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

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## ABSTRACT

*Scientific database has proven that Vietnam is one of the most affected countries due to climate change impacts on aquaculture and economies of rural communities. Ben Tre region has suffered immensely from recent salt water intrusion. Climate change generates sea level rise, increase in temperature and salt water intrusion. In 2005 losses had increased to US$37 million. We conducted three focus group discussions (FGDs) to assist in the identification of vulnerable sectors and households and community adaptation strategies to climate change. Households were also evaluated based on the levels of vulnerability. Residents have requested the construction of a water treatment plant and a dike system. CEA is employed as the tool for evaluating the two planned adaptations: Building a freshwater-supplying factory and Building a sea dike system. Total costs include initial investment and annual operating costs. We also conducted a benefit cost analysis since the outcomes of the strategies are different. The distribution of vulnerability index showed that 31% of households are highly vulnerable to climatic risk while 56% of households are not vulnerable at all. The sea dike is three times more expensive than the freshwater plant. In addition to the higher investment, it is more costly to keep the sea dike under operation annually. The water treatment plant is more cost effective in servicing the communities with freshwater but the dike has a higher benefit cost ratio when all costs are internalized and secondary benefits to agriculture and aquaculture are considered.*

**Keywords**: Climate Change Impacts, Vulnerability Assessment and Economic Analysis of Adaptation Strategies.

## INTRODUCTION

Scientific information and climatic mapping show that 10 of Vietnam's susceptible provinces to climate change are among the top 25% most vulnerable areas in Southeast Asia, and that Ben Tre is one of these [20]. The forecasted impacts of climate change on prevailing weather include changes in rainfall, temperatures which include alterations in intensity and severity of floods, typhoons and storms and sea level rise. In Vietnam, climate change has been noted to foster temperature increases and sea level rise, which have caused permanent inundation, increased flooding, as well as salt water intrusion [7, 18]. Over the past 50 years, Vietnam has experienced an increase of 0.5-0.7$^0$C in annual average temperature, and a 20 cm rise in sea level. Scientific calculations show that average temperature in Vietnam could probably increase 3$^0$C and that the sea level is likely to rise 1 m in 2100.

Economic damages caused by salt water intrusion from 1995 to 2008 amounted to VND 672,325 billion (USD 32,423,080,632) including 15,782 ha of dead or less productive paddy, 13,700 ha of shed unripe coconut, 360 ha of less productive aquaculture, and 5,289 t of dead shrimp [19]. The Ben Tre region has suffered immensely from recent salt water intrusion. In 2003, salt water intrusion caused agricultural losses amounting to US$750,000 which affected 16,000 households. By 2005 losses had increased to US$37 million [16]. The intrusion also put 132,823 households into a situation of continued lack of fresh water [4]. The number of people reportedly not having access to fresh water was estimated at 110,000 out of a population of 280,000.

The regional governments have noted these climatic changes and have included strategies in their plans to prevent further damages and to assist residents to cope with these changes. However, there have been few studies that evaluate the economic and financial impacts of these strategic measures which can be costly to rural poor households, communities and the society. It is, therefore, important to investigate the effects of climate change on the well-being of people in these regions and to learn more of their adaptation strategies.

Several studies show that climate change will impact not only the climatic variability, but also the frequency and intensity of extreme events that will definitely harm the long-term sustainable development of the country [1, 2, 12]. This has intensified in recent years with major floods occurring more frequently. Limiting the effect of environmental degradation on individual livelihoods and on broader prospects for sustainable economic growth can be achieved by reducing vulnerability, enhancing resilience, and promoting adaptive strategies. These are urgent and critical for the well-being of the farmers, fishers, forest dwellers, and urban population of Vietnam [2]. Thus, the concept of human security in Vietnam is attributed to food, livelihood and social security [15].

### Vulnerability

Embedded in the definition of vulnerability is the notion of risk, dangers or hazards. A widely used definition of vulnerability is “the degree to which a system, subsystem, or system component is likely to experience harm due to exposure to a hazard, a perturbation or stress/ stressor” [17]. According to Adger [3], vulnerability is the exposure of individuals or groups to livelihoods of stress and uncertainty. Based on Hewitt [10] vulnerability to hazards includes a lack of resources, poverty, marginalization which forces the individual into a set of coping behaviors to withstand the stress. The economics literature generally defines vulnerability as an outcome of a process of households’ responses to risks and the adaptive mechanisms used to avoid or mitigate the effects of hazards [6].

Vietnam's National Strategy for Environmental Protection emphasizes continued institutional development, capacity building, and integration of environmental considerations into main economic planning and general decision-making. The efforts however have been sporadic and concentrated on building water canals in specific areas.

### Selection Method for Planned Adaptation Strategies

The measurement of adaptation measures must be evaluated at the local level since that can be costly. These adaptation strategies usually are initiated as projects and must be economically and financially evaluated before they are adopted. Usually a cost-benefit analysis (CBA) approach is used for evaluating projects that might generate benefits over an extended period of time. When projects with different cost structures are expected to produce the similar outcomes, cost-effectiveness analysis (CEA), whereby the costs are compared with outcomes measured in natural units, is appropriate for project selection [9]. Cost-effectiveness analysis assumes that a certain benefit or outcome is desired, and that there are several alternative ways to achieve it. CEA is comparative and asks which of the alternative is the cheapest for providing the service.

## OBJECTIVES OF THE STUDY

In this paper we identify and assess the impacts of such climatic changes in Ben Tre Province in the Mekong Delta and conduct an economic analysis of the adaptation strategies adopted by the community to address these impacts. Specifically we: (1) Evaluated impacts of climate change on aquaculture and fisheries in three districts in Ben Tre Province; and determine the extent of vulnerability of individuals living in the selected communities; and (2) Measure the cost effectiveness of two adaptation strategies to minimize the effects of climate change.

## METHODOLOGY

### Site Selection

The area of research is in the Ben Tre Province in Vietnam. This is an area with substantial numbers of vulnerable households living in low coastal zones, the majority of which are dependent on coastal resources for their livelihoods. 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 studied sites.

### Data Collection

Both secondary and primary data were collected to facilitate the analysis needed for this study. Secondary data on effects of climate change in Vietnam from other previous studies were collected and results validated through a Focus Group Discussion (FGD). Existing GIS maps were examined to identify vulnerable groups in Ben Tre Province. This was then used as a basis for collecting more specific primary data on perceptions, effects, and costs and benefits associated with climate change and adaptation strategies in the Ben Tre Province. The first FGD was held in the presence of eight provincial officials. The two objectives of the first FGD were: (i) to inform the authorities of the research objectives and (ii) to provide a forum in which to discuss the situation of climate change in Ben Tre. The second FGD was held on the basis of the first FGD but this time in the presence of 10 Binh Dai District government officials from the People's Committee, the Department of Agriculture and Rural Development, the Department of Natural Resources and Environment, the Department of Economic Development, as well as authority representatives from Thua Duc coastal commune. The third FGD welcomed the participation of 12 farmers from different communes in Binh Dai and Ba Tri Districts. The participants were selected by the district authority officials. The purpose of this FGD was to exchange ideas about the objectives of the research with the farmers and determine the level of awareness regarding climate change and sea level rise.

**Household Analysis**

Three hundred households that were involved in the survey were equally divided among three studied coastal districts. In each commune, the survey covered all villages with the hope that the samples represented the population. Respondents were chosen based on the economic structure of the commune in order to involve as many occupations as possible, including agriculture, aquaculture and fishing. Data collected from the household surveys were analyzed to demonstrate how harmful each climatic event is in terms of monetary loss, types of damages and the number of affected households.

**Household Vulnerability Indices**

Based on data collected from the household surveys, vulnerability indices were estimated. Vulnerability is defined as the probability that a household will fall below a minimum consumption threshold level, or probability that the household will move to poverty in the future. The analysis is based on the assumption that climate extremes, climatic shocks or hazards, will affect the probability that households' consumption will fall below a given minimum vulnerability level [8].

Household consumption function is defined as:

$$\ln C_h = X_h \beta + e_h \tag{Eq. 1}$$

Where:

$C_h$ = per capita consumption expenditure of HH; $X_h$ = observable household characteristics and climatic shocks;

$e_h$ = mean-zero disturbance term

Applied three-step feasible generalized least squares (FGLS) procedure to estimate:

$$\hat{E}\left[\ln C_h \middle| X_h\right] = X_h \hat{\beta}$$
$$\hat{V}\left[\ln C_h \middle| X_h = \hat{\sigma}^2_{e,h} = X_h \hat{\theta}\right] \tag{Eq. 2}$$

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

$$\hat{V}_h = \hat{\Pr}(\ln C_h < \ln \middle| X_h) = \Phi\left(\frac{\ln z - X_h \hat{\beta}}{\sqrt{X_h \hat{\theta}}}\right) \tag{Eq. 3}$$

Where:

z = consumption threshold (minimum per capita consumption below which one will be considered vulnerable, USD 1.25 and USD 1.50);

Φ(.)= cumulative density of the standard normal

The following is key independent variables used in the regression:

Number of floods that affected the community (over the last 10 years)

Ω=1, if affected by coastal erosion; Ω=2, if affected by saltwater intrusion

Age=Age of head of household; Gender=Gender of head of household

Years=Years of schooling of head of household;

Dependency ratio = number of members below 15 and above 64 per household

D =1, if house is owned; D=2, if household is involved in farming; D=3, if household is involved in fishing; D=4, if household is involved in livestock; D=5, if household is involved in aquaculture.

**CEA of Planned Adaptation Strategies**

Based on the results of the FGDs and household surveys, two planned adaptations were evaluated using cost-effectiveness analysis. The two projects are building a freshwater-supplying factory and building a sea dike. The purpose of conducting CEA of the two adaptations is to provide the local government with advice on which adaptation should be given priority because the investment in each project is extremely large. In addition to the physical benefit to households, monetary value is assigned to the benefits. For the freshwater plant, monetary benefit is equal to unit price multiplied by the amount of freshwater consumed by households. For the sea dike, monetary benefit is measured as revenue gained from the increase in productivity of agriculture as the dike helps prevent salt water from damaging agricultural production. With a monetary value the Benefit/Cost ratios are calculated.

## RESULTS

It was illustrated from the first FGD that the three coastal districts Binh Dai, Ba Tri and Thanh Phu witnessed the worst damage from climate change impacts and sea level rise. Changeable weather phenomenon, increasing temperature and salinity, together with the larger gap between day and night time temperatures and sea level rise are sufficient signs of climate change prevailing in Binh Dai District. Alternation in seasonal wind direction also causes variation in currents on river valleys, thus influencing soil erosion.

In Thua Duc commune, productivity of shrimp from extensive farming within mangrove forest decreased noticeably (from VND 7-10 million per crop prior to 2007 to only VND 5 million per crop after 2007). Increases in temperature and salinity thickens the exoskeleton of black tiger and white leg shrimp; hence slowing their growth. Such harsh conditions also lengthen the culture period by an average of one month. The clam culturing areas are assessed to be highly vulnerable to climate change and sea level rise, that both changed the environmental conditions and the ecology.

During the FGDs participants revealed that in 2010 that massive clam deaths (up to 90%) inflicted enormous losses on farmers Sixty-five respondents reported that their agricultural production was harmed by salt water intrusion which resulted in a total loss of VND 710,810,000 (or USD 34,279). Aquaculture production of 14 households was damaged by salt water which led to monetary loss of VND 644,050,000 (USD 31,060). Replacing fish stock, replanting farm or/and reinforcing pond/cages were also performed.

### Household Vulnerability Index

The mean vulnerability index is 0.43, which means on average there is a 43% probability that a household will fall below the minimum consumption threshold level of USD 1.25 per capita per day. It is worth noting that the vulnerability index ranges from zero to one and the standard deviation is 0.41 which generates a C.V. of 95% which represents a large dispersion. The distribution of vulnerability index shows that 31% of households are highly vulnerable to climatic risk, while 56% of households are not vulnerable and 14% are moderately vulnerable.

There are three points very obvious from Figure 1. First, “not poor households” (IV, V, VI) outnumber “poor households” (I, II, III). Secondly, the vulnerability index tends to distribute at both ends –highly vulnerable or not vulnerable- staying apart from the mean value. Thirdly, it is interesting to note from the figure that not poor households are more highly vulnerable than poor households.

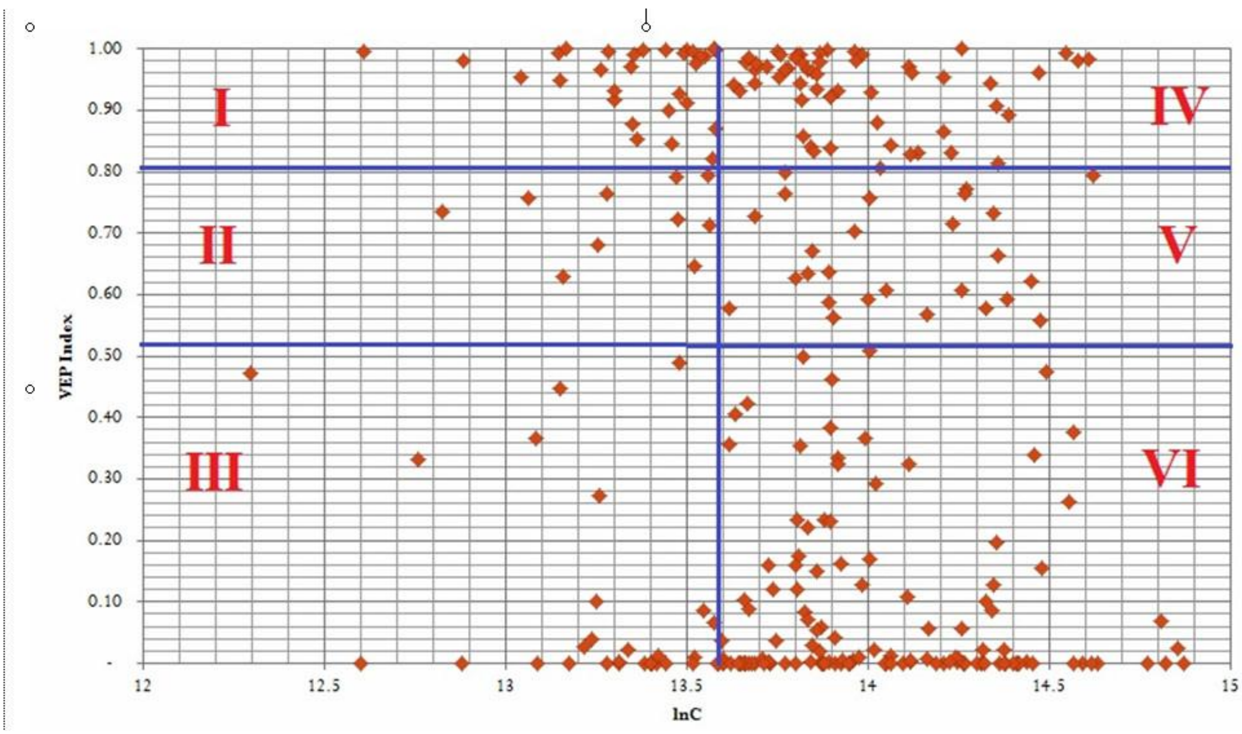


**Figure 1. Graph of distribution of vulnerability index**

### CEA of the Project on Building a Freshwater-Supplying Factory

The freshwater-supplying factory is projected to be built to meet the following objectives: (1) Providing sufficient fresh water for family routine, agriculture, industry, tourism, services and miscellaneous activities within four districts namely Thanh Phu, Cho Lach, Mo Cay Nam, and Mo Cay Bac. The project serves as an adaptation to mitigate impacts of climate change, more precisely salt water intrusion, which has always been affecting livelihoods of local residents. In addition, the project serves as an adaptation for (2) Reducing as much as possible the possibility of diseases caused by use of unsafe fresh water and (3) Increasing the proportion of rural residents who have access to clean and safe fresh water.

Investment is divided into seven categories as mentioned in table I. Total amount for the whole project which spreads over four districts is VND 998,271,183,914 (USD 48,141,935), of which VND 249,567,795,979 (USD 12,035,484) is allocated for Thanh Phu District.

**Table I: Investment of the Freshwater-Supplying Factory within Thanh Phu District**

| **Category** | **Expenses (VND)** | **Expenses (USD)** |
|---|---|---|
| Construction | 184,221,086,019 | 8,884,119 |
| Machines and equipment | 9,761,440,370 | 470,748 |
| Project management | 1,895,461,177 | 91,409 |
| Project consultancy | 5,907,569,190 | 284,894 |
| Clear-the-ground compensation | 3,270,250,000 | 157,709 |
| Inflationary costs | 42,864,132,393 | 2,067,136 |
| Miscellaneous | 1,647,856,829 | 79,468 |
| **Total investment** | **249,567,795,979** | **12,035,484** |

Source: From Ben Tre DARD [5]

Operating costs include chemical, electricity, labor and miscellaneous costs. Operating costs start to occur in 2015 when the plant is under operation. 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. Thanh Phu District consumes 25% of total amount of freshwater produced. Therefore, total operating cost allocated for Thanh Phu District would be USD 44,560 from 2015 to 2019, and USD 113,157 from 2020 to 2049.

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 is assumed to be 1.16% per year. With this information, the total number of households until 2049 can be easily calculated. During four years of construction, the project does not generate any benefit. From 2015 to 2019, the number of benefiting households is equal to 85% of the total number of households. From 2020 to 2049, the figure mounts to 90%. Monetary benefit is calculated by multiplying the amount of water consumed within Thanh Phu District with unit price.

Based on the costs and the physical benefits from the project, CE ratio is calculated using the formula CE ratio = Present value of costs/Total physical benefits. Costs include initial investment and annual operating costs which are discounted to compute present value. Benefit/Cost ratio is equal to present value of monetary benefits divided by present value of costs. CE ratio of the water treatment plant is USD 183.281 per benefited household. Benefit/Cost ratio is 0.2516.

### CEA of the Project on Building a Sea Dike System

The sea dike system with the dimension of 52.4 km x 7.5 m x 4.0 m is planned to meet the following objectives: (1) Preventing flooding caused by tides, typhoons, and sea level rise in favor of 10 communes in Thanh Phu district; (2) Reducing salt water contamination; (3) Integrated with national defense strategies as well as transportation development.

Total investment of the sea dike system amounts to VND 2,999,704,000,000 (USD 144,661,651.23), which is divided into six categories as in table II. The construction of the sea dike lasts for 6 years (Table II).

**Table II: Investment of the Sea Dike System**

| Category | Expenses (VND) | Expenses (USD) |
|---|---|---|
| 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** |

Source: From Ben Tre DARD [4]

Operating costs of the sea dike include maintenance which is the major and miscellaneous cost. Operating costs start to occur in 2013 (see more at appendix). Replacement cost occurs in 2030 which is equal to VND 302,150,000,000VND (USD 14,571,277.01) [4].

The population in projected area in 2011 was 66,504 persons with the average number of persons per household of 3.845 persons. Population growth rate is assumed to be 1.16% per year. With this information, the total number of households until 2049 can be easily calculated (see appendix). The number of households benefiting from the sea dike first occurs in 2012 and keeps increasing until 2049 [4]. Monetary benefit is measured as money gained from the increase in productivity of agriculture as the dike will prevent salt water from damaging agricultural production. This value is obtained from the secondary data. CE ratio of the dike is USD 4,085 per benefiting household. Benefit/Cost ratio of the sea dike is 1.4905.

The construction of a freshwater plant requires smaller investment than a sea dike. In addition to the higher investment, it is more costly to keep the sea dike under operation annually. The freshwater plant serves more beneficiaries than the sea dike. According to the CE ratios, the water treatment plant is more cost effective than the sea dike. Nonetheless, if benefits are measured in terms of value, one dollar investment in the sea dike generates more dollars than that invested in the freshwater plant. The water treatment plant is more cost effective in servicing the communities with freshwater but the dike has a higher benefit cost ratio when all costs are internalized and secondary benefits to agriculture and aquaculture are considered.

**Table III: Comparison between The Freshwater Factory and The Sea Dike System**

| Criteria | Comparison |
|---|---|
| Initial investment | Freshwater plant requires less initial investment |
| Annual operating cost | Freshwater plant requires less annual operating cost |

| | |
|---|---|
| Physical benefit | Freshwater plant generates more physical benefit |
| CE ratio | Freshwater plant has much smaller CE ratio |
| Benefit/Cost ratio | Sea dike has much higher Benefit/Cost ratio |

**Discussions of CEA Results**

Table III provides a comparison between the freshwater plant and the sea dike. The construction of a freshwater plant requires smaller investment than a sea dike. Specifically, the sea dike is three times more expensive than the freshwater plant. This increases to some extent the feasibility of the water treatment plant. In addition to the higher investment, it is more costly to keep the sea dike under operation annually. In terms of physical benefit, the freshwater plant serves more beneficiaries than the sea dike. This is understandable because the freshwater plant is meant to serve the whole district while the sea dike covers only 10 communes within the district.

According to the CE ratios, the water treatment plant appears to be more cost effective than the sea dike. Nonetheless, if benefit is measured in terms of value, one dollar investment in the sea dike generates more dollars than that invested in the freshwater plant.

## CONCLUSIONS

Statistics show that most recent typhoons resulted in VND 3,196,550,000 (USD 154,155) loss. Recent damages from salt water intrusion mounted to VND 1,599,803,000 (USD 77,151). As compared to typhoons and salt water intrusion, erosions have affected fewer numbers of households. Estimated loss from most recent erosion damage amounted to VND 590,800,000 (USD 28,492). Households spent VND 3,852,981,436 (USD 185,811) on essential activities to deal with damages caused by typhoons. VND 2,122,917,000 (USD 102,378) was the sum of money spent on household activities to mitigate impacts of salt water intrusion. Similarly, it costs households VND 1,310,100,000 (USD 63,180) to implement actions to cope with the impacts of erosions. About 31 % of the population in the area is susceptible to climate change. Poverty is associated to climatic vulnerability.

Results from CEA showed that the water treatment plant is more cost effective than the sea dike system. Nonetheless, the dike has a higher Benefit/Cost ratio than the treatment plant even though the investment and operating costs are much higher for the dike.

## POLICY IMPLICATIONS

Information from the study suggests that provincial government should integrate programs/projects dealing with climate change into its socio-economic development plans. Awareness and knowledge play an important role in determining human actions. Hence, it is crucial that the provincial government should implement more activities to raise awareness and improve knowledge about climate change for local authority officials as well as residents. Hence local government should use a participatory approach in the efforts to mitigate the effects of climate change. The central government should consider the measures taken by residents to cope with climate change and should adopt a participatory approach in dealing with climate change.

Prevention is better than cure. In dealing with problems associated with climate change, it is recommendable that the provincial government places more emphasis on preventive adaptations rather than curative measures.

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## APPENDIX

### Information on Fresh Water Plant

The water plant is built for supplying four districts with potable water, including Thanh Phu District. Meanwhile, the sea dike is built for Thanh Phu District only. Therefore, adjustments are made for the water plant by dividing the total initial investment of the water plant by 4.0 to obtain the initial investment for Thanh Phu District. This is of course a rough estimation. A modified discount rate of 10.0 percent was used. Total investment will be allocated as follows: (Investment for Thanh Phu District will be 25% of those figures)

Year 2011: VND 6,662,000,000 (USD 321,277)

Year 2012: VND 40,539,000,000 (USD 1,955,006)

Year 2013: VND 470,825,000,000 (USD 22,705,681)

Year 2014: VND 480,245,000,000 (USD 23,159,963)

According to the project, the amount of fresh water produced within 2015 and 2019 is 6,954,000 $m^3$, equivalent to 77% of designed capacity. The amount of fresh water produced from 2020 to 2049 is 10,164,000 $m^3$, equivalent to 49% of designed capacity. Operating costs include chemical, electricity, labor and miscellaneous costs. Operating costs start to occur in 2015 when the plant is under operation. 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 [5]. Thanh Phu District consumes 25% of total amount of freshwater produced. Therefore, total operating cost allocated for Thanh Phu District would be USD 44,560 from 2015 to 2019, and USD 113,157 from 2020 to 2049.

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 is assumed to be 1.16% per year. Monetary benefit is calculated by multiplying the amount of water consumed within Thanh Phu District with unit price. Unit price of freshwater is assumed to be constant, that is, VND 3,500/$m^3$. Here we assume that 95% of freshwater produced will be consumed. The rest 5% is wasted along pipelines. From 2015 to 2019, monetary benefit would be VND 5,780,512,500 (USD 287,767) [5]. From 2020 to 2049, the amount would be VND 8,448,825,000 (USD 407,447).

**Information on Dike**

The sea dike system with the dimension of 52.4 km x 7.5 m x 4.0 m is planned to preventing flooding caused by tides, typhoons, and sea level rise, and to reducing salt water contamination in favor of 10 communes in Thanh Phu District. Total investment of the sea dike system amounts to VND 2,999,704,000,000 (USD 144,661,651.23), which is allocated for 6 years of construction.

**Table IV: Investment Progress of the Sea Dike (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** |

**Table V: Operating Cost of the Sea Dike System**

| Year | Expense (VND) | Expense (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 |

The number of population in projected area in 2011 was 66,504 persons with the average number of persons per household of 3.845 persons. Population growth rate is assumed to be 1.16% per year. The number of households benefiting from the sea dike first occurs in 2012 and keeps increasing until 2049 following the theme below:

- 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. [4]

**Table VI: Monetary Benefit of the Sea Dike System**

| Year | Monetary benefit (USD) |
|---|---|
| 2012 | 4,991,536 |
| 2013 | 7,487,305 |
| 2014 | 9,983,073 |
| 2015 | 12,478,841 |
| 2016 | 17,470,378 |
| 2017 | 19,966,146 |
| 2018-2020 | 22,461,914 |
| From 2021 | 24,957,682 |