climate change and sea level rise, that both changed the environmental conditions and the ecology.

Regarding adaptation tactics, Binh Dai District has implemented a couple of projects: building a raw freshwater reservoir and water supply system, evacuating people from eroded areas, planting 101 ha of mangrove swamps and those to barricade sea tides, and implementing 20 salt water irrigation systems.

4.2.3. The third focus group discussion

In addition to conducting hazard mapping, historical timeline and vulnerability matrix which are shown in the following sections, there are several features drawn during the 3rd discussion. Residents showed initial awareness of climate change as well as initiated planned actions against the situation of climate change, for example: (i) Changing the seasonal culturing schedule, (ii) In the past, people were accustomed to leaving small holes in the walls near the roofs for ventilation. They, nevertheless, realize that those holes are the reasons why their houses were unroofed when typhoons swept by (especially the one in 2006); (iii) Most house basements and the edges of farming ponds are also raised to avoid possible floods in the future as well as to prevent salt water intrusion; (iv) Buying or building containers to reserve rain water during rainy seasons for later use in the dry seasons when water is often salty; (v) Building underground shelters to hide from typhoons which may occur in the future. Residents' awareness of climate change was assessed more closely during the household survey which is presented in section 4.7.

4.3. HAZARD MAPPING

The hazard map for Thua Duc commune, which consists of five villages, is displayed in figure 10. In the villages of Thua Tien and Thua Trung, agriculture is the main occupation which includes peanut, watermelon, mango and jicama. Residents in Thua Long and Thua Thanh villages earn their living through fishing and aquaculture (blood cockle farming). In the last village, Thua Loi, shrimp farming is the main occupation. The tidal flats surrounding the shoreline of the commune is employed for clam production which generates income for every resident in the commune.

Figure 11 depict the hazard map for An Thuy commune which is comprised of five villages. In An Thuan, An Thanh and An Thoi villages, most of the residents are fishers. Whereas, residents in An Loi village prefer to do shrimp farming at industrial scale. Finally, in An Binh village, salt making, cow rearing, rice growing, and aquaculture (shrimp, crab, and tilapia) are main occupations. As in Thua Duc commune, the tidal flats in An Thuy commune are destined for clam farming.

The hazard map for Giao Thanh commune is depicted in figure 12. In Giao Hiep, Giao Tan and Giao Loi villages, a number of residents take advantage of the rotation between shrimp and rice in order to mitigate the impact of salt water intrusion. In addition to rice, watermelon, jicama and sweet potation are also grown in Giao Hiep, while vegetables are planted in Giao Loi. Finally, it is in Giao Hoa village where industry-scale shrimp farming takes place.

From the figures, salt water intrusion takes affect every corner of the three communes. For those who do agriculture, salt water is truly a disturbing issue. In addition to having adverse effects on agriculture and to some extent on aquaculture, salt water invasion is the culprit for the severe lack of freshwater for family routines.

Regarding typhoon, Thua Duc commune suffered the most compared to the two other communes. Devastating typhoon Durian in 2006 swept over the commune which resulted in severe damages to every corner of the commune.

Erosion is not mentioned in the figures because of its random occurrence. Land loss, as well as losses from agriculture and aquaculture, has been recorded as a consequence of soil erosion.

With respect to sea level rise, this is quite a strange concept to residents. They actually confused it with what is called tide. Talking about sea level rise and tide, residents reported that tide has invaded further inland in recent years.

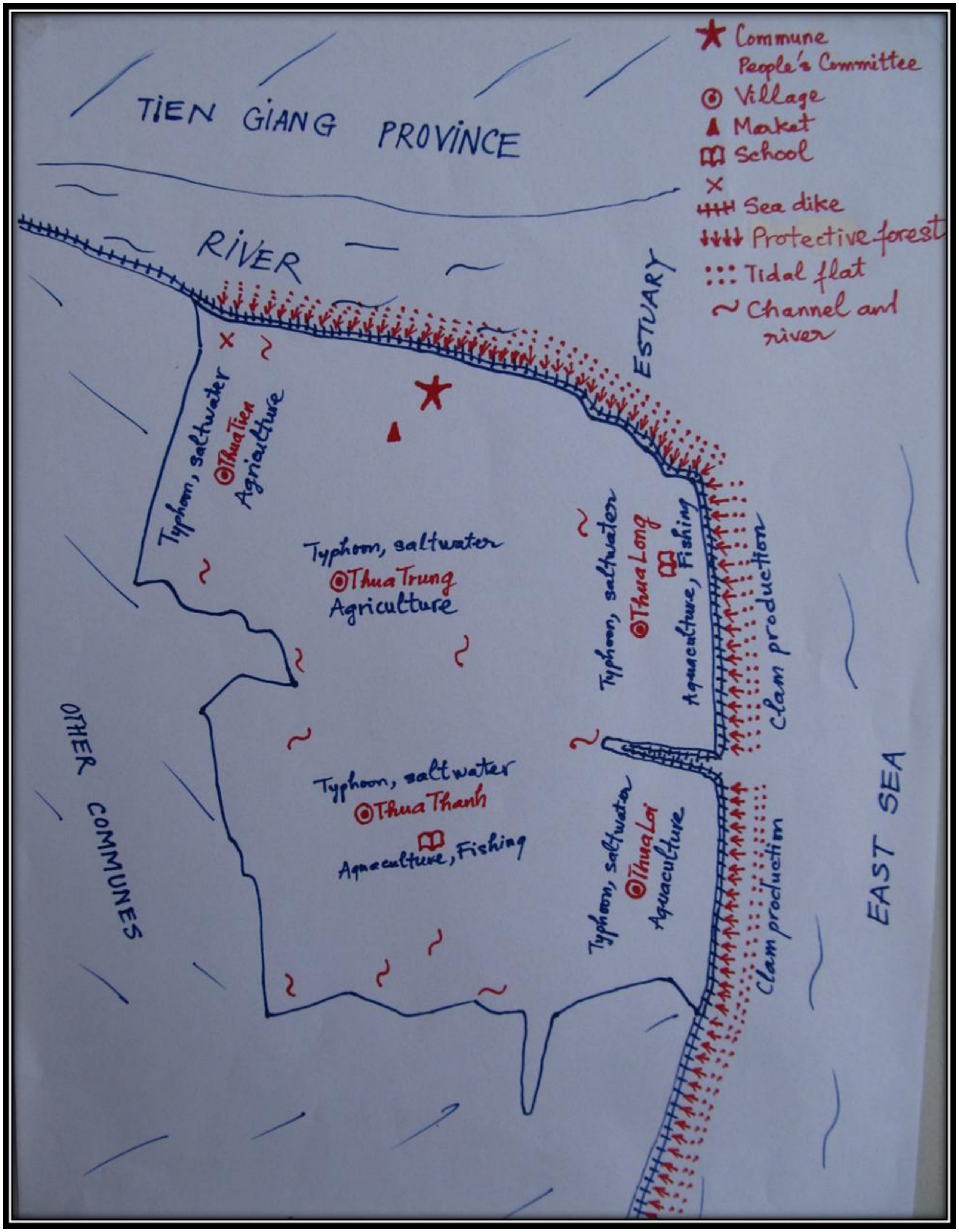

Figure 10. Hazard mapping for Thua Duc commune, Binh Dai district, Ben Tre

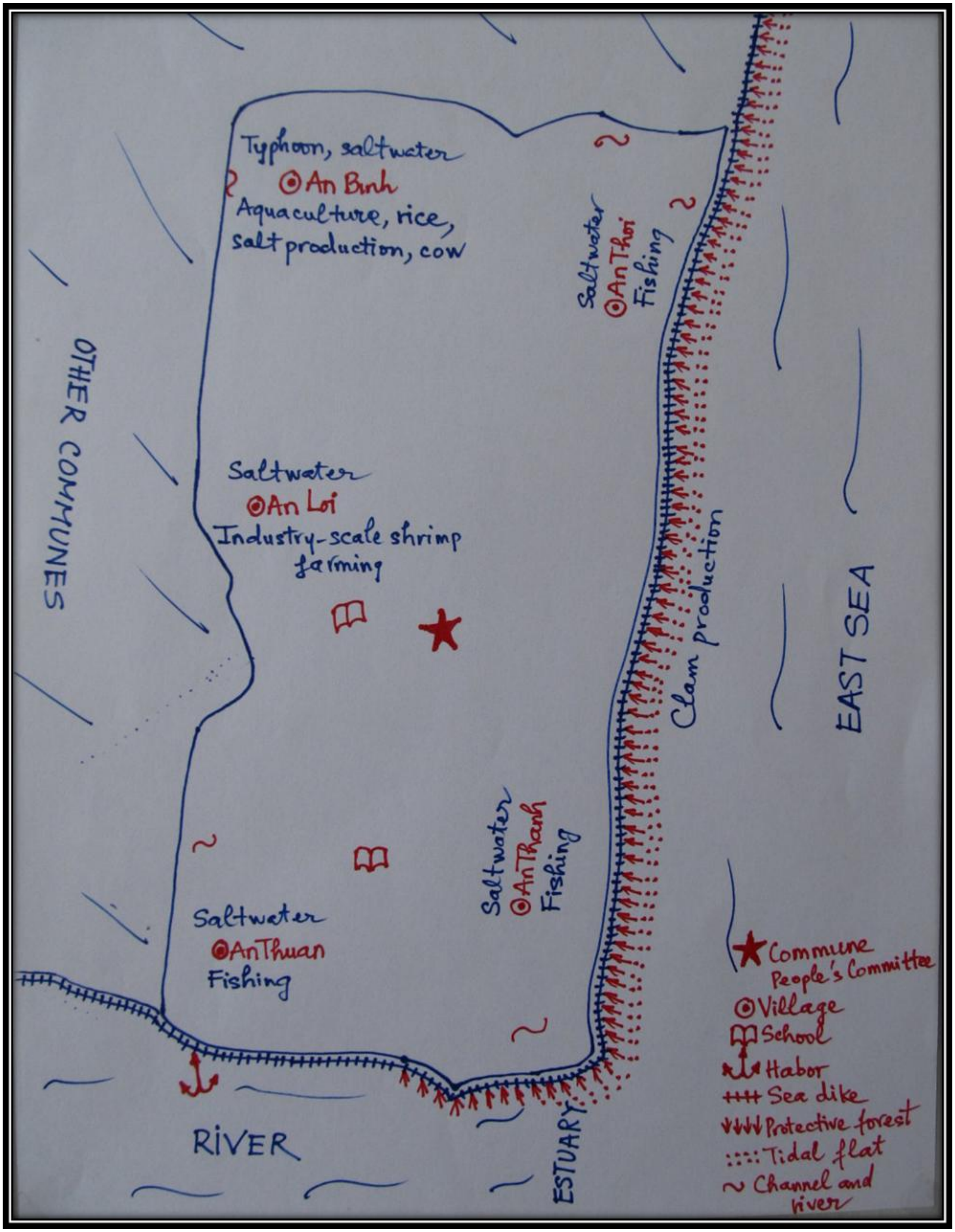

Figure 11. Hazard mapping for An Thuy commune, Ba Tri district, Ben Tre

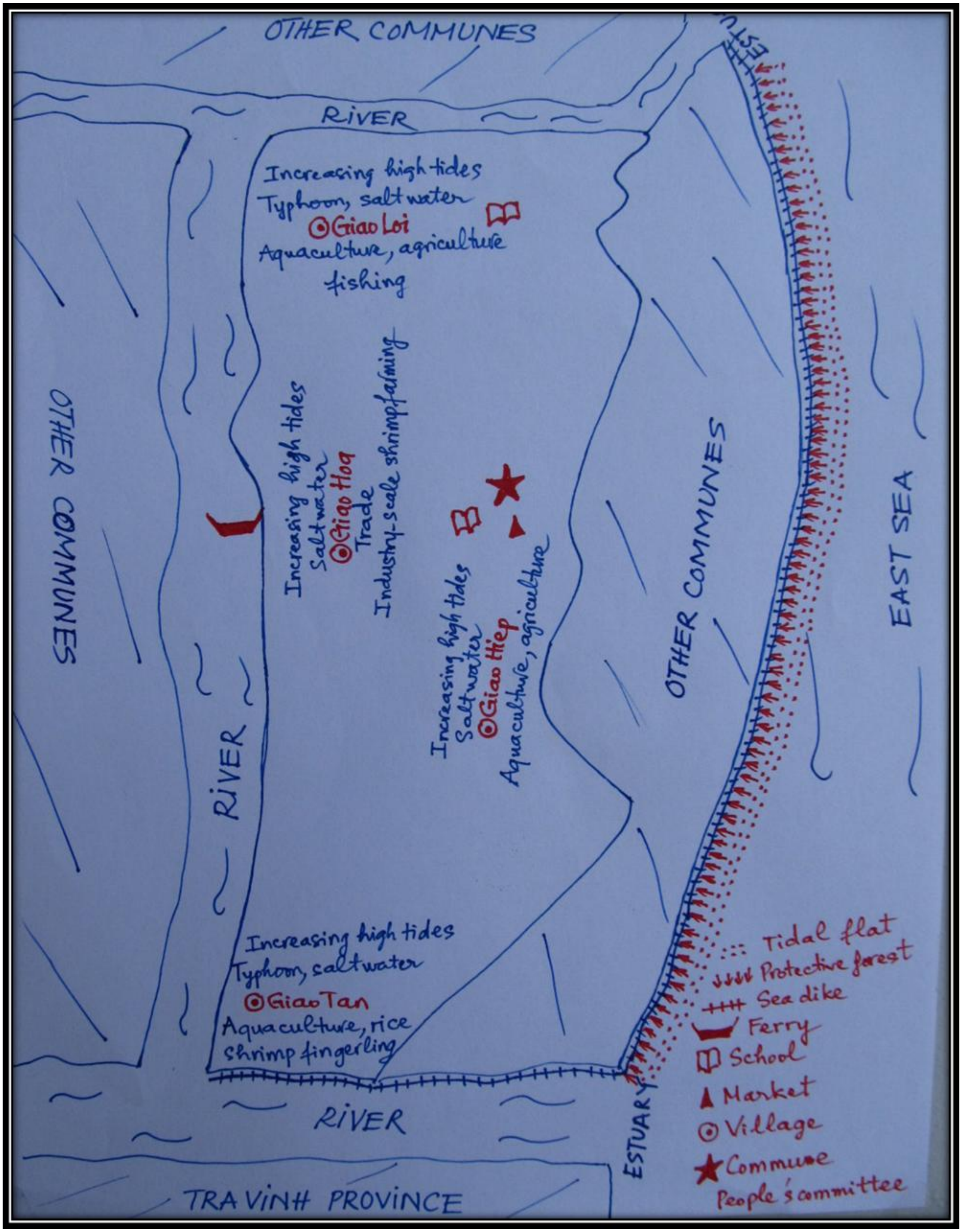

Figure 12. Hazard mapping for Giang Ha commune, Thanh Phu district, Ben Tre

4.4. VULNERABILITY MATRIX

Based on the frequency of devastation and the susceptibility of the various activities to typhoons, salt water intrusion, erosion and sea level rise, three communes Thua Duc, An Thuy and Giao Thanh are classed according to high vulnerability (H), medium vulnerability(M), low vulnerability (L), and not vulnerable yet (N) (table 3, 4, and 5).

From the tables, Thua Duc commune is more vulnerable to typhoons than the other two. However, the fishing sector of An Thuy commune is more affected than those of Thua Duc and Giao Thanh. This is because fishing is the main occupation of a very large number of residents in An Thuy. It could be, however, questionable that how fishing is affected by typhoons. As a typhoon is coming, it is not a wise idea for fishers to leave harbors for fishing or to continue their ongoing fishing on the sea; stoppage of fishing leads to income loss.

All three communes are susceptible to salt water intrusion which impedes cultivation and contaminates freshwater sources; An Thuy is less vulnerable than the other two communes. As reported by residents, salt water intrusion can produce adverse effects on shrimp farming but the frequency of devastation is less than that on crops because shrimp have a higher degree of salt water tolerance.

In comparison with the other three climatic events, erosion is less harmful. As a consequence of rising sea level, cultivation and aquaculture will be damaged due to permanent flooding. Households' assets and infrastructures are also threatened by sea level rise. According to the scenarios for sea level rise, Giao Thanh will be less vulnerable than the other two communes.

Table 3: Vulnerability matrix for Thua Duc commune

Scale **H**: High vulnerability **M**: Medium vulnerability **L**: Low vulnerability **N**: Not vulnerable ***Vulnerability categories***	***Climatic events***			
	Typhoon	Saltwater intrusion	Erosion	Sea level rise
Cultivation	H	H	L	H
Livestock	N	N	N	N
Aquaculture	L	M	N	H
Fishing	M	N	N	N
Houses and household assets	H	N	L	H
Family routines (cooking, washing, etc.)	H	H	N	H
Health	N	N	N	N
Infrastructures	N	N	N	M

Table 4: Vulnerability matrix for An Thuy commune

Scale **H**: High vulnerability **M**: Medium vulnerability **L**: Low vulnerability **N**: Not vulnerable ***Vulnerability categories***	***Climatic events***			
	Typhoon	Saltwater intrusion	Erosion	Sea level rise
Cultivation	L	M	N	H
Livestock	N	N	N	N
Aquaculture	L	L	N	H
Fishing	H	N	N	N
Houses and household assets	L	N	N	H
Family routines (cooking, washing, etc.)	N	M	N	H
Health	N	N	N	N
Infrastructures	N	N	N	M

Table 5: Vulnerability matrix for Giao Thanh commune

Scale **H**: High vulnerability **M**: Medium vulnerability **L**: Low vulnerability **N**: Not vulnerable ***Vulnerability categories***	***Climatic events***			
	Typhoon	Saltwater intrusion	Erosion	Sea level rise
Cultivation	M	H	L	M
Livestock	N	N	N	N
Aquaculture	M	H	L	M
Fishing	L	N	N	N
Houses and household assets	L	N	L	M
Family routines (cooking, washing, etc.)	L	H	N	N
Health	N	L	N	N
Infrastructures	N	N	N	N

In table 6, vulnerability categories are ranked based on the number of Hs, Ms, Ls and Ns they have. The purpose of this ranking is to show which category is most susceptible to typhoons, salt water intrusion, erosion and sea level rise. The category which has the largest number of Hs will be ranked first. If two categories have the same number of Hs, they will be ranked based on their number of Ms, and so on. As in table 6, cultivation is most vulnerable to the climatic events, followed by family routines and aquaculture. The result is of no surprise since agriculture and aquaculture are in nature subject to weather fluctuations. Livestock which include cattle and poultry shows no vulnerability.

Table 6: Rankings of vulnerability categories

Vulnerability categories	H	M	L	N	Ranking
Cultivation	5	3	3	1	1
Family routines (cooking, washing, etc.)	5	1	1	5	2
Aquaculture	3	3	4	2	3
Houses and household assets	3	1	4	4	4
Fishing	1	1	1	9	5
Infrastructures	0	2	0	10	6
Health	0	0	1	11	7
Livestock	0	0	0	12	8

Climatic events are then ranked in the same way to tell us which event is most harmful to those categories (table 7). Ranking results show that sea level rise is the most threatening. Nonetheless, sea level rise will only occur in some year in near future. Salt water intrusion is therefore the most devastating event at present time.

Table 7: Rankings of climatic events

Climatic events	H	M	L	N	Ranking
Sea level rise	8	5	0	11	1
Salt water intrusion	5	3	2	14	2
Typhoon	4	3	7	10	3
Erosion	0	0	5	19	4

4.5. HISTORICAL TIMELINE OF CLIMATIC HAZARDS

Ben Tre was known as a typhoon-free province up to 1997 when it was hit by the first and worst typhoon called Linda (table 8, 9, and 10). Nine years later, typhoon Durian swept by the province causing severe damage. Nine years free of typhoons was quite a long period, which made almost all local residents disbelieve in the occurrence of Durian when they were informed about the movement of the typhoon towards Ben Tre. As a consequence, very few preparations were made to cope with the typhoon. Thuc Duc commune was most devastated by Durian; thousands of houses were collapsed or unroofed as the typhoon passed by. Until recently, residents in Thua Duc commune were scared as they recall what happened in that year.

Salt water intrusion has become part of residents' livelihood especially in coastal communes. Residents cannot even recall exactly the first-time occurrence. As reported by residents in the three communes of Thua Duc, An Thuy, and Giao Thanh, salt water intrusion has worsen since 2009 in terms of increasing salinity and duration. In Thua Duc, salt water intrusion has made the second cropping of jicama or peanut impossible. In Giao Thanh, in order to cope with harmful salt water, farmers have stopped growing two rice croppings per year and adopted what is called rice-shrimp rotation. The switch has so far claimed its success, and therefore generated benefits to farmers.

Regarding erosion, it is believed to have first occurred in 2005. Due to the intricate system of rivers and channels, erosion mainly occurs along riverbanks. Strong waves are said to be the cause. Nonetheless, in the studied sites, erosion is not a serious problem. It does occur but in a scattered manner.

Thua Duc and An Thuy communes are well-known for their purely natural clam which were granted with MSC certificate (Certified Sustainable Seafood) by Marine Stewardship Council (MSC) and World Wild Fund of Nature (WWF) in 2009. Clam production serves as an important source of income to residents in the two communes. Nonetheless, in 2010 the number of dead clam increased abnormally. In the turn of 2011, 90% of clam died which resulted in significant loss of income. Scientific examination on samples of dead clam revealed that clams died from a single-cellular parasite named *perkinsus sp* which grows well under high temperature and salinity conditions.

Residents in Thua Duc commune claimed that they have witnessed certain changes in weather since 2009, say, hotter weather, and earlier and stronger southeast winds. Similarly, according to residents in Giao Thanh commune, the weather has seemed more unpredictable since 2009 because it occurs in an irregular pattern compared to years in the past.

In An Thuy commune, fishers have experienced a sharp reduction of fishing yield since 2008, which together with increased fuel cost, poses a risk to fishers' livelihoods.

Increasing high tides has been witnessed by residents in both Thua Duc and Giao Thanh commune. In Giao Thanh, an increase in high tides has led to what is termed "quick flooding". Although quick flooding does not harm properties, it is really annoying to residents' everyday life.

According to the climate change scenarios for Ben Tre, the province will suffer from impacts of sea level rise from 2020 if no adaptation strategies are adopted. Of three communes, Thua Duc is forecasted to be most flooded.

Table 8: Historical timeline of climatic hazards for Thua Duc commune

Not sure	Salt water intrusion has occurred
In 1997	Devastating typhoon Linda
From 2005	Erosion has occurred
2006	Typhoon Durian resulted severe damages.
Not sure	Impossible to plant the 2nd cropping of jicama or peanut due to salt water intrusion
From 2009	Hotter weather. Earlier and stronger southeast winds
From 2009	Salt water intrusion has increased in terms of duration and salinity
From 2010	Increasing high tides
In 2011	90% of clam died.
From 2020	Starting to be affected by sea level rise

Table 9: Historical timeline of climatic hazards for An Thuy commune

Not sure	Salt water intrusion has occurred
In 1997	Devastating typhoon Linda
In 2006	Typhoon Durian occurred but did not cause much loss.
From 2008	Fishing yield has plummeted
From 2009	Salt water intrusion has increased in terms of duration and salinity.
In 2011	90% of clam died.
From 2020	Starting to be affected by sea level rise

Table 10: Historical timeline of climatic hazards for Giao Thanh commune

Not sure	Salt water intrusion has occurred
In 1997	Devastating typhoon Linda
Not sure	Erosion first occurred.
2006	Typhoon Durian caused damage.
2008	Planting one rice crop and one shrimp crop instead of two rice crops.
From 2009	Weather has appeared irregular
From 2009	Salt water intrusion has increased in terms of duration and salinity.
From 2010	High tides have increased considerably causing “quick flooding”.
From 2020	Affected by sea level rise.

4.6. VALUING DAMAGES FROM CLIMATE RELATED DISASTERS

4.6.1. Damages and values of damages from typhoons

Respondents were asked to value the damages caused by the most severe typhoon during the last 10 years which is, of no surprise, typhoon Durian in 2006. Among three hundred surveyed households 205 households were affected by the typhoon a total value of loss of USD

154,155 (table 11). Despite the short life of few hours, the incident brought about heavy damages to houses, equipment and other - assets, agriculture, aquaculture, fishing and infrastructure. There were one hundred and seventy-two of 205 households reported that their houses suffered from damages which summed up to total losses of USD 51,114, equivalent to 33.16% of the total loss caused by the typhoon (figure 13). It is calculated that aquaculture incurred the most severe damage (USD 53,004) which accounted for 34.38% of the total loss although there were just 39 farmers impacted by the typhoon. Forty farmers working in agriculture and 20 fishers experienced considerable losses of USD 16,784 (10.89%) and USD 18,789 (12.19%) respectively.

Table 11: Damages from typhoon Durian

Types of damages	No of affected households	Value of loss (USD)
Damage to house	172	51,114
Damage to appliance	50	5,619
Damage to livestock	2	149
Damage to assets	15	6,351
Loss in agriculture production	40	16,784
Loss in fishing income	20	18,789
Loss in aquaculture production	39	53,004
Income loss due to work stoppage	6	511
Loss in salt production	3	1,350
Land loss	1	482
Total loss		154,155

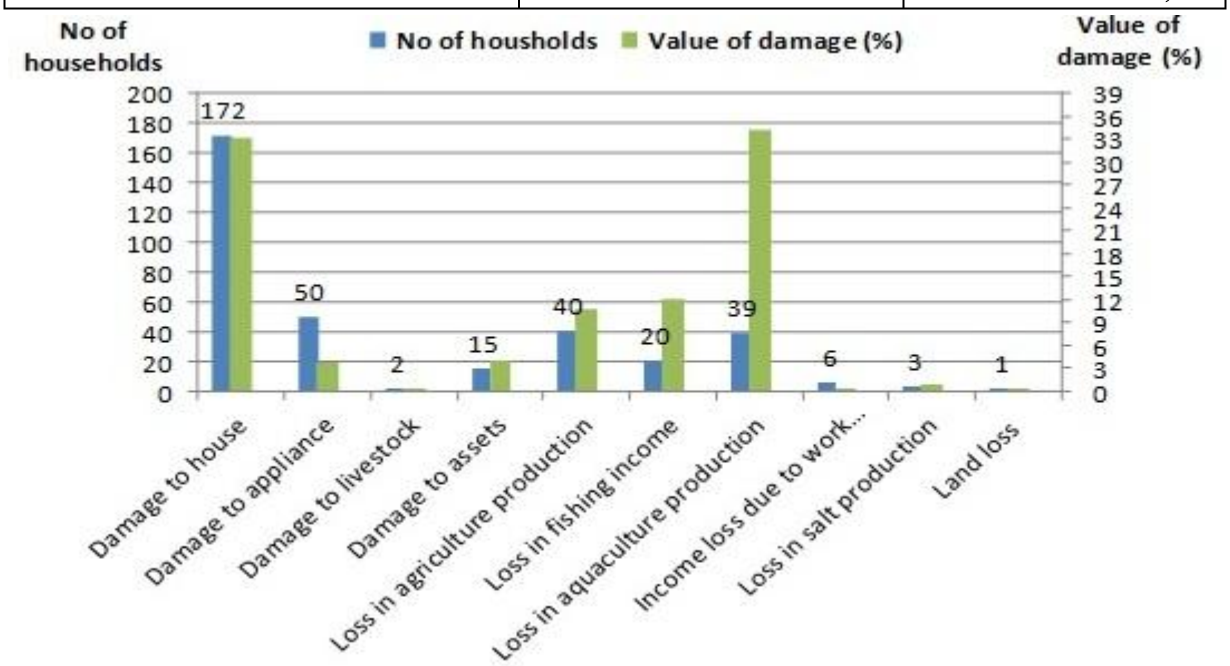

Figure 13: Number of affected households and value of damage (%) caused by Durian

4.6.2. Damages and values of damages from salt water intrusion

Respondents were requested to work out values of losses caused by the most recent salt water intrusion. Among three hundred surveyed households, there were 271 households affected by salt water intrusion with the total loss of USD 77,151 (table 12). All of the survey participants agreed that the level of salinity has increased over the past decades, especially in recent years.

As salt water intruded inland, it had about serious consequences on agricultural production, freshwater supplies for family routines, aquaculture production, diseases, and lifetime of tools. Specifically, it caused a lack of fresh water in 146 households at estimated loss of USD 10,385 which accounted for 13.46% of the total loss caused by salt water intrusion (figure 14). Aquaculture production of 14 households was also attenuated by salt water which resulted in USD 31,060 loss which was responsible for 40% of the total loss. Salt water intrusion, furthermore, harmed agriculture, causing 65 farmers to lose their crops at a value amounting to USD 34,279 (44.43%) - the largest loss of all. Skin diseases, woman disease and shorter tool lifetime are other impacts of salt water intrusion but are minor impacts.

Table 12: Damages from the most recent salt water intrusion

Types of damages	No of households	Value of loss (USD)
Loss in agricultural production	65	34,279
Lack of freshwater for family routines	146	10,385
Loss in aquaculture production	14	31,060
Skin disease	4	1,235
Women disease	2	96
Tools have shorter lifetime	1	96
Total loss		**77,151**

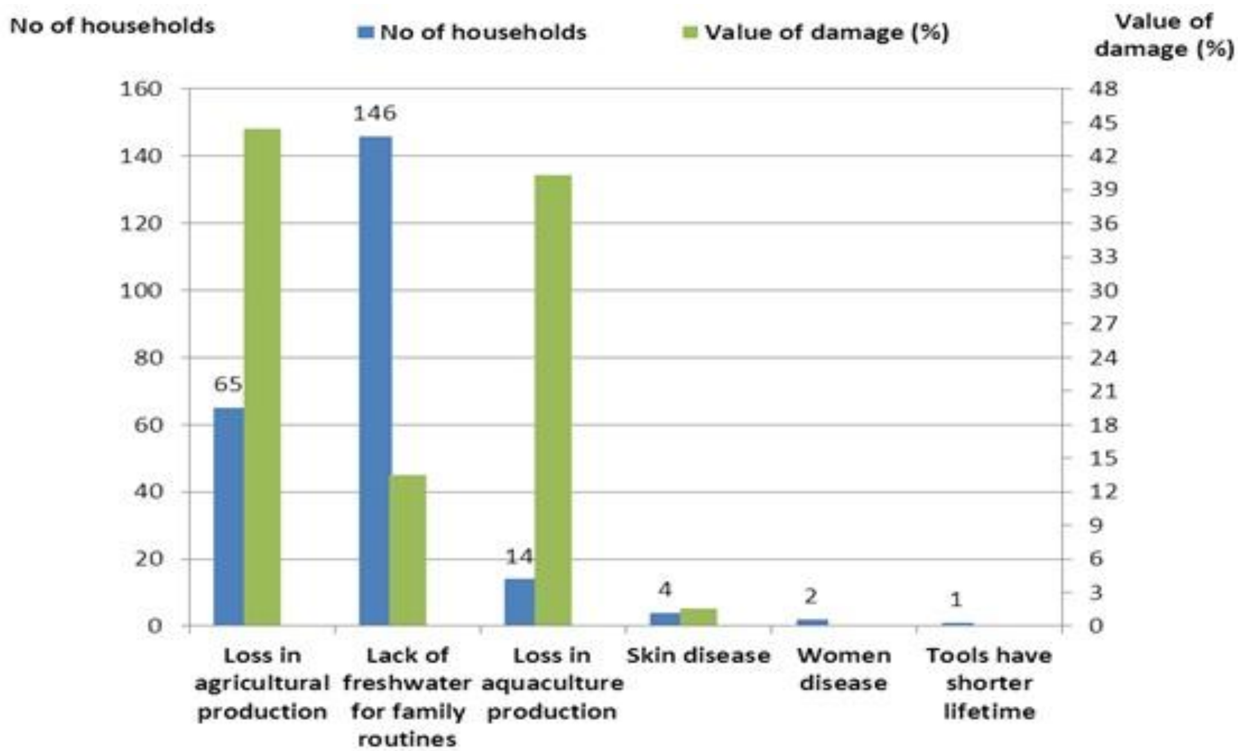

Figure 14: Number of affected households and value of damages (%) caused by salt water

4.6.3. Damages and values of damages from erosion

The number of households (only 36 households) affected by erosion is considerably small in comparison with typhoons and salt water intrusion. Erosion was, however, responsible for a lot of damages to houses, assets, land, aquaculture and agriculture production which resulted in total losses of USD 28,492 (table 13). Ten of 36 households suffered from land loss with the value of USD 13,744 accounting for 48.24% of the total loss (figure 15). Losses in aquaculture and agriculture were substantial: USD 8,970 (31.48%) for aquaculture and USD 3,419 (12%) for agriculture. Damages on assets and houses were USD 5,160 and USD 2,749 respectively.

Table 13: Damages from the most recent erosion

Types of damages	**No of affected households**	**Value of loss (USD)**
Damage to house	3	2,749
Damage to appliance	0	0
Damage to livestock	0	0
Damage to assets	4	5,160
Loss in Agriculture production	9	3,419
Loss in Fishing income	0	0
Loss in Aquaculture production	12	8,970
Income loss due to work stoppage	0	0
Land loss	10	13,744
Total loss		28,492

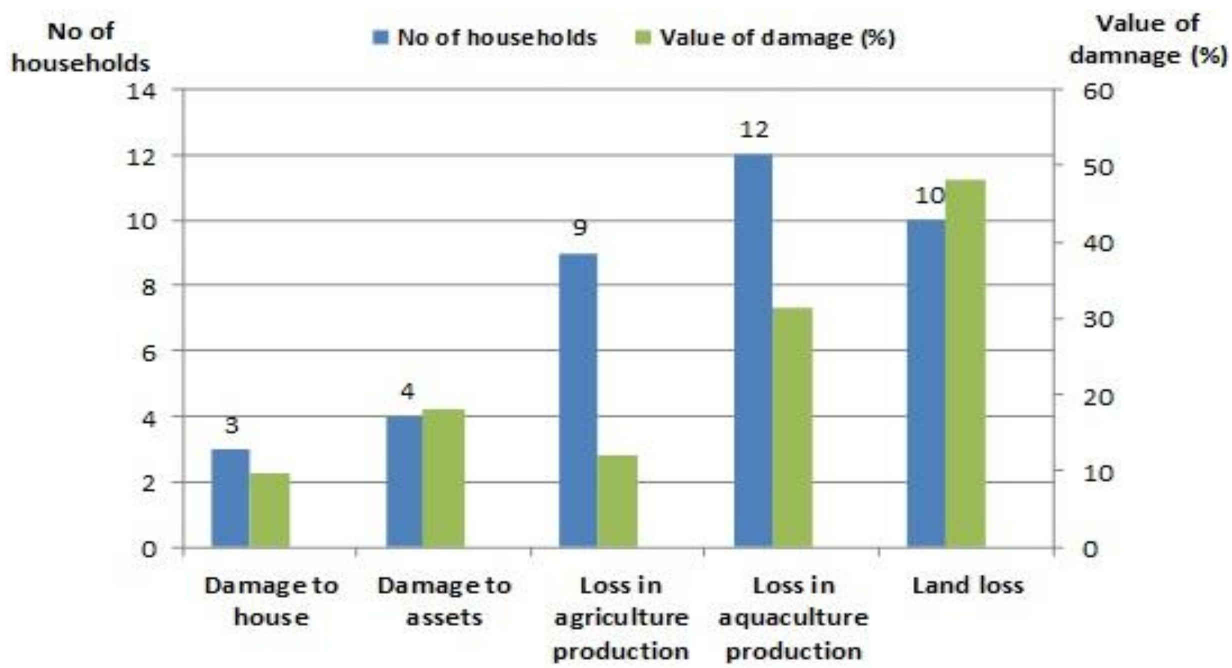

Figure 15: Number of affected households and value of damages (%) caused by erosion

4.7. HOUSEHOLD'S AWARENESS AND PREPAREDNESS OF CLIMATE CHANGE

4.7.1. Household's awareness of climate change

As can be seen in figure 16, 38.55% of total surveyed households reported that they have no information/knowledge of climate change and 59.67% of households have a little knowledge. The number of households that have adequate knowledge on climate change accounts for only 2% of the total. No households reported being fully knowledgeable of climate change.

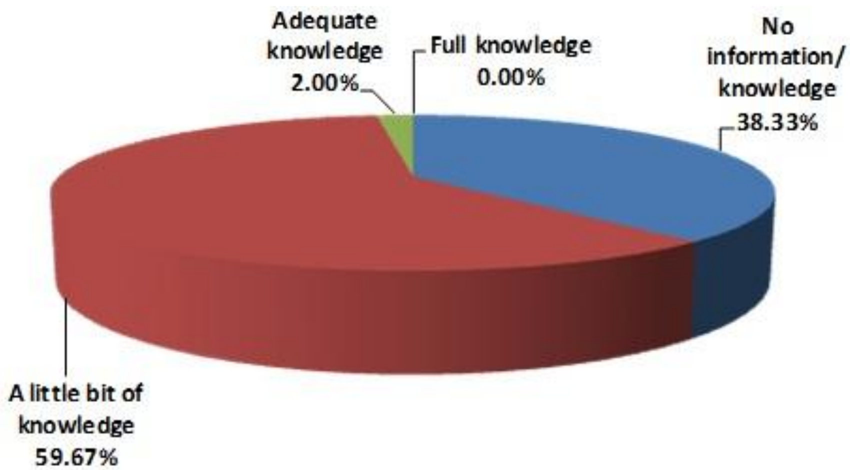

Figure 16: Households' awareness of climate change

4.7.2. Household's preparedness for climate change

What can be seen obviously from the figure 17 is that the majority (65%) of households have not made any preparations for climate change. This can be justified by the large number of households which have no or a little awareness of climate change (98%). There are only 0.67% of the total households that are adequately prepared for climate change although the number of households that have adequate knowledge of climate change is 2%. The rest (34.33% of the total) are somewhat prepared; no households are fully prepared.

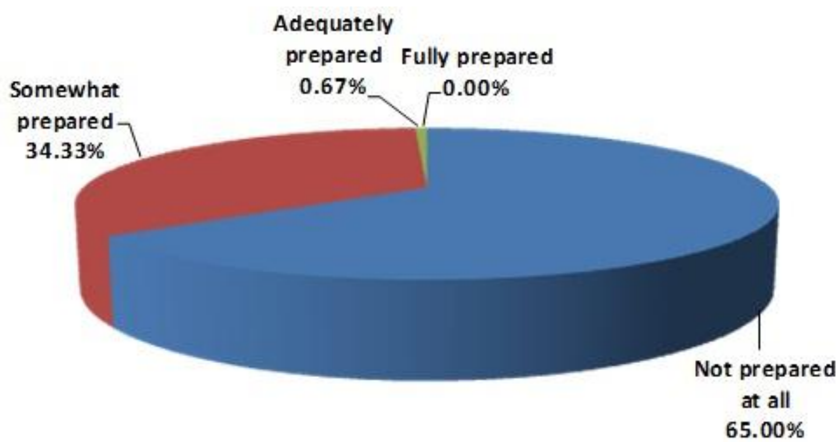

Figure 17: Households' preparedness for climate change

4.8. TYPES AND COSTS OF HOUSEHOLD'S AUTONOMOUS ADAPTATIONS

4.8.1. Autonomous adaptations to typhoons

What can be notably seen from table 14 is that only a small number of households undertook action in order to deal with the typhoon before it hit. This is explained by the indifference of the majority of local residents although they did receive early warnings from local authorities. Such indifference originated from the disbelief of the occurrence of the typhoon. House improvement and evacuation were the two most common actions undertaken by households.

Table 14: Actions undertaken by households before the typhoon

Action	No of households
Undertook improvement on houses	38
Evacuated to a safe place	41
Dug canals	0
Planted tree along the perimeter of properties	1
Harvested crops or fish early	1
Applied typhoon resilient farming methods	0
Reinforced cages/ponds	2
Moved fishing or farming equipment to safe place	7
Joined savings groups/cooperatives	1
Pursued other means to generate additional income	0
Built sand dikes around farms	4
Prepared food	2
Moved properties to safe place	4

Figure 18 tells us about actions undertaken by households after the typhoon. Given the severe damage to houses, it is not surprising that house improvement (repairs) was the action performed by most households (172). On average, it costs one household USD 688 to undertake house repairs. Besides repairing houses, replacing fish stock, replanting farms and reinforcing ponds/cages were also performed. On average, it costs one household USD 90 to replant its farm, USD 357 to replace fish stock, and USD 507 to strengthen ponds/cages. Thirty-one households had to borrow money to cope with damages and income losses. The average sum of money borrowed by one household was USD 1,064. Thirty-seven households received financial aid of USD 156 on average from the local government. Seventy-one households decided to save money to deal with future typhoons as well as other incidents, but they refused to reveal their savings.

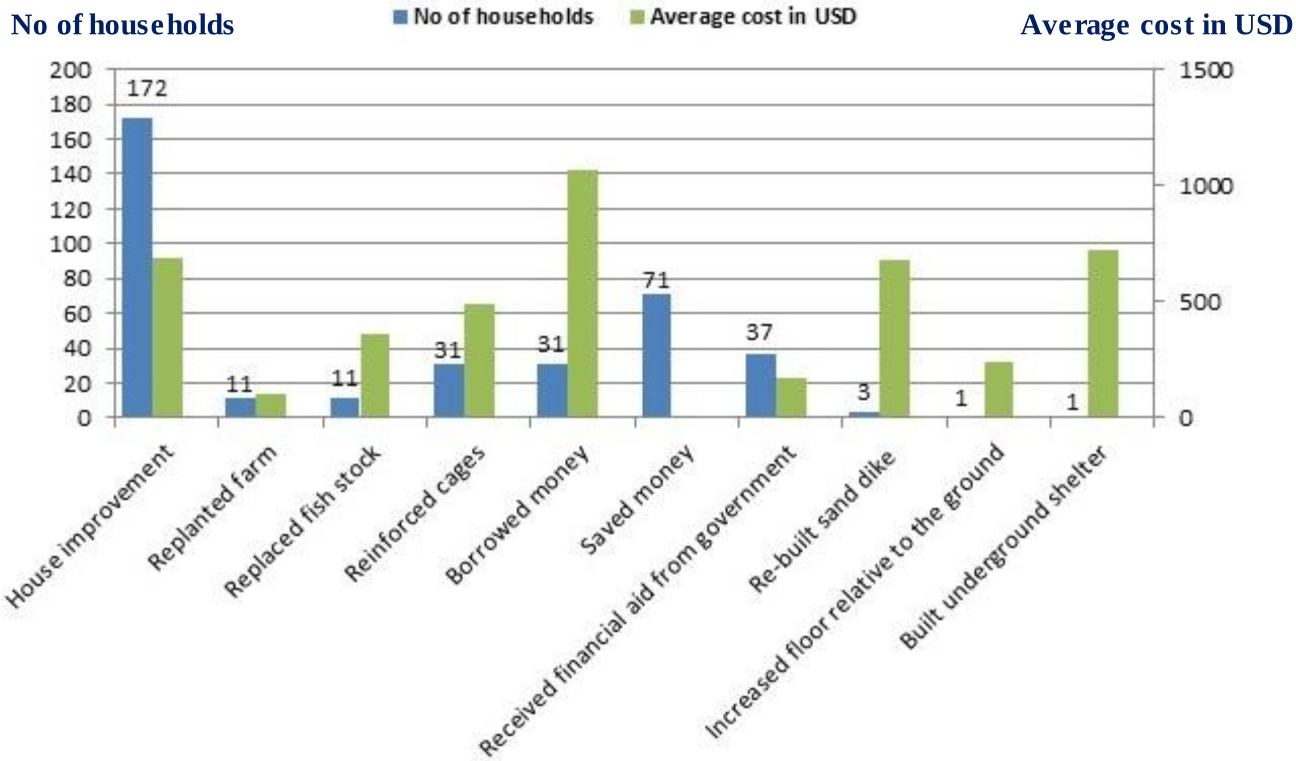

Figure 18: Actions undertaken by households after the typhoon and corresponding costs.

4.8.2. Autonomous adaptations to salt water intrusion

In figure 19, the passive actions which households carried out in order to deal with impacts of salt water intrusion are shown. Of 271 households impacted by salt water intrusion, 270 households harvested rain water at the average cost of USD 189.80 per household to build/buy water containers which are often concrete tanks or large baked clay jars. Rain water is used mainly as drinking water. Besides, 143 households bought water from vendors in dry seasons in order make up for the lack of fresh water for daily routines. Purchased fresh water is used mainly for cooking and washing. On average it costs one household USD 71.28 to buy water to meet its fresh water needs. In aquaculture, 41 fish farmers built sand dikes around their ponds to mitigate the effects of salt water intrusion. This action costs one household USD 933.71 on average-the largest amount spent on an adaptive action. Thirty-two households tapped water from a different source, which means that they constructed new wells with the hope that they would be low in salinity. It took one household USD 83 on average to build a new well.

The other actions listed in the questionnaire, are, "treating water", "pumping freshwater into ponds/farms", and "switching to new species/plants". However, these options received no responses from respondents, therefore were not seen in figure 19.

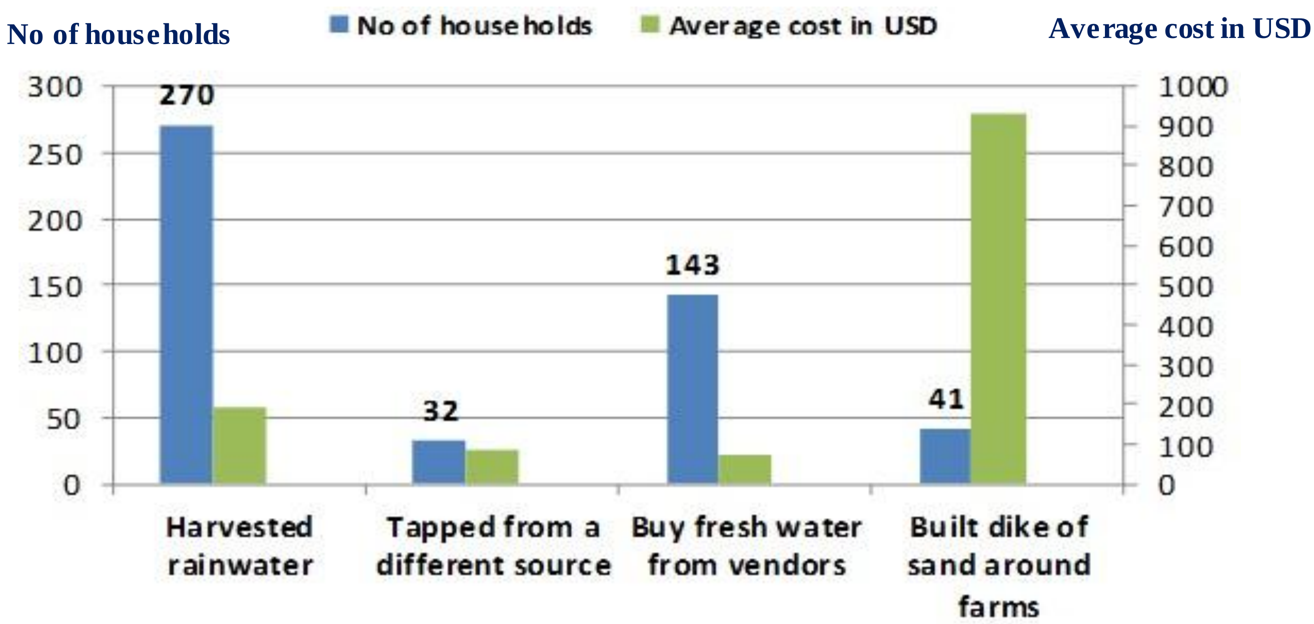

Figure 19: Actions to deal with salt water intrusion and corresponding costs

4.8.3. Autonomous adaptations to erosion

From figure 20, installing temporary protective structures are utilized most by households which cost one household USD 827.15. Compared to other actions which received fewer responses from respondents, this cost is lowest. One household had to relocate permanently at the cost of USD 14,468. Seven respondents reported that they made use of mangroves as an adaptation to erosion. However, since they received plants from the local government, planting mangroves occurred at no costs to them. On average it costs one household USD 3,520 to build permanent structures and USD 2,860 to reinforce ponds/cages.

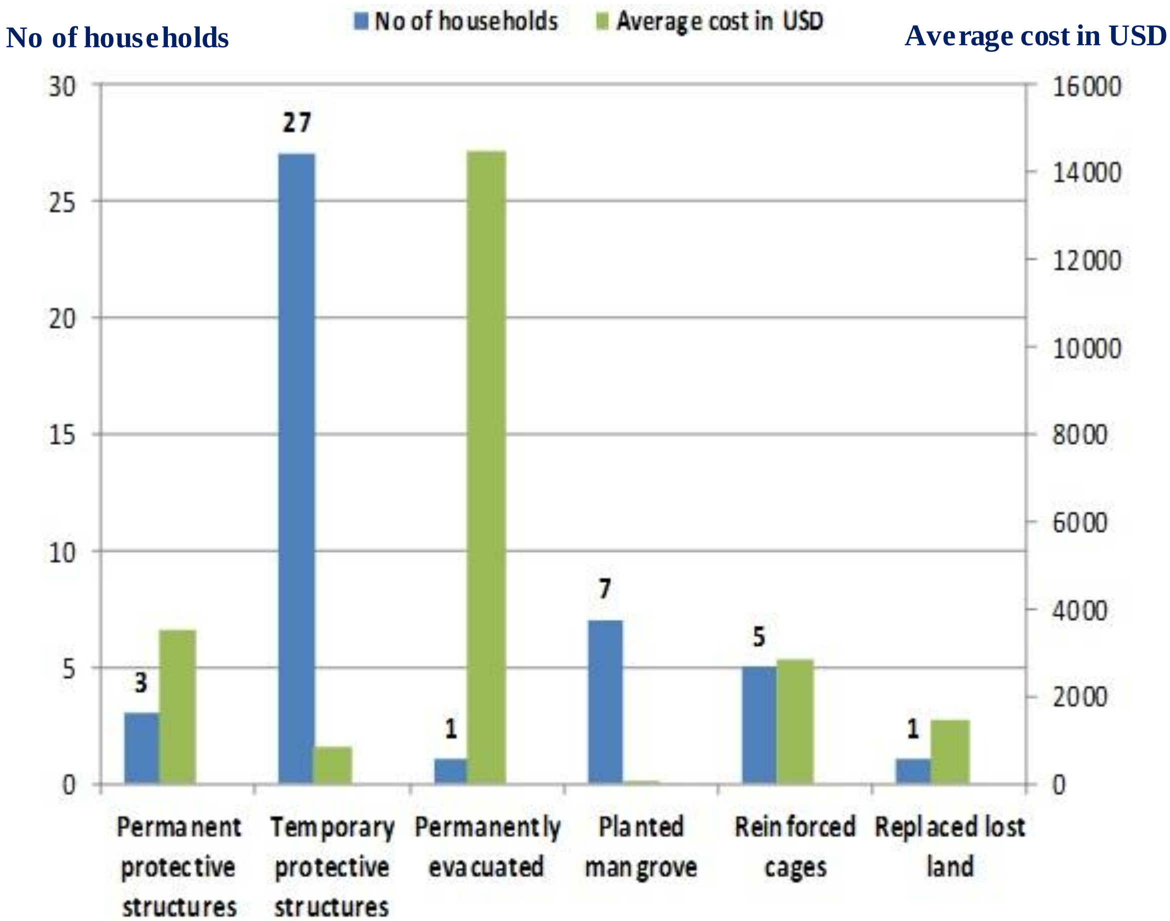

Figure 20: Actions to deal with erosion and corresponding costs

4.9. CEA OF PLANNED ADAPTATION STRATEGIES

When projects with different cost structures are not expected to produce the same outcomes, cost-effectiveness analysis, whereby the costs are compared with outcomes measured in natural units, is appropriate for project selection. In this study, CEA is employed as the tool for evaluating the two planned adaptations: an irrigating system and a new sea dike system. In this case, physical benefit is measured in terms of the number of protected hectares (of land) from each project. The criterion for decision making is the cost expended to protect one hectare of land.

4.9.1. CEA of the sea dike system

The sea dike system which bounds 10 communes of southern Thanh Phu district is destined for (1) preventing flooding caused by tides, typhoons, and sea level rise and (2) attenuating salt water contamination. The dike system consists of the sea dike which is 52.4 km of length and 16 sewers which are built under the dike (figure 21). Total investment of the sea dike system amounts to USD 144,661,651.23 which is divided into six line items as in table 15. The construction of the sea dike should last for six years.

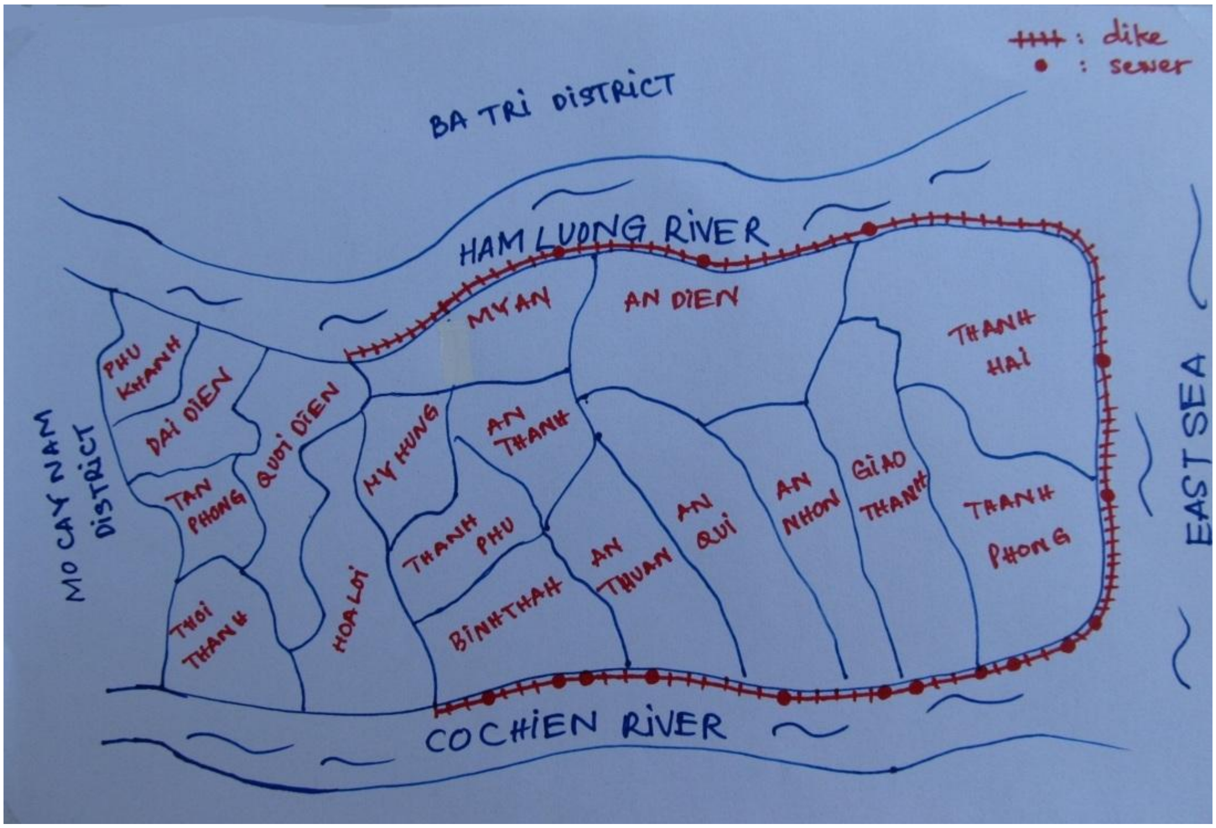

Figure 21: Location of the new sea dike

Table 15: Investment of the sea dike system

Category	Expenses (USD)
Construction	80,526,475.69
Clear-the-ground compensation	15,376,157.41
Project management	831,693.67
Project consultancy	5,879,050.93
Miscellaneous	2,979,021.99
Provision costs	39,069,251.54
Total investment	**144,661,651.23**

Source: Ben Tre DARD 2010

Operating costs of the sea dike include maintenance which is the major and miscellaneous cost. Operating costs begin in the third year of construction. Replacement cost occurs in the 20^{th} year at the expense of USD 14,571,277.01 (Ben Tre DARD 2010). Costs which occur along the 30-year lifespan of the project are discounted at the rate of 10% to calculate the present value. Regarding physical benefit, the sea dike will help protect 37,370 hectares of land from flooding and invasive salt water (Ben Tre DARD 2010).

Based on the costs which include initial investment and annual operating costs and the physical benefit from the project, CE ratio is calculated using the formula CE ratio = Present value of costs/ Physical benefit. CE ratio of the sea dike system turns out to be USD 3,480.27 per protected hectare of land. Detailed information on the calculation of the CEA is seen in appendix B.

4.9.2. CEA of the irrigating system

The irrigating system is destined to serve five communes of northern Thanh Phu district and 17 communes of Mo Cay Nam district, which geographically lies right above Thanh Phu. Just like the sea dike, the irrigating system is aimed at (1) preventing potential flooding caused by tides and sea level rise, and (2) mitigating salt water intrusion. It is comprised of 22 sewers which are built under rivers, a dike which is 25.237 km of length, and a bridge which is 73.6 m of length and 7 m of width (figure 22). Total investment for the irrigating system is USD 48,063,736 which is separated into seven line items in table 16. The construction should be completed after three years.

Table 16: Investment of the irrigating system

Category	Expenses
Construction	31,353,202
Machine and equipment	1,786,479
Clear-the-ground compensation	2,375,227
Project management	341,677
Project consultancy	2,779,009
Miscellaneous	437,229
Provision costs	8,990,911
Total investment	**48,036,736**

Source: Ben Tre DARD 2011

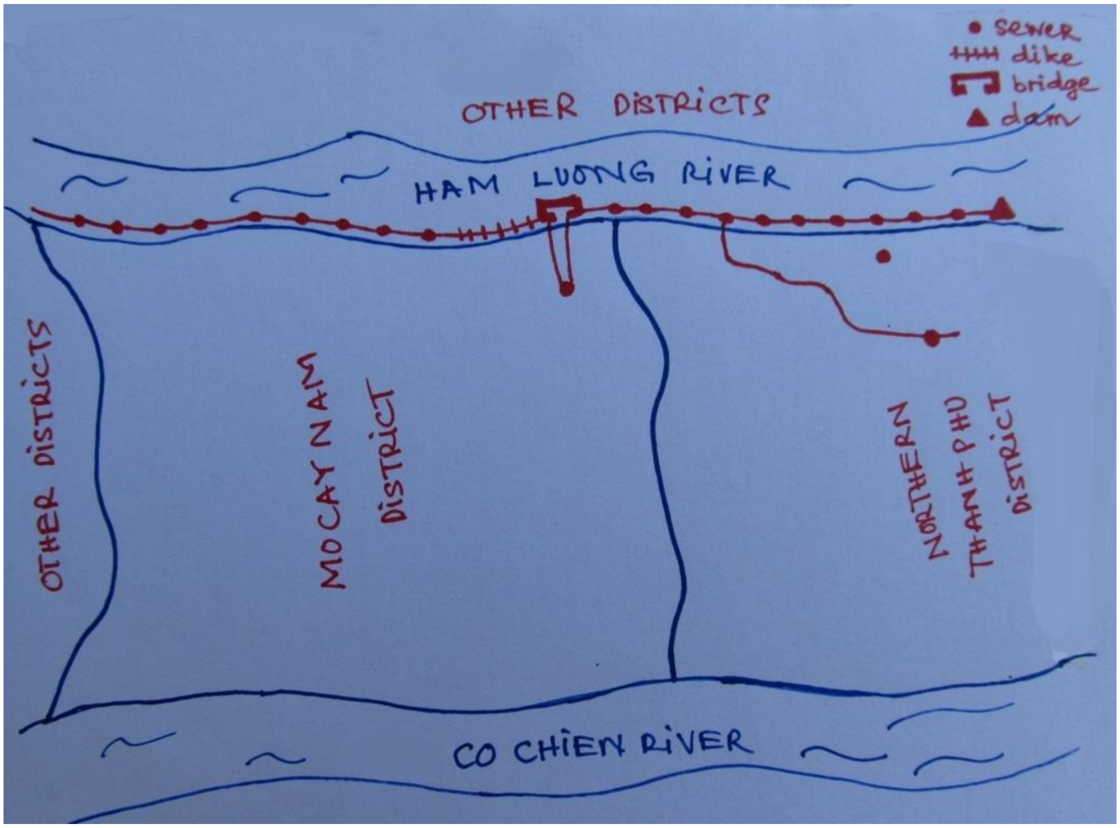

Figure 22: Location of the irrigating system

Operating cost for the irrigating system is assumed to be USD 373,137 which begins in the 4th year after the construction is already finished (Ben Tre DARD 2011). Costs which occur along the 30-year lifespan of the project are discounted at the rate of 10% to calculate present value. Regarding physical benefit, the irrigating system will help protect 29,244 hectares of land from flooding and invasive salt water (Ben Tre DARD 2011).

Based on the costs which include initial investment and annual operating costs and the physical benefit from the project, CE ratio is calculated using the formula CE ratio = Present value of costs/ Physical benefit. CE ratio of the irrigating system turns out to be USD 1,516 per protected hectare of land. Detailed information of the calculation of the CEA for the irrigation system can be seen in appendix C.

CHAPTER 5
DISCUSSION AND CONCLUSION

5.1. DISCUSSION

The study has sketched out a detailed picture of the impacts of climate change, specifically sea level rise, typhoon, salt water intrusion and erosion, in Ben Tre province. Regarding sea level rise, the threat is no longer an academic issue which appears in scientific research. Instead, it is becoming more and more real. Particularly for Ben Tre province, sea level will threaten the livelihoods of millions of people by engendering permanent inundation which in turn results in relocation of households and reduction of agriculture and aquaculture. Even those who have the least imagination can probably realize challenging issues associated with any household relocation. Sea level rise does pose a risk to the GDP of the province. Moreover, rural areas where households are more condensed, it is forecasted there will be permanent flooding more severe than in urban areas. Such extrapolation is disturbing since the capacity of the poor to cope with climate change impacts is constrained by limited financial resources.

Everyone who comes to Ben Tre and listens to residents should be aware of difficulties brought about by salt water intrusion-the most serious disaster in the province in terms of both quantity and quality of damages. Two hundred seventy-one respondents of all 300 were impacted by salt water with total loss estimated at USD 77,151. It is worth to bear in mind that the figure only reflects the damages from the most recent intrusion of merely 271 households. Salt water intrusion occurs every year throughout the entire province. Without any help from calculations, one can visualize how large the aggregated loss is for the whole province during a particular time horizon.

By referring back to table 15 in chapter 4, it can be seen that salt water is more harmful to agriculture than to aquaculture. This is justified by the higher tolerance of aquaculture species to salinity as compared to plants and trees. Nonetheless, in terms of value, aquaculture incurred approximately as much as did agriculture (USD 31,060 compared to USD 34,279), which can be explained by higher investment and higher output price of aquaculture products. In addition, salt water intrusion interrupted to family routine activities due to lack of freshwater. A few words can express the inconvenience caused by the lack of freshwater. Although households can harvest rainwater or buy freshwater from vendors to use as an alternative source, they have to use it frugally.

It used to be believed that it was firmly attached to the minds of almost every resident in Ben Tre that the province was free from typhoons. The belief actually held true until 1997 when the first and the worst typhoon named Linda hit the province. Nine year later in 2006, another devastating typhoon called Durian officially removed the belief from all residents' mind.

Durian, which lasted for only a few hours, was responsible for a huge amount of devastation amounting to USD 154,155, and filled inhabitants with fear years after. Aquaculture, one of the chief economic activities in the province, suffered the most severe loss in the incident (USD 53,004) because of the huge investment in a vast area of thousands of hectares; loss in fishing income and agriculture followed up (USD 18,789 and USD 16,784 respectively). In addition to impairing economic activities, the incident was also attributed to serious devastation on resident's houses. In Ben Tre, wood, bamboo and nipa palms were main construction materials before the typhoon, making houses prone to damages from strong winds. This explained why a number of houses were collapsed or unroofed as Durian with velocity of over 133 km per hour swept houses, equipment, and other family owned and assets which also posed heavy on families in the area.

As mentioned before, erosion is the less serious climatic risk to all in Ben Tre. This is verified by the number of households affected by erosion in the sample: 36 of all 300. In terms of value, total loss caused by erosion (USD 28,492) was even smaller than losses incurred by aquaculture alone (USD 31,060 and USD 53,004 respectively) due to salt water intrusion or typhoon.

By examining autonomous adaptations of households in order to mitigate the impacts of these climatic risks, one may be of the impression that the adaptations are pretty simple. "Simple" here means not requiring much technical know-how for application. In the case of typhoon, before it came, households made some home improvement as simple as putting sand bags on the roofs, and/or evacuated. After it ended, all they did were mainly repairs: repairing houses, replanting farms, replacing fish stock, and repairing animal cages. Those actions are not only simple but also re-active. This could be explained by households' lack of experience in coping with typhoons. More active actions like increasing flooring above ground to prevent flooding of the ground floors, saving money for future incidents, or making underground shelter to hide in during typhoon, did not capture extract much response from respondents.

Concerning salt water intrusion, adaptations are somewhat more preventive but remain as simple as possible: harvesting rainwater and/or buying freshwater from vendors. Nonetheless, due to financial as well as technical shortages, that is all they can do. More technique-consuming adaptations like treating water or switching to new species/plants, although listed in the questionnaire, received no selections from respondents.

By assessing the awareness of respondents on climate change, the study revealed that 98% of respondents have no or just a little knowledge of climate change. For those who indicated having a little bit knowledge, their awareness of climate change is simply associated with observed changes in wind, rainfall and temperature patterns. Similarly, sea level rise to them is simply the rise of tides. Since climate change is not only a scientific occurrence written scholarly papers, but a real world phenomenon, such low awareness levels of residents, could serve as a hindrance to the efficacy of provincial programs and actions in dealing with climate change.

As the majority of respondents have very low awareness of climate change, it came as no surprise to see that 65% of surveyed respondents reported that they have not made any preparations for climate change. As we can recall, before typhoon Durian hit, very few residents believed in its occurrence and therefore very few preparations were made.

The CEA analysis for two adaptations which are under consideration by the provincial committee: building a sea dike system and building an irrigating system were calculated. Both projects are destined to prevent flooding and attenuate salt water intrusion. The purpose of the analysis is to advise the provincial government on which adaptation should be given priority because the investment of each project is extremely large.

For the sea dike, it costs USD 3,480.27 to protect one hectare of land while the irrigating system costs only USD 1,516 to provide identical service. Thus, the irrigating system appears to be more cost effective than the sea dike. Furthermore, the sea dike is three times more expensive than the irrigation system. This increases to some extent the feasibility of the irrigation system. Therefore, given that the provincial government cannot afford the two projects at a time, it is recommended that priority should be given to the irrigating system.

5.2. CONCLUSION

Climate change mapping shows that Vietnam's 10 most endangered provinces are among the top 25% most vulnerable areas in Southeast Asia, and that Ben Tre is among these (Yusuf and Francisco 2010). Particularly at the studied sites, data collected from the household survey indicated that there were serious damages caused by climatic events. Statistics show that typhoon Durian which lasted for a few hours resulted in USD 154,155 loss. Damages from recent salt water intrusion mounted to USD 77,151. As compared to typhoons and salt water intrusion, erosions have affected fewer numbers of households. Estimated loss from most recent erosion damage amounted to USD 28,492. Damages caused by these climatic events actually surpassed those figures listed above because the expense on actions undertaken by households can also be considered as losses. It is important to bear in mind that those figures are calculated based on a sample of merely 300 households. Therefore, the value of damages is definitely much larger for the whole community. In order to cope with climatic risks, households performed mainly simple actions that require limited financial and technical household resources. Assessment of respondents' awareness of climate change indicated that 98% of respondents have no or a little knowledge of climate change. With such a low awareness, it came as no surprise to see that 65% of respondents reported that they have not made any preparations to counter the effects of climate change. Results from CEA showed that the irrigating system is more cost effective than the sea dike. Therefore, given that the provincial government cannot afford the two projects at a time, it is adviseable that the priority is given to the irrigating system.

5.3. IMPLICATIONS

A vivid picture of climate change impacts has been delineated through this study with the hope that it could serve as a reminder for the provincial government to incorporate programs/actions to mitigate climate change impacts into its socio-economic development plans.

As we know, proper actions originate from proper awareness. Hence, it is crucial that the provincial government should implement more activities to supplement low households' awareness of climate changes.

Coping with climate change requires a firm financial foundation. Hence, the provincial government is expected to be proactive in seeking national as well as foreign investments and/or financial aid to deal with impacts of climate change.

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APPENDICES

APPENDIX A: Questionnaire

Climate Change Impacts, Vulnerability Assessments and Economic Analysis of Adaptation Strategies in Ben Tre Province, Vietnam

IDENTIFICATION AND OTHER INFORMATION

BARANGAY/ VILLAGE: ………………………………………………. ……………………………………………………………………………………….	**BARANGAY CODE**				
RESPONDENT NAME: …………………………………………………. ………………………………………………………………………………	**RESPONDENT CODE**				
RELATIONSHIP OF RESPONDENT TO HH HEAD: **CODES:** 1-Head 2-Wife/Spouse 3-Son/daughter 4-Son-/daughter-in-Law 5-Grandson/daughter 6- Father/mother 7-Other relative 8- HH helper 9-No relationship	**CODE**				

MODULE 1: HOUSEHOLD INFORMATION

	1	2	3	4	5	6	7	8
	Name of Household Members	**What is the relationship of [NAME] to Household Head?**	**What is the gender of [NAME]?** **CODES:** 1-Male 2-Female	**What is the age of [NAME] as of his/her last birthday?**	**What is [NAME] marital status?**	**Years of Schooling**	**Primary Occupation** (Write occupation mentioned and put numerical code after interview)	**Secondary Occupation** (Write occupation mentioned and put numerical code after interview)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

CODES FOR COLUMN 2	**CODES FOR COLUMN 5**	**CODES FOR COLUMNS 7 AND 8**
1-Head 2-Wife/Spouse 3-Son/Daughter 4-Son-/Daughter-in-law 5-Grandson/Daughter 6-Father/Mother 7-Other relative 8-HH helper 9-No relationship	1-Single 2-Married 3-Widowed 4-Divorced/Separated 5-Common law/Live-in 6-Unknown/No answer	1- Officials of government., organizations, corporations, managers, managing proprietors & supervisors (business owner, store owners, wholesale buying and selling) 2-Professionals (e.g. Teachers, Engineers, etc.) 3-Technicians and associated professions 4-Clerical support workers 5-Service-oriented workers (e.g. BNS, BHW, Daycare workers, sales, shop or market workers and barangays *tanods*) 6-Farmers, fishers and forestry workers (includes gatherers of non-timber forest products) 7-Trades and related workers (e.g. masons, carpenters, construction laborers) 8-Plant and machine operators and assemblers (truck/bus/tricycle/heavy equipment drivers, seamen) 9-Laborers and unskilled workers 10-Special occupations (e.g. military personnel)

MODULE 2: WATER USE

WATER SOURCE CODE	Water Source	1 **Is [NAME OF SOURCE] available for the household?** Go down the list to verify which sources are available to the household. Then for any with a **YES**, **ASK QUESTIONS 2-8** **CODES:** 1- Yes 2- No	2 **In the rainy and dry seasons, how would you judge the taste of the water from [SOURCE]? (before any treatment the household may do)** **CODES:** 1-Sweet(>> 4) 2-Rusty (>>4) 3-Salty (>> 3)		3 **In the rainy and dry seasons, how would you compare the level of saltiness of water from [SOURCE] within the community 10 years ago? (before any treatment)** **CODES:** 1-Less Salty 2-Same 3-Saltier		4 **In the rainy and dry seasons, how would you judge the color of the water from [SOURCE]? (before any treatment the household may do)** **CODES:** 1-Greenish 2-Orange/Rusty 3-Brownish 4-Turbid 5 - Clear		5 **In the rainy and dry seasons, how would you judge the reliability of the water from [SOURCE]?** **CODES:** 1-Excellent 2-Good 3-Fair/ Normal 4-Poor		6 **How far is the nearest [SOURCE] from your house?**	7 **What percentage of your drinking water consumption is taken from [SOURCE]?**	8 **What type of water treatment do you do before drinking water from this [SOURCE]?** **CODES:** 0-None 1- Boil water 2- Filter water Others, specify ________
			DRY	**RAINY**	**DRY**	**RAINY**	**DRY**	**RAINY**	**DRY**	**RAINY**	**METERS**	**PERCENT**	
1	Private water connection												
2	Public taps												
3	Public well												
4	Privately-owned Shallow Tube Wells (STW)/ Pump												
5	Group-owned Shallow Tube Wells (STW)/ Pump												
6	Neighbors that sell or give water away												
7	Private dug well												
8	Buying water from commercial vendors												
9	Other surface water sources (rivers/streams/lakes)												
10	Rainwater												

MODULE 3: INFORMATION ON DWELLING PLACE

Question	Answer
1. How many years have you resided in your current residence?	
1. a. Did you reside in another house before occupying your current residence? **CODES:** 1-Yes (>> 1b) 2-No (>> 2)	
1.b. Where did you reside before? **CODES:** 1-Within the village 2-Outside the village Others, specify ___________________	
1.c. Why did you migrate or move? **CODES:** 1-Because sea level has reached our previous house 2-Because typhoon destroyed our previous house 3-Because of conflict and other security concerns Other reasons, specify ___________________	
1.d. How much did it cost you to move?	VND
2. What is the tenure status on the housing unit occupied by the HH? **CODES:** 1-Owned (>> 2a) 2-Rented (>> 2b) 3-Living with others (>> 3) Others, specify________________ (>> 3)	
2a. If you were to sell the house today, how much would it sell for?	VND
2b. How much is your rent per month?	VND
3. How many floors does the housing unit have? **CODES:** 1-Single floor (>> 4) 2-One-story with elevated ground floor (>> 4) 3-Two floors (>> 5) 4-More than two floors (>> 5)	
4. How high is the floor in the first level of the house relative to the ground? (>> 7)	……….. cm
5. What type of construction material is the roofing of the house made of? **CODES:** 1-Permanent materials (galvanized iron, aluminum, tile, concrete, brick stone, asbestos) 2-Light materials (thatch roof, *sawali*, salvaged/makeshift materials) 3-Mixed but predominantly permanent materials 4-Mixed but predominantly light materials 5-Not applicable	
6. What type of construction materials is the house wall made of? **CODES:** 1-Permanent materials (galvanized iron, aluminum, tile, concrete, brick stone, asbestos) 2-Light materials (thatch wall, *sawali*, salvaged/makeshift materials) 3-Mixed but predominantly permanent materials 4-Mixed but predominantly light materials 5-Not applicable	
7. Is there electricity in the house/building? **CODES:** 1-Yes (>> 10) 2-No (>> 11)	
8. How many years have you had electricity?	______years
9. Do you have piped water? **CODES:** 1-Yes (>> 12) 2-No (>> 13)	
10. How many years have you had piped water connection?	______years
11. What kind of toilet facility does the household use? **CODES:** 1-Flush 2-Hanging toilet 3-Open pit latrine 4-None (>> 17)	
12. How do you dispose your garbage? **CODES:** 1-Wrap and throw 2-Bury under the ground 3-Throw in an open pit 4-Regularly collected by Local Government Units Others, specify ________________	

Question	Answer
13. Is there a mangrove in front of your house? **CODES:** 1-Yes (>>21) 2-No(>>22)	
14. How far is the mangrove from your house?	______ meters
15. What is the distance of your house to the coastline at ***high tide***?	______ meters
16. What is the distance of your house to the coastline at ***low tide***?	______ meters
17. What is the distance of your house to the nearest river, creek, or stream?	______ meters
18. How far is your house from the nearest evacuation center?	______ meters
19. How far is your house from the nearest market/ *talipapa*?	______ meters
20. How far is your house from the nearest satellite clinic?	______ meters
21. How far is your house from the nearest hospital?	______ meters

MODULE 4: HOUSEHOLD CONSUMPTION

Code	Expenditure item	Average Amount in a given period	Period
1	Food (Cash)		in a day
2	Food (Non-cash)		in a day
3	Clothing		in a year
4	Utilities (Electricity, water, fuel, etc.)		in a month
5	Household facilities (Repair, maintenance, etc.)		in a month
6	Non-food items (Toiletries)		in a month
7	Health expenses (Medicine, hospital fees, etc.)		in a year
8	Transportation and communication		in a year
9	Recreation (Liquors, cigarettes, gambling, etc.)		in a month
10	Education (Including tuition, books, allowance, transportation, etc.)		in a semester
	Other expenses pls. specify. ______________________		in a month

MODULE 5: INFORMATION ON FARMING ACTIVITY

Screening Questions:

1. Have you or any of your household members been involved in any farming activity in the last cropping period? _____________________
   CODES: 1-Yes (>>2)
   2-No (>>MODULE 6)
2. How were you involved in farming? _______________
   CODES: 1-Cultivating own land (>>MODULES 5A-5D)
   2-Shareholder/ Tenant (>>3)
   3-Hired farm worker (>>4)
3. How much did you receive as a shareholder? ____________________
4. How much did you receive as a farm worker last cropping season? ___________________

MODULE 5A: GENERAL INFORMATION

1. Is the farm an upland or lowland farm? _______________
   CODES: 1-Upland
   2-Lowland
2. What is the total area of all plots you currently cultivate? _____________ sq. m.

MODULE 5B: CROP PRODUCTION AND DISPOSAL

	1	2	3	4	5		6	7	8	9
CROP CODE	**What are the three (3) main crops you raised last cropping season?**	**How many cropping per year for this crop?**	**Total area planted last cropping season (hectare)**	**How much was the output sold? (Price/kg)**	**Total output of [CROP] from irrigated and rained plots**		**How much of the total harvest did you sell?**	**How much of the total harvest did you consume?**	**How much of the total harvest did you use to pay contractual obligations?**	**How much of the total harvest did you store?**
					Irrigated Plot	**Rained Plot**				
	Crop Name				kg	kg	kg	kg	kg	kg

MODULE 5C: CROP INPUT EXPENDITURE

INPUT CODE	1		2	
	Have you used any of the following inputs to the main crops you mentioned in the previous section?		Can you tell me how much you spent last cropping season for [INPUTS]?	
	INPUTS	CODES: 1-Yes; 2-No	CASH	RECEIVED IN KIND (Estimate Value)
	FERTILIZERS			
1	Inorganic fertilizer (Chemicals)			
2	Organic fertilizer			
	INSECTICIDES			
3	Inorganic pesticides (Chemicals)			
4	Organic pesticides			
	HIRED LABOR			
5	Land preparation (Plowing, weeding, etc.)			
6	Spraying			
7	Fertilizing			
8	Irrigation			
9	Harvesting			
	POST HARVEST			
10	Threshing			
11	Milling			
12	Drying			
	SEEDS			
	TRANSPORT AND STORAGE			
13	Transportation to market			
14	Rental of storage facilities			
15	Rented farm animal			

MODULE 5D: FARMING ASSETS

Farming Asset Code	FARMING ASSET	Does household own a [ITEM]? CODES: 1-Yes; 2-No	How many [ITEM]s do you own?	What is the age of this [ITEM]? If more than one item, average age.	How much did you buy or acquire this [ASSET]?
1	Agricultural Equipment (Hoe, Axe, Sickle, Ox-Cart, Wheelbarrow, etc.)				
2	Water Pump				
3	Tractor				
4	Tiller				
	Others, specify				

MODULE 6: INFROMATION ON FISHING ACTIVITIES

Screening Question: Have you or any of your household members been involved in any fishing activity in the last six months? ____________

CODES: 1-Yes (>>MODULES 6A-6D)
2-No (>>MODULE 7)

MODULE 6A: GENERAL INFORMATION

1. How far is the fishing area from the barangay shoreline? (Please indicate number)
   No. of hours: ______ hrs. No. of km: ________ kms.
2. What is the type of fishing boat do you use? __________
   CODES: 1--Non-motorized boat
   2--Motorized boat
3. How many hours do you spend per fishing trip? ___________ hrs.
4. How many fishing trips do you make in a day? ________
5. On average, how many days do you fish in a month? ________ days
6. On average, how many months in a year do you fish? ________ months

MODULE 6B: FISH PRODUCTION AND DISPOSAL (Show pictures of fishes, if possible.)

Fishing gear used	**GEAR CODE** (see codes for fishing gears *ANNEX)	**Local name of species caught**	**FISH CODE** (see codes for species caught **ANNEX)	**Total catch per trip (kg)**	**Price/ kg**	**How much of the total harvest did you sell?** kg	**How much of the total harvest did you consume?** kg	**How much of the total harvest did you use to pay contractual obligations?** kg	**Did you observe any change in the volume of catch for this species?** **CODES:** 1-Decline 2-Increase 3-None

MODULE 6C: FISHING INPUTS

INPUT CODE	1 Have you used any of the following inputs to catch fishes you mentioned in the previous section?		2 Can you tell me how much you usually spend for [INPUTS] every fishing trip?	
	INPUTS	**CODES**: 1-Yes; 2-No	**CASH**	**RECEIVED IN KIND (Estimate Value)**
1	Gasoline			
2	Hired Labor			
3	Food			
4	Ice			
5	Rental of storage facilities			
	Others (specify)			

MODULE 6D: FISHING ASSETS

Fishing Asset Code	FISHING ASSET	Does household own a [ITEM]? CODES: 1- Yes 2-No	How many [ITEM]s do you own?	What is the age of this [ITEM]? If more than one item, average age.	How much did you buy/ acquire the [ITEM] If more than one item, average price.
1	Motorized Boat				
2	Non-Motorized Boat				
3	Fish nets				
4	Ice Boxes				
	Others, specify ______________				

MODULE 7: INFORMATION ON AQUACULTURE OR MARICULTURE ACTIVITIES

Screening Question:
Have you or any of your household members been involved in any aquaculture or mariculture activity? _________
CODES: 1-Yes (>>MODULES 7A-7C)
2-No (>>MODULE 8)

MODULE 7A: GENERAL INFORMATION

1. What is the total area of all your fishponds? _____________ sq. m.
2. What is the total area of owned fishponds? ______________ sq. m.
3. What is the total area of leased/ rented fishponds? _______ sq. m.

MODULE 7B: AQUACULTURE PRODUCTION AND DISTRIBUTION

Local name of species cultured	**FISH CODE** (see codes for species raised **ANNEX)	**No. of cropping in a year**	**What was your total harvest?** kg	**Price/ kg. Sold**	**How much of the total harvest did you sell?** kg	**How much of the total harvest did you consume?** kg	**How much of the total harvest did you use to pay contractual obligations** kg	**Did you observe any change in the volume of production of this species?** **CODES:** 1-Decline 2-Increase 3-None

MODULE 7C: AQUACULTURE INPUTS

INPUT CODE	**1**		**2**	
	Have you used any of the following inputs for your fish culture activities?		**Can you tell me how much you usually spend for [INPUTS] last cropping season?**	
	INPUTS	**CODES:** 1-Yes; 2-No	**CASH**	**RECEIVED IN KIND (Estimate Value)**
1	Gasoline			
2	Hired Labor			
3	Electricity			
4	Feeds			
5	Fingerlings			
6	Maintenance of Facilities			
	Others (specify)			

MODULE 8: INCOME FROM OTHER SOURCES

Screening Question:
During the past 12 months, how much did ***you or any member of your household*** receive income from other sources other than those already mentioned? ____________
CODES: 1-Yes (>>MODULE 8)
2-No (>>MODULE 9)

During the past 12 months, how much did you or any member of your household receive income from the following sources? **CODES**: 1-Yes 2-No		**NET INCOME**	
		Cash	**Non-Cash**
Salary and wages (of **all Household Members**) from government or private employment			
Wholesale and retail trade including market vending, sidewalk vending and peddling, selling groceries, beverages, snacks, and farm products, etc.			
Net share of crops, fruits and vegetables produced or livestock and poultry raised by other households.			
Transportation, storage and communication service such as operation of tricycle, lorries, jeepneys, pedicabs; storage and warehousing activities, messengerial services, telephone rentals, etc.			
Mining and quarrying activities such as mineral extraction like salt making, gold mining, gravel, sand and stone quarrying, etc.			
Construction like repair of houses, building or and structure			
Remittances from Overseas Contract Workers			
Cash receipts, support, assistance, relief and other income from domestic sources, including assistance from government and private sources.			
Interest from bank deposits, interest from loans extended to other families			
Other sources not classified elsewhere			
TOTAL NET INCOME FROM OTHER SOURCES (SUM ENTRIES IN ALL COLUMNS AFTER INTERVIEW)			

MODULE 9: ASSET OWNERSHIP

ASSET CODE	Asset Name	1 Does household own a/an [ITEM]? CODES: 1-Yes 2-No (>> Next Asset)	2 How many [ITEM]s do you own? Number	3 What is the age of this [ITEM]? If more than one item, average age. Years	4 How much did you buy/acquire the [ITEM]? If more than one item, average price.
	Household Assets				
1	Television Set				
2	Radio/ Stereo				
3	Refrigerator				
4	Washing Machine				
5	Gas Range/ Stove				
6	Electric Fan				
7	Cellular Phone				
8	Telephone				
9	Dining Table/ Chairs				
10	Bed				
11	Sofa Set				
	Productive Assets				
12	Bicycle/ Rickshaw				
13	Motorcycle/ Scooter				
14	Car/ Jeep				

MODULE 10: LIVESTOCK OWNERSHIP

ANI-MAL CODE	1 During the past twelve months, has any member of your household raised any [ANIMAL NAME]?	CODES: 1-Yes 2-No	2 How many [ANIMAL NAME] does your household own at present? Number of Animals	3 How old [AVERAGE AGE] are the animals? Age	4 How many of these animals were bought? Number of Animals	5 If you were to sell them today, how much would people pay for all of your [ANIMAL NAME]? [AVERAGE PRICE]
1	Water Buffalo					
2	Cow					
3	Pigs					
4	Chickens/ Other Poultry					
5	Others (specify)					

MODULE 11: HISTORY, IMPACTS and ADAPTATION TO TYPHOON

History of Typhoons

1. How many typhoons affected your community from 2001 to 2010? _____________ typhoons
2. How many typhoons affected your house from 2001 to 2010? _____________ typhoons

Note to Enumerator:
If 0 (or no) typhoon >> Skip to MODULE 12
If only 1 typhoon experience >> Answer Worst Case of typhoon Section **ONLY**
If more than 1 typhoon events >> Answer **BOTH** Worst Case and Latest Case Scenario, if applicable

Worst Case of Typhoon

Enumerator Introduction: I would like you now to remember or think about the worst case of typhoon you have experienced during 2001 to 2010.

1. How many days did it take for your household to recover from the financial impacts of the ***worst typhoon***? ____________________ days
2. How many days did it take for your household to recover from the emotional distress after the ***worst typhoon***? ____________________ days
3. How many days after the ***worst typhoon*** did it take for your household to go back to your "normal" situation? ____________days

Latest Case of Typhoon

Enumerator Introduction: I would like you now to remember or think about the ***latest*** case of typhoon you have experienced during ***2001 to 2010.***

1. How many days did it take for your household to recover from the financial impacts of the latest typhoon incident? ____________________ days
2. How many days did it take for your household to recover from the emotional distress after the latest typhoon incident? ____________________ days
3. How many days after the latest typhoon incident did it take for your household to go back to your "normal" situation? ____________days

Impacts of typhoon on Property and Livelihood

Enumerator Introduction: I would like to inquire now regarding damages to your properties and livelihood you experienced after a typhoon event.

Damage Code	DAMAGES	Did your household experience damage to the following? [Enumerator should go through the list] CODES: 1-Yes 2-No	What was the value of damages after the *Worst Case* of typhoon?	What was the value of damages after the *Latest Case* of typhoon?
1	Damage / Loss to House			
2	Damages/ Loss to Appliances (Stereos, TV, Cellphones, Sofa sets, etc.)			
3	Damage/ Loss to Livestock			
4	Damage to Assets (Boats, Motorcycles, etc.)			
5	Loss in Agricultural Production			
6	Loss in Fishing Income			
7	Loss in Aquaculture Production			
8	Income Loss due to work stoppage			
9	Loss in salt production			
	Others, specify			

Household Coping Mechanisms and Adaptation Responses to Typhoons

1. Before the typhoon event that you mentioned earlier, were you able to undertake preparations to protect your HH from potential damages? What are these? What were your estimated expenses?

CODE	ACTIVITIES	CODES: 1-Yes; 2-No	EXPENSES
1	Undertook improvements to make house more resilient to typhoon.		
2	Evacuated to a safe place		
3	Dug canals		
4	Planted trees along the perimeter of property		
5	Harvested crops or fish early		
6	Applied typhoon resilient farming methods (Specify)_______________________		
7	Built sand dikes around farms		
8	Reinforced ponds/fish cages/animal pens		
9	Moved fishing or farming equipment to safe place		
10	Joined savings-credit group/cooperative		
11	Pursued other means to generate additional income		
	Others (Specify)_______________________		

2. What activities did your household undertake <u>during</u> and <u>immediately after</u> the typhoon event?

CODE	ACTIVITIES	CODES: 1-Yes; 2-No	EXPENSES
1	Undertook repairs/improvements to make house more resilient to typhoon.		
2	Evacuated to a safe place		
3	Dug canals		
4	Planted trees along the perimeter of property		
5	Replanted farm		
6	Replaced fish stock		
7	Replaced livestock		
8	Re-built sand dikes around farms		
9	Reinforced ponds/fish cages/animal pens		
10	Received financial aid from government		
11	Pursued other means to generate additional income		
12	Saved money for climatic risks in the future		
13	Borrowed money to cope with income losses and damages		
	Others (Specify)_______________________		

3. Rank the top five options you think you would do in the future to deal with typhoon.

a. Relocate permanently _________
b. Modify house to make it more resilient to typhoons (e.g. house on stilts, concrete walls) _________
c. Set up personal savings to prepare for future typhoons _________
d. Join savings groups or livelihood groups to ensure access to emergency funds _________
e. Modify planting schedule _________
f. Avail of insurance _________
g. Participate in community activities/ projects to address problems associated with typhoon _________

Others, specify ___________________________________

MODULE 12: HISTORY, IMPACTS and ADAPTATION TO COASTAL EROSION

Screening Questions:

1. Are you aware if the community is being affected by coastal soil erosion? __________
   CODES: 1-Yes
   2-No
2. Has your household's properties (for example house, livestock, etc.) or livelihood (for example: fishing, aquaculture, farms, etc.) been affected by coastal erosion? __________
   CODES: 1-Yes (>> Proceed with MODULE 12)
   2-No (>> Skip to MODULE 13)

History of Coastal Erosion

1. How far is your house from the shoreline 10 years ago? _________ meters
2. How far would you think your house would be from the shoreline five years from now? _____ meters
3. For the past 10 years, how many instances of soil erosion have your household witnessed or seen? ______ soil erosions
4. Can you specify the maximum loss of land caused by soil erosion? ______hectares
5. Of all instances of soil erosion within the past 10 years, how many affected your household?_________ instances of soil erosion
6. What is the usual cause of coastal erosion? __________

CODES FOR CAUSES OF COASTAL EROSION	
SINGLE EVENTS:	COMBINATION OF EVENTS:
1- Heavy Rains	6-Heavy Rains + Typhoon
2-Typhoon	7-Heavy Rains + Typhoon + Strong waves
3-Strong waves	8-Heavy Rains + Typhoon + Storm Surge
4-Storm Surge	9-Heavy Rains + Typhoon + Strong Waves Tide + Storm Surge
5-Others (specify)	10-Others (specify)

Impacts of Coastal Erosion

Enumerator Introduction: I would like to inquire now regarding damages to your properties and livelihood due to coastal erosion.

Coastal Erosion Damage Code	DAMAGES	Did your household experience damage to the following because of coastal erosion? **CODES**: 1-Yes; 2-No	What was the value of damages due to coastal erosion?
1	Damage / Loss to House		
2	Damages/ Loss to Appliances (Stereos, TV, Cellphones, Sofa sets, etc.)		
3	Damage/ Loss to Livestock		
4	Damage to Assets (Boats, Motorcycles, etc.)		
5	Loss in Agricultural Production		
6	Loss in Fishing Income		
7	Loss in Aquaculture Production		
8	Income Loss due to work stoppage		
9	Land loss		
	Others, specify		

Household Coping Mechanisms and Adaptation Responses to Coastal Erosion

1. What did your HH do to cope/ protect from potential damages? From coastal erosion? What were your estimated expenses?

CODE	ACTIVITIES	CODES: 1-Yes; 2-No	EXPENSES
1	Installed permanent protective structures (i.e sea walls made of concrete and similar materials)		
2	Installed temporary and semi-permanent protective structures (i.e. sea walls made of wood and similar materials, sand bags, etc.)		
3	Evacuated/ Migrated to a safe place temporarily		
4	Evacuated/ Migrated to a safe place permanently		
5	Planted mangrove trees along the shoreline		
6	Reinforced ponds/fish cages/animal pens		
7	Pursued other means to generate additional income		
8	Joined savings-credit group/cooperative		
	Others (Specify)______________________		

2. Rank the top five options you think you would do in the future to deal with erosion
   a. Relocate permanently _______
   b. Install permanent protective structures (i. e., sea walls made of concrete and similar materials) _______
   c. Installed temporary and semi-permanent protective structures (i.e sea walls made of wood and similar materials, sand bags, etc.) _______
   d. Set up personal savings to prepare for future soil erosion _______
   e. Join savings groups or livelihood groups to ensure access to emergency funds _______
   f. Planted mangrove trees along the shoreline _______

MODULE 13: HISTORY, IMPACTS and ADAPTATION TO SALTWATER INTRUSION

Screening Question:

1. Have your house been affected by salt water intrusion
   CODES: 1-Yes (>> Proceed with MODULE 13)
   2-No (>> Skip to MODULE 14)

History of Saltwater Intrusion

1. If you are a farmer, do you think the irrigation water is now affected by saltwater intrusion? _____________
2. When did the saltwater intrusion first occur in your community? _________ years ago
3. How many times in a year is fresh water contaminated with salt water? __________ times
4. How long does each last? ________________________
5. Does salt water intrusion occur regularly or irregularly? ________
   CODES: 1-Regularly
   2-Irregularly
6. Has the level of contamination caused by salt water increased over years? ______
   CODES: 1-Yes
   2-No

Impacts of Saltwater Intrusion

Enumerator Introduction: I would like to inquire now regarding damages to your health and livelihood due to saltwater intrusion.

Saltwater Intrusion Damage Code	**DAMAGES**	**Did your household experience damage to the following because of saltwater intrusion?** [Enumerator should go through the list] **CODES:** 1-Yes; 2 - No	**What was the value of damages due to saltwater intrusion?**
1	Loss in Agricultural Production		
2	Lack of fresh water for family routines		
3	Loss in aquaculture production		
4	Skin disease		
5	Women disease		
6	Tools have shorter lifetime		
	Others, Specify		

Household Coping Mechanisms and Adaptation Responses to Saltwater Intrusion

1. What have your HH done to cope with/ protect from potential damages due to saltwater intrusion? What were your estimated expenses?

CODE	**ACTIVITIES**	**CODES:** 1-Yes; 2-No	**EXPENSES**
1	Harvested rainwater as an alternative source of drinking water		
2	Tapped from a different water source		
3	Treated water		
4	Pumped fresh water into ponds and/or rice fields to reduce the level of salinity.		
5	Switching to livestock or plants that are more compatible with salt-contaminated water.		
6	Buy fresh water for family routines		
7	Built dikes of sand around farms		
	Others, specify		

2. Rank the top five options you think you would do in the future to deal with salt water intrusion.
   a. Relocate permanently ____________
   b. Harvest rainwater as an alternative source of drinking water ____________
   c. Tap from a different water source ____________
   d. Pump fresh water into ponds and/or rice fields to reduce the level of salinity ____________
   e. Switching to livestock or plants that are more compatible with salt-contaminated water ____________
   f. Buy fresh water for family routines ___________
   g. Build sand dikes around farms
   Others, specify __________________________________

MODULE 14: OTHER GENERAL IMPACTS

1. Have you noticed any change in the diversity of fish catch in your fishing area?
   __Yes ___No
   Since when? ________

2. Have you noticed any change in the sizes of any fish species?
   __Yes ___No
   If yes, what species? ___________, _____________ Since when? ___________

3. Changes in target species composition

Target species		**Peak months**	
What are the 5 most important fish species caught/ resources harvested?		**What time of the year is the resource caught/harvested?**	
5 YEARS AGO	**PRESENT**	**5 YEARS AGO**	**PRESENT**
1.			
2.			
3.			
4.			
5.			

MODULE 15: SOCIAL CAPITAL

1. What is the available medium to your household for receiving information/news?
   CODES: 1-Yes; 2-No
   a. TV _________
   b. Radio _________
   c. Internet _________
   d. Newspaper _________
   e. Information from Neighbors _________
   f. Information from Local Government Officials _________
   g. Telephone/Cellphone _________
   h. Others (Specify)_______________

2. Has your HH ever asked help from the following people to cope with any problems (such as financial, etc.)? **CODES:** 1-Yes; 2-No
   a. From relatives ______
   b. From friends ______
   c. From government agencies ______
   d. From barangay officials ______
   e. Others (specify)________________

3. Does your family have ready access to credit in cases of emergencies or when you are encountering financial problems from any of the following sources?
   CODES: 1-Yes; 2-No
   a. Relatives _______
   b. Friends _______
   c. Government ______
   d. Credit Cooperative ____
   e. Employer _______
   f. Informal Credit _______

4. Number of contacts (relatives or friends) that you are sure can provide you financial help when in need: ______________________ persons

5. Has your household ever taken any loan or credit? __________
CODES: 1-Yes (>>6);
2-No (>> 7)

6. Current Amount of Debt: __________

7. Suppose someone in the village/neighborhood had something unfortunate happened to them, such as a father's sudden death, do you think they would turn to you for help in this situation?_________
CODES: 1-Yes; 2-No

8. Do you have relatives/ friends ***inside*** the community to whom you can reside temporarily, should you need to evacuate during a calamity? ____________ **CODES:** 1-Yes (>>9); 2-No (>>10)

9. How many are these relatives/ friends would you have to whom you can reside temporarily? ______

10. Do you have relatives/ friends ***outside*** the community to whom you can reside temporarily, should you need to evacuate during a calamity? ____________ **CODES:** 1-Yes (>>11); 2-No (>>12)

11. How many are these relatives/ friends would you have to whom you can reside temporarily? ______

12. Organizational membership

Organization	**1** **Have you or any member of your household been a member of any of the organizations?** **CODES:** 1-Yes 2- No	**2** **How would you describe you or your household member's participation in this organization?** **CODES:** 1-Adviser/Officer/Board Member 2-Active Member 3-Non-Active member 4-Others, specify ____________________
Agricultural		
Labor		
Religious		
Youth		
Women		
Political		
Others, Specify ____________		

MODULE 16: AWARENESS AND PERCEPTION OF CLIMATE CHANGE

1. Can you assess your knowledge about climate change and its impacts ____________
   CODES:
   1-No information/knowledge
   2-A little bit of knowledge
   3-Adequate knowledge
   4-Fully knowledgeable

2. Rate your preparedness to deal with future climate change impacts ________________
   CODES:
   1-Not prepared at all
   2-Somewhat prepared
   3-Adequately prepared
   4-Fully prepared

3. Which statement do you think is correct? ________
   CODES:
   1-The impacts will be more severe than in the past
   2-The impacts will be about the same as in the past
   3-Not sure

MODULE 17: DISASTER PREPAREDNESS AND EARLY WARNING SYSTEMS IN THE COMMUNITY

1. Do you receive any advisory before a typhoon occurs? ___________
   CODES:
   1-Yes (>>2)
   2- No (>>4)

2. Did you get typhoon advisory/information from any of the following sources? **CODES**: 1- Yes; 2- No
   a. Radio _________
   b. TV _________
   c. Neighbors _________
   d. Friends/Relatives _________
   e. Barangay / Village Officials _________
   f. Local Government_________
   Others (Specify)_____________

3. How many hours in advance did you receive the typhoon advisory/warning? _________ hours

4. Has anyone in your household received any training on disaster preparedness in the last 5 years? __________
   CODES: 1-Yes (>> 8)
   2-No (>> 9)

5. How many members received any training on disaster preparedness in the last 5 years? _________

6. Does your household have any of the following insurance plans?
   CODES: 1-Yes; 2-No
   a. Medical Insurance ________
   b. Life Insurance ________
   c. Accident Insurance ________
   d. Property Insurance ________
   Other insurance plans (Specify) _____________

7. What assistance does your household need so that it will be better able to cope with the adverse impacts of climate change? (Do not dictate options, *mark options based on respondent's answer*)
   CODES: 1- Yes; 2- No
   a. Financial Assistance _________
   b. Construction of Sea walls/ Sea Dikes and other protective structures
   c. Planting of Mangroves and other conservation activities
   d. Insurance __________
   e. Information Dissemination and Education Campaign_______
   f. Early Warning Systems
   Others (specify) ___________________

MODULE 18: COMMUNITY COPING MECHANISMS AND ADAPTATION RESPONSES

1. What do you think are the top five interventions needed by your community in order to address the problems associated with typhoons?

ACTIVITIES	Please rank the top 5 interventions needed to address typhoon
a. Community evacuation	
b. Permanent Relocation	
c. Disaster preparedness training	
d. Information Dissemination and Education Campaign	
e. Early Warning Systems e.g.	
f. Cleaning of canals and water ways	
g. Dig canals	
h. Rescue and emergency assistance	
i. Relief operations	
j. Replanting of mangroves and forests	
k. Solid Waste Management or addressing garbage problems	
l. Financial assistance	
Others (specify) ____________________	

2. What do you think are the top five interventions needed by your community in order to address the problem of coastal erosion?

INTERVENTIONS	**Please rank the top 5 interventions needed to address SLR and Coastal Erosion**
a. Community evacuation	
b. Permanent Relocation	
c. Information Dissemination and Education Campaign	
d. Early Warning Systems for Storm Surges	
e. Relocation of Households	
g. Installation of sea wall and dikes	
h. Repair of existing sea wall/ dikes	
k. Implementation of Coastal Zoning Ordinances	
l. Mangrove Rehabilitation/ Conservation	
m. Financial assistance	
Others, specify ___________________________	

3. What do you think are the top five interventions needed by your community in order to address the problem of saltwater intrusion?

INTERVENTIONS	**Please rank the top 5 interventions needed to address Salt Water Intrusion**
a. Information dissemination	
b. Permanent Relocation of Households	
c. Distribution of water treatment devices/ medicines to households	
d. Installation of community water treatment facilities	
e. Installation of piped water connections from a different water source in the community	
f. Financial assistance	
g. Build a dam	
h. Build a fresh water factory	
Others, specify __________________________	

4. Are the following coastal resource management strategies present in the community?
CODES: 1- Yes; 2- No
   a. Marine Protected Areas/fish sanctuary _________
   b. Riverbank rehabilitation _________
   c. Mangrove plantation _________
   d. Upland reforestation _________
   e. Coastal Protection/ Police _________
   Other coastal resource management strategies (specify) _______________

5. Are the following environmental problems present in the community?
CODES: 1- Yes; 2- No
   a. Poor waste management (garbage problem) _________
   b. Poor sanitation (e.g. lack of toilet facilities) _________
   c. Mangrove deforestation _________
   d. Deforestation __________
   e. Use of destructive fishing methods _________
   f. Sand quarrying _________
   Other environmental problems, specify _______________

APPENDIX B: CE ratio for the construction of the sea dike system.

1. Investment progress

Total investment of the sea dike system amounts to USD 144,661,651.23 which is allocated in 6 years as in table 17.

Table 17: Investment progress of the sea dike (USD)

Category	1st and 2nd years	3rd and 4th years	5th and 6th years
Construction	7,669,994	35,261,429	37,595,052
Clear-the-ground compensation	12,754,871	987,654	1,633,632
Project management	98,524	357,976	375,193
Project consultancy	956,115	2,408,468	2,514,468
Miscellaneous	503,569	1,228,781	1,246,672
Inflationary costs	8,133,729	14,890,432	16,045,091
Total investment	**30,116,802**	**55,134,742**	**59,410,108**

Source: Ben Tre DARD 2010

2. Operating costs

Table 18: Operating cost of the sea dike system

Year	Expense (USD)
3	211,226.85
4	316,840.28
5	422,453.70
6	528,067.13
7	633,680.56
8	739,293.98
9	844,907.41
10	950,520.83
11-30	1,056,134.26

Source: Ben Tre DARD 2010

3. CE ratio calculation

Table 19: CE ratio for the sea dike

Year	Costs (USD)	Physical benefit	Present value of cost	CE ratio
1	15,081,308	31,370 hectare of land	USD 109,176,145.47	USD 3,480.27
2	15,081,308			
3	28,748,384			
4	28,853,998			
5	29,607,494			
6	28,847,946			
7	633,681			
8	739,294			
9	844,907			
10	950,521			
11	1,056,134			
12	1,056,134			
13	1,056,134			
14	1,056,134			
15	1,056,134			
16	1,056,134			
17	1,056,134			
18	1,056,134			
19	1,056,134			
20	15,627,411			
21	1,056,134			
22	1,056,134			
23	1,056,134			
24	1,056,134			
25	1,056,134			
26	1,056,134			
27	1,056,134			
28	1,056,134			
29	1,056,134			
30	1,056,134			

APPENDIX C: CE ratio for the construction of the irrigating system

1. Investment progress

Total investment of USD 144,661,651.23 is allocated in 3 years as in table 20.

Table 20: Investment progress of the irrigating system (USD)

Year 1	**Year 2**	**Year 3**
USD 28,838,241	USD 14,419,121	USD 4,806,373

Source: Ben Tre DARD 2011

2. CE ratio calculation:

Table 21: CE ratio for the irrigating system

Year	Cost (USD)	Physical benefit	Present value of costs	CE ratio
1	28,838,241	29,244 hectare of land	USD 44,333,906.85	USD 1,516
2	14,419,121			
3	4,806,373			
4	373,137			
5	373,137			
6	373,137			
7	373,137			
8	373,137			
9	373,137			
10	373,137			
11	373,137			
12	373,137			
13	373,137			
14	373,137			
15	373,137			
16	373,137			
17	373,137			
18	373,137			
19	373,137			
20	373,137			
21	373,137			
22	373,137			
23	373,137			
24	373,137			
25	373,137			
26	373,137			
27	373,137			
28	373,137			
29	373,137			
30	373,137			