Climate Change Impact, Vulnerability Assessment, and Economic Analysis of Adaptation Strategies in Ben Tre Province, Vietnam

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February, 2017

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CLIMATE CHANGE IMPACT, VULNERABILITY ASSESSMENT, AND ECONOMIC ANALYSIS OF CLIMATE CHANGE ADAPTATION STRATEGIES IN BEN TRE PROVINCE, VIETNAM

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EXECUTIVE SUMMARY

Vietnam is one of the most vulnerable countries to the impacts of climate change. The country's 10 most vulnerable provinces are among the top 25% most susceptible regions in Southeast Asia, in which eight of these ten provinces are located in the Mekong River Delta, including Ben Tre province. In the past few years, Ben Tre has suffered immensely from saltwater intrusion; unusual typhoons have also caused severe damages to the province. Accordingly, rural households in Ben Tre have been considered as highly vulnerable to the effects of climate change, which prompted the communities to plan and adopt adaptation measures to cope with these changes.

This study identified the impacts of climatic change on the rural households of Ben Tre province, and subsequently conducted an economic analysis of the planned climate change adaptation (CCA) strategies of the community. Three focus group discussions (FGDs) were conducted in the study in order to identify the vulnerable sectors and households in the chosen sites. A household survey among 300 respondents was also conducted to obtain information on Ben Tre residents' awareness and knowledge of climate change, and on the autonomous CCA strategies being used by the residents. The researchers subsequently conducted a cost-effectiveness analysis of two CCA strategies planned by the provincial government.

Results of the FGDs showed that community leaders were aware of climate change and were making adjustments to cope with the changes in climatic patterns. The results of the household survey, on the other hand, showed that the local rural households had little knowledge of climate change; they simply related the phenomenon to certain biological and physical events (e.g., changes in temperature, rainfall, wind patterns, and typhoon occurrence). Meanwhile, data showed that the total damages caused by the most recent typhoons, saltwater intrusion, and erosions in the province were USD 154,155; USD 77,151; and USD 28,492, respectively. However, the total value of the damages caused by these climatic events was actually higher because the cost of the measures undertaken by households to mitigate the effects of these climatic events could also be considered as losses.

In order to prevent damages from sea level rise, the provincial government planned to build new and upgrade existing sea walls. The residents also requested for desalination water plants for water treatment. The local authorities have already begun designing these two interventions; hence, this study evaluated the investment strategies of the local government considering the limited resources available. Based on the cost-effectiveness ratio, the freshwater treatment plant would be more cost effective than the sea dike system.

Households were also evaluated in terms of their vulnerability to climate change based on how the phenomenon has affected their livelihoods. The percentage distribution of the vulnerability index showed that 31% of the households in the study sites were highly vulnerable to climatic hazard, while 56% of households were not vulnerable at all.

1.0 INTRODUCTION AND RATIONALE

Climate change is one of the most challenging issues faced by humanity in the 21st century. Records show that the effects of climate change have been affecting agricultural production, rural livelihoods, and the environment throughout the world. Scientific data on climate change research and mathematical modeling have all shown that Vietnam is one of the most affected countries by climate change.

In Vietnam, temperature increase and sea level rise—which can cause permanent inundation, increased floods, and saltwater intrusion—have impeded agricultural development and have posed risks to industrial production and socioeconomic systems in the country. Over the past 50 years, Vietnam has experienced an increase of 0.5°C–0.7°C in annual average temperature and a 20-centimeter rise in sea level. Climatic changes have caused hazards like typhoons, floods, and droughts to intensify and to occur more frequently in the past 20 years. Scientific calculations show that average temperature in Vietnam could probably increase by 3°C, and that sea level would likely rise by 1 meter by 2100. In the case of a one-meter sea level rise, approximately 40,000 km^2 of coastal plains in Vietnam will suffer from permanent inundation, specifically, 15,116 km^2 in the Mekong Delta. This translates to permanent inundation of about 37.8% of the total area of Vietnam (MONRE 2009).

Climate change mapping shows that Vietnam's 10 most susceptible provinces are among the top 25% most vulnerable areas in Southeast Asia—and Ben Tre is one of these provinces (Yusuf and Francisco 2010). The Ben Tre region has suffered immensely from saltwater intrusion. In 2003, saltwater intrusion caused agricultural losses amounting to USD 750,000, which affected 16,000 households. The *South China Morning Post* (April 2008) reported that losses had increased to USD 37 million in 2005. The number of people reportedly not having access to freshwater was estimated to be 110,000 out of a population of 280,000. Salty droughts in 2010 also either destroyed or impeded the productivity of 1,575 ha of rice land and 10,162 ha of farmland for fruits, and resulted in some 4,500 ha of unproductive lands. The total damage and losses was approximated at VND 198 billion (Oxfam 2008). Saltwater intrusion also resulted in decreased freshwater availability, an increase in poverty rate, decrease in land use, and a population shift. Continued rise in sea level is, therefore, bound to have serious negative impacts on an already impoverished region.

Regional governments have noted these climatic changes, and thus have included strategies in their regional plans to prevent further damages and to assist residents in coping with these changes. However, there have been no studies that have evaluated the economic and financial impacts of these strategic measures, which can be costly to rural poor households, communities, and the society as a whole. It is, therefore, against this backdrop that this study was conducted.

1.1 Local Settings

1.1.1 Geographical location

The province of Ben Tre is located in the Mekong Delta and has a complex system of internal rivers measuring over 382 km in total length. These branches of internal rivers originate from the Mekong River system and then meet in the East Sea (also called the West Philippine Sea) at four big estuaries. Accompanying this system are fertile lands, bordering 65 km of the coastline, and a privileged sea area, which is part of the exclusive economic zone of approximately 20,000 km^2. Mekong Delta is a low-lying plain and a major agricultural production area in Vietnam.

In Figure 1, Ben Tre has the shape of a pied fantail; the upstream source divides into dispersed smaller branches that follow the eastern direction to the sea. The province has an area of about 2,300 km^2. It borders Tien Giang province on the north by the Tien River, and by Vinh Long and Tra Vinh provinces on the west, and by Co Chien River on the south. Four big rivers (i.e., Tien Giang, Ba Lai, Ham Luong, and Co Chien Rivers) surround and divide Ben Tre into three separate land areas.

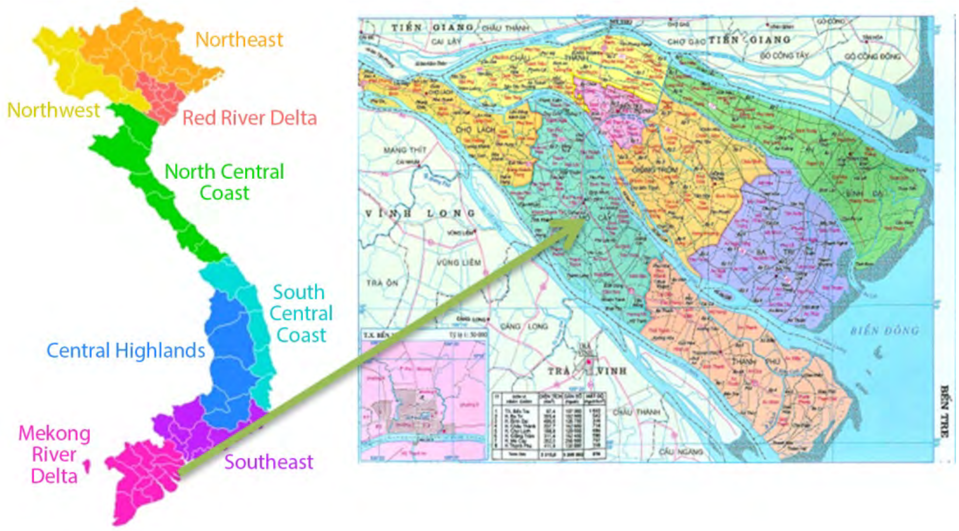

Figure 1. Maps of Vietnam and Ben Tre province

1.1.2 Climate and hydrological features

According to the reports and official statistical sources of the Ben Tre Centre for Hydro-meteorological Forecasting, the rainy season in Ben Tre starts in May and lasts until November; the dry season is 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 with other areas. The temperature of the province is relatively high, which is favorable for the production of certain crops and livestock. The average temperature recorded is about 27°C. The hottest months are April and May when the average temperature is up to about 29°C. The coolest month is December, with average temperature as low as 25°C (Ben Tre CEHMF 2010).

In terms of hydrology, Ben Tre has a network of interlaced rivers, ditches, and canals that favors irrigation and forms a transportation network. There is a canal or channel in every 1–2 km along the main rivers.

The terrain of Ben Tre is mostly below the average sea level. Most rivers are affected by the East Sea tidal regime, which enables saltwater to follow the tides into rivers. Many rivers and canals have relatively large width, and the width of estuaries ranges 2–3 km. As a result, the river water is seriously contaminated with salt. In dry seasons, saltwater intrusion occurs in almost every area of the province, causing severe freshwater shortages. Generally, the most serious salinity problem is experienced in April. In areas close to the sea, the level of salinity is never below 2 $^0/_{00}$. On the event of the rainy season, owing to precipitation and freshwater from the upstream of the Mekong River system, the water is less saline (Ben Tre DARD 2007).

1.1.3 Socioeconomic features

The *Ben Tre 2010 Statistical Yearbook* supplied the socioeconomic data for this study. The total population of Ben Tre in 2009 was 1,255,946, with households numbering 358,691. The average household size was four. About 90% of the population lived in rural areas (Table 1). The average monthly income per capita in 2008 was VND 891,440 (USD 43) and VND 1,165,390 (USD 56) in rural and urban areas, respectively. The unemployment rate in 2009 was about 11.7%. Most of the residents had little formal education (Table 2). The primary occupations were farming, fishing, labor for manufacturing and construction, petty trade, and motorcycle repairing. Approximately 50% of all employed residents were 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 364,000 tons (Table 3). The main livestock in 2010 included pig production (431,562); chickens (2,937,969); and ducks (1,764,566). The production of fisheries amounted to 290,585 tons in 2010. The gross output of the fishery sector was VND 7,478,813 million (USD 360,668,065), of which 67.5% was supplied by aquaculture (Table 4). The industrial output value reached VND 9,575,873 million (USD 461,799,430) in 2010, of which 93.6% came from manufacturing.

Table 1. Population, number of households, and average persons per household by district in 2009

Districts	Total Population	No. of Households	Ave No. of Persons per Household	Population	
				Urban	Rural
Ben Tre	116,099	34,583	3.32	61,968	54,131
Chau Thanh	157,216	46,113	3.39	3,538	153,678
Cho Lach	123,538	35,659	3.45	7,632	115,906
Mo Cay	242,642	71,442	3.38	11,330	231,312
Giong Trom	168,744	50,321	3.34	9,857	158,887
Binh Dai	132,193	36,994	3.56	9,859	122,334
Ba Tri	187,398	49,349	3.78	10,813	176,585
Thanh Phu	128,116	34,230	3.73	9,317	118,799
Total	1,255,946	358,691	3.48	124,314	1,131,632

Source: Ben Tre Statistical Office (2011)

Table 2. Proportion of population aged 15 and over by level of education and by district in 2009 (in percent)

Districts	% Qualification	Short-Term Training	Vocational Degree	College	Bachelor and Higher
Ben Tre	81.2	2.6	6.6	2.1	7.4
Chau Thanh	92.7	1.8	2.9	1.1	1.6
Cho Lach	95.5	1.4	1.7	0.8	1.1
Mo Cay	94.9	0.9	1.9	1.1	1.2
Giong Trom	94.9	0.9	2.1	1.0	1.2
Binh Dai	94.8	1.0	1.9	1.0	1.4
Ba Tri	95.7	0.8	1.6	0.9	1.0
Thanh Phu	96.1	0.7	1.5	0.8	0.8
Total	93.5	1.2	2.4	1.1	1.8

Source: Ben Tre Statistical Office (2011)

Table 3. Gross output of agriculture at current price in 2010 by sector and by district (in million VND)

Districts	Total Value	Of Which		
		Value of Crop Production	Value of Livestock Production	Value of Services
Ben Tre	364,553	289,892	47,698	26,963
Chau Thanh	1,486,760	1,154,526	210,717	121,517
Cho Lach	1,279,915	969,330	147,446	163,139
Mo Cay South	1,825,118	602,375	957,342	265,401
Mo Cay North	1,374,868	549,096	598,503	227,270
Giong Trom	2,106,453	1,319,775	549,720	236,958
Binh Dai	843,519	598,195	160,352	84,973
Ba Tri	1,845,763	1,086,838	484,613	275,312
Thanh Phu	890,000	571,947	242,825	129,228
Total	12,017,951	7,087,974	3,399,216	1,530,761

Source: Ben Tre Statistical Office (2011)

Table 4. Fisheries gross output (at current price), 2010, by sector, by district (in million VND)

Places	Total Value	Of Which		
		Value of Capture Fisheries	Value of Aquaculture	Value of Services
Ben Tre	62,045	640	5,262	56,143
Chau Thanh	517,950	23,604	485,453	8,911
Cho Lach	402,847	1,734	401,114	–
Mo Cay South	330,578	64,715	265,863	–
Mo Cay North	63,023	13,885	49,138	–
Giong Trom	555,362	26,311	528,041	1,011
Binh Dai	3,085,545	1,052,505	2,012,473	20,567
Ba Tri	1,580,178	953,528	616,972	9,678
Thanh Phu	881,285	180,873	687,443	12,969
Total	7,478,813	2,317,794	5,051,741	109,278

Source: Ben Tre Statistical Office (2011)

1.2 Climate Risks to Address

1.2.1 Saltwater intrusion

In the dry season, Ben Tre suffers from saltwater intrusion, which leads to a shortage of freshwater for domestic and agricultural purposes. A salinity level of 1 $^0/_{00}$ can be detected throughout the entire province when the salinity threshold for drinking water should be <0.25 $^0/_{00}$. This phenomenon happens in the province due to the following reasons:

1. Ben Tre terrain is flat and possesses abundant river and channel systems. Such features make the province prone to saltwater intrusion as saltwater from the sea tend to flow into freshwater bodies inland. Furthermore, 94.2% of the province area is as low as 1–2 meters, and is affected by the East Sea tidal regime.

2. The water flow and velocity of rivers and channels are not strong enough during the dry season to negate the saltwater that flows in an opposite direction. Sea tides also cause saltwater to penetrate deeper into freshwater bodies.
3. High average temperature, summer solstice, low average rainfall, and monsoon rains during the summer months facilitate severe saltwater intrusion. Moreover, the rapid increase in aquaculture activities in the province has reduced mangrove forests. These factors all help enable sea waves and tides to penetrate deeper inland.
4. In Ben Tre, groundwater is extracted since surface water is contaminated with saltwater. However, population growth and economic activities have led to decreased groundwater reserves, which further aggravates the situation (Ben Tre DARD 2007).

Economic damages caused by saltwater intrusion from 1995 to 2008 amounted to VND 672,325 billion (USD 32,423,080,632). Damages include 15,782 ha of nonproductive paddy; 13,700 ha of shed unripe coconut; 360 ha of less productive aquaculture; and 5,289 tons of dead shrimp. About 132,823 households also suffered from continued water shortage (Ben Tre DPI 2010).

Climate change will lead to higher temperatures, longer dry seasons, and rising sea level. All of these climate change effects will increase the extent of affected areas and the duration of saltwater intrusion. It is predicted that by 2020, sea level would rise by 11 cm, which would make the 4 $^{0}/_{00}$-salinity boundary at 15–25 km away from the coastline. The situation would be more serious by 2050 when sea level rises by 30 cm. By this time, the 4 $^{0}/_{00}$-salinity boundary would be at a distance of 40 km from the coastline. Based on this scenario, areas that are now suffering from the 4 $^{0}/_{00}$ salinity would experience 8–10 $^{0}/_{00}$ salinity. Such forecasts do not take into account the effects of droughts, longer dry seasons, and less water flow from upstream (MONRE 2009).

1.2.2 Sea level rise

Greenhouse gases (GHG) (e.g., water vapor, CO_2, CH_4, N_2O) are important components of the earth's atmosphere. They allow the lower atmosphere to absorb the heat radiated from the earth's surface, thereby trapping heat within the earth system. The whole process keeps the planet from becoming an icy sphere, with surface temperatures of about 0°F. However, over the past century, the amounts of GHG in the atmosphere have been increasing rapidly, mainly due to the burning of fossil fuels, which release CO_2 into the atmosphere. Consequently, in the past 100 years, global temperatures have been increasing more rapidly than the historic record shows. Scientists believe that this accelerated heating of the atmosphere is due to the increasing amounts of these GHG that trap more and more heat. The increase in global temperatures has caused glaciers to melt and for water to expand, which ultimately cause sea level to rise.

Vietnam is one of the countries threatened by sea level rise in terms of land loss, affected residents, production loss, and decrease in GDP. Sea level rise will affect various economic activities in several regions of Vietnam, especially in the Mekong Delta. Estimates show that sea level in Vietnam would rise 75–100 cm by 2100, in accordance with the high and medium GHG emission schemes, respectively (MONRE 2008).

As one of the provinces located in the Mekong Delta, Ben Tre is definitely vulnerable to the effects of sea level rise. Based on the scenario for sea level rise of Vietnam compiled by the Ministry of Natural Resources and Environment (MONRE), Ben Tre has actively developed its own scenario. The inundated area is depicted in Table 5 and Figure 2 in accordance with the high (A1FI) and medium (B2) GHG emission schemes.

Table 5. Inundated area of Ben Tre province according to B2 and A1FI GHG emission schemes

Indicator	2020	2030	2050	2070	2100
B2 emission scheme					
Sea level rise (cm)	12.00	17.00	30.00	46.00	75.00
Inundated area (km^2)	272.09	290.45	342.10	425.67	725.50
Inundated area (%)	12.24	13.07	15.39	19.15	32.62
A1F1 emission scheme					
Sea level rise (cm)	12.00	17.00	33.00	57.00	100.00
Inundated area (km^2)	272.09	290.45	352.10	509.76	1115.24
Inundated area (%)	12.24	13.07	15.84	22.93	50.17

Source: Ben Tre PPC (2011)

Note: Total area considered in the scenarios is 2,223.06 km^2

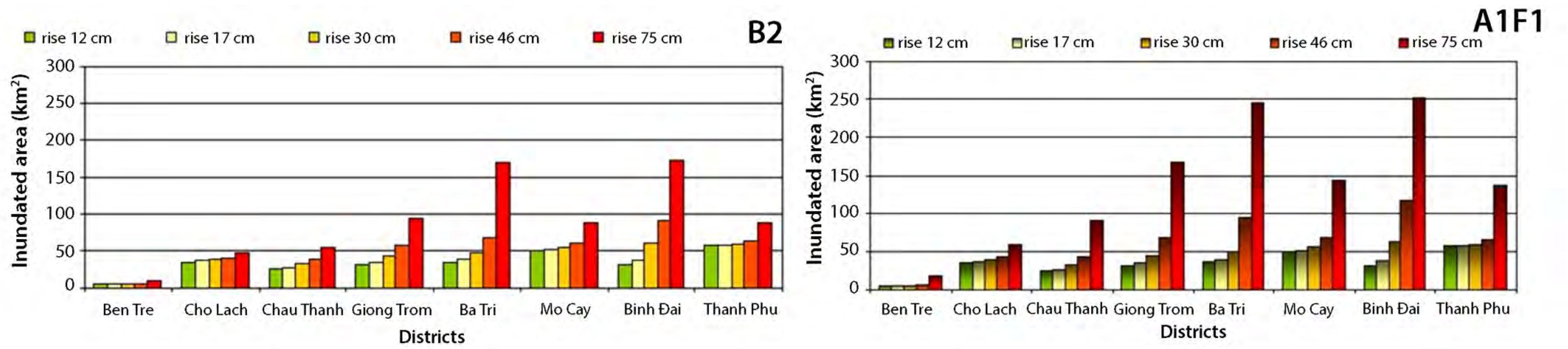

Figure 2. Inundated area (by district) according to B2 and A1FI GHG emission schemes

Source: Ben Tre PPC (2011)

Sea level rise will decrease the area for agriculture and aquaculture, which will significantly affect the productivity of these sectors. Figure 3 indicates that as the sea level rises, cultivated areas for paddy and for perennial industrial crops and fruit will be inundated. Aquaculture enterprises will also be affected (Figure 4). Likewise, when sea level rises, people who live on low-lying lands will be forced to relocate if no protective structures will be implemented (Ben Tre DONRE 2008). Table 6 specifies the number of residents who live in the forecasted inundated area.

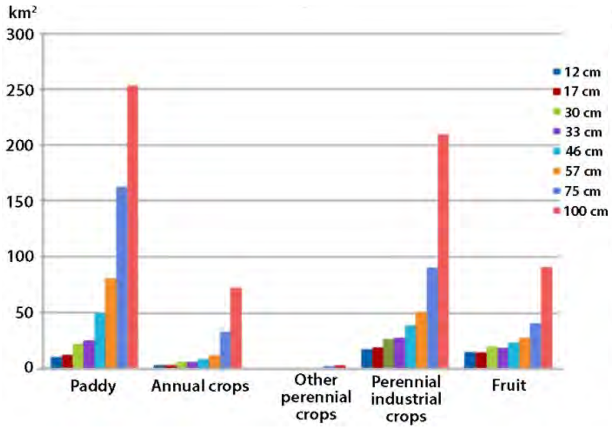

Figure 3. Inundated agricultural area, by crop

Source: Ben Tre PPC (2011)

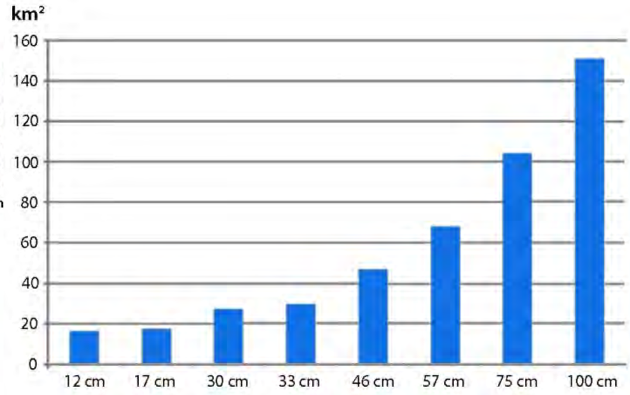

Figure 4. Inundated aquaculture area

Source: Ben Tre PPC (2011)

Table 6. Number of residents affected by sea level rise

Indicator	2020	2030	2050	2070	2100
B2 emission scenario					
Sea level rise (cm)	12.00	17.00	30.00	46.00	75.00
Number of people affected	97,890	102,054	123,365	166,034	356,615
A1F1 emission scenario					
Sea level rise (cm)	12.00	17.00	33.00	57.00	100.00
Number of people affected	97,890	102,054	127,675	215,574	589,821

Source: Ben Tre PPC (2011)

1.2.3 Typhoons and flooding

Generally, Ben Tre suffers from very few typhoons. In 1997, Typhoon Linda had wind velocity of 120 kph and accounted for damages of about VND 300 billion. Nine years later, Typhoon Durian, with wind velocity of over 133 kph, severely devastated the province, which resulted in 17 deaths, 162 injured people, and 71,340 collapsed or unroofed houses (Ben Tre CEHMF 2010).

Meanwhile, flooding in Ben Tre is mainly attributed to the floodwater from upstream, since Ben Tre is located in the downstream area of the Mekong River. Therefore, the upper districts of the provinces suffer from flooding. From 1996 to 2008, total damages from flooding amounted to VND 365,635 billion (Ben Tre CEHMF 2010). Figure 5 shows the two districts that mostly suffer from flooding .

Figure 5. Districts suffering from flooding

1.2.4 Erosion

The province of Ben Tre is divided by an intricate system of rivers and channels. Therefore, erosion occurs mostly along the riverside due to strong waves and tides, and due to indirect causes such as sand mine, structures on the banks, and heavy traffic of vessels. Official data show that riverside erosion during the period 1995–2008 affected 1,826 households, devastated 366,547 ha of land, and severely damaged 501 houses. Total loss was worth about VND 73,341 billion (USD 3,536,892,361) (Ben Tre DPI 2010).

1.3 Objectives of the Study

In general, this study aimed to identify and assess the impacts of sea level rise, saltwater intrusion, coastal erosion, and typhoon/flooding in Ben Tre province; and to conduct an economic analysis of the climate change adaptation (CCA) strategies adopted by the community to address these impacts. Three coastal communes, namely, Thua Duc of Binh Dai district, An Thuy of Ba Tri district, and Giao Thanh of Thanh Phu district were chosen as the study sites. Specifically, the study sought

1. To identify and document the bio-geophysical impacts of sea level rise, saltwater intrusion, coastal erosion, and typhoon/flooding in Ben Tre;
2. To evaluate the impacts of these climate change effects on the coastal residents, and to conduct a vulnerability assessment;
3. To identify the household, community, and government CCA measures to be implemented to cope with these impacts; and
4. To measure the economic losses/benefits of at least two CCA strategies among the identified CCA measures for implementation.

2.0 METHODOLOGY

2.1 Focus Group Discussions and Community-Based Vulnerability Assessment

2.1.1 First focus group discussion

The researchers conducted the first focus group discussion (FGD), which included eight provincial officials, namely, the officials of the Provincial People's Committee (PPC) of Ben Tre province, Ben Tre Bureau of the National Target Program to Respond to Climate Change, Ben Tre Department of Aquaculture and Rural Development (DARD), Ben Tre Department of Natural Resources and Environment (DONRE), Ben Tre Department of Science and Technology, Ben Tre Department of Plan and Investment, and Ben Tre Department of Finance. This FGD aimed to inform the local authorities of the research objectives, and to provide a forum for discussing the following climate change-related issues in Ben Tre province.

Areas with worst climate change impact. The first FGD illustrated that the three coastal districts Binh Dai, Ba Tri, and Thanh Phu witnessed the worst damage from the effects of climate change impacts, particularly sea level rise. According to the B2 climate change scenarios (estimation of the average sea level rise published by the MONRE in 2009), if sea level would rise by 30 cm by 2050, 16.23% (60.27 km^2) of the natural area of Binh Dai district would be covered in water; Thanh Phu, 15.61% (60.01 km^2); and Ba Tri, 47.43 km^2. About 7.8% (23.19 km^2) of the total aquaculture area in Ben Tre would also be submerged, and most of these areas belong to the same three coastal districts.

Indications of climate change in Ben Tre. Climate change has caused fluctuations in weather patterns; typical examples of such are the unusual occurrence of typhoon no. 5 in 1997 and typhoon no. 9 in 2006. In addition, the average annual temperature in the province increased by approximately 0.3°C from 1990 to 2005. Also, the gap between daytime and nighttime temperature has also expanded. The amount and frequency of precipitation 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. Likewise, saltwater intrusions have constantly posed a serious threat to Ben Tre and have had severe impacts on drinking water.

Impacts of climate changes on Ben Tre. According to the B2 climate change scenarios, when sea level ascends to 75 cm, 46.13% of the Binh Dai district land area would be submerged in water; Ba Tri and Thanh Phu districts would also suffer the same situation, albeit with different severity (51.3% and 23.17%, respectively). Aquaculture, forestry, and agriculture are the most vulnerable sectors to climate change, which means productivity in these sectors would decrease. Such a reduction will impose risks to the local residents, who count on agriculture and aquaculture for their livelihoods; this would then cause a decrease in the province's GDP. Moreover, sea level rise will also worsen the salinity in the province. Coastal areas would be the most affected by saltwater intrusion, which means that coastal communities would further face shortage of freshwater supply for domestic use.

Damage to infrastructure (e.g., buildings, bridges, and roads) is also one of the most problematic climate change-related concerns in the province, considering Ben Tre has the lowest terrain in the Mekong Delta, being the lowest part of the Mekong River Basin. Meanwhile, erosion is a normal occurrence along the coast or riverside due to the strong water currents, tides, waves, and abnormal winds (often during the August to November of the Lunar calendar). However, with the forecasted rise in sea level, coastal erosion is expected to worsen.

Ben Tre has a total 3,598 ha of forestland and has a diverse mangrove ecosystem, especially along the three coastal districts. Changes in climatic patterns, nonetheless, have damaged the ecosystem and have adversely affected the livelihoods of the coastal communities. The high temperature, which has changed the natural habitat and processes in the ecosystem, has decreased the number of plants and aquatic species in the coastal areas of the province. Changes in climatic patterns have also affected the coastal ecosystem and distorted the fisheries resources, thereby affecting the coastal fishing communities. Furthermore, fishing activities have been hindered by the risk of typhoons and tropical depression.

Action plans to adapt to the impacts of climate change in Ben Tre province. In the first FGD, the participants were able to sketch a major five-year action plan to address the impacts of climate change. The plan included implementing the following projects:

1. Building irrigation systems, such as the Quoi Dien, Cau Sap irrigation systems and the Ham Luong saltwater prevention dam;
2. Construction of sea walls to bound Binh Dai, Ba Tri, and Thanh Phu coastal districts;
3. Promotion of mangrove-planting project along the sea walls—the chosen species were mainly mangroves, cypress, and other fruit-bearing tress;
4. Construction of freshwater treatment plant to provide piped water for coastal residence; and
5. Information campaign on climate change, its impact, and response techniques.

In 2010, the Office of Climate Change program of Ben Tre implemented a wide-scale information campaign through two consultative courses designed for the communities, three district conferences, and one provincial conference. Mass media were also utilized to assist the people in obtaining information on how to deal with climate change. Twice a month, the website www.baodongkhoi.com.vn was updated with climate change information; once a month, the Ben Tre television station broadcasted news regarding the climate change situation.

Financial resources. The CCA-related activities of the province had been funded by the following NGOs, along with the government budget (central and provincial government):

1. Oxfam (2009–2011) – provided financial support of about USD 25,000 for a project aimed to improve the capability of local communities in managing climate-related risks by diversifying livelihoods;
2. World Wildlife Fund (2011–2012) – supplied financial support of approximately USD 150,000 to provide technical assistance to the local government on how to apply ecosystem-based CCA; and
3. Danish International Development Agency (2009–2013) – provided financial support of USD 8 million for CCA-related initiatives.

2.1.2 Second FGD

The second FGD followed the same design as the first FGD, but included 10 Binh Dai district officials from the People's Committee, DARD, DONRE, Department of Economic Development; and authority representatives from Thua Duc coastal commune. The participants were mainly chosen based on their experience in and knowledge on agriculture, aquaculture, and climate change. This FGD focused primarily on discussing the objectives of the research project with local officials. At the same time, it served as a platform for people to share their opinions and observations on the impacts of climate change (particularly sea level rise) in Binh Dai district. In addition, the research group gained insights and verified the responses of the first FGD.

Shifting climatic patterns, increasing temperature and salinity level, larger difference between day and night time temperatures, and sea level rise are some of the climate change effects that have been occurring in Binh Dai district. The alternating seasonal wind direction has also caused variation in currents in river valleys, thus exacerbating soil erosion. In Thua Duc commune, productivity of shrimp (extensive) farming within the mangrove forest significantly decreased—from VND 7–10 million per crop prior to 2007 to only VND 5 million per crop after 2007. This is because when the temperature and salinity of the water increases, the exoskeleton of black tiger and white leg shrimp thickens; hence, slowing their growth. Such harsh conditions also lengthen the culture period by an average of one month. Accordingly, aquaculture productivity declines.

In 2010, massive clam deaths (up to 90%) in Ben Tre inflicted enormous income losses on aquaculture farmers. The clam-culturing areas in the province were assessed to be highly vulnerable to climate change since increased salinity (caused by sea level rise) and temperature in the water change environmental conditions and marine ecology.

Accordingly, Binh Dai district implemented several CCA projects: (1) building a raw freshwater reservoir and water supply system, (2) evacuating people from eroded and erosion-prone areas, (3) planting 101 ha of mangrove swamps, and (4) implementing 20 saltwater irrigation systems.

2.1.3 Third FGD

After the second FGD, the research team, along with the head of the Office of Ben Tre PPC and representatives of the Ben Tre DONRE, investigated areas in Binh Dai and Ba Tri coastal districts that had been severely impacted by climate change. Specifically, they investigated the following areas and incidents: two clam-culturing cooperatives that had suffered massive clam deaths, three black tiger and white leg shrimp farms, the erosion occurring along the river, damaged constructions and infrastructure in the districts, and the dam in Ba Lai River. The investigations enabled the research team to develop contacts with the residents of the local community before launching the third FGD.

A total of 12 farmers from the different communes of Binh Dai and Ba Tri districts participated in the third FGD. The participants had been selected by the district authority officials. Some of the participants came from the largest zones of aquaculture and agricultural production in the districts. The researchers aimed to discuss the objectives of the research with the farmer participants and to determine their level of awareness of climate change, particularly of sea level rise.

Several conclusions were drawn during the discussion. The farmers showed initial awareness of climate change and sea level rise, and initiated actions to cope with climate-related events as follows:

1. *Changing seasonal culturing schedule*
2. *Modifying/upgrading houses and other properties*. The local residents had been accustomed to leaving small holes on the walls near the roofs for ventilation. They then realized that these holes were the reason why their houses had been unroofed during typhoon events (especially the one in 2006); thus, they modified their houses to rectify this problem. Likewise, the residents also modified their house basements and the edges of farming ponds by raising them to avoid getting flooded and to prevent saltwater intrusion.

3. *Buying or building water containers* to be used for collecting water during the rainy season; the water collected will then be used during the dry season when water is often salty.
4. *Building underground bunks* to serve as shelters during strong typhoons.

2.2 Household Analysis

A total of 300 households participated in the survey, equally divided among the three studied coastal districts. The survey covered all villages in each commune with the hope that the sampled households represented the population. The respondents were chosen based on the economic structure of the commune, and involved respondents engaged in as many different occupations as possible, including those in agriculture, aquaculture, and fishing.

The data collected from the household surveys were then analyzed to demonstrate how harmful each climatic event had been in terms of monetary loss, types of damages, and the number of affected households. Based on the results of the FGDs and on the household surveys, two planned CCA measures were identified and evaluated using cost-effectiveness analysis (CEA). The two CCA projects chosen were *building a freshwater treatment plant* and *building a sea dike*. The CEA of the two CCA options were conducted to provide the local government with sound advice on which adaptation should be prioritized considering the high investment cost of each project.

Vulnerability indices of the coastal households were also estimated based on the data collected from the household surveys. Vulnerability is defined as the probability that a household will fall below a minimum consumption threshold level (or probability that household will move to poverty in the future). The analysis is based on the assumption that climate extremes, climatic shocks, or climate hazards will affect the probability that households' consumption will fall below a given minimum vulnerability level (Deressa, Hassan and Ringler 2009).

Household consumption function is defined as

$$\ln C_h = X_h\beta + e_h \qquad \text{Equation (1)}$$

where:

C_h = per capita consumption expenditure of household,
X_h = observable household characteristics and climatic shocks, and
e_h = mean-zero disturbance term.

The three-step feasible generalized least squares procedure was then applied to estimate

$$\hat{E}\,[\ln C_h \,|\, X_h] = X_h\hat{B} \quad \text{and} \qquad \text{Equation (2)}$$

$$\hat{V}\left[\ln C_h \,|\, X_h = \hat{\sigma}^2_{e,h} = X_h\hat{\theta}\right]. \qquad \text{Equation (3)}$$

Assuming that consumption is log-normally distributed, vulnerability is then estimated as

$$\hat{V}_h = \hat{P}r\,(\ln C_h < \ln \,|\, X_h) = \Phi\left(\frac{\ln z - X_h\hat{\beta}}{\sqrt{X_h\hat{\theta}}}\right). \qquad \text{Equation (4)}$$

where:

z = consumption threshold (the minimum per capita consumption below which one will be considered vulnerable, USD 1.25 and USD 1.50); and
$\Phi(.)$ = cumulative density of the standard normal.

The following key variables were then used in the regression:

- Number of floods that affected the community (over the last 10 years);
- D = 1, if affected by coastal erosion;
- D = 1, if affected by saltwater intrusion;
- Age of head of household;
- Gender of head of household;
- Years of schooling of head of household;
- Dependence ratio = number of members below 15 and above 64 per household;
- D = 1, if house is owned;
- Credit access (number of contacts);
- D = 1, if household is involved in farming;
- D = 1, if household is involved in fishing;
- D = 1, if household is involved in livestock; and
- D = 1, if household is involved in aquaculture.

3.0 COMMUNITY-BASED HAZARD AND PHYSICAL VULNERABILITY MAPPING

3.1. Historical Timeline Analysis of Bio-geophysical Impacts

Ben Tre used to be known as a typhoon-free province until 1997 when it was hit by its first and worst typhoon called Typhoon Linda. Nine years later, Typhoon Durian devastated the province causing much damage. Nine years of being typhoon-free was quite a long period; thus, almost all of the local residents were surprised and caught unprepared when the local authorities announced that Typhoon Durian would hit the province. As a consequence, the province was badly devastated by the typhoon.

On the other hand, saltwater intrusion has become part of the residents' daily lives, especially those living in the coastal area. A large number of residents could not even recall when it first occurred (Table 7). Meanwhile, the local residents believed that the first erosion incident happened in 2005. Due to the endowed, intricate system of rivers and channels, erosion mainly occurs along riverbanks. Strong waves were said to be the cause.

According to the climate change scenarios for Ben Tre, the province is predicted to suffer from the impacts of sea level rise by 2020 if no CCA strategies will be adopted.

Table 7. Historical timeline bio-geophysical impacts in Thua Duc, An Thuy, and Giao Thanh

Period	Event Marker
Thua Duc commune	
Not sure	Saltwater intrusion occurred.
1997	Typhoon Linda caused great damage.
2002	Ba Lai dam was built to prevent saltwater from the sea.
From 2005	Riverside erosion occurred.
2006	Typhoon Durian resulted in collapsed or unroofed houses.
Not sure	Saltwater intrusion made it impossible to plant the second crop of jicama or peanut.
From 2009	Temperatures increased. Southeast winds came earlier and was stronger.
From 2009	Saltwater intrusion worsened in terms of duration and salinity.
From 2010	Tides became stronger.
2011	90% of clam died.
From 2020	The commune was affected by sea level rise.
An Thuy commune	
Not sure	Saltwater intrusion occurred.
1997	Typhoon Linda caused great damage.
2002	Ba Lai dam was built to prevent saltwater from the sea.
2006	Typhoon Durian hit the commune, but did not cause much loss.
From 2008	Fish yield of fishermen decreased.
From 2009	Saltwater intrusion worsened, in terms of duration and salinity.
2011	90% of clam died.
From 2020	The commune was affected by sea level rise.
Giao Thanh commune	
Not sure	Saltwater intrusion occurred.
1997	Typhoon Linda caused great damage.
Not sure	Riverside erosion first occurred.
2006	Typhoon Durian occurred and caused damage.
Not sure	Farmers started planting one rice crop and one shrimp crop instead of two rice and shrimp crops.
2009	A typhoon caused damages houses, agriculture, and aquaculture.
From 2009	Weather seemed more irregular.
From 2009	Saltwater intrusion worsened in terms of duration and salinity.

3.2 Vulnerability Matrix

Based on the frequency of devastation and on the susceptibility of the various agricultural activities to typhoons, saltwater intrusion, sea level rise, and erosion since 1997, the three communes (i.e., Thua Duc, An Thuy, and Giao Thanh) were categorized according to high (H), medium (M), low (L), and not vulnerable (N) (Table 8). Results showed that Thua Duc commune was the most vulnerable to typhoons. All three communes were fairly susceptible to saltwater intrusion that have caused severe crop damage and freshwater contamination.

Compared with the other three climatic events, erosion causes the fewest problems in the three communes. Saltwater intrusion, on the other hand, causes less damage to shrimp culture than to other aquaculture crops because shrimps have higher saltwater tolerance. Sea level rise threatens households' assets and infrastructure as well.

Table 8. Vulnerable matrix of Thua Duc, An Thuy, and Giao Thanh

Vulnerability Categories	Climatic Events			
	Typhoon	Saltwater Intrusion	Sea Level Rise	Erosion
Thua Duc				
Cultivation	H	H	H	N
Livestock	N	N	N	N
Aquaculture	L	L	H	N
Fishing	L	N	N	N
Family routines*	H	H	N	N
Health	N	N	N	N
Houses and household assets	H	N	H	L
Infrastructures	N	N	M	N
Sea walls	N	N	N	N
An Thuy				
Cultivation	L	H	H	N
Livestock	N	N	N	N
Aquaculture	L	L	H	N
Fishing	L	N	N	N
Family routines*	N	H	N	N
Health	N	N	N	N
Houses and household assets	L	N	H	N
Infrastructures	N	N	M	N
Sea walls	N	N	N	N
Cultivation	L	H	H	N
Giao Thanh				
Cultivation	M	H	H	N
Livestock	N	N	N	N
Aquaculture	M	L	H	L
Fishing	N	N	N	N
Family routines	N	H	N	N
Health	N	L	N	N
Houses and household assets	M	N	H	L
Infrastructures	N	N	M	N
Sea walls	N	N	N	N

Notes: (1) H = high vulnerability, M = medium vulnerability, L = low vulnerability, N = Not vulnerable yet; (2) * refers to activities such as cooking, washing, bathing, etc.

3.3 Households and Sectors at Risk from Bio-geophysical Impacts

Based on the historical timeline analysis, saltwater intrusion is common among the three communes. As reported by the local residents, saltwater intrusion has caused significant losses to agriculture and has resulted in the lack of freshwater supply for domestic use. Furthermore, saltwater intrusion has also resulted in reduced shrimp farming productivity.

Thua Duc commune suffered the most from typhoons among all the other communes in the entire province. Typhoon Durian swept over Thua Duc in 2006, which resulted in thousands of collapsed or unroofed houses. An Thuy suffered only slightly from Typhoon Linda. In Giao Thanh, residents reported that they had also been devastated by a typhoon in 2009.

Although erosion was only slightly mentioned in the historical timeline, it had occurred randomly throughout Giao Thanh commune. Land loss and losses from agriculture and aquaculture were also as a consequence of soil erosion.

Throughout Giao Thanh, the residents have witnessed higher high tides in recent years. Fortunately, flooding caused by higher high tides last for only a few hours, and therefore, has not created much harm.

4.0 EVALUATING DAMAGES FROM CLIMATE HAZARDS

4.1 Damage Value from Climate Hazards

Table 9 shows the cost of damage incurred by the 300 sample households at the study sites due to the effects of climate change. Among the 300, 205 reported that they had been affected by typhoons. It had taken them an average of 40 days to recover from financial losses, 27 days to recover from emotional distress, and 33 days to return to their normal lives. Of the 205, 172 respondents reported that they had suffered from damages to their houses, with total damages amounting to more than VND 1 billion (USD 51,000). Losses to agriculture and aquaculture were also significant at VND 348,040,000 (USD 16,784) and VND 1,099,100,000 (USD 53,004), respectively. Total damage costs resulting from the most recent typhoons amounted to more than VND 3 billion (USD 154,000).

Meanwhile, of the 300 households, 271 (90%) reported that they had been affected by saltwater intrusion. The respondents reported that saltwater had started nine years ago, and each occurrence had lasted for 168 days on average. All 271 respondents agreed that salinity has worsened over the years. A total of 65 respondents reported that their agricultural production had been harmed by saltwater intrusion, which resulted in a total loss of VND 710,810,000 (USD 34,279). Aquaculture production of 14 households was impeded by saltwater, which led to VND 644,050,000 (USD 31,060) monetary loss. Saltwater intrusion further caused 146 households to suffer from lack of freshwater for domestic use, which cost them VND 215,343,000 (USD 10,385). Total losses generated by saltwater intrusion amounted to VND 1,599,803,000 or USD 77,151.

Table 9. Value of damages from climate hazards

Type of Damage	No. of Affected Households	Damage Value	
		VND	USD
Typhoons (n = 205)			
Damage to house	172	1,059,900,000	51,114
Damage to appliance	50	116,510,000	5,619
Damage to livestock	2	3,100,000	149
Damage to assets	15	131,700,000	6,351
Loss in agriculture production	40	348,040,000	16,784
Loss in fishing income	20	389,600,000	18,789
Loss in aquaculture production	39	1,099,100,000	53,004
Income loss due to work stoppage	6	10,600,000	511
Loss in salt production	3	28,000,000	1,350
Land loss	1	10,000,000	482
Total loss		3,196,550,000	154,155

Table 9 continued

Type of Damage	No. of Affected Households	Damage Value	
		VND	USD
Saltwater intrusion (n = 271)			
Loss in agricultural production	65	710,810,000	34,279
Lack of freshwater for family routines	146	215,343,000	10,385
Loss in aquaculture production	14	644,050,000	31,060
Skin disease	4	25,600,000	1,235
Women disease	2	2,000,000	96
Tools have shorter lifetime	1	2,000,000	96
Total loss		1,599,803,000	77,151
Erosion (n = 36)			
Damage to house	3	57,000,000	2,749
Damage to appliance	0	0	0
Damage to livestock	0	0	0
Damage to assets	4	107,000,000	5,160
Loss in agriculture production	9	70,900,000	3,419
Loss in fishing income	0	0	0
Loss in aquaculture production	12	186,000,000	8,970
Income loss due to work stoppage	0	0	0
Land loss	10	285,000,000	13,744
Total loss		590,800,000	28,492

The number of respondents who reported being affected by erosion was just 36 (12%), which was much lower than that by typhoons and saltwater intrusion. According to most of the respondents, erosion occurred mainly due to the strong waves. As can be seen in Table 9, erosion caused much damage to agriculture and aquaculture production and resulted in land loss as well. Loss in aquaculture and agriculture due to erosion was VND 186,000,000 (USD 8,970) and VND 70,900,000 (USD 3,419), respectively. Value of lost land was estimated at VND 285,000,000 (USD 13,744). Damages to houses and assets were VND 57,000,000 (USD 2,749) and VND 107,000,000 (USD 5,160) respectively.

4.2 Cost of the Measures Employed by Households in Response to Climate Hazards

Table 10 presents the cost of the actions undertaken by households during and after typhoons. Given the severe damage to houses, most households did *house improvements (repairs)* after typhoon events. On average, it cost one household VND 14,275,640 (USD 688) to undertake house repairs. Aside from house repairs, the local residents also *replaced fish stock, replanted farm, or/and reinforced pond/cages after typhoons*. On average, it cost one household VND 1,872,917 (USD 90) to *replant farm;* VND 7,409,091 (USD 357) to *replace fish stock*; and VND 10,523,333 (USD 507) to *reinforce ponds/cages*. A number of households had to *borrow money* to cope with the damages and income losses. The average sum of *money borrowed* by one household was VND 22,064,516 (USD 1,064). The total expense of taking action during and after the typhoon amounted to more than VND 3.8 billion (more than USD 185,000). This amount could be considered as the secondary losses incurred by households due to typhoons.

Table 10. Cost of measures adopted by households to cope with climate hazards

Action	No of Affected Households	Average Expense		Total Expense	
		VND	USD	VND	USD
Typhoons (n = 205)					
House improvement	172	14,275,640	688	2,455,409,406	118,413
Evacuation	60	24,561	1	1,399,406	67
Planted trees around properties	2	250,000	12	500,000	24
Replanted farm	11	1,872,917	90	22,474,406	1,084
Replaced fish stock	11	7,409,091	357	81,499,406	3,930
Reinforced cages/ponds	31	10,523,333	507	315,699,406	15,225
Joined savings groups/cooperatives	1	600,000	29	600,000	29
Pursued other means of additional income	1	100,000,000	4,823	100,000,000	4,823
Borrowed money	31	22,064,516	1,064	683,999,406	32,986
Saved money	71	NA	NA	NA	NA
Financial aid from local government	37	3,235,000	156	129,400,000	6,240
Build sand dike around farm	3	14,000,000	675	42,000,000	2,025
Increase floor relative to ground	1	5,000,000	241	5,000,000	241
Build underground shelter	1	15,000,000	723	15,000,000	723
Total expense				3,852,981,436	185,811
Saltwater intrusion (n = 271)					
Harvested rainwater	270	3,994,925	193	1,062,650,000	51,247
Tapped from different source	32	1,721,563	83	55,090,000	2,657
Buy freshwater from vendors	143	1,478,021	71	211,357,000	10,193
Built dike of sand around farms/ponds	41	19,845,500	957	793,820,000	38,282
Total expense				2,122,917,000	102,378

Table 10 continued

Action	No. of Affected Households	Average Expense		Total Expense	
		VND	USD	VND	USD
Erosion (n = 36)					
Installed permanent protective structures	3	73,000,000	3,520	219,000,000	10,561
Installed temporary protective structures	27	17,151,852	827	463,100,000	22,333
Permanently evacuated	1	300,000,000	14,468	300,000,000	14,468
Planted mangrove along the shoreline	6	250,000	12	1,500,000	72
Reinforced cages/ponds	5	59,300,000	2,860	296,500,000	14,299
Planted mangrove trees around houses	1	0	0	0	0
Replaced lost land	1	30,000,000	1,447	30,000,000	1,447
Total expense				1,310,100,000	63,180

Note: Figures reported in this table are from multiple responses.

On the other hand, in order to cope with the lack of freshwater caused by saltwater intrusion, *rainwater* has been used by 271 respondents as an alternative source of drinking water (Table 10). It cost one household VND 3,994,925 (USD 193) to *buy or build containers for harvesting rainwater* in the rainy seasons. *Buying freshwater from vendors* was also used as an adaptation. In an effort to prevent saltwater from intruding into farms or ponds, 41 respondents *built dikes made of sand*. It cost one household an average of VND 19,845,500 (USD 957) to *build a sand dike*. Total expense spent on action plans to deal with saltwater intrusion was VND 2.1 billion (USD 102,378).

Temporary protective structures were used by 27 households to protect their properties against erosion, which cost one household VND 17,151,852 (USD 827) (Table 10). *Ponds/cages reinforcement* cost VND 59,300,000 (USD 2,860), and *installing permanent protective structures* cost VND 73,000,000 (USD 3,520) on average. Total expense for all activities performed by households was VND 1.3 billion (USD 63,180).

5.0 HOUSEHOLD ADAPTATIONS

5.1 Household Adaptations against Future Climate Risks

As can be seen from Table 11, *modifying house to make it more resilient* and *participate in community projects/activities addressing typhoons* were the most selected household adaptations against future typhoons. Other household measures that received high rankings were *joining savings groups/cooperatives* and *setting up personal savings to prepare for future typhoon*.

In order to deal with the risk of lack of freshwater due to saltwater intrusion, *harvesting rainwater* was viewed to be the first priority, followed by *buying freshwater from commercial vendors*, and *tapping freshwater from a different source* (Table 11). Meanwhile, to reduce the impact of saltwater intrusion on agriculture and aquaculture, the measures *pumping freshwater into ponds or farms*, *dike heightening*, and *switching to new livestock or crops* were considered by the respondents. Those households whose third rice crops were often damaged by saltwater decided to *plant the third rice crop immediately after the second crop* to avoid the threats posed by saltwater intrusion on crop productivity.

Meanwhile, *installing protective structure* was prioritized by the respondents to mitigate the impacts of future erosion. *Planting mangroves* also received high consideration.

6.0 CEA OF PLANNED ADAPTATIONS

6.1 Identifying Planned Adaptation Strategies

In order to address problems associated with typhoons, *community evacuation* was identified to be the most needed by the community, followed by providing *financial assistance*, establishing *early warning system*, *replanting mangroves and forests*, and institutionalizing *rescue and emergency assistance*. Although *community evacuation* captured the most attention from the respondents, establishing *early warning system* was actually the first prioritized CCA measure. Table 12 displays the CCA measures expected by the community from the local government.

Table 11. Household adaptation measures preferred by respondents against future climate risks (n = 300)

Action	No. of Selections per Rank					Total
	1	2	3	4	5	
Typhoons (n = 205)						
Relocate permanently	2	3	2	3	1	11
Modify house to make it more resilient	167	21	5	3	1	197
Dig canals to mitigate flooding	0	8	8	6	2	24
Set up personal savings to prepare for future typhoon	4	19	29	14	2	68
Join savings groups/cooperatives	0	13	31	18	9	71
Modify planting schedule	0	3	6	4	4	17
Avail of insurance	2	3	2	3	4	14
Participate in community projects addressing typhoons	11	78	50	16	8	163
Prepare food	1	13	9	2	2	27
Evacuation	2	15	6	3	1	27
Build sand dike around farm	1	3	0	0	0	4
Modify pond	10	13	0	2	0	25
Build evacuation center	0	1	1	0	0	2
Saltwater intrusion (n = 271)						
Harvest rainwater	256	13	2	0	0	271
Tap from a different source	13	53	59	9	0	134
Pump freshwater into ponds or farms	0	3	17	16	3	39
Switch to new livestock or plants	0	0	4	7	7	18
Buy freshwater from commercial vendors	0	167	50	13	7	237
Heighten dike	0	13	9	2	0	24
Plant third rice crop immediately after second rice crop	0	13	0	0	0	13
Erosion (n = 36)						
Installed permanent protective structures	21	8	4	0	0	33
Installed temporary protective structures	9	18	5	2	1	35
Set up personal savings for future erosions	1	2	3	7	3	16
Join savings groups/cooperatives	0	1	2	3	4	10
Plant mangroves along the shoreline	3	4	18	6	2	33

Note: Figures reported in this table are from multiple responses.

Table 12. CCA measures for implementation as identified by the community

Adaptations	No. of answers per rank (n = 300)					Total
	1	2	3	4	5	
Typhoon						
Community evacuation	60	63	50	28	20	221
Disaster preparedness training	18	29	26	18	31	122
Information dissemination and education campaign	9	28	26	18	22	103
Early warning system	107	35	26	23	11	202
Build new/strengthen existing flood mitigation infrastructures	20	26	14	11	12	84
Rescue and emergency assistance	9	22	61	37	17	146
Relief operation	3	22	18	42	28	113
Replant mangroves and forests	16	29	29	47	39	161
Solid waste management or addressing garbage problems	0	1	0	5	10	16
Financial assistance	40	27	36	50	62	215
Dike maintenance	11	4	2	0	8	25
Erosion and sea level rise						
Community evacuation	47	33	21	43	24	168
Permanent relocation	21	25	35	21	11	113
Information dissemination and education campaign	11	25	45	33	44	158
Early warning system	24	15	28	19	20	106
Installation of sea dike	113	71	59	21	5	269
Repair of existing sea dike	26	86	30	35	32	209
Mangrove rehabilitation/conservation	24	20	48	47	47	186
Financial assistance	29	21	28	68	86	232
Saltwater intrusion						
Community evacuation	47	33	21	43	24	168
Permanent relocation	21	25	35	21	11	113
Distribution of water treatment devices/medicines to households	33	61	63	54	46	257
Installation of community water treatment facilities	10	40	73	78	32	233
Information dissemination and education campaign	11	25	45	33	44	158
Early warning system	24	15	28	19	20	106
Installation of sea dike	113	71	59	21	5	269
Repair of existing sea dike	26	86	30	35	32	209
Mangrove rehabilitation/conversation	24	20	48	47	47	186
Financial assistance	29	21	28	68	86	232

On the other hand, *mangrove rehabilitation/conservation* was highly appreciated by the respondents to deal particularly with erosion and sea level rise (Table 12). To respond to the threats posed by sea level rise, *installation of sea dike* and *repairing existing sea dikes* were viewed to be the most appropriate CCA measures. Also recording high priority from respondents was the provision of *financial assistance*. Only 113 out of the 300 respondents considered *permanent relocation* as an appropriate adaptation. The community also deemed the *construction of a freshwater treatment plant* to be highly important. *Financial assistance* and *water treatment facilities/devices* were also highly appreciated by the community.

6.2 Selection Method of Planned CCA Strategies

When projects with different cost structures are not expected to produce the same outcomes, cost-effectiveness analysis (CEA)—in which the costs are compared with the outcomes (measured in natural units)—is an appropriate method to determine which project should be selected for implementation. CEA 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 used to evaluate two planned CCA strategy: *building a freshwater treatment plant* and *building a sea dike system*. Given the state of disrepair and the need to improve the existing sea dikes, policy makers should consider the cost effectiveness of building a completely new structure. In this case, physical benefit is measured in terms of the number of households that would benefit from each project. The criterion for decision making is the cost expended to benefit one household. However, it cannot be denied that households would benefit from the freshwater treatment plant and the sea dike in different ways. The water facility would provide households with freshwater while the sea dike, aside from other services, would reduce the saltwater intrusion that harms agricultural production.

Hence, in addition to the physical benefit to households, monetary value is assigned to the benefits. In the freshwater treatment facility, monetary benefit was estimated based on the unit price multiplied by the amount of freshwater consumed by households. For the sea dike, monetary benefit was measured as the revenue that would be gained from the increase in agricultural productivity, as the dike would help prevent saltwater from damaging agricultural crops. With a monetary value, the benefit-cost ratios (BCR) could be calculated, which somehow resembles the ROI (return over investment) ratio in finance. BCR shows how much dollar returns can be generated from one dollar investment.

A 2007 study by the Asian Development Bank found that developed nations tend to use real rates between 3% and 7%, whereas developing nations use a higher rate of 8% or more; the higher rate reflects the higher risk and uncertainty of public investments in these nations (Zhuang et al. 2007). In the study, a higher discount rate of 10%, which accounts for risk and uncertainty, was employed to calculate the present value of all costs and monetary benefits of each project. The freshwater treatment plant would be built to supply freshwater for domestic use to four districts, including Thanh Phu district. Meanwhile, the sea dike would be built for Thanh Phu district only. Therefore, the cost of the initial investment had to be adjusted for the latter adaptation measure by dividing the total initial investment of the water plant by 4 to obtain the initial investment for Thanh Phu district.

Here, the study assumed that the four districts would receive the same amount of investment. Note that this is only a rough estimation. The number of households that would benefit from the water plant would belong to Thanh Phu district only; hence, the annual operating cost was calculated according to the water produced within Thanh Phu district.

6.3 Results of CEA

The planned freshwater treatment plant intended to achieve the following objectives:

1. To provide sufficient freshwater for domestic, agricultural, industrial, tourism, services, and miscellaneous use within the four districts of Ben Tre, namely, Thanh Phu, Cho Lach, Mo Cay Nam, and Mo Cay Bac districts. The project would serve as a CCA strategy against saltwater intrusion, which has always been affecting the livelihoods of the local residents.
2. To reduce the possibility of diseases due to the use of unsafe fresh water.
3. To increase the proportion of rural residents who have access to clean and safe fresh water.

Investment was divided into seven categories (Table 13). The total amount for the whole project, which is spread over the four districts, would be VND 998,271,183,914 (USD 48,141,935), of which VND 249,567,795,979 (USD 12,035,484) would be allotted for the facility in Than Phu district. According to the project design, the amount of freshwater that was planned to be produced from 2015 to 2019 is 6,954,000 m^3, which is equivalent to 77% of the facility's designed capacity. The amount of freshwater that was planned to be produced from 2020 to 2049 is 10,164,000 m^3, equivalent to 49% of the designed capacity. Operating costs include chemical, electricity, labor, and miscellaneous costs. It was assumed that operating costs would start in 2015, when the plant was planned to be operational. Total operating cost would be VND 3,695.98 million per year (USD 178,240) for the period of 2015–2019, and VND 11,044.60 million per year (USD 532,629) by then (Ben Tre DARD 2011). Thanh Phu district would consume 25% of the total amount of freshwater produced. Therefore, total operating cost that was planned to be allocated for Thanh Phu district was USD 44,560 from 2015 to 2019, and USD 113,157 from 2020 to 2049 (Appendix 1).

Table 13. Investments needed to build a freshwater treatment facility and sea dike system in Than Phu district

Category	Cost	
	VND	USD
Freshwater treatment facility[1]		
Construction	184,221,086,019	8,884,119.00
Machines and equipment	9,761,440,370	470,748.00
Project management	1,895,461,177	91,409.00
Project consultancy	5,907,569,190	284,894.00
Clear-the-ground compensation	3,270,250,000	157,709.00
Inflationary costs	42,864,132,393	2,067,136.00
Miscellaneous	1,647,856,829	79,468.00
Total investment	249,567,795,979	12,035,484.00
Sea dike system[2]		
Construction	1,669,797,000,000	80,526,475.69
Clear-the-ground compensation	318,840,000,000	15,376,157.41
Project management	17,246,000,000	831,693.67
Project consultancy	121,908,000,000	5,879,050.93
Miscellaneous	61,773,000,000	2,979,021.99
Provision costs	810,140,000,000	39,069,251.54
Total investment	2,999,704,000,000	144,661,651.23

Sources: (1) Ben Tre DARD (2011) (2) Ben Tre DARD (2010)

In 2010, the population of Thanh Phu district was 121,902, with the average number of persons per household of 3.73. Population growth rate was assumed to be 1.16% per year. Based on this assumption, the total number of households until 2049 can be easily calculated. In the four years of construction, the project was projected not to generate any benefit. It was then assumed that from 2015 to 2019, the number of benefiting households would be equal to 85% of the total number of households. From 2020 to 2049, this figure would increase to 90%. Such assumptions reflect that a proportion of the total households in the district would not take advantage of the freshwater generated from the project because they would be unable to cover the costs of investment for piped water connection. Likewise, there are a few households in the community that are not affected by saltwater intrusion and may be unwilling to participate.

Monetary benefit was then calculated by multiplying the amount of water consumed within Thanh Phu district with unit price. Unit price of freshwater was assumed to be constant, that is, VND 3,500/m^3. Assume that 95% of freshwater produced would be consumed; the rest of the 5% would be wasted along the pipelines. It was then calculated that from 2015 to 2019, monetary benefit would be VND 5,780,512,500 (USD 287,767) (Ben Tre DARD 2011). From 2020 to 2049, the amount would be VND 8,448,825,000 (USD 407,447) (See Appendix 1).

Based on the costs and the physical benefits from the project, the CE ratio was calculated using the formula

$$\textit{CE ratio} = \frac{\textit{Present value of costs}}{\textit{Total physical benefit.}}$$

The costs include initial investment and annual operating costs, which are discounted to compute the present value. The BCR is equal to the present value of the monetary benefits divided by the present value of costs. Therefore, the CE ratio of the water treatment plant was calculated to be USD 183.281 per benefited household. The benefit-cost ratio was 0.2516 (Appendix 1).

Meanwhile, the planned sea dike system with the dimension of 52.4 km x 7.5 m x 4.0 m had the following objectives:

1. To prevent flooding caused by tides, typhoons, and sea level rise in favor of 10 communes in Thanh Phu district;
2. To reduce saltwater contamination; and
3. To integrate into national defense strategies and transportation development.

Total investment for the sea dike system was calculated to be VND 2,999,704,000,000 (USD 144,661,651), which was divided into six categories (Table 13). The construction of the sea dike would last for six years. Operating costs of the sea dike would include maintenance and miscellaneous costs. Operating costs was assumed to start in 2013 (Appendix 2). Replacement cost was projected to occur in 2030, with the amount of VND 302,150,000,000 (USD 14,571,277.01) (Ben Tre DARD 2010).

The population in the area where the sea dike system was planned to be built (10 communes in Thanh Phu district) in 2011 was 66,504 persons, with the average number of persons per household of 3.845 persons. Population growth rate was assumed to be 1.16% per year. With this information, the total number of households until 2049 can be calculated (Appendix 2). The assumption was that households would start benefiting from the sea dike starting 2012, and the number of beneficiaries was projected to continue increasing until 2049 (Ben Tre DARD 2010). Monetary benefit was then measured as the money gained from the increase in agricultural productivity; the dike was expected to prevent saltwater from damaging agricultural production. This value was obtained from the secondary data.

Based on the costs and the physical benefit from the project, the CE ratio was calculated using the formula

$$CE\ ratio = \frac{Present\ value\ of\ costs}{Total\ physical\ benefit}.$$

The costs include initial investment and annual operating costs. The BCR is equal to the present value of monetary benefit divided by present value of costs. Accordingly, the calculated CE ratio of the dike was USD 4,085 per household beneficiary. The BCR of the sea dike was calculated to be 1.4905 (Appendix 2).

6.4 Discussion of CEA Results

Table 14 provides a comparison between the freshwater plant and the sea dike. The construction of the freshwater plant would require smaller investment than the sea dike. Specifically, the sea dike is three times more expensive than the freshwater plant, which increases (to some extent) the feasibility of the water treatment plant. In addition to the higher investment, it would be more costly to maintain the sea dike annually.

In terms of physical benefit, the freshwater plant would benefit more people than the sea dike would. This is understandable since the freshwater plant was planned to serve the whole district, whereas the sea dike would cover only 10 communes within the district. According to the CE ratios, the water treatment plant appeared to be more cost effective than the sea dike. Nonetheless, if benefits would be measured in terms of value, then one dollar investment in the sea dike would generate more dollars than that invested in the freshwater plant.

Table 14. Comparison between the freshwater factory and the sea dike system

Criteria	Comparison
Initial investment	Freshwater plant would require less initial investment.
Annual operating cost	Freshwater plant would require less annual operating cost.
Physical benefit	Freshwater plant would generate more physical benefit.
CE ratio	Freshwater plant has much smaller CE ratio.
Benefit/Cost ratio	Sea dike has much higher BCR.

With all the comparisons listed above, the freshwater plant seemed more acceptable than the sea dike in four of the selected criteria. Therefore, based on the analysis, the freshwater plant should be prioritized given that the government cannot afford to implement the two projects simultaneously. Moreover, the local residents would have been more appreciative of the freshwater plant than they would have of the sea dike, since they have been waiting for the latter for a long time. Nevertheless, if the provincial government would have placed more emphasis on dollar returns, they would be more likely to proceed with the construction of the sea dike.

The estimation of the monetary benefits above did not include enough types of benefits generated by the two projects. In the water treatment plant, the benefit that was not included was that households can buy freshwater at a lower price than that offered by commercial vendors. Although rainwater has been used as an alternative source of drinking water for a very long time, it does not necessarily mean that households would have stopped harvesting rainwater once the freshwater supply network has been established. Likewise, during the household survey, only a few respondents reported that they had incurred diseases due to saltwater intrusion. Therefore, the benefit from disease prevention could be omitted.

On the other hand, the omitted benefit from the sea dike was the avoidance of damages caused by sea level rise. However, the "missing" benefit generated by the sea dike would have been much larger than that generated by the water treatment plant. Thus, if these benefits would be included in the computation of the BCR, then the results of the comparison between the two projects would have been still the same.

7.0 HOUSEHOLD VULNERABILITY INDEX

The VEP framework was used in this study to measure household vulnerability. VEP estimates show the probability that a household will fall below the minimum consumption threshold level at which they will be considered as poor. The threshold used in this study was the World Bank minimum of USD 1.25 per capita per day. The estimates have a range of values from 0 to 1, with 0 having the lowest vulnerability and 1 the highest vulnerability.

In this study, households with a VEP estimate of 0.00–0.49 were considered not vulnerable, those with 0.50–0.79 were considered moderately vulnerable, and those with 0.80–1.0 were highly vulnerable. The variables used in the regression were gender and education of household head; dependency ratio; household assets; number of contacts for credit; percentage of income from agriculture, fishery, and forestry; dummy variables whether household is involved in farming, fishing, gleaning, and livestock raising; number of floods experienced by household; and dummy variables for erosion and saltwater intrusion.

Table 15 summarizes the VEP estimates and the vulnerability incidence of the study sites. Results showed that 46% of the sample households were vulnerable. Of this, 31% were highly vulnerable, whereas 15% were moderately vulnerable. Mean VEP for the highly vulnerable group was significantly higher than those of the other groups at 0.91. The moderately vulnerable had a mean VEP of 0.67, and the non-vulnerable had a low mean VEP of 0.09.

Table 15. Distribution of households according to level of vulnerability and mean VEP estimates

Vulnerability Level	Not Vulnerable	Moderately Vulnerable	Highly Vulnerable	All
Number of households	156.00	44.00	90.00	290.00
% of households	54.00	15.00	31.00	100.00
Mean VEP	0.09	0.67	0.91	0.43
SD of VEP estimates	0.15	0.08	0.05	0.39

It is important to analyze and characterize the profile of those households that were found to be vulnerable. Such information can guide the government, private organizations, and the community on the best implementation strategy for a CCA program. The results of the analysis could also serve as a rough guide in identifying which sectors to prioritize and what possible interventions to carry out. It could also be a means by which CCA planners can roughly assess the adaptation needs of the communities living in the study sites. In this study, the researchers looked at the primary occupation of the household head, their knowledge of climate change, their preparedness to deal with future climate change impacts, and the damages and impacts that they experienced from past climate-related hazards and events. Looking at the role of gender could also provide interesting insights.

In the vulnerable group, about 80% of the household heads were employed as farmers, fishers, or forestry workers (Table 16). This proportion was lower for the non-vulnerable group at only 63%. Because majority of the vulnerable group relies on agriculture, fishery, and forestry, policy and decision makers should therefore implement interventions that would help the people engaged in these sectors. Such interventions could be in the form of providing alternative livelihoods to augment their income. People whose livelihoods are engaged in these sectors highly depend on natural resources, which are highly sensitive to external shocks, including those that are climate-related.

Knowledge and information are crucial elements in ensuring that households are able to implement adequate preparations to withstand the impacts of climate change. However, results showed that quite a significant proportion of households declared that they had no knowledge about climate change. This proportion was highest for the moderately vulnerable (55%), while 36% and 32% of the non-vulnerable and highly vulnerable groups, respectively, reported that they had no knowledge of climate change (Table 17). The proportions that were not informed about the issue can be considered substantial; hence, implementing an education and information campaign may be relevant in the study sites.

In the survey, household respondents were asked to evaluate their degree of preparedness in dealing with the future impacts of climate change. Gathering such information is relevant as it can give an idea on whether households undertake autonomous adaptations, and whether their stance is proactive or reactive.

Results showed that a high percentage of households thought that they were unprepared for future calamities (Table 17). In fact, for all groups, more than 50% thought that they were unprepared, with the moderately vulnerable group having the highest proportion at 73%.

Table 16. Distribution of households based on the occupation of household head (percentage distribution)

Occupation	Not Vulnerable	Moderately Vulnerable	Highly Vulnerable	All
Officials of government, organizations, and corporations; managers; managing proprietors; and supervisors (e.g., business owner, store owners, wholesale buying and selling)	1	0	0	1
Professionals	1	0	0	1
Technicians and associated professions	1	0	0	0
Farmers, fishers, and forestry workers (includes gatherers of non-timber forest products)	63	80	81	71
Trades and related workers (e.g. masons, carpenters, construction laborers)	6	5	7	6
Plant and machine operators and assemblers (truck/bus/tricycle/heavy equipment drivers, seamen)	3	0	0	1
Laborers and unskilled workers	14	2	7	10
Total	100	100	100	100

Table 17. Level of knowledge (on climate change) and preparedness (on dealing with future climate change impacts) of households

Level	Not Vulnerable	Moderately Vulnerable	Highly Vulnerable	All
Knowledge				
No information	36	55	32	38
A little bit of knowledge	60	41	67	59
Adequate knowledge	3	5	1	3
Fully knowledgeable	0	0	0	0
Total	100	100	100	100
Preparedness				
Not prepared	66	73	58	64
Somewhat prepared	33	27	42	35
Adequately prepared	1	0	0	1
Fully prepared	0	0	0	0
Total	100	100	100	100

Looking at the impact of past hazards on the vulnerable households can also guide planners in devising strategic and targeted CCA programs. Table 18 summarizes the incidence of these impacts among the households with different levels of vulnerability. Based on the results, typhoon and flooding and saltwater intrusion had the widest impacts in the study sites. Majority of the respondents reported sustaining damages to their house due to typhoon and flooding, while a large proportion also reported experiencing shortage in freshwater supply and income losses from agricultural and aquaculture production. Thus, CCA options that will help address these problems would be strategic as it can benefit many households, especially the highly vulnerable ones.

It is often asserted that CCA programs and interventions should be gender-sensitive. Thus, the composition of the vulnerable households in terms of gender should also be analyzed. Based on the data gathered from the household survey (Table 19), about 11% of the highly vulnerable households were female-headed, while this percentage increases to 16% in the moderately vulnerable group. In terms of incidence, vulnerability was higher for male-headed households (48%), although this was also substantially high for female-headed households at 36% (Table 20).

Table 18. Incidence of climate-related impacts based on vulnerability (in percentage)

Impact	Percent Affected			
	Not Vulnerable	Moderately Vulnerable	Highly Vulnerable	All
Typhoon and flooding				
Damage to house	60	50	56	57
Damage/loss of appliances	19	11	16	17
Damage to assets (boats, motorcycles)	4	7	6	5
Loss in agricultural production	13	9	18	14
Loss in fishing income	6	7	4	6
Loss in aquaculture production	12	14	16	13
Income loss due to work stoppage	1	0	3	2
Erosion and sea level rise				
Damage to house	1	2	0	1
Damage to assets (boats, motorcycles)	2	5	0	2
Loss in agricultural production	3	5	4	4
Loss in aquaculture production	4	5	7	5
Saltwater intrusion				
Loss in agricultural production	19	30	23	22
Household members got sick due to gastrointestinal diseases	2	0	6	2
Household experienced lack of fresh water for domestic uses	46	50	46	47

Table 19. Distribution households based on gender of household head (percentage share).

Level	Male	Female	Total
Not Vulnerable	80	20	100
Moderately Vulnerable	84	16	100
Highly Vulnerable	89	11	100
All	83	17	100

Table 20. Incidence of vulnerability for male- vs. female-headed households (in percent)

Level	Male	Female
Moderately Vulnerable	15	15
Highly Vulnerable	33	21
All Vulnerable	48	36

8.0 INSTITUTIONAL ANALYSIS

8.1 Decision Making and Planning by LGUs to Deal with Climate Change

Based on the results of the FGDs and meetings with the communities organized by the local governmental units (LGUs) (mostly funded by NGOs), and on the climate change scenarios (i.e., increase in temperature and precipitation and sea level rise) of Ben Tre province designed in 2010, the provincial government—in cooperation with experts—conducted the following studies:

1. preliminary assessment of the impacts of climate change on natural environment, human, economy, society, vulnerable areas (especially coastal areas); and
2. identification of the areas and economic sectors in the coastal areas most vulnerable to the effects of climate change.

Table 21 presents the CCA programs that were being considered for implementation in the coastal districts. The programs presented were based on the results of the meetings and studies, which helped the provincial government to build CCA action plan in Ben Tre province.

Table 21. CCA programs being considered for implementation

Program	Project
Program on mitigating the impacts of global warming and sea level rise on marine ecosystems and coastal areas	Applying integrated management of coastal areas and ecosystem based management
	Establishing construction-free zones in coastal areas
	Building permanent coastal routes, taking into account the height of sea level rise
	Building permanent coastal routes, taking into account the height of sea level rise
	Building new or upgrading existing sea dikes and dikes in estuaries
	Developing early warning systems
	Protecting mangrove ecosystems and coastal wetlands
Program on sustainable development of agriculture under climate change conditions	Conserving the indigenous plants and animals
	Investing in scientific and technological applications to develop new varieties of seed with higher productivity and adaptability to water shortage, drought, and salinity
	Changing the production structures of plants and animals to adapt to climate change
	Improving rainwater drainage in the coastal and riverine lowlands
	Applying water-saving irrigation technology and new farming methods to increase yield and reduce greenhouse gases
	Building freshwater plants/water treatment plants

Table 21 continued

Program	Project
Program for improving the quality of forests and protecting mangrove forest ecosystems	Adjusting macroeconomic policies on socialization of reforestation and forest protection and management
	Improving social policies such as forest exploitation, taking into consideration poverty reduction strategies
	Encouraging and creating favorable conditions for dwellers in coastal areas to be benefit reforestation
	Minimizing the degradation of natural forests by prohibiting the exploitation of natural forests
	Protecting mangrove ecosystems on wetlands
	Building area of forest seed supply
Program on developing fisheries and aquaculture with adaptation to climate change	Discovering climate change-resistant species with high adaptability to high temperature and salinity
	Increasing the depth of ponds to create the proper temperature and to reduce damage due to rising temperatures and rapid evaporation of water
	Developing the capacity of aquatic breeding and commercial farming
	Establishing marine protected areas
	Promoting research in the field of fish movement forecast and changes in fishing grounds
	Restructuring some rice-growing areas from domesticated rice into crop rotation system
	Developing freshwater fish in dams, lakes and ponds, and models of integrating agriculture, forestry, and fisheries
	Building freshwater plants/water treatment plants
Program for improving and expanding the health care system dealing with climate change	Strengthening health care system from the provincial to commune and village levels
	Raising public awareness of the damages to health caused by climate change and the corresponding appropriate preventions
	Monitoring diseases caused by climate change
	Building freshwater treatment plants

8.2 Awareness, Perception, and Capacity of LGUs to Deal with Climate Change

After conducting FGDs and having several meetings with the local officials, the research team found out that the local government was already implementing the following activities to raise awareness on climate change:

1. Establishing awareness groups (AGs) from district to commune and village levels, and assigning specific tasks to each member of the AGs. Three types of awareness-raising activities were being promoted at the time of the study:
    - Training courses/workshops for members of the AGs
    - Disseminating educational materials/documents/leaflets to promote awareness about the negative impacts of climate change
    - Meeting and working with communities to mobilize people to participate in the implementation of CCA projects

2. Organizing several events on the occasion of Earth Day, World Meteorological Day, World Water Day, and World Environment Day.

However, these activities were not conducted regularly/continuously due to lack of funds.

Owing to the support of several NGOs, some of the communes have been applying community participatory methods to encourage communities to actively participate in addressing the following issues:

1. Preliminary assessment of the impact of climate change on villages on the basis of climate change scenarios;
2. Finding and selecting specific measures to cope with climate change including activities, technical options, and projects; and
3. Raising awareness and responsibility of community in adapting to the effects of climate change.

The other communes, however, passively depended on the provincial government's plans. Therefore, these LGUs need to be capacitated on climate change adaptation.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Climate change mapping shows that Vietnam's 10 most endangered provinces are among the top 25% most vulnerable areas in Southeast Asia—Ben Tre is one of these provinces (Yusuf and Francisco 2010).

In the studied sites, data collected from the household survey indicated that serious damages had been incurred from climatic events. For one, the most recent typhoons resulted in losses worth VND 3,196,550,000 (USD 154,155). For another, recent damages from saltwater intrusion amounted to VND 1,599,803,000 (USD 77,151). Compared to typhoons and saltwater intrusion, erosions have affected fewer numbers of households. Estimated loss from the most recent erosion amounted to VND 590,800,000 (USD 28,492).

The total damages caused by these climatic events actually surpassed those figures listed above because the cost of the measures undertaken by households after such climatic events can also be considered as losses. Households spent a total of VND 3,852,981,436 (USD 185,811) on essential activities to deal with the after-effects caused by typhoons. Meanwhile, the total cost of establishing measures to mitigate the impacts of saltwater intrusion amounted to VND 2,122,917,000 (USD 102,378). Similarly, households spent a total of VND 1,310,100,000 (USD 63,180) to set up measures to address the after-effects of erosions. Note that these figures were calculated based on a sample of just 300 households. Therefore, the value of damages would be definitely much larger for the whole community.

In order to deal with future typhoons, *modifying houses to make them more resilient* and *participating in community projects/activities addressing typhoons* were two of the measures that were selected by most respondents. Regarding saltwater intrusion, *harvesting rainwater* was viewed as the first priority, followed by *buying freshwater from commercial vendors*, and *tapping freshwater from a different source*. In order to mitigate impacts of future erosions, *installing protective structures* and *mangrove plantation* were viewed as priorities by most respondents.

Aside from the autonomous measures adopted by households, the community also disclosed their expectations from the local government for support in case such climatic events occur in the future. In order to address problems associated with typhoons, the local residents deemed *community evacuation* to be the most needed action, followed by *financial assistance*, *establishing early warning system*, *replanting mangroves and forests*, and institutionalizing *rescue and emergency assistance*. In dealing with erosion, *mangrove rehabilitation/conservation* was highly appreciated by the respondents. Regarding sea level rise, *building new or repairing existing sea dikes* were viewed to be the most appropriate adaptation measures. Considering saltwater intrusion, the community highly regarded the *construction of a freshwater treatment facility*.

Results of the CEA showed that building a freshwater treatment plant would be more cost effective than building a sea dike system. Nonetheless, the dike had a higher BCR than the treatment plant, although results of the analysis indicated that the investment and operating costs of the dike are much higher.

Based on the results of the study and their implications, the provincial government should integrate CCA programs/projects into its socioeconomic development plans. Knowledge and awareness of climate change play an important role in determining human actions toward the issue at hand. Hence, the provincial government should implement more activities geared toward raising the awareness and knowledge of the local residents and authorities about climate change. Likewise, the central government should consider the measures taken by the residents to cope with climate change, and should adopt a participatory approach in dealing with the issue.

Prevention is better than cure. In dealing with problems associated with climate change, the provincial government should emphasize more on preventive adaptations rather than curative measures.

Coping with climate change requires strong financial capability, which is a challenge to the province itself. Hence, the provincial government should be proactive in seeking national financial support and foreign investments and/or financial aid to deal with effects of climate change.

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APPENDICES

Appendix 1. Activities, Costs, Benefits, Assumptions, and Calculation of CEA for the Construction of the Freshwater Treatment Plant in Ben Tre Province

A1.1 Calendar of activities

Table A1.1. Calendar of activities for the construction of the water treatment plant

Period	Activities
August 2011 to December 2012	Field research for project development Approval of project Capital preparation Designing and project estimates Approval of design and project estimates Clear-the-ground compensation Calls for tender
January 2013 to December 2014	Construction Test operation Training and technology transfer Acceptance and official operation

Source: Ben Tre DARD (2011)

A1.2 Investment progress

Based on the total amount of investment and project progress, the total investment was planned to be allocated as follows (Ben Tre DARD 2011):

Year 1: VND 6,662,000,000 (USD 321,277)

Year 2: VND 40,539,000,000 (USD 1,955,006)

Year 3: VND 470,825,000,000 (USD 22,705,681)

Year 4: VND 480,245,000,000 (USD 23,159,963)

A1.3 Estimates on the operating costs of the water treatment plant

Table A1.2. Operating costs of the water treatment plant

Cost Item		Assumptions	Cost Based on Assumptions
Electricity, labor, chemical (C1)	Electricity	Use of electricity for the period 2015–2019 would be 3,759,600 kWh per year Use of electricity from 2020 would be 8,114,333 kWh per year Price of electricity would be VND 1,250/kWh	From 2015 to 2019: 3,759,600 x 1,250 = VND 4,700 million per year From 2020: 8,114,333 x 1,250 = VND 10,143 million per year
	Labor		VND 500 million per year
	Chemical	Use of chemicals for the period 2015–2019 would be 4,000 kg per year Use of chemicals from 2020 would be 5,700 kg per year Price of chemicals is averaged as VND 14,000/kg	From 2015 to 2019: 4,000 x 14,000 = VND 56 million per year From 2020: 5,700 x 14,000 = VND 79.8 million per year
Miscellaneous		Equal to 3% of C1	From 2015 to 2019: 3% x C1= VND 157.95 million per year From 2020: 3% x C1 = VND 321.684 million per year

Source: Ben Tre DARD (2011)

Total operating costs. Based on the calculation above, total production cost was planned to be VND 3,695.98 million per year (USD 178,240) for the period 2015–2019, and VND 11,044.60 million per year (USD 532,629) by then. Thanh Phu district would consume 25% of the total amount of freshwater produced. Therefore, total production cost allocated for Thanh Phu district was estimated to be USD 44,560 from 2015 to 2019, and USD 113,157 from 2020.

A1.4 Estimates of benefits

The population of Thanh Phu district in 2010 was 121,902, with the average number of persons per household of 3.73. Population growth rate was assumed to be 1.16% per year. With this information, the total number of households until 2049 can be easily calculated. In the four years of construction, the project would not generate any benefit. From 2015 to 2019, it was assumed the number of household beneficiaries would be equal to 85% of the total number of households. From 2020, the number of household beneficiaries would be 90%.

Monetary benefit was calculated by multiplying the amount of water consumed within Thanh Phu district with the unit price. The unit price of freshwater was assumed to be constant, that is, VND 3,500/m^3. Assume that 95% of freshwater produced will be consumed. From 2015 to 2019, monetary benefit would be

25% x VND 3,500/m^3 x 6,954,000 m^3 x 95% = VND 5,780,512,500 (USD 287,767).

From 2020 to 2049, the amount would be as follows (Ben Tre DARD 2011):

25% x VND 3,500/m3 x 10,164,000 m^3 x 95% = VND 8,448,825,000 (USD 407,447).

A1.5. CE and benefit-cost ratios of the water treatment plant

Table A1.3. CE ratio and benefit-cost ratio of the freshwater plant

Year	Cost (USD)	Physical Benefit (Household)	Monetary Benefit (USD)	CE Ratio	Benefit/Cost Ratio
2011	80,319	0	0		0.00
2012	488,751	0	0		0.00
2013	5,676,420	0	0		0.00
2014	5,789,991	0	0		0.00
2015	44,560	30,819	278,767	1.45	6.26
2016	44,560	31,176	278,767	1.43	6.26
2017	44,560	31,538	278,767	1.41	6.26
2018	44,560	31,904	278,767	1.40	6.26
2019	44,560	32,274	278,767	1.38	6.26
2020	133,157	36,489	407,447	3.65	3.06
2021	133,157	36,912	407,447	3.61	3.06
2022	133,157	37,341	407,447	3.57	3.06
2023	133,157	37,774	407,447	3.53	3.06
2024	133,157	38,212	407,447	3.48	3.06
2025	133,157	38,655	407,447	3.44	3.06
2026	133,157	39,104	407,447	3.41	3.06
2027	133,157	39,557	407,447	3.37	3.06
2028	133,157	40,016	407,447	3.33	3.06

Table A1.3 continued

Year	Cost (USD)	Physical Benefit (Household)	Monetary Benefit (USD)	CE Ratio	Benefit/Cost Ratio
2029	133,157	40,480	407,447	3.29	3.06
2030	133,157	40,950	407,447	3.25	3.06
2031	133,157	41,425	407,447	3.21	3.06
2032	133,157	41,905	407,447	3.18	3.06
2033	133,157	42,392	407,447	3.14	3.06
2034	133,157	42,883	407,447	3.11	3.06
2035	133,157	43,381	407,447	3.07	3.06
2036	133,157	43,884	407,447	3.03	3.06
2037	133,157	44,393	407,447	3.00	3.06
2038	133,157	44,908	407,447	2.97	3.06
2039	133,157	45,429	407,447	2.93	3.06
2040	133,157	45,956	407,447	2.90	3.06
2041	133,157	46,489	407,447	2.86	3.06
2042	133,157	47,028	407,447	2.83	3.06
2043	133,157	47,574	407,447	2.80	3.06
2044	133,157	48,126	407,447	2.77	3.06
2045	133,157	48,684	407,447	2.74	3.06
2046	133,157	49,249	407,447	2.70	3.06
2047	133,157	49,820	407,447	2.67	3.06
2048	133,157	50,398	407,447	2.64	3.06
2049	133,157	50,982	407,447	2.61	3.06

Present value of costs: USD 9,344,091.13

Total physical benefits: 50,982 households

CE ratio: USD 183.281 per benefited household

Present value of monetary benefits: USD 2,350,718.07

Benefit/Cost ratio: 0.2516

Appendix 2: Activities, Costs, Benefits, Assumptions, and Calculation of CEA for the Construction of the Sea Dike System

A2.1 Investment progress

Table A2.1. Investment progress of the sea dike (in USD)

Category	2011–2012	2013–2014	2015–2016
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)

A2.2 Operating costs

Table A2.2. Operating cost of the sea dike system

Year	Cost	
	VND	USD
2013	4,380,000,000	211,226.85
2014	6,570,000,000	316,840.28
2015	8,760,000,000	422,453.70
2016	10,950,000,000	528,067.13
2017	13,140,000,000	633,680.56
2018	15,330,000,000	739,293.98
2019	17,520,000,000	844,907.41
2020	19,710,000,000	950,520.83
2021–2049	21,900,000,000	1,056,134.26

Source: Ben Tre DARD (2010)

A2.3. Estimates of benefits

The number of population in the projected area (i.e., 10 communes of Thanh Phu district where the sea dike was planned to be built) in 2011 was 66,504 persons, with the average number of persons per household of 3.845 persons. Population growth rate was assumed to be 1.16% per year. With this information, the total number of households until 2049 can be easily calculated. The number of households benefiting from the sea dike was assumed to occur starting 2012, and would keep on increasing until 2049 following the theme below (Ben Tre DARD 2010):

- The number of benefited households in 2012 is 20% of total households.
- The number of benefited households in 2013 is 30% of total households.
- The number of benefited households in 2014 is 40% of total households.
- The number of benefited households in 2015 is 50% of total households.
- The number of benefited households in 2016 is 70% of total households.
- The number of benefited households in 2017 is 80% of total households.
- The number of benefited households from 2018–2020 is 90% of total households.
- The number of benefited households from 2021–2049 is 100% of total households.

Monetary benefit was measured as the money gained from the increase in agricultural productivity, as the dike was expected to prevent saltwater from damaged agricultural production. This value was obtained from the secondary data (Table A2.3).

A2.4 CE Ratios and Benefit-Cost Ratios of the Planned Sea Dike System

Table A2.3. CE ratio and benefit-cost ratio of the sea dike

Year	Cost (USD)	Physical Benefit (Household)	Monetary Benefit (USD)	CE ratio	Benefit/Cost Ratio
2011	15,081,308	0	0		
2012	15,081,308	3,499	4,991,536	4,309.717	0.33
2013	28,748,384	5,310	7,487,305	5,414.061	0.26
2014	28,853,998	7,162	9,983,073	4,028.730	0.34
2015	29,607,494	9,056	12,478,841	3,269.226	0.42
2016	28,847,946	12,826	17,470,378	2,249.165	0.61
2017	633,681	14,828	19,966,146	42.730	31.51
2018	739,294	16,875	22,461,914	43.810	30.38
2019	844,907	17,071	22,461,914	49.490	26.59
2020	950,521	17,269	22,461,914	55.040	23.63
2021	1,056,134	19,411	24,957,682	54.410	23.63
2022	1,056,134	19,636	24,957,682	53.790	23.63
2023	1,056,134	19,864	24,957,682	53.170	23.63
2024	1,056,134	20,094	24,957,682	52.560	23.63
2025	1,056,134	20,327	24,957,682	51.960	23.63
2026	1,056,134	20,563	24,957,682	51.360	23.63
2027	1,056,134	20,801	24,957,682	50.770	23.63
2028	1,056,134	21,043	24,957,682	50.190	23.63
2029	1,056,134	21,287	24,957,682	49.610	23.63
2030	15,627,411	21,534	24,957,682	725.720	1.60
2031	1,056,134	21,784	24,957,682	48.480	23.63
2032	1,056,134	22,036	24,957,682	47.930	23.63
2033	1,056,134	22,292	24,957,682	47.380	23.63
2034	1,056,134	22,550	24,957,682	46.830	23.63
2035	1,056,134	22,812	24,957,682	46.300	23.63
2036	1,056,134	23,077	24,957,682	45.770	23.63
2037	1,056,134	23,344	24,957,682	45.240	23.63
2038	1,056,134	23,615	24,957,682	44.720	23.63
2039	1,056,134	23,889	24,957,682	44.210	23.63
2040	1,056,134	24,166	24,957,682	43.700	23.63
2041	1,056,134	24,446	24,957,682	43.200	23.63
2042	1,056,134	24,730	24,957,682	42.710	23.63
2043	1,056,134	25,017	24,957,682	42.220	23.63
2044	1,056,134	25,307	24,957,682	41.730	23.63
2045	1,056,134	25,601	24,957,682	41.250	23.63
2046	1,056,134	25,898	24,957,682	40.780	23.63
2047	1,056,134	26,198	24,957,682	40.310	23.63
2048	1,056,134	26,502	24,957,682	39.850	23.63
2049	1,056,134	26,809	24,957,682	39.390	23.63

Present value of costs: USD 109,524,713.42

Total physical benefits: 26,809 households

CE ratio: USD 4,085.31 per benefited household

Present value of monetary benefits: USD 163,246,456.07

Benefit/Cost ratio: 1.4905

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