CHAPTER 6 IN-DEPTH STUDY

This Chapter 6 presents the results of In-depth study carried out in Phase II from January 2012 to June 2012. In-depth study has examined some priority issues prevalent in the Project area summarized in "Climate Change Adaptation Framework", e.g. saline intrusion, lack of fresh water, inundation coupled with poor drainage and heavy rainfall, seashore erosion, latent risk associated with shrimp culture, etc. The in-depth study aims at recommending measures to cope with and/or adapt to those priority issues, whereby making the master plan more realistic to work and making the projects more work. Therefore, the results of the in-depth study will have to be fully incorporated in the priority project design and the Master Plan.

6.1 Studies Linked up with Issues Identified

The objective of the In-Depth Study is to examine specific and priority issues which are needed to clarify prior to the designing of priority projects for the coastal areas in Mekong Delta. The priority issues have been identified and drafted in "Climate Change Adaptation Framework", then, the studies on 6 specific issues are conducted to identify adaptable measures against possible phenomenon by climate change. The studies conducted are;

1) Study on the best-suited polder area improvement coping with saline intrusion (North Ben Tre),
2) Study on the fresh water recruitment for Tra Vinh paddy areas (from Vinh Long province),
3) Study on the water management for the Bac Lieu centre and its coastal area,
4) Study on the flow mobilization in the water tranquil areas of the Ca Mau peninsula,
5) Study on the best-suited sea dyke types adaptive to the local situation, and
6) Study on the sustainability of extensive to semi (family level) intensive shrimp cultures.

6.2 Study on the Best-suited Polder Area Improvement coping with Saline Intrusion (North Ben Tre Area)

6.2.1 Rationale

Saline intrusion is the top priority issue against climate change identified in the coastal are of Mekong Delta. Slow but concrete sea level rise has been observed and recorded during last 2 decades so saline intrusion area has gradually been wide-spreading. North Ben Tre is one of the most affected areas by saline water intrusion since years ago. The Government has so far constructed sea water prevention sluice gates as well as a barrage at a downstream location of Ba Lai river. These facilities are well functioning; however further saline intrusion is expected up until the north western tip of the North Ben Tre province in future.

Figure 6.2.1 Study Area of North Ben Tre (Polder Area Improvement)

Therefore Ben Tre DARD (Department of Agriculture and Rural Development) has a plan to further establish sluice gates and sift the fresh-water intake point toward the upstream tip of the area. This in-depth study examines the technical feasibility of the current plan and recommends best-suited polder area improvement coping with saline intrusion based on simulations and some research-study.

In addition, given the Ba Lai barrage (sluice gate) in early 2000s, there may be an issue of eutrophication (overabundance of nutrients) in the Song Ba Lai (Ba Lai river) since the river is closed by the sluice gate. Therefore this study carries out periodical water quality check in order to examine the eutrophication level caused by the blockage of the river.

6.2.2 Components of Study

This study consists of three major components; one is hydraulic simulation on availability of fresh water from sluices which are going to be constructed, the second is salinity level measurement at different depth of river, and the third is water quality test at the dead end of canal system.

1) Simulation

The simulation aims to identify the potential fresh water intake under sea level rise condition; now intake is planned at “Tan Phu”, the most upstream point of Ben Tre province. In the simulation, several types of river discharges are employed and rainfall is also considered;

- ✓ Simulation model covers not only whole Mekong Delta but also some areas along Mekong River up to Kratie in Cambodia; the whole area of the model is applied for each simulation.
- ✓ Boundary conditions are given at; Kratie for upstream boundary with hourly water and salinity level, coastal 9 stations for downstream boundary with hourly water and salinity level.
- ✓ Model calibrations are applied by hourly data of 365days in targeted years; an average year for 2008, a flood year for 2000, a draught year for 1998.
- ✓ Model calibration in rainy season (flood) is conducted by comparison with 23 inland hourly water level stations; simulation errors are verified less than 5%.
- ✓ Model calibration in dry season (draught) is conducted by comparison with 12 inland stations; the same magnitude and trend are confirmed between observed hourly but intermittence data and simulation results.
- ✓ Discharge in 1991 represents the current discharge which has a similar annual value to the average discharge between 1991and 2000.
- ✓ Discharge in 1998 represents the experienced minimum discharge.
- ✓ Probable discharges by certain percents are employed for planning/design purpose on hydraulic system/structures projected during the period between 2011 and 2050 coupled with sea level rise.
- ✓ Rainfall data in 1998 are employed which are obtained from My Tho meteorological station.
- ✓ Different sea levels are applied to the simulation from 0cm to 100cm according to climate change scenario.

Water demand in Ben Tre province is calculated based on the latest land use map in 2008, then monthly water demand is calculated according to the map. Total 12 intake places are examined in the simulation so as to maximize irrigation efficiency. Based on these conditions, present and future situations have been compared and risks and advantages in future have been identified.

2) Salinity Content Measurement

Salinity content is measured in order to confirm existence of phenomenon of salt wedge formulation during sea water intrusion into river. The measurement is done at three different depths in a river; at the lowest point near the river bottom, medium point, the highest point near river water surface. This measurement is now going on and will be reported in a coming version of report.

3) Water quality test

Water quality test has been conducted to sampled water collected at 4 locations along the Ba Lai river as; 1) at the behind of the Ba Lai sluice gate, 2) at the front of the Ba Lai sluice gate, 3) at the intermediate point between the Ba Lai sluice and junction point with Giao Hoa canal, and 4) at the junction point with the Giao Hoa canal. This test is also now going on and it will be also reported in a coming report.

6.2.3 Simulation Results

1) Cases of Simulation

Total 26 cases of simulations have been conducted. To grasp current situation, an average discharge 1991-2000 (MRC) is employed. The minimum experienced discharge is selected in order to understand the most serious condition of drought from recorded data. Some projected discharges are also adopted for design and planning purposes; a discharge of 5% probability means the design standard of drought for urban water supply purpose in the projected year(s), a discharge of 15% probability is for the policy objective of irrigation project plan and design against drought by Vietnamese government, a discharge of 25% probability is for the existing plan and design standard on irrigation project, and a discharge of 50% probability represents future common condition. Cases are shown below.

Table 6.2.1 Conducted Simulation Cases for Saline Intrusion to Ben Tre Province

No.	Cases[1]	Selection of the Discharge	SLR (cm)	Hydraulic Facilities	Water demand
1	**FBD 91-00 SLR00**	Average Discharge of 1991-2000	0	Plan is implemented	2008
2	**FBD 91-00 SLR17**	Average Discharge of 1991-2000	17	Plan is implemented	2008
3	**FBD 91-00 SLR30**	Average Discharge of 1991-2000	30	Plan is implemented	2008
4	**FBD 91-00 SLR50**	Average Discharge of 1991-2000	50	Plan is implemented	2008
5	**FBD 91-00 SLR100**	Average Discharge of 1991-2000	100	Plan is implemented	2008
6	**DY 1998 SLR00**	Dry Year Discharge (1998)	0	Plan is implemented	2008
7	**DY 1998 SLR17**	Dry Year Discharge (1998)	17	Plan is implemented	2008
8	**DY 1998 SLR30**	Dry Year Discharge (1998)	30	Plan is implemented	2008
9	**DY 1998 SLR50**	Dry Year Discharge (1998)	50	Plan is implemented	2008
10	**DY 1998 SLR100**	Dry Year Discharge (1998)	100	Plan is implemented	2008
11	**DPD 5% SLR17**	Projected Drought Discharge (Probability 5%, 2011-2050; B2)	17	Plan is implemented	2008
12	**DPD 5% SLR30**	Projected Drought Discharge (Probability 5%, 2011-2050; B2)	30	Plan is implemented	2008
13	**DPD 5% SLR50**	Projected Drought Discharge (Probability 5%, 2011-2050; B2)	50	Plan is implemented	2008
14	**DPD 5% SLR100**	Projected Drought Discharge (Probability 5%, 2011-2050; B2)	100	Plan is implemented	2008
15	**DPD 15% SLR17**	Projected Drought Discharge (Probability 15%, 2011-2050; B2)	17	Plan is implemented	2008
16	**DPD 15% SLR30**	Projected Drought Discharge (Probability 15%, 2011-2050; B2)	30	Plan is implemented	2008
17	**DPD 15% SLR50**	Projected Drought Discharge (Probability 15%, 2011-2050; B2)	50	Plan is implemented	2008
18	**DPD 15% SLR100**	Projected Drought Discharge (Probability 15%, 2011-2050; B2)	100	Plan is implemented	2008
19	**DPD 25% SLR17**	Projected Drought Discharge (Probability 25%, 2011-2050; B2)	17	Plan is implemented	2008
20	**DPD 25% SLR30**	Projected Drought Discharge (Probability 25%, 2011-2050; B2)	30	Plan is implemented	2008
21	**DPD 25% SLR50**	Projected Drought Discharge (Probability 25%, 2011-2050; B2)	50	Plan is implemented	2008
22	**DPD 25% SLR100**	Projected Drought Discharge (Probability 25%, 2011-2050; B2)	100	Plan is implemented	2008
23	**DPD 50% SLR17**	Projected Drought Discharge (Probability 50%, 2011-2050; B2)	17	Plan is implemented	2008
24	**DPD 50% SLR30**	Projected Drought Discharge (Probability 50%, 2011-2050; B2)	30	Plan is implemented	2008
25	**DPD 50% SLR50**	Projected Drought Discharge (Probability 50%, 2011-2050; B2)	50	Plan is implemented	2008
26	**DPD 50% SLR100**	Projected Drought Discharge (Probability 50%, 2011-2050; B2)	100	Plan is implemented	2008

Note; SLR: Sea Level Rise

[1] FBD; Base Discharge in Flood season, FPD; Projected Discharge in Flood season, DY; Dry Year Discharge in certain year, DBD; Base Discharge in Dry season by average, DPD; Projected Discharge in Dry season under basin Development plan

There are some conditions for the aforementioned simulation;

- ✓ The hydraulic structures of North Ben Tre are considered to be implemented in accordance with existing development plan.
- ✓ The minimum water level for canals is fixed at -2m for navigation purpose by Ministry of Transportation, then, a rule is applied that irrigation is not possible when water level in canal becomes -2m; water level at the end of Main canal should not be lower than -2m. This means that the upstream point of Balai barrage (dead end point of main canal) should be the control point of water level for this project.
- ✓ Salinity level should be lower than 2g/L for irrigation according to planning and design standard of SIWRP; fresh water in this simulation is defined water having salinity level less than 2g/L.

2) Results

2.1) Saline Intrusion

A study on saline intrusion has been conducted in order to evaluate potential places of fresh water intake. For the purpose of irrigation use, saline contents of the water shall not be more than 2g/L. There are total four major candidate locations for sluices/gates construction out of 12 locations of existing construction plan. The names of those candidates are; Ben Ro and Ben Tre are at west side of the North Ben Tre isle pointing at from upstream, Tan Phu and An Hoa are located in east side of the North Ben Tre isle in order from upstream side. Result is summarized in the following figures;

Average Discharge 1991-2000:

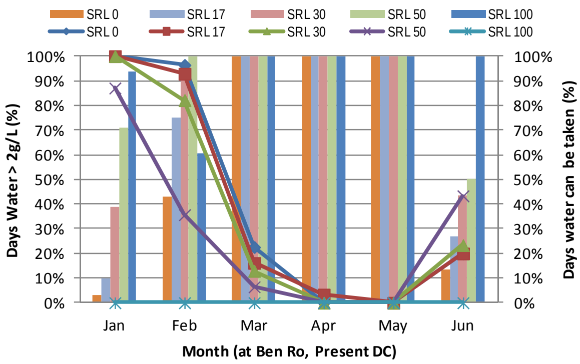


Figure 6.2.2 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): average Discharge of '91-00, at Ben Ro Intake: west)
Source: Sub-IHESV and Study Team

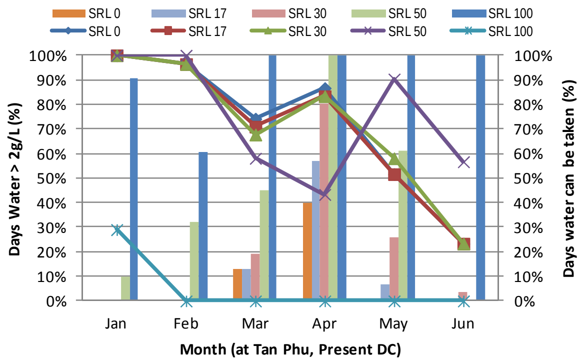


Figure 6.2.3 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): average Discharge of '91-00, at Tan Phu Intake: east)
Source: Sub-IHESV and Study Team

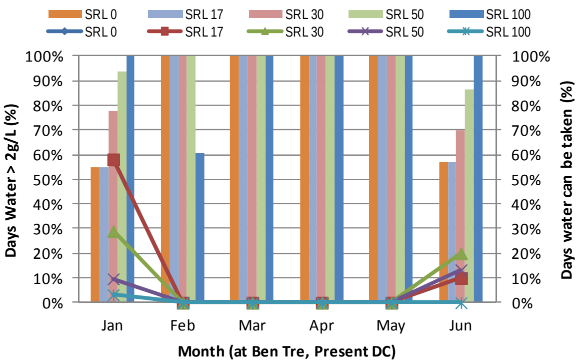


Figure 6.2.4 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): average Discharge of '91-00at Ben Tre Intake: west)
Source: Sub-IHESV and Study Team

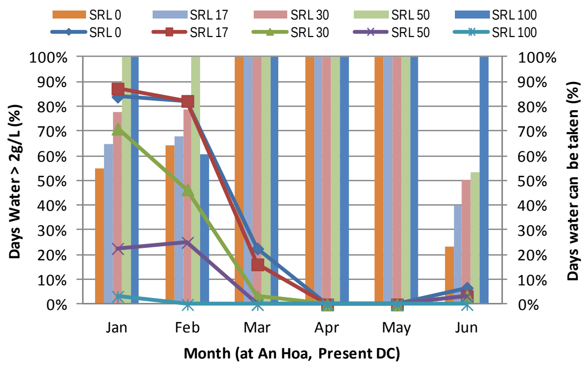


Figure 6.2.5 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): average Discharge of '91-00, at An Hoa Intake: east)
Source: Sub-IHESV and Study Team

The average discharge of 1991-2000 represents the observed ordinary river flow in recent years. In figures, bars show percentage of days in a month that saline contents is equal or higher than 2g/L at each intake point. Lines show percentage of days in a month that fresh water is available some time a day taking into account of both saline content (< 2g/L) and water level at intake points (river water level needs to be higher than canal water level).

Saline intrusion without sea level rise can be seen at those 4 locations in April. Villagers living nearby those stations have reported during interview by the Study Team that they have experiences of saline intrusion in the dry season. The study team also has confirmed saline intrusion in April at Ben Tre and An Hoa through field observation described in 6.4.2 of this Chapter. Since North Ben Tre is completely surrounded by the Mekong River, saline intrusion at the most upstream places will limit villagers' access to fresh water. To increase availability of fresh water from the upstream place of North Ben Tre, fresh water intake by gate operation plays important role.

Intake is possible at Tan Phu in all months of dry season except the case of 100cm sea level rise. At Ben Tre, fresh water is not available completely in March, April and May. Intermediate condition of these two cases can be observed at Ben Ro and An Hoa that fresh water can be taken until March but not available in April and May.

- ✓ Saline intrusion occurs at all candidate locations of sluice gate construction of North Ben Tre in April even in an average year.
- ✓ Tan Phu is a candidate for a main intake point throughout of a year without high sea level rise.
- ✓ Gate shall be closed from February to May at Ben Tre intake in order to prevent saline intrusion.
- ✓ Frequent gate operation of open and close will be necessary at Ben Ro and An Hoa in March because the number of days, which fresh water is available, is quite limited.

<u>Discharge 1998 (Dry Year)</u>:

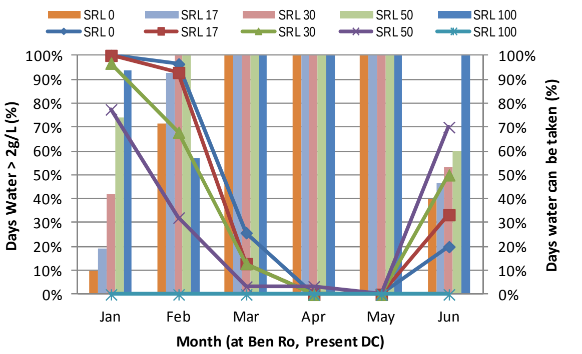


Figure 6.2.6 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Dry Year Discharge of 1998, at Ben Ro Intake: west)
Source: Sub-IHESV and Study Team

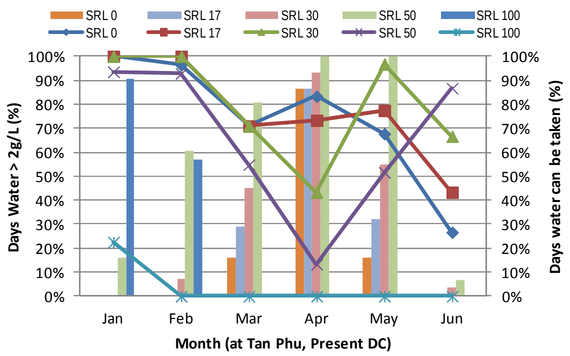


Figure 6.2.7 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Dry Year Discharge of 1998, at Tan Phu Intake: east)
Source: Sub-IHESV and Study Team

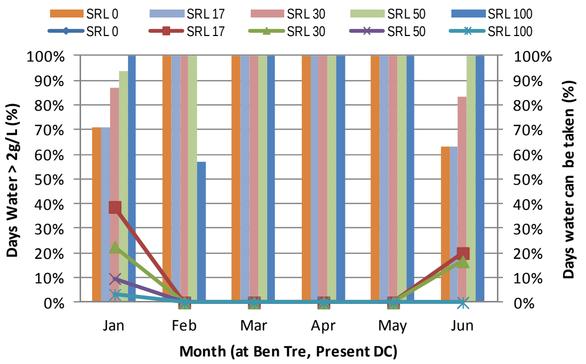


Figure 6.2.8 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line) Dry Year Discharge of 1998, at Ben Tre Intake: west)
Source: Sub-IHESV and Study Team

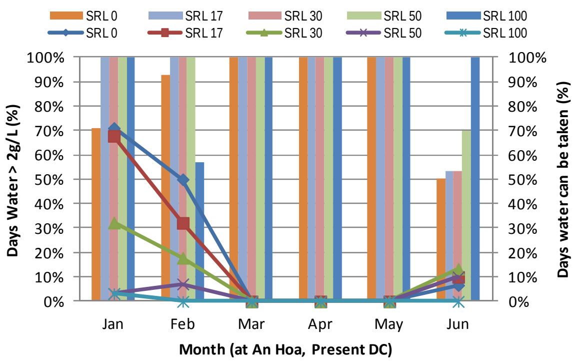


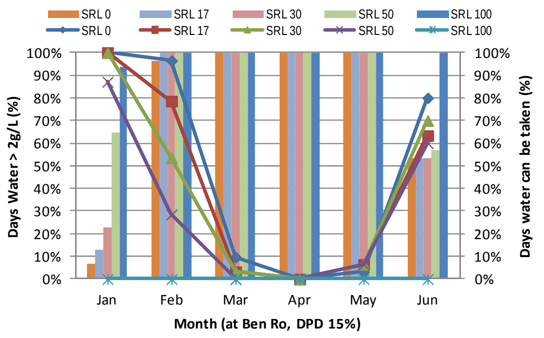
Figure 6.2.9 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line) Dry Year Discharge of 1998, at An Hoa Intake: east)
Source: Sub-IHESV and Study Team

The discharge of 1998 represents the experienced minimum discharge in Mekong Delta in recent years. Figure 6.2.7 shows that Tan Phu can take fresh water throughout the year up to 2050 except in the case of 100cm sea level rise (projected year 2100). Tan Phu is located in the most upstream and east side in North Ben Tre isle. Opposite side (west) of Tan Phu in North Ben Tre isle is Ben Ro but fresh water in April and May is not available so much in comparison to Tan Phu. Sluices in downstream side, Ben Tre and An Hoa show similar trend with Ben Ro. In comparison with the case of discharge 1991-2000, An Hoa shows decrease of available days of fresh water from January to March as shown in Figure 6.2.9.

- ✓ It can be said that Tan Phu has a potential of fresh water intake in dry season in comparison with other places except 100cm sea level rise case.
- ✓ A similar trend can be seen at Ben Ro, An Hoa, and Ben Tre in two cases; the average discharge 1991-2000 and discharge 1998.
- ✓ From March to June, there are no bars in figure (Tan Phu) that computer program running has stopped because of low water level in main canal in case of SLR 100cm.

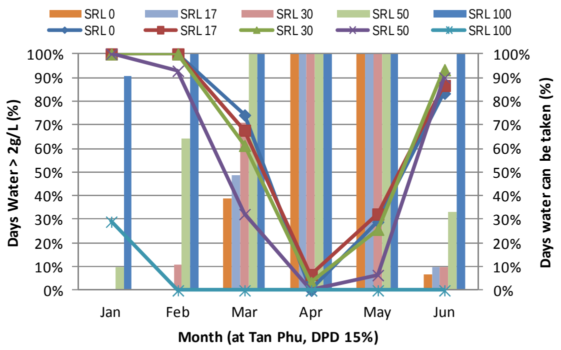
Decrease of available days of fresh water intake can be seen from April in Tan Phu that rain fall may affect water level of main canal; water level of main canal becomes higher than river water level. Available days of fresh water intake at other sluices also show nearly the same tendency; available day decreases from January, few days in March – May, but it recovers in June.

<u>Discharge of 15% Provability</u>:



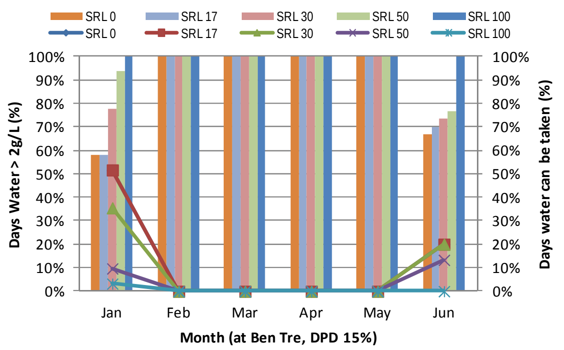
<u>Figure 6.2.10 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Projected Discharge of 15% Provability, at Ben Ro Intake: west)</u>

Source: Sub-IHESV and Study Team



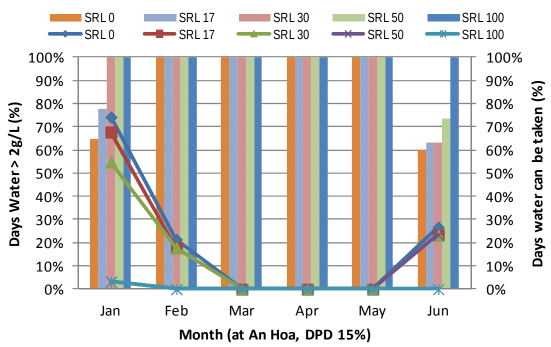
<u>Figure 6.2.11 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Projected Discharge of 15% Provability, at Tan Phu Intake: east)</u>

Source: Sub-IHESV and Study Team



<u>Figure 6.2.12 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Projected Discharge of 15% Provability, at Ben Tre Intake: west)</u>

Source: Sub-IHESV and Study Team



<u>Figure 6.2.13 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Projected Discharge of 15% Provability, at An Hoa Intake: east)</u>

Source: Sub-IHESV and Study Team

Projected discharge of 15% probability represents targeted design discharge for irrigation purpose of Vietnam government. At the present time, SIWRP uses discharge of 25% probability because of shortage of irrigable water in planning.

- ✓ Salinity intrusion becomes serious from February to May at Ben Ro, Ben Tre, and An Hoa.
- ✓ Possible day of fresh water intake falls down extremely in April at Tan Phu.

2.2) Water Level

Water level of -2m is the lowest limitation for navigation system. The maximum salinity content of irrigation purpose is 2g/L. Total 12 intakes are planned for construction in North Ben Tre according to the existing implementation plan to satisfy water demand of the area. The following figures indicate water level at the control point (Balai barrage) taking into account both the minimum water level and the maximum saline content. If water level (shown by line) is higher than -2m, water in canal can be taken and used for irrigation and domestic purposes.

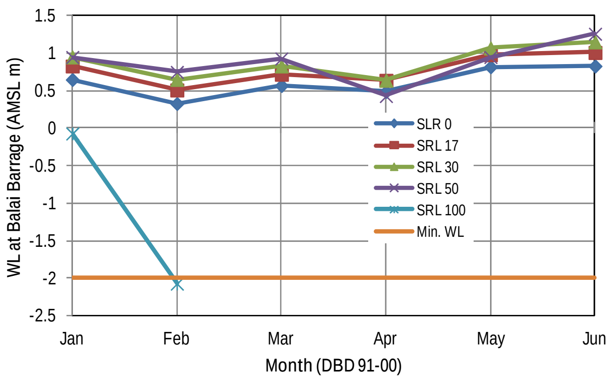


Figure 6.2.14 Water Level at Control Point (Upstream of Balai Barrage) under 1991-2000 mean Discharge
Source: Sub-IHESV and Study Team

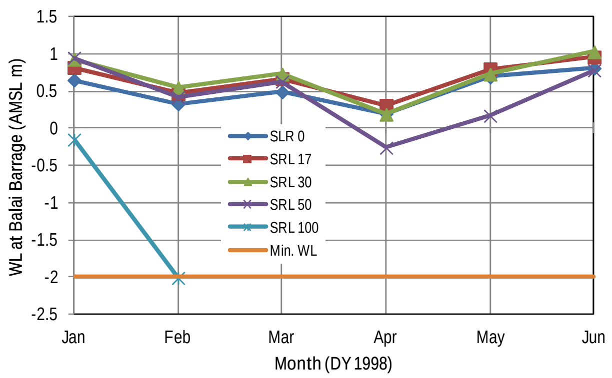


Figure 6.2.15 Water Level at Control Point (Upstream of Balai Barrage) under Dry Year 1998 Discharge
Source: Sub-IHESV and Study Team

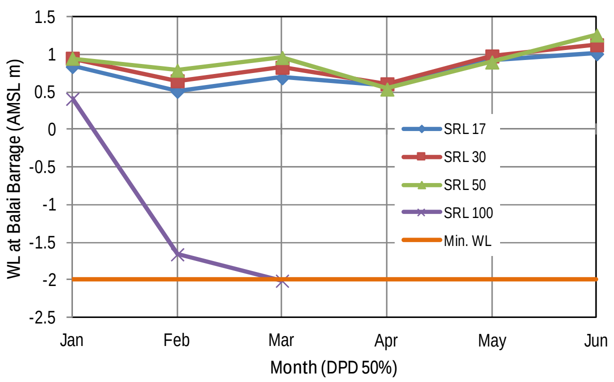


Figure 6.2.16 Water Level at Control Point (Upstream of Balai Barrage) under Discharge of Probability 50%
Source: Sub-IHESV and Study Team

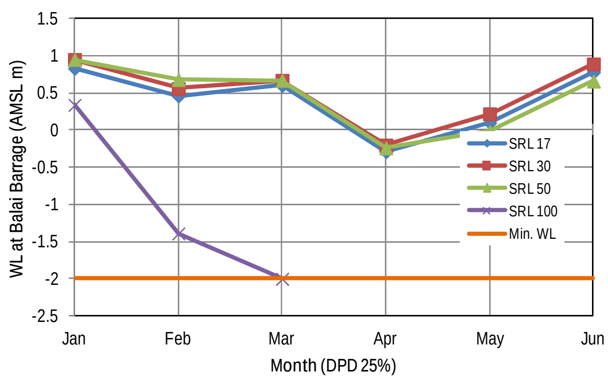


Figure 6.2.17 Water Level at Control Point (Upstream of Balai Barrage) under Discharge of Probability 25%
Source: Sub-IHESV and Study Team

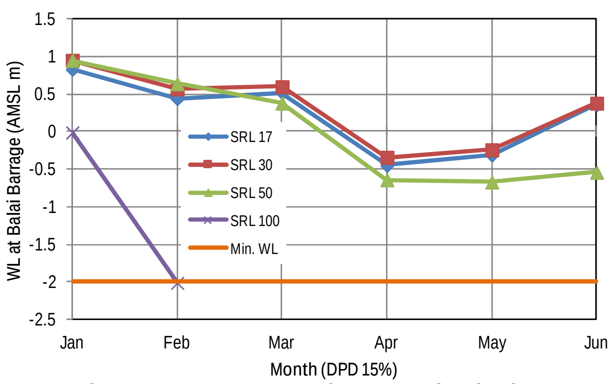


Figure 6.2.18 Water Level at Control Point (Upstream of Balai Barrage) under Discharge of Probability 15%
Source: Sub-IHESV and Study Team

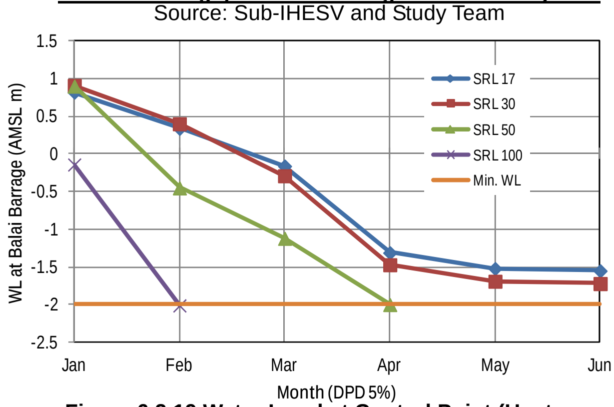


Figure 6.2.19 Water Level at Control Point (Upstream of Balai Barrage) under Discharge of Probability 5%
Source: Sub-IHESV and Study Team

All cases show that water levels at the control point decrease by -2m in February and/or March in case of SRL 100cm. In a series of sea level rise simulations (17cm, 30cm, and 50cm), water level does not decrease down to -2m at the control point (except probability 5%). It means that stored water in the main canal can be used for water supply in North Ben Tre isle. The following table shows balance of water demand and supply by average discharge 1991-2000 coupled with sea level rise 30cm (scenario in 2050).

Table 6.2.2 Water Supply Capacity of each Sluice and Water Demand in Ben Tre (P=15%, SLR30cm)

No.	Name of Sluice	Jan	Freb	Mar	Apr	May	June	Total
1	Rach Chua	0.2	0.2	0.3	0.1	0.2	0.2	1.2
2	Tan Phu	4.5	12.1	8.2	0.6	5.2	6.4	37
3	Bon Thon	3.3	4.1	1.5	0.2	1.1	2.4	12.6
4	Kinh Dieu	1.1	0.9	0.1	0	0	0.6	2.7
5	Vam Nhua	0.2	0.1	0	0	0	0	0.3
6	An Hoa	10.4	5.3	0	0	0	1.9	17.6
7	Ben Ro	1.7	0.5	0	0	0	0.5	2.7
8	Thuc Dao	0.5	0.1	0	0	0	0.1	0.7
9	Bai Dac	0.7	0	0	0	0	0.2	0.9
10	Ong Doc	0.7	0	0	0	0	0.2	0.9
11	Song Ma	0.2	0	0	0	0	0	0.2
12	Ben Tre	6.4	0	0	0	0	1.5	7.9
Supply Capacity (m3/sec)		**29.9**	**23.3**	**10.1**	**0.9**	**6.5**	**14**	**84.7**
Water Demand (m3/sec)		**26.32**	**32.89**	**22.93**	**15.86**	**5.8**	**7.26**	**168.2**
Balance (m3)		**9,279,360**	**-24,857,280**	**-33,255,360**	**-38,776,320**	**1,814,400**	**17,470,080**	**-68,325,120**

The table shows that total deficit in this dry season reaches 68million m^3 starting from February and this water deficit continues until April.

3) Discussions

Total 12 intake places have been examined; Tan Phu can be said that it is the most reliable intake place in Ben Tre isle in terms of salinity level and available days of fresh water intake (see Figure 6.2.2 -6.2.9), however, total supply of water from 12 intakes is not enough in March and April (in case of discharge of 15% probability) shown in Table 6.2.2.

Insufficient water can be taken from canal-storage in March and April because its storage capacity at +0.5m AMSL (water level in March of 15% provability discharge) is about 78million m^3. Water level at the Ba Lai goes down from +0.5m to -0.5m in April as a result of water consumption of about 39million m^3. A relationship between water level and storage capacity is shown in Figure 6.2.20.

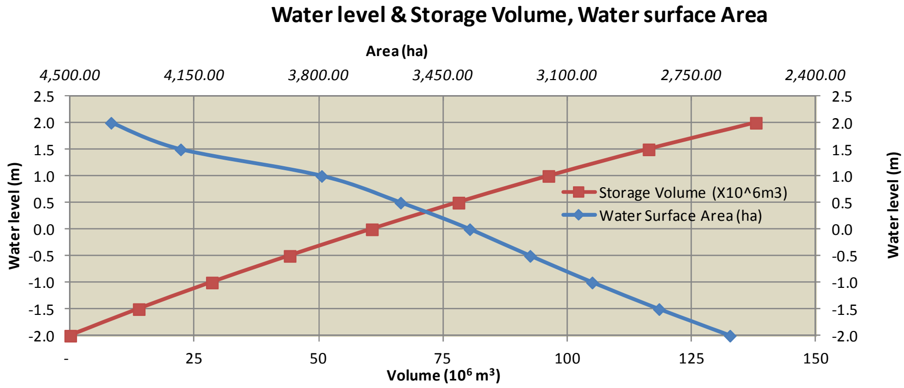


Figure 6.2.20 Area and Storage Capacity Curve for Ben Tre Main Canal
Source: Sub-IHESV and Study Team

Canals in North Ben Tre isle can store about 137million m^3 of water above -2m AMSL. Water level in the canal shall always be kept as high as possible in order to prevent the area from severe drought. Slide gate can be considered to be a suitable gate type instead of swing type gate because smooth operation of open and close can be performed. Gate operation of open and close will require adequate information through monitoring system of both saline content and water level in and around the area. Consequently, introduction of integrated monitoring and operation system will be a key to cope with saline intrusion especially for climate change in future.

6.2.4 Study on Salt Wedge Appearance

In some of estuaries of big rivers, it is known that salt wedge takes place. Salt wedge means that sea water whose unit weight is heavier than freshwater intrudes into the river crawling on the river bed while the fresh water which unit weight is lighter than sea water, lies above the sea water. If this kind of differentiated water stratum takes place in the estuaries of Mekong River, there is a possibility of selective intake of fresh water by, for example, introducing double sliding gate. Double sliding gates make it possible to intake upper portion of water where lighter fresh water exists, leaving the heavier salt water not to be in-taken.

To know and confirm occurrence of salt wedge, salinity level measurement at 3 depths was done at the planed construction places of An Hoa sluice and Ben Tre sluice. Figure 6.2.21 shows the salinity level recorded at Ben Tre site and Figure 6.2.22 show the record of An Hoa site. Both data were measured during high tide. The figures show there is not much different in the salinity level by depth. The salinity level starts rising from end of March, peaking at around mid April, and starts descending toward May, however during the ascending and descending the period no noticeable difference in the salinity level takes up. Therefore, it is concluded that selective fresh water intake is not possible at the sites where Ben Tre and An Hoa sluices are to be constructed.

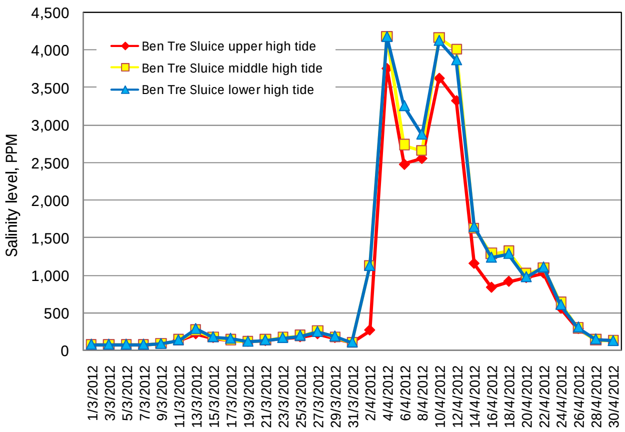


Figure 6.2.21 Salinity Level at Ben Tre Sluice Site

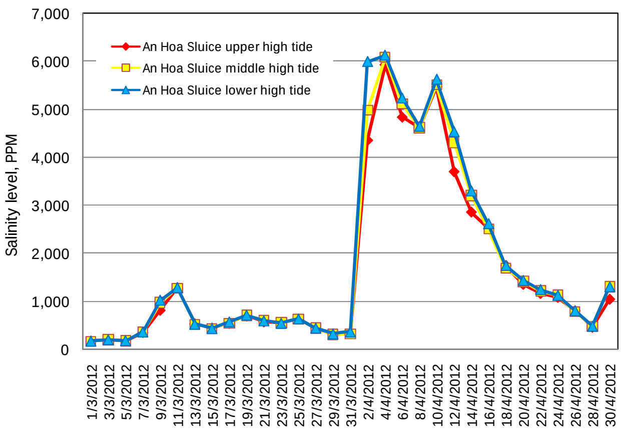


Figure 6.2.22 Salinity Level at An Hoa Tre Sluice Site

6.2.5 Introduction of Effective Gate

Aforementioend examintion revealed that there is no salt wedge appreance in the planned sites of Ben Tre sluice and An Hoa sluice, and probably to the extent of Mekong River estuaries. It means that during dry season saline water intrusion results in no chance of fresh water intake. However, there might be a time in a day when the salinity level of the water becomes low. If there is time when the salinity level goes down in a day, the gate can be opened to intake the fresh water while the gate should remain closed when the salinity level is high. To know this possibility, records of water level and corresponding salinity levels were collected.

The records shown in Figure 6.2.23 were collected from DONRE, Ben Tre, for the measuring station of My Hoa, located at the entrance point of Ben Tre channel (Ben Tre sluice is planned at about 5 km downstream (inland from My Hoa). As shown in the figure, salinity level goes up and goes down significantly depending on the water level. In general, when the water level is high, the salinity level becomes high while the water level goes down, the salinity level does the same. It implies that when the water level is high the tidal effect is strong, sea water pushes fresh water back into the river upstream, whereby salinity level of the river water becomes high.

Taking this fact into consideration, there is a possibility of in-taking fresh water in a short period of hours in a day even during dry season. To intake fresh water for, say, 2-3 hours only in a day, the gate should be of vertical sliding type instead of swing gate currently employed widely in Mekong Delta. Therefore, it is recommended that the gate type to be introduced for Ben Tre and An Hoa sluices should be of vertical sliding type and should be operated by artificial power (note that the currently common swing gate is operated by utilizing the difference of water level up and downstream sides of the gate, so that frequent and on-time operation is not possible).

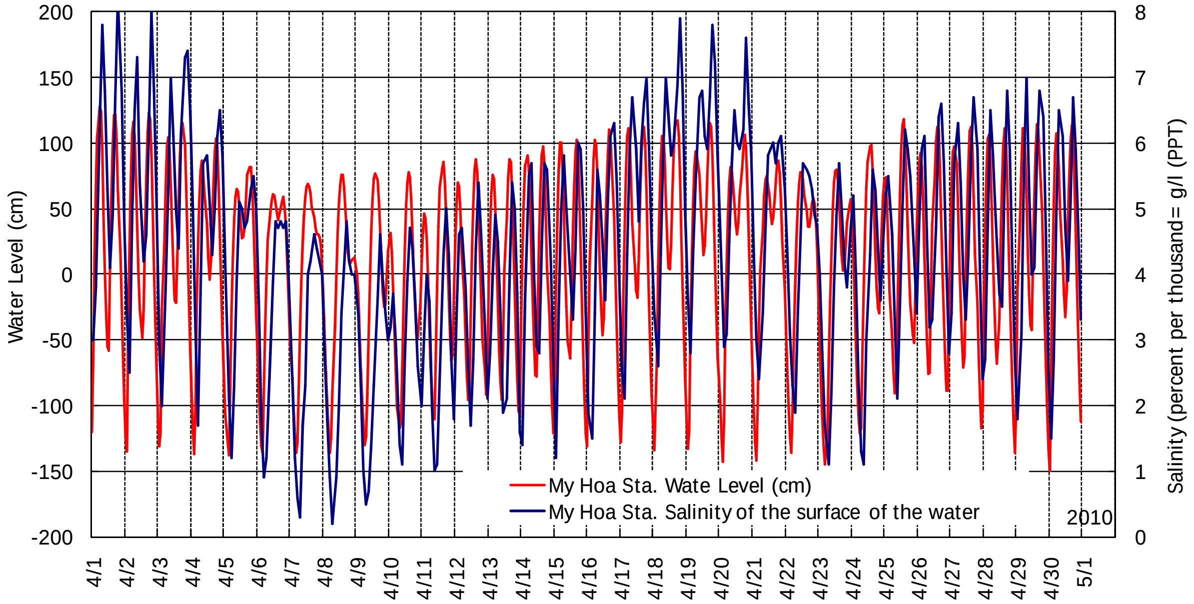


Figure 6.2.23 Water Level and Corresponding Salinity Level Recorded at My Hoa Station,
Source: DONRE of Ben Tre Province

6.2.6 Water Quality at Ba Lai River (Closed River)

Ba Lai river flows at almost central part of North Ben Tre; before reaching estuary of this river there is a sluice gate constructed in year 2002. The gate serves for the purpose of preventing saline water coming from the nearby downstream sea, whereby it is closed during dry season (during rainy season it is opened to release flood water to the sea). The water quality in the Ba Lai river may be worsened, especially in terms of eutrophication, due to close of the Ba Lai river at the end coupled with additional gates being constructed in future to prevent upcoming saline water.

Figure 6.2.24 Location of the Water Sample Collected

To examine the future water quality worsening, water quality of the Ba Lai river, as the first step, was investigated. Table 6.2.3 shows the water quality test results of the samples collected right before the Ba Lai sluice gate (see Figure 6.2.24 for the location. Also the samples were collected at upper and mid points of the Ba Lai river showing better water quality test results). Some samples fail to meet the standards as shown in the table, yet there is no significant problem and the conditions are expected to improve in and after May, the onset of rainy season. Therefore, it is, though preliminary examination, expected that acute water quality problem would hardly take place even in future because fresh water is planned to intake from upper part of the north Ben Tre during dry season and also the present quality could be said to be not much worse.

Table 6.2.3 Water Quality Test Results for Water Sample from Ba Lai Most Downstream Point

Indicator		Monthly Average			Worst	Vietnamese National Regulation		
		Feb.	March	Apr.		Surface water for aquatic life	Irrigation	Coastal water, aquaculture
Eutrophication	NO_3-N (mg/l)	0.028	0.020	0.297	0.366	<0.02	<0.04	-
	NH_4-N (mg/l)	0.131	0.171	0.054	0.274	<1.0	<0.5	<0.1
	PO_4 (mg/l)	0.082	0.094	0.048	0.183	-	<0.3	-
Water pollution	DO (mg/l)	4.22	5.91	5.42	3.74	>4	>2	>5
	BOD (mg/l)	0.9	0.7	0.5	1.0	-	<15	-
Turbidity	TSS (mg/l)	51	88	97	128	<100	<50	<50
Acidity	SO_4 (mg/l)*	50	400	1,477	1,549	-	<600	-
	pH	7.65	7.71	7.61	7.85	6.5-8.5	5.5-9.0	6.5-8.5
Salinity	EC(μS/cm)	1,243	8,358	29,567	31,700	-	-	-
	TDS (mg/l)**	796	5,349	18,923	20,288	<1000	<2000	-

Source; JICA Project Team

6.3 Study on the Fresh Water Recruitment for Tra Vinh Paddy Areas (from Vinh Long province)

6.3.1 Rationale

Tran Vinh province has been affected by sea water intrusion, and in year 2011 it is said that serious harvest loss more than 70% occurred in about 8,000 ha of winter-spring paddy and harvest loss about 30-70% was found in the areas of about 3,000ha (the total paddy area in Tra Vinh province arrived at 92,000 ha in 2010, GSO). To protect the paddy area in the Tra Vinh province, construction of sluice gates at the mouths of channels (water supply and drainage canals) alone is not enough. Here in this province, there should be canal extension towards upstream area that there is a candidate of fresh water intake place in Vinh Long province shown in the Figure 6.3.1.

Figure 6.3.1 Study Area; Tra Vinh (Fresh Water Recruitment)

The project here presented is of trans-boundary, for which the freshwater is taken in the Vinh Long province and ferried to the downstream province, which is Tra Vinh province. In this regard, this study examined 1) technical feasibility of trans-boundary water conveyance, and 2) preparation of resettlement plan in and around the project.

6.3.2 Components of Study

This study consists of two major components; one is hydraulic simulation on fresh water availability from an intake which is planned at the place facing Mekong River in Vinh Long province, the second is to examine existing resettlement plan prepared by Tra Vinh DARD and conduct field survey conforming to JICA guideline.

1) Simulation

Simulations on the saline intrusion have been conducted for the area of Tran Vinh and Vinh Long provinces with projected discharges and several sea level rise scenarios. The simulations aim to examine technical feasibility of the project for conveying fresh water from upstream side. If water quality and water head are not enough for this water conveyance, some other new candidates of intake place shall be found out instead of the existing plan. In order to maximize intake efficiency, total 11 sluices have been considered as candidates of intake taking fresh water into the area. In the simulation, several types of river discharges are employed. Conditions of the simulation are as follows;

- ✓ Simulation model covers not only whole Mekong Delta but also some areas along Mekong River up to Kratie in Cambodia; the whole area of the model is applied for each simulation.
- ✓ Boundary conditions are given at; Kratie for upstream boundary with hourly water and salinity level, coastal 9 stations for downstream boundary with hourly water and salinity level.
- ✓ Model calibrations are applied by hourly data of 365days in targeted years; an average year for 2008, a flood year for 2000, a draught year for 1998.
- ✓ Model calibration in rainy season (flood) is conducted by comparison with 23 inland hourly water level stations; simulation errors are verified less than 5%.
- ✓ Model calibration in dry season (draught) is conducted by comparison with 12 inland stations; the same magnitude and trend are confirmed between observed hourly but intermittence data and simulation results.
- ✓ Discharge in 1991 represents the current discharge which has a similar in annual value to the average discharge between 1991 and 2000.
- ✓ Discharge in 1998 represents the experienced minimum discharge which saline intrusion is examined with sea level rise.
- ✓ Probable discharges by certain percents are employed for planning/design purpose on hydraulic system/structures projected during the period between 2011 and 2050 coupled with sea level rise.
- ✓ Rainfall data in 2008 are employed which are obtained from Tra Vinh and My Tho meteorological stations.
- ✓ Different sea levels are applied to the simulation from 0cm to 100cm according to climate change scenario.

Water demand in Tra Vinh province is calculated based on the latest land use map in 2008 and the map is also used for calculation of monthly water demand. Based on the aforementioned simulation, present condition and future condition have been compared and risks in future have been identified.

2) Resettlement Plan

In order to increase effect of trans-boundary water conveyance, canal system improvement (widening and dredging) is one of the best methods. Since existing canals are narrow and there are residential areas where people make daily livings along the canals, resettlement is not avoidable for this project. Tra Vinh provincial DARD has carried out preliminary settlement plan with required cost. Based on this plan and additional field survey, detailed resettlement plan is prepared with reference to a JICA guideline. This resettlement plan shall be confirmed in a coming stage of study.

6.3.3 Simulation Results

1) Cases of Simulation

Total 26 cases of simulations are conducted. In order to grasp current situation, an average discharge 1991-2000 (MRC) is employed. The minimum experienced discharge is selected to understand the most serious condition of drought from recorded data. Some projected discharges are also adopted for design and planning purposes; a discharge of 5% probability means the design standard of drought for urban water supply purpose in the projected year(s), a discharge of 15% probability is for the policy objective of irrigation project plan and design against drought by Vietnamese government, a discharge of 25% probability is for the existing plan and design standard on irrigation project, and a discharge of 50% probability represents future common condition. Cases are shown below.

Table 6.3.1 Conducted Simulation Cases for Saline Intrusion to Tra Vinh Province

No.	Cases (Saline Simulation)	Selection of the Discharge	SLR (cm)	Hydraulic Facilities	Water demand
1	**FBD 91-00 SLR00**	Average Discharge of 1991-2000	00	Plan is implemented	2008
2	**FBD 91-00 SLR17**	Average Discharge of 1991-2000	17	Plan is implemented	2008
3	**FBD 91-00 SLR30**	Average Discharge of 1991-2000	30	Plan is implemented	2008
4	**FBD 91-00 SLR50**	Average Discharge of 1991-2000	50	Plan is implemented	2008
5	**FBD 91-00 SLR100**	Average Discharge of 1991-2000	100	Plan is implemented	2008
6	**DY 1998 SLR00**	Dry Year Discharge (1998)	00	Plan is implemented	2008
7	**DY 1998 SLR17**	Dry Year Discharge (1998)	17	Plan is implemented	2008
8	**DY 1998 SLR30**	Dry Year Discharge (1998)	30	Plan is implemented	2008
9	**DY 1998 SLR50**	Dry Year Discharge (1998)	50	Plan is implemented	2008
10	**DY 1998 SLR100**	Dry Year Discharge (1998)	100	Plan is implemented	2008
11	**DPD 5% SLR17**	Projected Drought Discharge (Probability 5%, 2011-2050; B2)	17	Plan is implemented	2008
12	**DPD 5% SLR30**	Projected Drought Discharge (Probability 5%, 2011-2050; B2)	30	Plan is implemented	2008
13	**DPD 5% SLR50**	Projected Drought Discharge (Probability 5%, 2011-2050; B2)	50	Plan is implemented	2008
14	**DPD 5% SLR100**	Projected Drought Discharge (Probability 5%, 2011-2050; B2)	100	Plan is implemented	2008
15	**DPD 15% SLR17**	Projected Drought Discharge (Probability 15%, 2011-2050; B2)	17	Plan is implemented	2008
16	**DPD 15% SLR30**	Projected Drought Discharge (Probability 15%, 2011-2050; B2)	30	Plan is implemented	2008
17	**DPD 15% SLR50**	Projected Drought Discharge (Probability 15%, 2011-2050; B2)	50	Plan is implemented	2008
18	**DPD 15% SLR100**	Projected Drought Discharge (Probability 15%, 2011-2050; B2)	100	Plan is implemented	2008
19	**DPD 25% SLR17**	Projected Drought Discharge (Probability 25%, 2011-2050; B2)	17	Plan is implemented	2008
20	**DPD 25% SLR30**	Projected Drought Discharge (Probability 25%, 2011-2050; B2)	30	Plan is implemented	2008
21	**DPD 25% SLR50**	Projected Drought Discharge (Probability 25%, 2011-2050; B2)	50	Plan is implemented	2008
22	**DPD 25% SLR100**	Projected Drought Discharge (Probability 25%, 2011-2050; B2)	100	Plan is implemented	2008
23	**DPD 50% SLR17**	Projected Drought Discharge (Probability 50%, 2011-2050; B2)	17	Plan is implemented	2008
24	**DPD 50% SLR30**	Projected Drought Discharge (Probability 50%, 2011-2050; B2)	30	Plan is implemented	2008
25	**DPD 50% SLR50**	Projected Drought Discharge (Probability 50%, 2011-2050; B2)	50	Plan is implemented	2008
26	**DPD 50% SLR100**	Projected Drought Discharge (Probability 50%, 2011-2050; B2)	100	Plan is implemented	2008

Note; SLR: Sea Level Rise

Some conditions have been developed in the simulation;

- ✓ Construction of hydraulic structures in Tra Vinh is considered to follow existing development plan.
- ✓ The minimum water level for canals is fixed at -1m for the sake of safe navigation purpose. By following the condition of this minimum water level, it is considered that irrigation is not possible when water level in canal reaches -1m; this means that the water level at the end of Main canal should not be lower than -1m; the upstream location of La Ban sluice (the dead end point of main canal) should be the control point of water level.
- ✓ Salinity level should be lower than 2g/L for irrigation according to planning and design standard of SIWRP; fresh water in this simulation is defined water having salinity level less than 2g/L.

2) Results

2.1) Saline Intrusion

Simulations on saline intrusion at intake places have been conducted. For irrigation purpose, saline contents of the water shall not exceed 2g/L. In this report, salinity level at 5 major intake locations is shown in order to grasp project features which the names of them are; Mang Thit1, Tan Dinh, and Ba Nghe locate along west side listed from upstream side, Mang Thit 2 and Vung Liem along east side from upstream. Results of the study are summarized as follows;

Average Discharge 1991-2000:

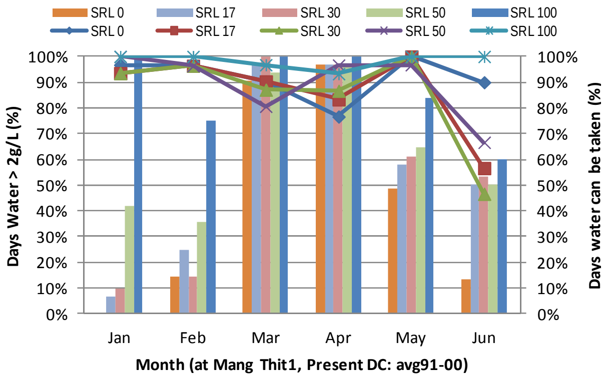


Figure 6.3.2 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): average Discharge of '91-00, at Mang Thit 1 Intake, west)
Source: Sub-IHESV and Study Team

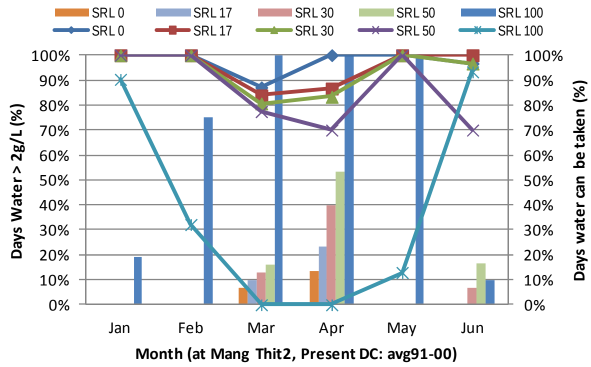


Figure 6.3.3 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): average Discharge of '91-00, at Mang Thit2 Intake, east)
Source: Sub-IHESV and Study Team

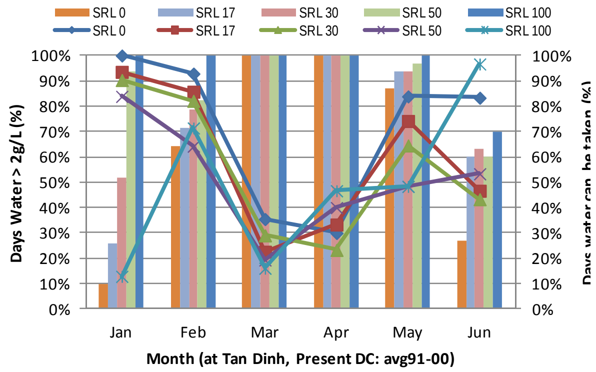


Figure 6.3.4 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): average Discharge of '91-00, at Tan Dinh Intake, west)
Source: Sub-IHESV and Study Team

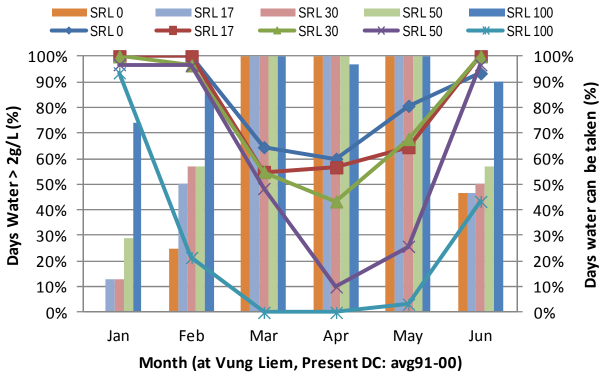


Figure 6.3.5 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): average Discharge of '91-00at Vung Liem Intake, east)
Source: Sub-IHESV and Study Team

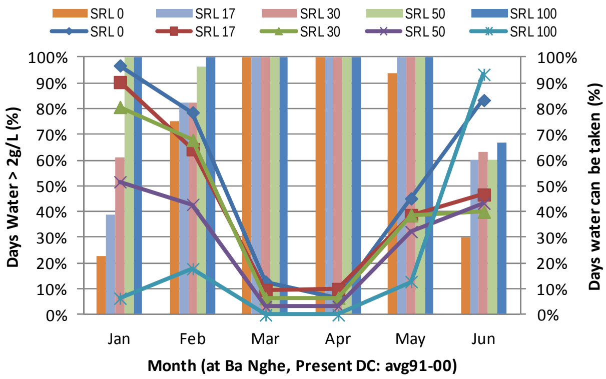


Figure 6.3.6 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): average Discharge of '91-00, at Ba Nghe Intake, west)
Source: Sub-IHESV and Study Team

The average discharge of 1991-2000 represents ordinary river flow in recent years. In figures, bars show percentage of days in a month that saline contents is equal or higher than 2g/L at each intake point. Lines show percentage of days in a month that fresh-water-intake is available some time a day taking into account of both saline content (< 2g/L) and water level at intake points (river water level needs to be higher than canal water level). Figures at left side indicate that intake places are at west side of Tra Vinh area and it is lined up from upstream side to down. The right side figures show that the intake places are located at east side of the area from upstream.

Saline intrusion without sea level rise occurs at those 5 locations in April. Field survey by the study team tells that villagers living nearby those stations have reported their experiences of saline intrusion in dry seasons. Water level at middle of May becomes the lowest in a year along the Mekong River in the Mekong Delta according to data obtained from Tan Chau and Chau Doc meteorological stations described in Chapter 2 of this report. The water level increases from middle of May, so that water level from April to middle of May can be said the lowest period in a year. Both sides of Tra Vinh Province are covered by saline water along Mekong River in this period so fresh water recruitment from Vinh Long Province becomes one of issues to be considered.

Apart from above, saline intrusion seems to be not so serious at upstream side (Mang Thit1 and Mang Thit2) under the discharge of average year. Available days of water-intake are limited in March and April at Ba Nghe and Tan Dinh. Vung Liem shows that saline intrusion from March to May is serious but fresh water intake is available more than half a month until 2050 (SRL17cm). Available days of fresh water intake show different trend between west and east side of Tra Vinh. Available days of fresh water intake at west side does not change much under different sea level rise in March and April while east side changes in a wide range: e.g. available days in March at Vung Liem under SRL0 is 65% (that of Tan Dinh is 35%) but that of SRL100cm becomes 0% (that of Tan Dinh is 20%). It may be caused by different discharge as follows;

Table 6.3.2 River Discharge in west and east of Tra Vinh Province

River name	River name	Discharge (m^3/sec)	Percentage	Accumulated Discharge
East side	Co Chien River	404	15.4%	566 (21.6%)
	Cung Hau River	162	6.2%	
West Side	Dinh An River	705	26.9%	1,197 (45.6%)
	Tran De River	492	18.7%	

(Source: SIWRP, calculated discharge from data 1996-2008)

Percentage in the table means the percentage against total discharge of Mekong River. According to the accumulated discharge in east and west, total discharge at east side of Tra Vinh is lower than west side and it is about half value of west side. Rich discharge at west side can push saline out easier than east side but poor discharge at east side may be difficult to push saline water out into downstream,.

- ✓ Saline intrusion occurs in April of an average year at the places; Mang Thit1, Tan Dinh, and Ba Nghe at west side Tra Vinh, Mang Thit 2 and Vung Liem at east side
- ✓ Saline intrusion at Ba Nghe is serious in March and April under the average discharge condition.
- ✓ Saline intrusion affect will be more serious in east side than west side due to weak discharge.
- ✓ Mang Thit1 and 2 will not be affected by saline intrusion so much until 2080.

The discharge of 1998 represents the experienced minimum discharge in Mekong Delta. Figures 6.3.7 – 6.3.11 show nearly the same tendency under the average discharge of 1991-2000. Ba Nghe, at the lowest site of Mekong river, shows increase of saline intrusion starting from February to May (bars in graph) and saline intrusion will happen almost every day.

- ✓ Discharge 1998 makes saline intrusion worse in Ba Nghe in comparison with the case of 1991-2000 average discharge.

- ✓ Fresh water intake at Ba Nghe in March and April is not available and saline intrusion into Tra Vinh will be caused from this point.
- ✓ Mang Thit2 does not show saline intrusion so much in both cases (1991-2000 average discharge and 1998 discharge) and it is considered that Mang Thit 2 is a kind of drainage canal from upstream of Vinh Long province.

Discharge 1998 (Dry Year):

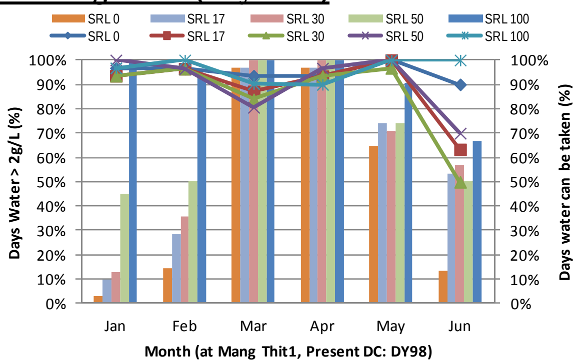


Figure 6.3.7 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Dry Year Discharge of 1998, at Mang Thit 1 Intake, west)
Source: Sub-IHESV and Study Team

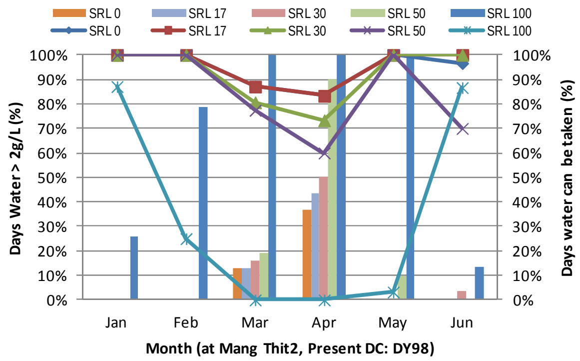


Figure 6.3.8 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Dry Year Discharge of 1998, at Mang Thit2 Intake, east)
Source: Sub-IHESV and Study Team

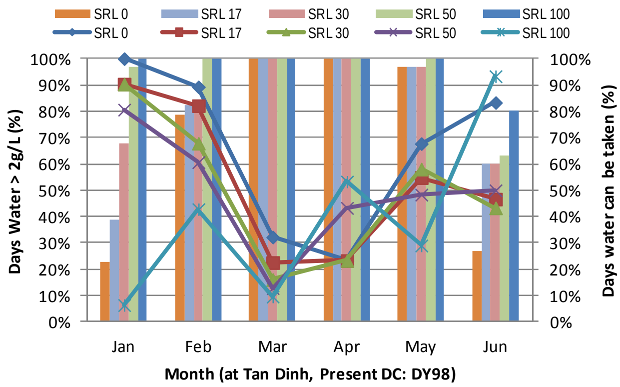


Figure 6.3.9 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Dry Year Discharge of 1998, at Tan Dinh Intake, west)
Source: Sub-IHESV and Study Team

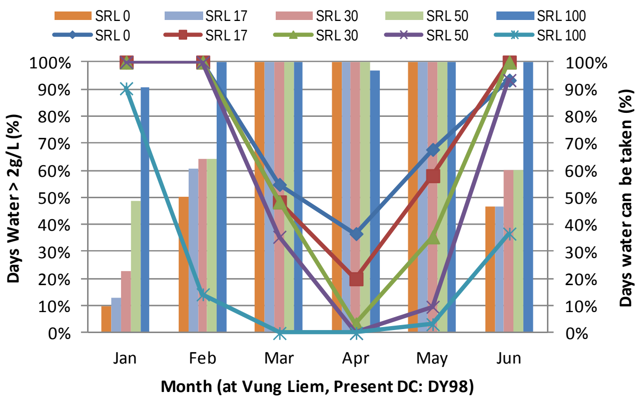


Figure 6.3.10 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Dry Year Discharge of 1998 at Vung Liem Intake, east)
Source: Sub-IHESV and Study Team

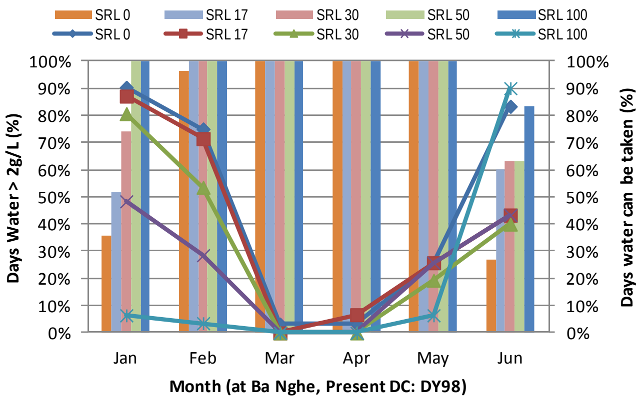


Figure 6.3.11 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Dry Year Discharge of 1998, at Ba Nghe Intake, west)
Source: Sub-IHESV and Study Team

Projected discharge of 15% provability represents targeted discharge for irrigation purpose of Vietnam government while SIWRP uses discharge of 25% probability because of shortage of irrigable water in planning at the present time. Available days for water intake decrease by nearly zero at sluices along east side of Tra Vinh. In west side, only Mang Thit1 is available for fresh water intake in whole dry season. Salinity intrusion and not-available days of fresh water intake become worse in east side; Mang Thit2 becomes difficult to intake fresh water in April.

- ✓ Fresh water intake is not available during two months at Vung Liem (April and May) and Ba Nghe (March and April).
- ✓ Fresh water intake becomes difficult in March at Tan Dinh and in April at Mang Thit2.
- ✓ Even though saline intrusion occurs all days in March and April, Mang Thit1 can take fresh water some hours in a day.

Discharge of 15% Probability:

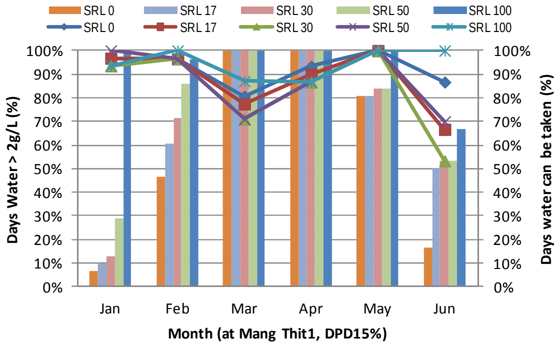


Figure 6.3.12 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Discharge of15% Probability, at Mang Thit 1 Intake, west)

Source: Sub-IHESV and Study Team

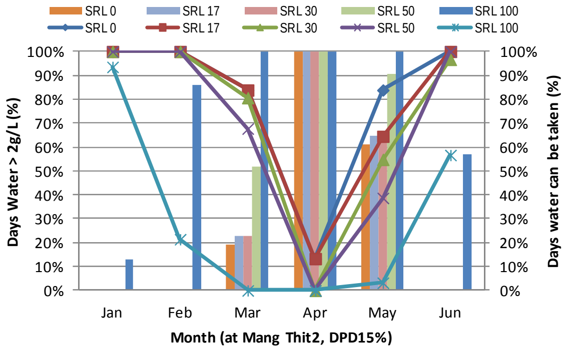


Figure 6.3.13 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Discharge of 15% Probability, at Mang Thit2 Intake, east)

Source: Sub-IHESV and Study Team

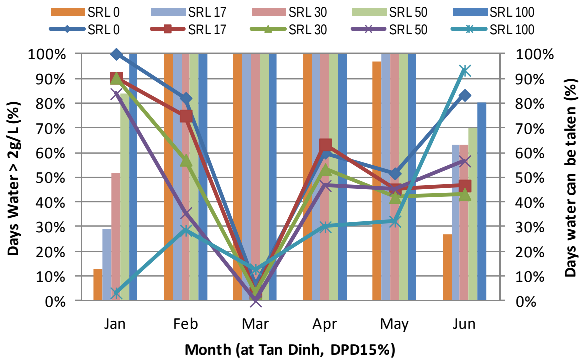


Figure 6.3.14 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Discharge of 15% Probability, at Tan Dinh Intake, west)

Source: Sub-IHESV and Study Team

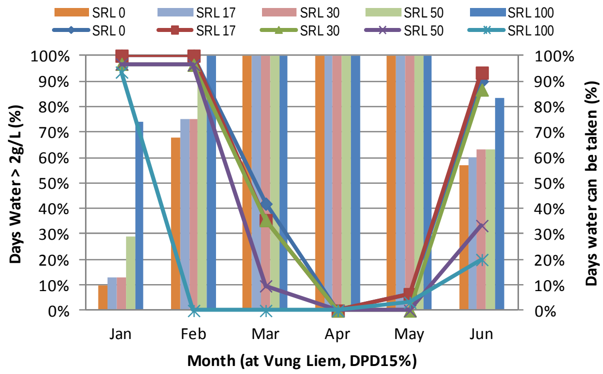


Figure 6.3.15 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Discharge of 15% Probability at Vung Liem Intake, east)

Source: Sub-IHESV and Study Team

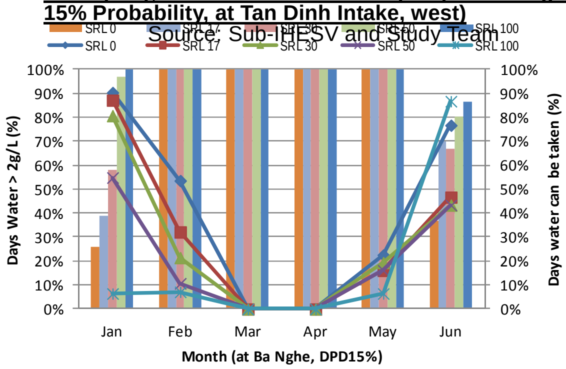


Figure 6.3.16 Number of Days; Saline Contents 2g/L or more (bar), and Intake is available (line): Discharge of 15% Probability, at Ba Nghe Intake, west)

Source: Sub-IHESV and Study Team

2.2) Water Level

Water level of -1m is the lowest limitation at La Ban for navigation system in Tra Vinh area. The maximum salinity content of irrigation purpose is less than 2g/L. Total 11 intakes are examined to understand future intake condition in Tra Vinh in accordance with the existing implementation plan. The following figures indicate water level at the control point (La Ban sluice) taking into account both the water level at inside/outside of sluices and the maximum saline content. If water level (shown by lines in graphs) is higher than -1m, intake of fresh water from canal is available.

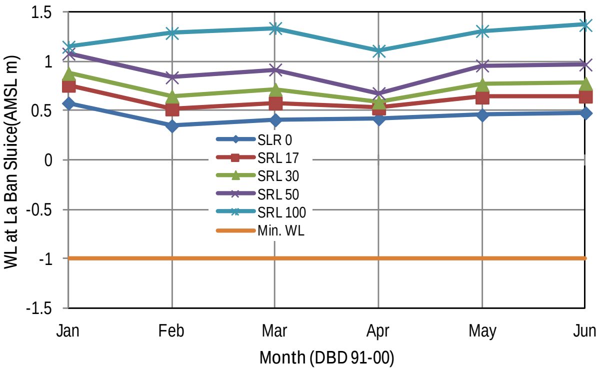


Figure 6.2.17 Water Level at Control Point (Upstream of La Ban Barrage) under 1991-2000 mean Discharge
Source: Sub-IHESV and Study Team

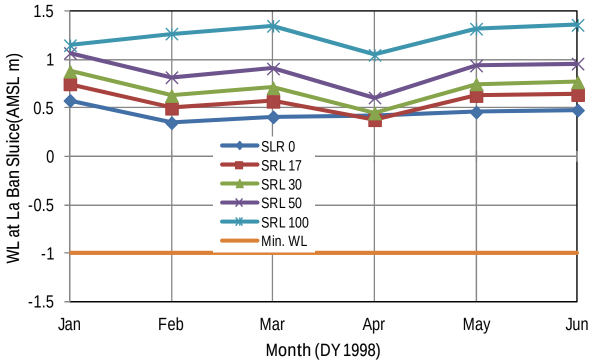


Figure 6.2.18 Water Level at Control Point (Upstream of La Ban Barrage) under Dry Year 1998 Discharge
Source: Sub-IHESV and Study Team

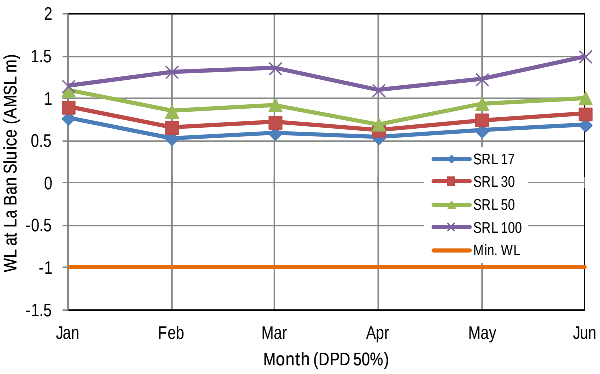


Figure 6.2.19 Water Level at Control Point (Upstream of La Ban Barrage) under Discharge of Probability 50%,
Source: Sub-IHESV and Study Team

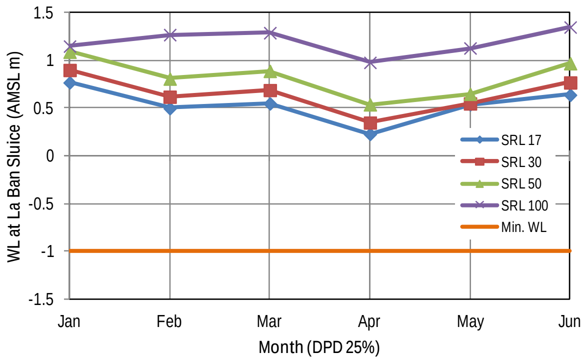


Figure 6.2.20 Water Level at Control Point (Upstream of La Ban Barrage) under Discharge of Probability 25%,
Source: Sub-IHESV and Study Team

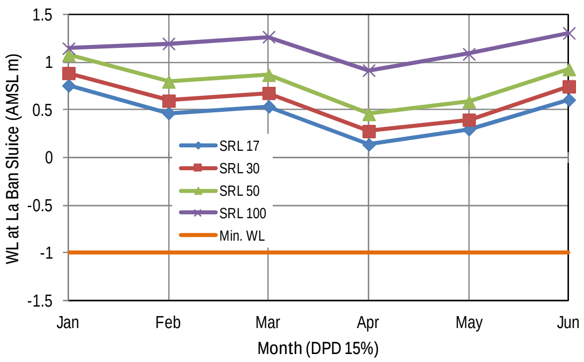


Figure 6.2.21 Water Level at Control Point (Upstream of La Ban Barrage) under Discharge of Probability 15%,
Source: Sub-IHESV and Study Team

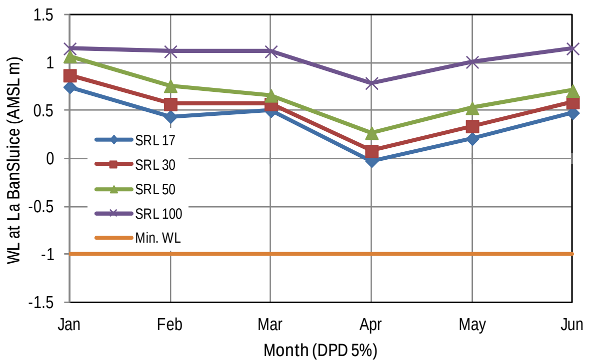


Figure 6.2.22 Water Level at Control Point (Upstream of La Ban Barrage) under Discharge of Probability 5%,
Source: Sub-IHESV and Study Team

All cases show that water level at the control point will not decrease down to -1m during dry season so water will be available in this area.

- ✓ April is the lowest water level month at the control point in most cases.

✓ There is no restriction by water level at the control point in all cases.

Then, water balance between supply and demand is shown in the following table; table is the summary of the case of average discharge 1991-2000 coupled with sea level rise 30cm (in 2050).

Table 6.3.3 Water Supply Capacity of each Sluice and Water Demand in Tra Vinh (P=15%, SLR30cm): m^3/sec

No.	Name of Sluice	Jan	Freb	Mar	Apr	May	June	Total
1	Mang Thit 1	23.5	20.5	10.8	45.0	37.2	7.9	144.9
2	Mang Thit 2	40.6	38.1	38.4	0.0	24.6	31.8	173.5
3	Bung Truong	1.9	1.5	0.4	2.3	2.2	0.7	9.0
4	Vung Liem	11.2	9.0	2.0	0.0	0.0	6.1	28.3
5	Ngang Am	1.9	2.6	0.8	0.0	0.0	1.8	7.1
Sub-total (supply in Vinh Long)		**79.1**	**71.7**	**52.4**	**47.3**	**64.0**	**48.3**	**362.8**
6	Tan Dinh	2.2	0.9	0.0	0.8	1.2	0.9	6.0
7	Ba Nghe	3.1	0.4	0.0	0.0	1.2	1.8	6.5
8	Rach Rum	2.8	0.3	0.0	0.0	0.6	1.7	5.4
9	My Van	7.1	0.5	0.0	0.0	0.9	4.1	12.6
10	Cai Hop	10.0	5.9	0.3	0.0	0.0	3.6	19.8
11	Lang The	15.0	4.6	0.0	0.0	0.0	4.0	23.6
Sub-total (supply in Tra Vinh)		**40.2**	**12.6**	**0.3**	**0.8**	**3.9**	**16.1**	**73.9**
Water Demand (Tra Vinh)		55.8	47.8	30.6	47.8	34.1	24.5	240.6
Balance (Tra Vinh only)		-15.61	-35.16	-30.31	-46.97	-30.21	-8.43	-166.69
Balance (Tra Vinh + Vinh Long)		63.5	36.5	22.1	0.3	33.8	39.9	436.7

Table 6.3.3 shows that water supply in Tra Vinh province does not satisfy water demand in the province; it is about 3.3 times difference between demand and supply (240.6/73.9). Water conveyance from upstream side is required to satisfy water demand.

3) Discussions

3.1) Water Resources

Since fresh water resources in Tra Vinh are limited, fresh water recruitment from upstream will play one of important roles to satisfy water demand in dry season. Vinh Long province is a candidate of water resource to transfer fresh water to Tra Vinh province. In fact, without water supply from Vinh Long province, it is considered fresh water is not available in Tra Vinh Province during dry season. There can be considered 2 major methods for fresh water intake from Vinh Long province, one is to utilize sluices which are going to be constructed, and the other is to introduce canal water further upstream side of Vinh Long.

Mang Thit1 and Mang Thit2 can be said multi-functional sluices for water resource development from view of hydraulic functions: purposes of these sluices are not only fresh water intake from Mekong River but also check gates of canal system continuing from upstream. Fresh water in canals will be drained together with decrease of Mekong River water level if these gates are always opened. These gates can keep fresh water in canals with high water level by gate operation. If these sluices are constructed, they can take fresh water not only from Mekong River but also from canal systems in Vinh Long province.

3.2) Stability of fresh water intake and gate operation

River flows at the west side and east side of Tra Vinh are quite different that the west side has double discharge in comparison with the east side. Introduction of water from the west side of the area shall be enhanced in order to satisfy water demand in Tra Vinh. Sluices of Mang Thit1 and Mang Thit2 are located at both edges of Mang Thit river which faces both side of Mekong River branches of Vinh Long province. Water flow direction of this river depends on water level at both sides of Mekong

River branches.

There is a potential to increase fresh water intake by gate operation at Mang Thit1 and Mang Thit2; if water level in Mang Thit river can be kept lower than Mekong River branches, water will be easily taken directly from these Mekong River branches. Indirectly, water also can be taken from upstream side through canal system in Vinh Long province. Effective water intake will contribute for water supply for Tra Vinh province; so that monitoring and operation system shall be considered in future development. It means that gate system shall be equipped with monitoring system (salinity and water level) and prompt operation shall be done in accordance with timely monitoring.

6.3.4 Potential Resettlement along the Canal to be Extended

The paddy production in Tra Vinh Province was damaged by the salt intrusion in 2011, therefore, water resource development shall be considered by not only the sluice gate construction at the river mouth but also canal width expansion of Say Don – May Tuc - Nga Hau canal from Tra Vinh to Vinh Long Province for the purpose of increase canal flow capacity. In such case, 254 households along the canal (1,199 persons in total) are voluntarily requested to resettle to other areas. Most of the households depend on farming, especially, paddy production. The Household Interview targeting 50 households (20% of total households) on top of the Census Survey covering the total 254 households was implemented.

According to the census survey result, average of cash income per capita is 6.2 million VND/year (29 million VND/household/year). The amount is much lower than that of average cash income per capita in Cuu Long River Delta, namely, 21.3 million VND/year (Statistical Yearbook of 2010). Regarding basic infrastructure, all households can access electricity and they use piped water, rain water or canal water for drinking. Moreover, around 150 house-structures are brick and 60 houses are thatched ones. Average farmland per household is 0.5 ha, most of farm households operate paddy production three times a year. The mean yield of paddy is 4.5 to 6.5 tons/ha according to the household interview. Estimated cost for resettlement, land recovery and so on is estimated at 343 billion VND as below:

Table 6.3.4 Estimated Cost for Resettlement and Land Recovery

No	Items of Compensation	Cost (million VND)
1	Houses	16,248
2	Other constructions	180,256
3	Residential land	73,944
4	Agricultural land	44,646
5	Plants and vegetables	9,207
6	Resettlement	12,954
7	Cost for supporting resettlement of Compensation Board	6,071
Total cost		343,326

6.4 Study on the Water Management for Coastal Area and Center in Bac Lieu Provinces

6.4.1 Rationale

Saline intrusion from East Sea affects human activities in coastal area of Bac Lieu province. Figure 6.4.1 shows land use in the province. Recruitment of sea water is common and it is essential in paddy-shrimp area (purple color) and shrimp area (orange color) but these areas are located in just adjacent to paddy area (light green color). Shrimp farming also requires fresh water especially in dry season in order to keep suitable salinity level of brackish water for shrimp growing which is in the range of 18-25g/L. Then, the shrimp farming area in Bac Lieu colored in orange requires fresh water for sustainable aquaculture. Technical possibility is examined by series of simulations for fresh water recruitment to shrimp farming areas. Fresh water will be conveyed from Bassac river through main canals passing through secondary canals in paddy area (right green color).

Figure 6.4.1 Study Area of Bac Lieu with Water Sub-unit (light green: Paddy area, purple: Paddy-Shrimp, orange: Shrimp)
(Source; Sub-IHESV and Study Team)

On the other hand intake of saline water becomes one of triggers for inundation in the province. Most of canals opening to the East Sea in the province are not equipped with sluice gates yet. Therefore the area between the coastal line and the Kinh Ca Mau – Back Lieu navigation canal (or the national highway No.1 running along the navigation canal; at the inland boundary of orange color area in the Figure 6.4.1) is sometimes affected by inundation coupled with high tide, and also recruitment of much sedimentation coming from Ca Mau peninsula area (sand comes from Ca Mau peninsula area through canals and deposits at the area).

This situation further exacerbates the drainage condition in Bac Lieu center. In fact, Can Van Lan Street of the Bac Lieu centre is recently inundated by 20-30 cm in depth 2 times a month corresponding to high tide period. In addition, if there is high tide coupled with heavy rainfall (say more than 150mm per day), there will be as much as 50cm inundation within the centre once to as many as 5 times a year. From these reasons, study on Bac Lieu center protection from inundation is conducted and a protection plan is prepared.

6.4.2 Components of Study

This study consists of two components; one is hydraulic simulation on availability of fresh water recruitment through main canals connecting from Bassac river to coastal shrimp farming area, the other is to prepare protection plan against inundation for Bac Lieu center.

1) Simulation

The simulation aims to find a way to supply water from Bassac river to coastal shrimp farming area. The simulation on the present condition comes first, then, cropping pattern is changed in order to create extra fresh water for the purpose. Then, water supply from Bassac river is examined:

- ✓ Simulation model covers not only whole Mekong Delta but also some areas along Mekong River up to Kratie in Cambodia; the whole area of the model is applied for each simulation.
- ✓ Boundary conditions are given at; Kratie for upstream boundary with hourly water and salinity level, coastal 9 stations for downstream boundary with hourly water and salinity level.
- ✓ Model calibrations are applied by hourly data of 365days in targeted years; an average year for 2008, a flood year for 2000, a draught year for 1998.
- ✓ Model calibration in rainy season (flood) is conducted by comparison with 23 inland hourly water level stations; simulation errors are verified less than 5%.
- ✓ Model calibration in dry season (draught) is conducted by comparison with 12 inland stations; the same magnitude and trend are confirmed between observed hourly but intermittence data and simulation results.
- ✓ Average discharge 1991-2000 is employed as a common discharge in recent years.
- ✓ Water demand in 2020 is generated and each demand for paddy and shrimp farming are

calculated.

- ✓ Some sea level rise cases are considered in the simulation; such as 0cm for present situation, 17cm for projected year 2030, 30cm for year 2050, and 100cm for year 2100.
- ✓ Saline content of 2g/L is allowed to supply paddy area as the maximum saline content according to a design/planning standard of irrigation water supply in SIWRP.
- ✓ Chang of cropping pattern is applied because paddy-shrimp farming requires less fresh water than paddy farming.

2) Inundation protection

It is considered that inundation in Bac Lieu center occurs due to heavy rain coupled with high tide. The peak of high tide usually continues only an hour or more and inundation also subsides together with tidal level down. Because of high salinity level of inundated water, corrosion on equipment and machineries is serious in this area even though inundation period is as short as an hour or little more. Therefore, high tide protection system and drainage system are studied as inundation protection.

6.4.3 Simulation Results

1) Present Situation

According to cropping pattern in the area, water demand in January is a maximum and it becomes critical condition of water supply. Area of each sub-unit of land use and the maximum water demand are summarized in table 6.4.1.

Table 6.4.1 Area of Sub-unit and the Maximum Water Demand of Sub-region in Bac Lieu Province

Sub-Regions	Fresh water (Paddy) sub-region		Paddy-shrimp sub-region		Shrimp Sub-region	
	Sub Unit	Area (ha)	Sub Unit	Area (ha)	Sub Unit	Area (ha)
Details	I	10,000	VI (east)	19,560	I	12,400
	II	25,860	I	11,455	II	14,140
	III	24,886	II	8,630	III	16,000
	IV	10,157	III	5,740	IV	15,300
	V	9,679	IV	14,100	V	20,240
			V	17,070	VI	19,300
			VI	2,183	VII	2,700
Total		***80,582ha***		***78,738ha***		***100,080ha***
Max. Water Demand (January)		***38.93m^3/sec***		***10.92 m^3/sec***		***16.93 m^3/sec***

Figure 6.4.2 Present Water Sub-unit Distribution and Targeted Area for Fresh Water Supply in Shrimp Area (orange color)
(Source; Sub-IHESV and Study Team)

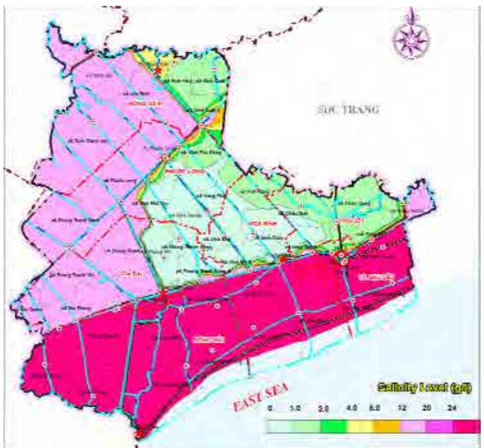


Figure 6.4.3 Present Saline Content Distribution
(Source; Sub-IHESV and Study Team)

Water demand in paddy area includes water requirement for paddy, upland crops, domestic use, livestock use, and others. Paddy-shrimp area can obtain brackish water from surrounding areas so fresh water demand becomes lower than shrimp area's demand. Sea water in shrimp area has to be diluted by fresh water and saline content after mixture is set at about 18-25g/L more or less. Total 4 sub-units in shrimp areas are targeted for fresh water supply. Simulation on the present condition is shown in Figure 6.4.2 and Figure 6.4.3. Simulation on the present situation shows total 1.53m^3/sec of fresh water can be transferable to the shrimp farming area.

2) Effectiveness of Cropping Pattern Change on Water Demand Reduction

Cropping pattern change can be considered to be one of non-structural methods to decrease fresh water demand in the Mekong delta. In this study, reduction of fresh water demand is examined by changing cropping pattern in order to confirm effectiveness of this non-structure method. A sub-unit in the paddy area is selected after some trials for this purpose. The selected area and saline contents of it are shown as follows:

Figure 6.4.4 A Selected Sub-unit II in Paddy Area and Targeted Area for Fresh Water Supply (I, II, III) in Shrimp Area (Orange)
(Source; Sub-IHESV and Study Team)

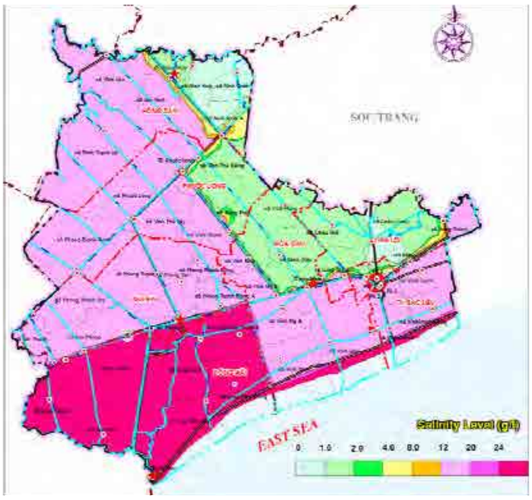


Figure 6.4.5 Saline Content Distribution after Cropping Pattern Change
(Source; Sub-IHESV and Study Team)

Sub-unit II in paddy-shrimp has an area of 25,860 ha and it can reduce water demand 3.67m^3/sec in January. If it is calculated simply, sub-unit II can create 8.99m^3/sec of fresh water, however, saline intrusion through main canals have to be stopped for the sake of keeping fresh water in paddy area so extra water for this purpose is required. The balanced value of 5.32m^3/sec is used for saline intrusion protection.

- ✓ Average water demand in paddy area in January: 38.93m^3/sec
- ✓ Average water demand in paddy-shrimp area in January: 10.92m^3/sec
- ✓ Area of sub-unit II & total paddy area: 25,860 ha (258,600,000m^2), 80,582 ha (805,820,000m^2)
- ✓ 258,600,000m^2 X (38.93m^3/sec - 10.92m^3/sec)/ 805,820,000m^2 = 8.99m^3/sec

Amount of transferable fresh water has increased from 1.53m3/sec to 5.20m3/sec (= 1.53 m3/sec + 3.67 m3/sec) but it seems to be somewhat doubtful about effectiveness of this non-structural method of cropping pattern change in terms of decreasing water demand. In this simulation, targeted sub-unit for water supply in shrimp area is reduced from four units to three units because fresh water supply from paddy area to sub-unit No.IV is quite difficult without pipe line (sub-unit No.IV does not connect paddy area directly).

3) Increase of Water Supply

Discharge capacity can be increased by canal enlargement and this is one of common methods in

Mekong delta as a structural countermeasure. In this study, effectiveness of this structural method is examined; total two canals are planned for cross section extension. A result of this simulation shows possibility of fresh water supply as required but it does not mean whether it is actually possible or not. There would be much resettlement along the canals. Stop lock is also provided in a main canal to control saline water intrusion. The result of simulation is shown as follows;

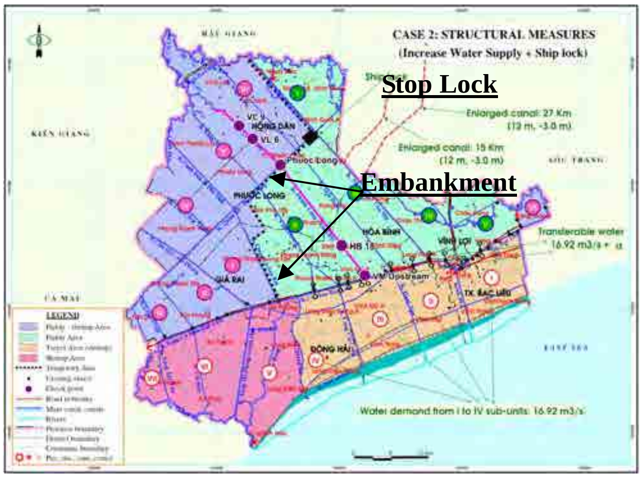


Figure 6.4.6 A Selected Sub-unit II in Paddy Area and Targeted Area for Fresh Water Supply (I, II, III, IV) in Shrimp Area (Orange)
(Source; Sub-IHESV and Study Team)

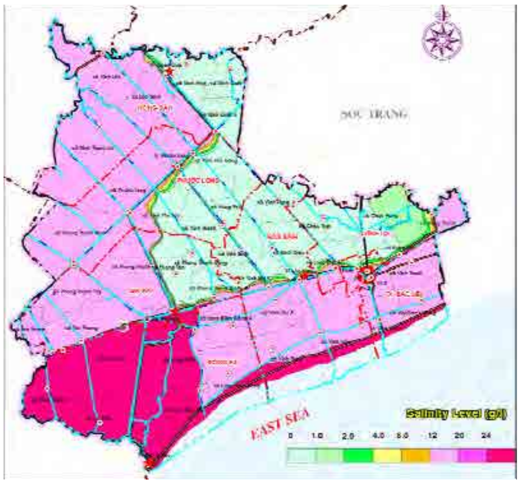


Figure 6.4.7 Saline Content Distribution after Canal Extension from Bassac River
(Source; Sub-IHESV and Study Team)

6.4.4 Discussions

Dense canal networks have been providing farmers in Mekong delta huge potential of paddy farming. Saline intrusion into canal networks also contributes the area income generation opportunity in terms of shrimp cultivation. Suitable saline contents of water differ completely between rice cropping and shrimp farming, and then, their fresh water requirements are quite different by seasons and by areas as a matter of course. Increase of fresh water demand is one of issues in Mekong delta especially in dry season; it may be caused by maximization of land use or climate change in recent years and future. A change of cropping pattern has been considered as one of methods for reducing fresh water requirement under such situations and this study has contributed to understand about effectiveness of cropping pattern change under the limited conditions.

This study has implied that decreasing of water requirement under complicated land use is not so effective because; 1) fresh water for paddy area has negative impact to saline water of neighboring shrimp farming area by decrease of saline contents, 2) extra fresh water head is required to keep fresh water area and push saline water away in main canal, 3) structural measures are necessary to keep saline water away from fresh water area e.g.; water lock and/or gate with embankment. It can be conceived that change of cropping pattern in large area may be able to contribute decrease of fresh water requirement. In addition, such large area shall be demarcated by large canals, not by medium or small canals because it requires complicated water quality by small units. It also can be said that non-structural measures and structural measures shall stand together otherwise it isn't effectively used.

6.4.5 Inundation Protection

1) General Layout of Inundation Protection Plan

A center of Bac Lieu Province is located in quite adjacent area from the East Sea coast; the center has high risks on inundation which will be accelerated by climate change. Sea level rise is one of well known phenomena of climate change in coastal areas but Bac Lieu center has not yet implemented any prevention system against sea level rise. In fact, inundation of the center is often reported during spring tide coupled with heavy rain and risk of corrosion on equipment and machinery is much higher than any other provincial centers in coastal areas.

Inundation protection system for the center is composed of two major functions; one is protection system for Bac Lieu center from tide water intrusion, the other is prompt drainage system from the center to decrease corrosion damage. In this study, two cases of sea level rise, 17cm for 2030 and 30cm for 2050, are examined and required facilities are planned and designed as follows;

Figure 6.4.8 General Layout of Inundation Protection Plan for the Bac Lieu Center
(Source; Sub-IHESV and Study Team)

Saline water at spring tide comes into Bac Lieu center through several routes (see right blue arrows in Figure 6.4.8) of canals opening to the East Sea. There are also several drainage routes at the north of Bac Lieu center which the drainage routes (see right green arrow in Figure 6.4.8) show almost opposite directions of the spring tide intrusion routes. These drainage routes run inside and edge-side of Bac Lieu center, therefore, drainage from the center becomes difficult and water level goes up easily when spring tide and rainfall come simultaneously. Taking into account of those conditions, sluice gates and pumping stations are planned to prevent the center from inundation.

2) Design of Infrastructures

In this section describes calculation of top elevation of structures especially for protection dike from spring tide. In coastal area, sea dike is planned for protection of coastal line from sea waves. The protection dike in this section differs from such sea dike; sea wave does not affect directly so much into inland such as Bac Lieu center. Top elevation calculation for the protection dike consists of four items as follows;

The top elevation of protection dike is calculated as follows;

$\nabla de = Htk + h1 + hd + a$

Where,

∇de: top elevation of the dike (= 2.1m)

Htk: elevation of water level at high tide without sea level rise (= 1.09m)

h1: wave height (=0.24m)
hd: back-water height (=0.29m)
a: freeboard (safety height; =0.4m)

Water level in 2000 is employed for the elevation of high tide water level, which is considered to be a flood year of Mekong delta. Wave height is calculated taking into account several factors such as dike slope, wind speed, and water depth.

Freeboard and extra height (0.48m = 0.4m + 0.08m) has enough height against sea level rise of 17cm and 30cm, which are projected value in the years of 2030 and 2050 respectively. It is therefore that calculated value of 2.1m is applicable for the top elevation of the protection dike in Bac Lieu center. Based on this value, sluice gate and drainage pump are planned. Bac Lieu center is divided into two parts and the project is also divided into two phases; old town and its vicinities are targeted to protect from inundation in phase 1, newly developing area at the west side is selected for phase 2 project. Drainage pumps are planned at the mouth of main canals with minimum numbers in the center, and sluices are placed at the mouths of remaining main canal.

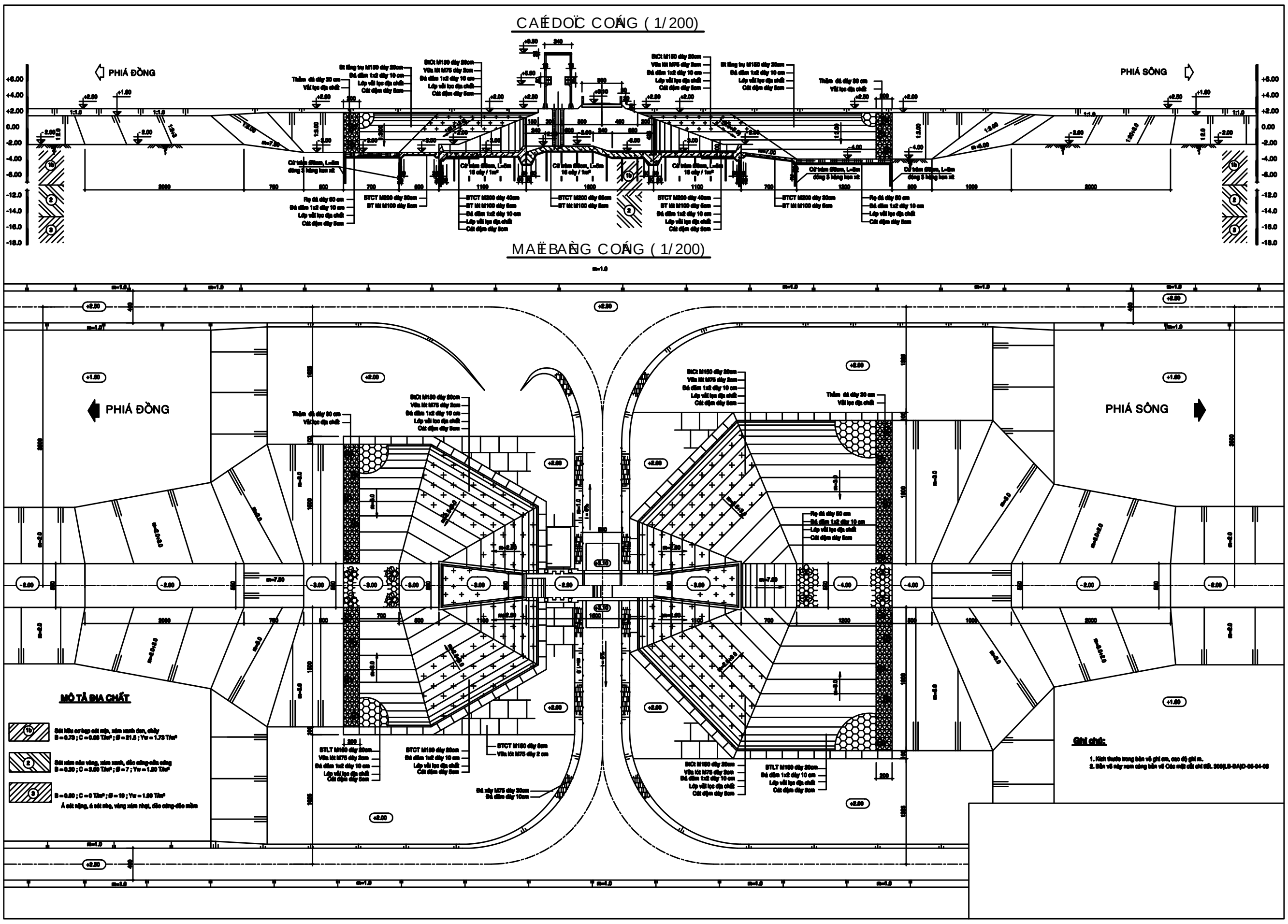


Figure 6.4.9 Typical Gates preventing Tidal Water Intrusion for the Bac Lieu Center
(Source; Sub-IHESV and Study Team)

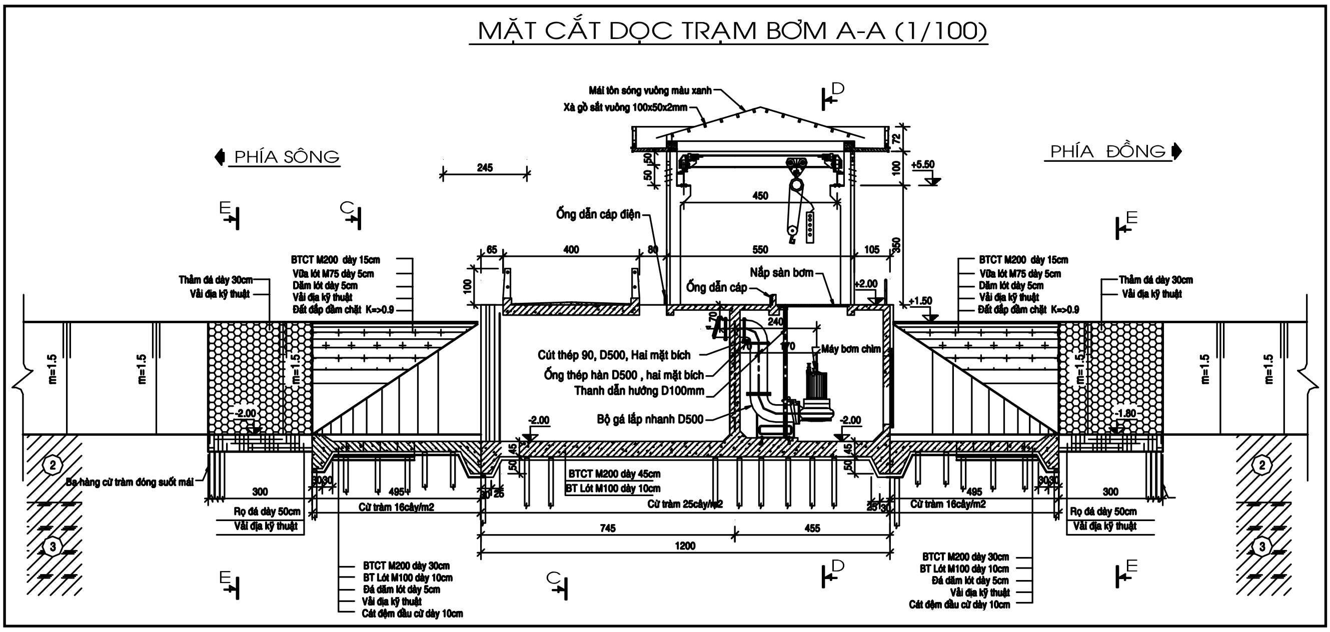


Figure 6.4.10 Typical Pumping Station for Drainage System for the Bac Lieu Center
(Source; Sub-IHESV and Study Team)

3) Cost Estimation

According to plan and design aforementioned, volume and cost for inundation prevention is summarized as follows;

Table 6.4.2 Summary of Volume and Cost for Inundation Prevention for Bac Lieu Center

NO	Item	Unit	Volume	Cost (million VND)		
				Construction	Land clearance	Total
	TOTAL			**2.208.821**	**1.316.715**	**3.525.536**
1	Build boundary bank	m^3	178.826	15.021	17.244	32.265
2	Dredge channel		546.877	10.938	14.551	25.488
	Main channel	m^3	*334.340*	*6.687*	*7.426*	*14.113*
	Branch channel	m^3	*212.536*	*4.251*	*7.125*	*11.376*
3	Build open sewer	m	21	42.000	9.450	51.450
4	Build vesicle Ø100	Pcs	10	5.000	3.000	8.000
5	Install one way valve	Pcs	20	3.000	-	3.000
6	Build pump station	Station	6	44.000	13.200	57.200
7	Build embankment to protect bank	m	15.436	1.188.572	1.080.520	2.269.092
8	Heighten foundation	m^3	2.140.000	642.000	-	642.000
9	Build regulating lake	m^3	3.960.001	79.200	78.750	157.950
10	Upgrade and expand road	m	8.739	179.090	100.000	279.090

6.5 Study on the Flow Mobilization in the Water Tranquil Areas of the CA Mau Peninsula

6.5.1 Rationale

Ca Mau peninsula is well known not able to receive fresh water from Mekong river (Basac river) since it is located furthest away from the river. Due to the fresh water shortage, brackish shrimp cultures have dominantly expanded in this area. Another dominant feature of the peninsula is tidal affect by east sea and west sea. These tidal regimes create water tranquil areas colored with pink in Figure 6.5.1. The area in Ca Mau extends along the boundary between east and west tide affect areas and turns to west side along the edge of flood affect areas.

Though shrimp culture can bring about high income, it on the other hand is associated with high risk of diseases. Some farmers reported once in every 2 – 5 years, they have to face at least 20 percent to as much as almost total loss due to some diseases e.g. white spot virus, yellow head virus, etc (refer to Figure 6.5.2[2]). Shrimp diseases in Figure 6.5.2 have occurred certainly in water tranquil area shown in Figure 6.5.1.

One of the key issues to reduce such disease is to mobilize water circulation in order to prevent the waste emitted by shrimp culture from being settled in once place causing water pollution. It means that when the water is very static and dormant, the shrimps tend to get diseases and once it occurs, the diseases can infect all along the neighbor shrimp ponds. To reduce this risk, there should be mobilization of the water flow. However, fresh water can hardly reach the peninsula and worse the peninsula is encroached by East and West Sea.

Sea water comes from eastern side of the peninsula and also from the western side almost at the same circulation period according to the tidal fluctuation. There may, however, be a possibility which can mobilize water flow by installing a series of sluice gate (up-and-down vertical gate) and operating them one by one from one side to the other side, e.g. from eastern sea side to the western sea side. Thus, one way water circulation may be established. Computer simulation is therefore required to know how best we can mobilize the water flow in this Ca Mau peninsula.

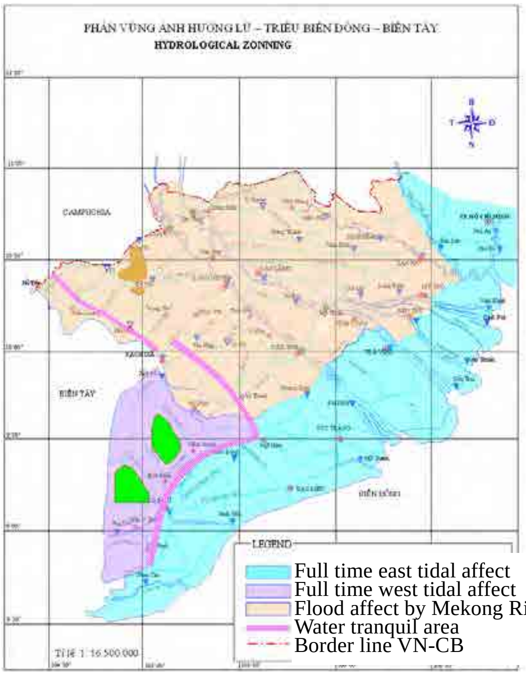


Figure 6.5.1 Zoning map of Mekong Delta by Tidal Effect Source: SIWRP and the Study Team

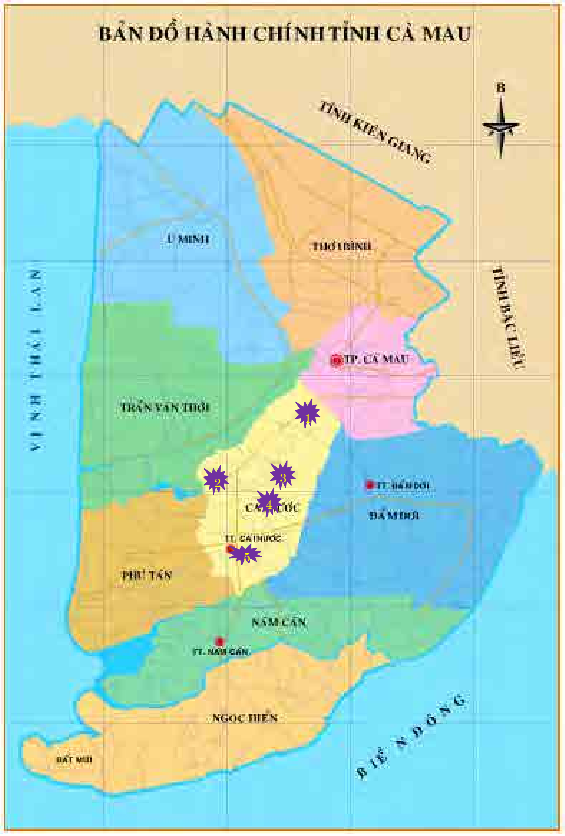


Figure 6.5.2 Locations of Shrimp Diseases Occurrence in Ca Mau 2012, expected mainly due to Water Pollution
Source: Home Page of Ca Mau Province

6.5.2 Approach of Study

1) Simulation Model

The simulation aims to confirm possibilities of water circulation by gate operation without using any artificial powers such as pumps. Two major canals can be considered in Ca Mau peninsula; one is Ganh Hao canal facing to east sea and the other is Song Doc canal connecting to west sea.

- ✓ Simulation model covers from Ganh Hao and Song Doc canals as northern edges to southern side of these canas in the peninsula.
- ✓ Boundary conditions are given at; Ganh Hao station for east sea water level and Ca Mau station for west sea water level with hourly sea water level. Sea water levels of these two points are also employed as water levels at other coastal canal mouths.
- ✓ Flow area is calculated from measured cross

[2] Regarding extensive shrimp farming in Cai Nuoc district of Ca Mau; 20ha of shrimp disease damage is reported in a homepage of Ca Mau province, and 80-90% of area is affected by diseases in Tran Thoi commune according to survey of Study Team.

section of each canal and it is converted into numerical value of water level.

✓ Model calibrations are applied by hourly data from January to June in 1998 (draught year), 2001 (an average year); the calibration results show similar trend and magnitude of measured values.

2) Simulation Cases

Gate operation itself cannot increase water head but it can keep water head during certain period. Water flow has been confirmed by the initial simulation to understand the present situation; under the condition of without gate operation, without rain fall, and without sea level rise. This simulation implies that natural flow in main canal occurs from the East Sea to the West Sea, and then this phenomenon means that tidal features of the areas will be the main cause. Rainfall has also been added in simulation and water flow throughout a year was examined. To increase water flow from east to west, gate operation was studied. An approach adopted in this study is summarized as follows;

Table 6.5.1 Approach of Simulation for Water Mobilization in Ca Mau Peninsula

Step	Description	Control	Rain	Tide	SRL
1	A main canal model	No gate	Nil	1998	Nil
2	A main canal model	No gate	2001	2001	Nil
3	A main canal model	Gates	2001	2001	Nil
4	Main canals + secondary canals model	No gate	2001	2001	Nil
5	Main canals + secondary canals model	Gates	Nil	2001	Nil
6	Main canals + secondary canals model	Gates	2001	2001	Nil
7	Main canals + secondary canals model	Gates	2001	2001	17cml
8	Main canals + secondary canals model with CL-CB barrage	Gates	2001	2001	Nil
9	Main canals + secondary canals model with CL-CB barrage	Gates	2001	2001	17cml
10	Main canals + secondary canals model with CL-CB barrage	Gates	2001	2001	30cm

6.5.3 Simulation Results

1) Dry Season Flow in Main Canal (single canal model)

A single line model of canal network is selected for simulation which connects the East Sea and West Sea. This single line model is composed of two canals; one is Ganh Hao canal (total length 57.7 km) connecting to the East Sea, the other is Song Doc canal (44.0 km) opens to the West Sea. Simulation is conducted giving two conditions of "without gates" and "with gates".

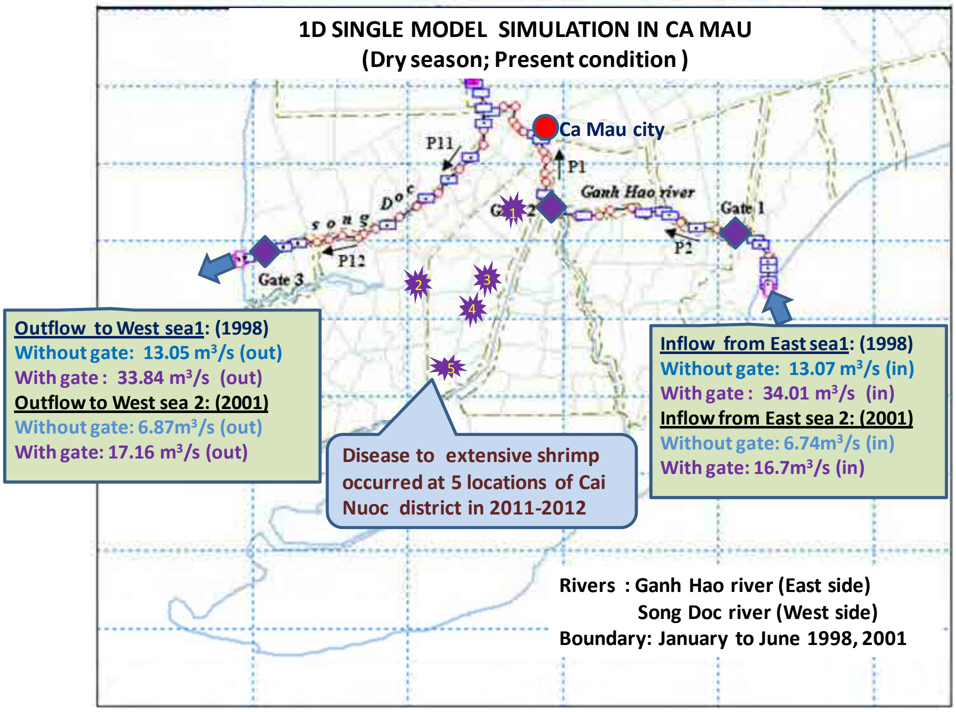


Figure 6.5.3 Simulation Result of Single Canal Model; without and with Gate
Source: IHESV and Study Team

As for gate operation, the gate at the East Sea "gate 1" is opened when water level becomes equal and more than 1m AMSL. The central gate "gate 2" is operated opposite procedure to the gate 1; when the gate 1 is opened the gate 2 is closed, and when the gate 1 is closed the gate 2 is opened. The gate at the West Sea is opened when the water level becomes lower than 0m AMSL at the West Sea. 0.03 is employed for a coefficient of rive resistance. Two observed tidal levels (year 1998 and 2001) at Ganh Hao and Song Doc are employed. The results of these simulations are shown in the following figure;

Natural flow is confirmed in single canal model under dry season tidal phenomenon in 1998 and 2001 simulations. The flow is about 13m^3/sec in average of 6 months from January to June 1998, about 7m^3/sec in 2001. With gate operation, flow from east to west increases by 34m^3/sec in 1998 and 17m^3/sec in 2001, both are about 2.4 times of flow in natural condition (without gate).

2) Dry Season Flow in Main Canals (multiple canal model 1)

Total 5 canals are added to the aforementioned model; total 7 number of canals are employed. Out of 7 canals, there is one canal connecting the East Sea and the West Sea which has big discharge but it flows almost independently without affecting discharge and flow direction so much to other remaining canals. The name of this canal is Cua Lon located in the southernmost place. Without accumulating discharge of Cua Lon canal, the result of simulation is shown in the following figure.

Natural flow capacity increases from 13m^3/sec to 22m^3/sec in 1998 model and 20m^3/sec in 2001 model with effect of five canals. Flow capacity with gate operation also increases up to about 50m^3/sec in 1998 model and about 50m^3/sec in 2001 model. Gate operation has increased discharge volume by about 2.3 – 2.5 times by natural flow. This 2001 model simulation shows effectiveness of gate operation; water mobilization capacity doesn't change so much between two cases; 1998 is a draught year and 2001 is an average year.

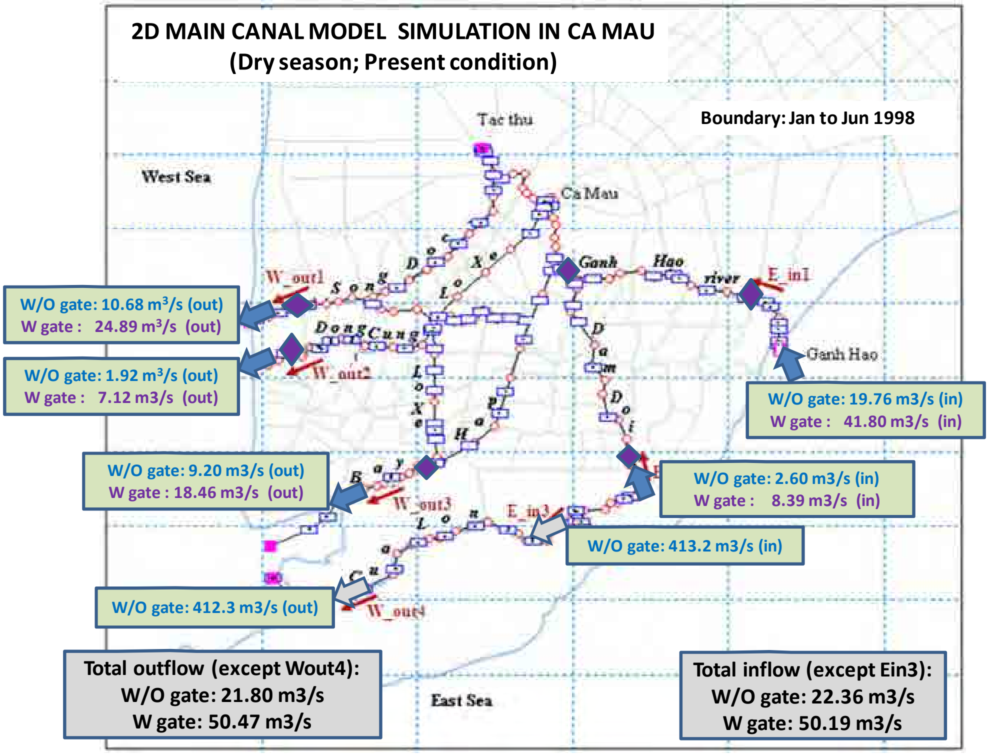


Figure 6.5.4 Simulation Result of multiple Main Canals Model; without and with Gate (1998)
Source: IHESV and Study Team

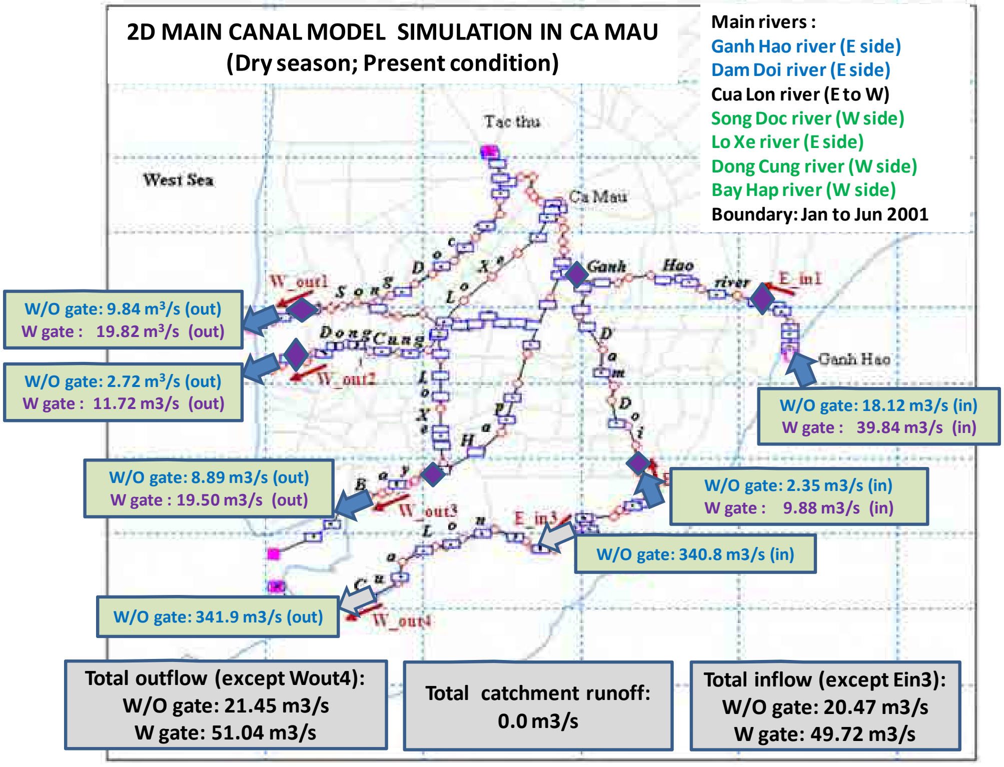


Figure 6.5.5 Simulation Result of multiple Main Canals Model; without and with Gate (2001)

Source: IHESV and Study Team

3) Dry Season Flow in Main and Secondary Canals (multiple canal model 2)

Canal net work in Ca Mau province is quite dense; this is because there is necessity to consider secondary canals in the model to understand present condition. 10 numbers of secondary canals are added to the model; consequently, total canal number becomes 17. Scenarios hereafter dealt with are only tidal level of 2001 because it is considered representing an average year.

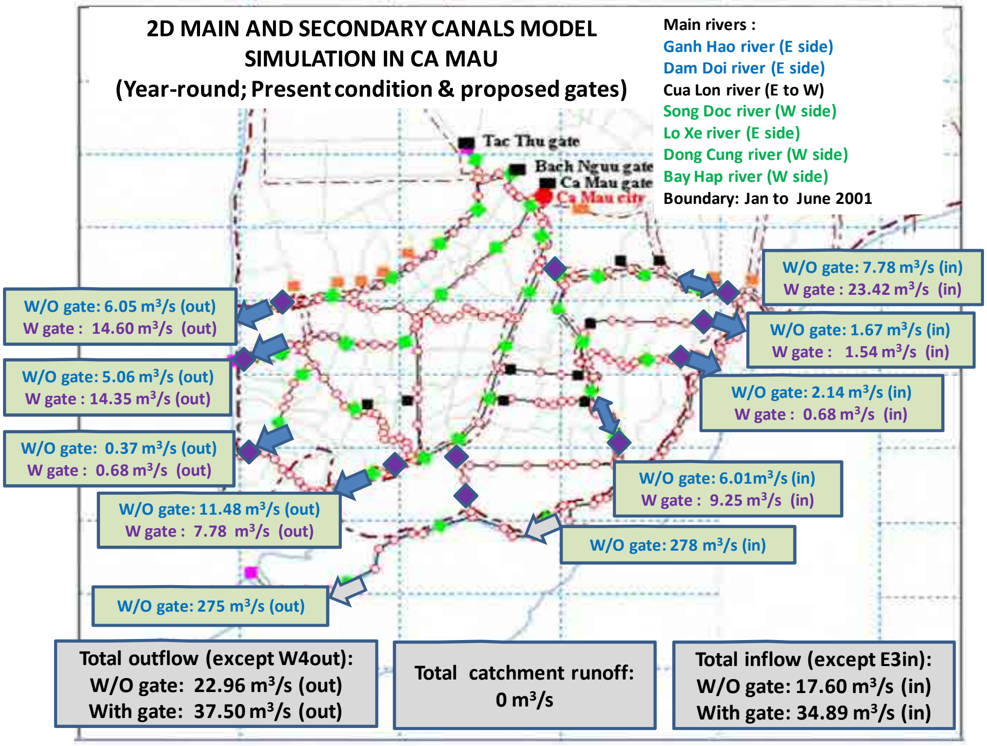


Figure 6.5.6 Simulation Result of Single Canal Model; without and with Gate (2001)

Source: IHESV and Study Team

Volume of water mobilization capacity decreases slightly in both cases of natural condition (without gate); water mobilization of main canals (about 27m^3/sec) decreases down to about 20m^3/sec by the result of secondary canal system being added. With gate operation, it decreases about 30% of discharge from 50m^3/sec to 35m^3/sec by effect of secondary canal systems. The main cause of these decreases is considered that it is most provably due to increase of water surface area of secondary canals. Though accumulated discharge decreases, gate operation is effective for water mobilization and it can increase discharge from natural condition.

4) Annual Flow in Main and Secondary Canals 1 (multiple canal model 3)

Flowing capacity in the canals may differ by seasons, so that simulation is conducted for throughout year. In this simulation, dry season means months from January to June, rainy season means months from July to December. Ca Mau has much rainfall and annual rainfall reaches about 2,800mm according to the average of 1998-2001. Runoff percentage is obtained from SIWRP and average value for this area is about 44%. Different value of rain fall and runoff are given to each catchment area of simulation model, and the model takes into account evaporation and seepage; and then, total runoff in this simulation model is calculated as 99.88m3/sec. A result of this simulation is summarized as follows;

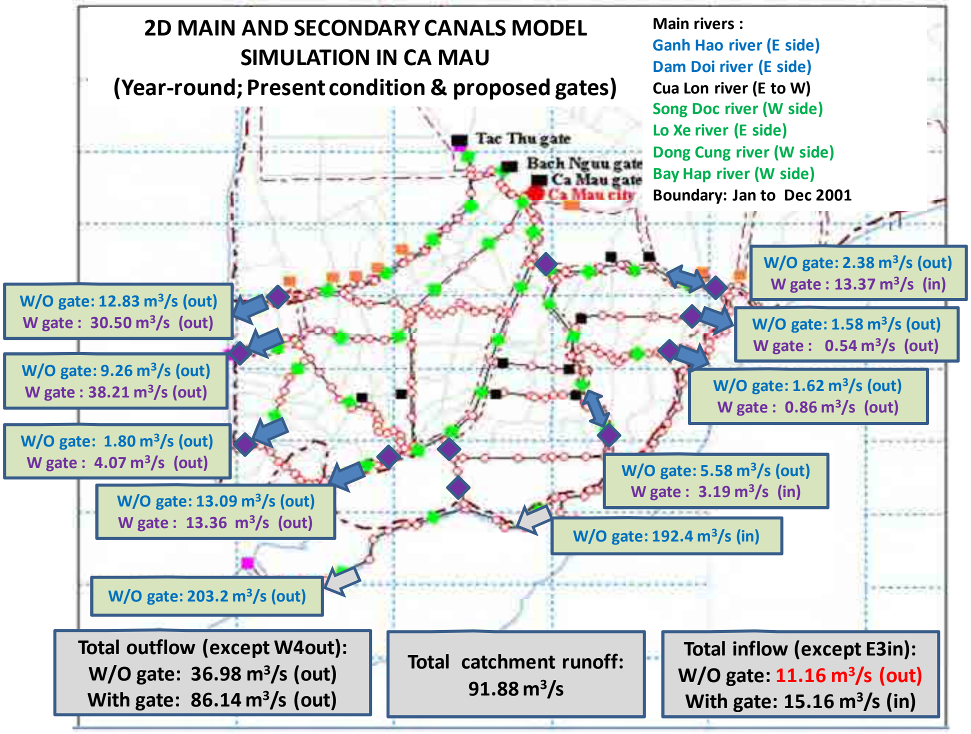


Figure 6.5.7 Simulation Result of Multiple Main and Secondary Canal Model; without and with Gate (2001)
Source: IHESV and Study Team

Simulation result shows that direction of annual natural flow is from inland to out (sea) side; water flow to the West Sea (36.98m^3/sec) is about three times larger than to the East Sea (11.16m^3/sec). With gate operation, flow direction changes in the East Sea side that water flow turns to inflow of 15.16m^3/sec. Outflow from the West Sea also increases with gate operation that total 86.14m^3/sec can flow out into the West Sea.

5) Annual Flow in Main and Secondary Canals 2 (multiple canal model 4)

Vietnam government plans to construct a gate in Cai Lon-Cai Be which is a drainage river in the Ca Mau peninsula. This gate is planned to open during rainy season and close in dry season in order to supply water to northern area of Ca Mau. If there is extra water to divert to southern area of Ca Mau, it can also mobilize water in the area. The result of this simulation is shown as follows;

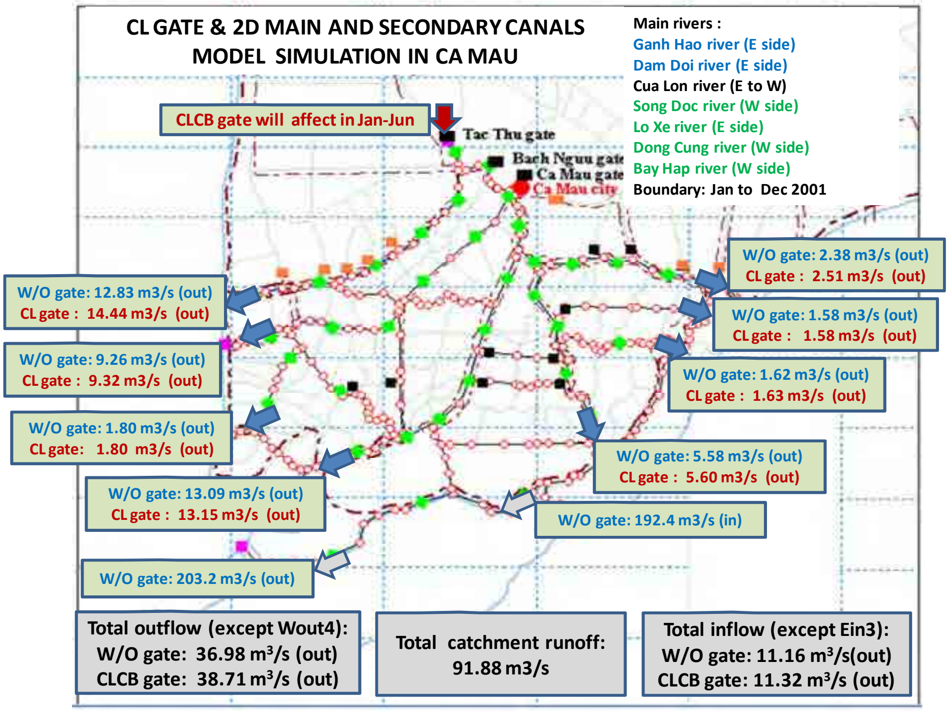


Figure 6.5.8 Simulation Result of Multiple Main and Secondary Canal Model; without and with Cai Lon-Cai Be Gate

Source: IHESV and Study Team

Discharge does not increase so much before and after Cai Lon – Cai Be gate operation that increase in east side is 0.16m3/sec and that of west is 1.73m^3/sec. It can be said that effect is quite limited for water mobilization contribution from Cai Lon – Cai Be.

5) Annual Flow in Main and Secondary Canals 3 (multiple canal model 5)

Some sea level rise effect on water mobilization is also examined which includes two cases; one is sea level rise of 17cm (2030) and the other is that of 30cm (2050).

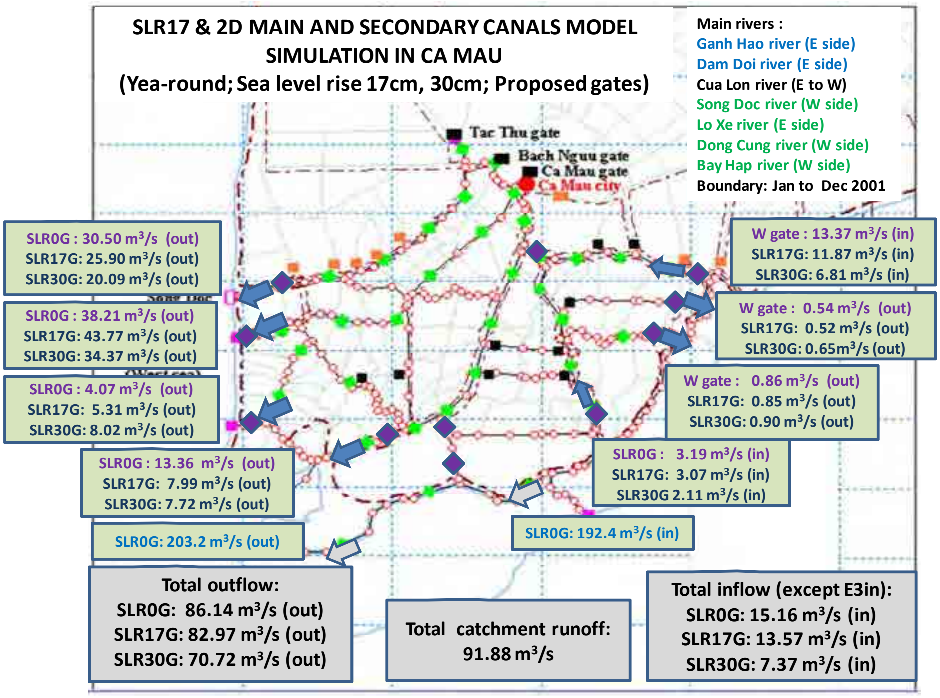


Figure 6.5.9 Simulation Result of Multiple Main and Secondary Canal Model under Sea Level Rise of 17cm and 30cm; without and with Cai Lon-Cai Be Gate

Source: IHESV and Study Team

Sea level rise affects water mobilization towards negative direction according to the result obtained. Inflow from the East Sea decreases and outflow to the East Sea also decreases gradually according to increase of sea level.

6) Summary of Simulation Results

Except inflow and outflow in Cua Lon canal (a southernmost canal in Ca Mau), results of simulations are summarized as follows;

Table 6.5.2 Results of Simulation on Water Mobilization in Ca Mau Peninsula

	Canal Network	Operation	Duration	Inflow (East Sea)	Outflow (West Sea)
1	A single main canal (1998)	Without gates	January - June	13.07m^3/sec	13.05m^3/sec
	A single main canal (1998)	With gates	January - June	34.01m^3/sec	33.84m^3/sec
2	A single main canal (2001)	Without gates	January - June	6.74m^3/sec	6.87m^3/sec
	A single main canal (2001)	With gates	January - June	16.7m^3/sec	17.16m^3/sec
3	Main canals (1998)	Without gates	January - June	22.36m^3/sec	21.80m^3/sec
	Main canals (1998)	With gates	January - June	50.19m^3/sec	50.47m^3/sec
4	Main canals (2001)	Without gates	January - June	20.47m^3/sec	21.45m^3/sec
	Main canals (2001)	With gates	January - June	49.72m^3/sec	51.04m^3/sec
5	Main+ secondary canals (2001)	Without gates	January - June	17.60m^3/sec	22.96m^3/sec
	Main+ secondary canals (2001)	With gates	January - June	34.89m^3/sec	37.50m^3/sec
6	Main+ secondary canals (2001)	Without gates	January - December	-11.16m^3/sec	36.98m^3/sec
	Main+ secondary canals (2001)	With gates	January - December	15.16m^3/sec	86.14m^3/sec
7	Main+ secondary canals (2001), CLCB	Without gates	January - December	11.16m^3/sec	36.98m^3/sec
	Main+ secondary canals (2001), CLCB	With gates	January - December	11.32m^3/sec	38.71m^3/sec
8	Main+ secondary canals, SLR0cm (2001)	With gates	January - December	15.16m^3/sec	86.14m^3/sec
	Main+ secondary canals, SLR17cm (2001)	With gates	January - December	13.57m^3/sec	82.97m^3/sec
	Main+ secondary canals, SLR30cm (2001)	With gates	January - December	7.37m^3/sec	70.72m^3/sec

6.5.4 Discussions

A series of simulations has implied that water mobilization in Ca Mau peninsula occurs naturally from the East Sea to the West Sea in dry season. In rainy season, out flow from inland becomes dominant at East Sea. Tidal water level difference between two seas is considered affecting this water mobilization phenomenon. The following line graph and histogram show water level difference between Ganh Hao point at the East Sea and Song Doc point in the West Sea every an hour from January to June in 1998 and 2001.

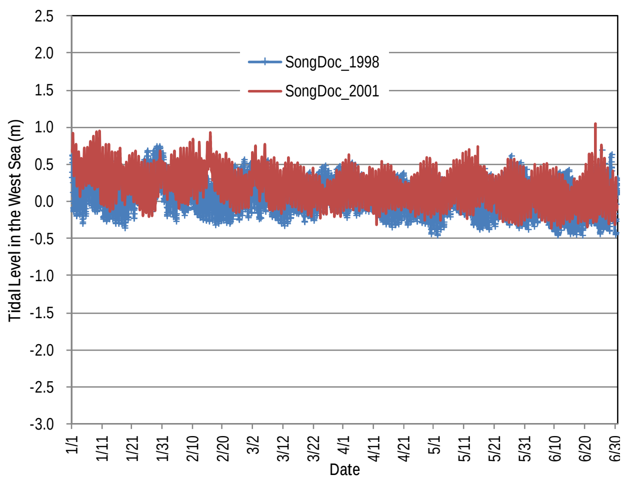


Figure 6.5.10 Hourly Change of Tidal Level in the West Sea (Song Doc Point) in 1998 and 2001

Source: IHESV and Study Team

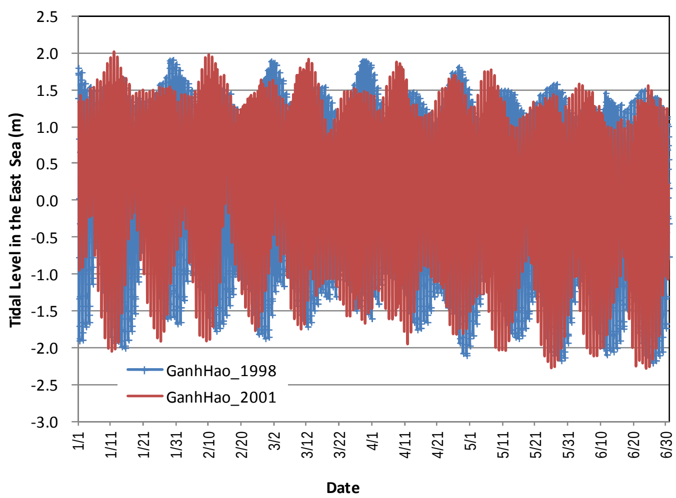


Figure 6.5.11 Hourly Change of Tidal Level in the East Sea (Ganh Hao) in 1998 and 2001

Source: IHESV and Study Team

Not much change can be seen in the left figure that tidal level in the West Sea does not change so much in comparison with the right side graph (the East Sea). Bottom of the blue line (tide in 1998) in the left figure decreases slightly more than the red line (tide in 2001) but top lines of both keep nearly the same value. Right side figure shows that there are not so much differences between two lines (red and blue) in the East Sea.

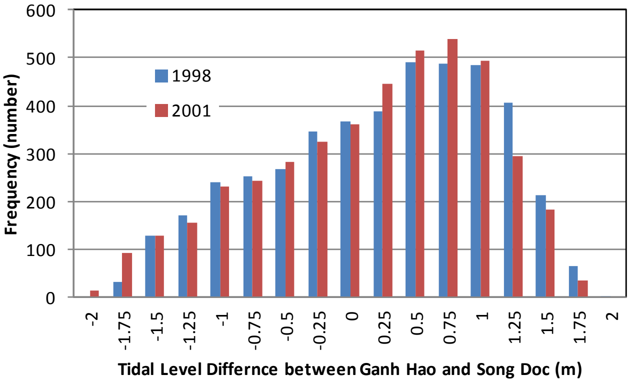


Figure 6.5.12 Histogram of Tidal Level Difference between Ganh Hao and Song Doc in 1998 and 2001
Source: IHESV and Study Team

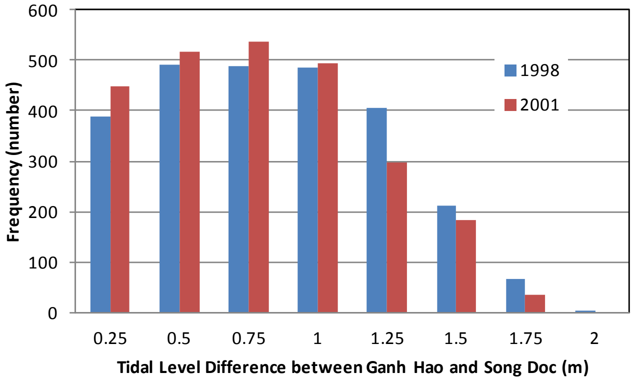


Figure 6.5.13 Highlighted Histogram of Tidal Level Difference between Ganh Hao and Song Doc in 1998 and 2001
Source: IHESV and Study Team

In figure 6.5.12 and 6.5.13, X axis indicates tidal level difference between the East Sea and the West Sea; positive value shows tidal level in the East Sea that it is higher than the West Sea. The positive values are highlighted further in the figure 6.5.13. The case 1998 shows more frequency of positive value in high zone such as 1.25m, 1.5m and 1.75m so water flow from the East Sea to the West Sea in 1998 could occur more frequently and strongly than that of 2001. In fact, averages of these tidal differences in 1998 and 2001 are 0.11m and 0.05m respectively.

Though natural flow from the East Sea to the West Sea differs by year, gate operation can increase its flow capacity and reduce fluctuation of flow capacity caused by tidal regime in different years such as the cases of 1998 and 2001. Natural flow capacity in 1998 is about 2m3/sec higher than the case of 2001 but gate operation results show not so much difference among them. In this study, only two cases are examined; it is a bit early to conclude like this, however, in other words, gate operation is one of ideas to increase flow capacity and reduce flow capacity fluctuation caused by different tidal regime in different years.

It is found that increase of sea level has a risk of reducing flow capacity of water mobilization from east to west, so that sea level rise under climate change in future will most likely accelerate shrimp diseases occurrence. In common idea on sea level rise, it is considered that sea level rise will be favorable for shrimp cultivation because availability of saline water becomes easier in comparison with a present situation; however, sea level rise may have a risk causing a kind of negative impact mentioned above. This study has implied a risk of diseases can be improved by gate operation with increasing water mobilization capacity in southern Ca Mau even though sea level rise under climate change. Simulation shows positive impact for shrimp diseases improvement but it is not confirmed yet in the field on natural water mobilization; actual situation shall be studied through field observation.

6.6 Study on the best-suited sea dyke types adaptive to the Local Situation

6.6.1 Rationale

One of the priority projects that the coastal provinces have planned is sea-dyke construction in the context of climate change, especially in the form of sea-level rise as well as more frequent and stronger storms. The Vietnamese Government has been constructing sea dyke and allocating fund necessary for the construction of the dykes under Program 667. There are several kinds of sea dykes e.g., 1) earth embankment, 2) earth embankment with some protection work in the front, 3) concrete made dyke, 4) masonry (or gabion) made dyke, etc. Also, there are some additional/combined works to those dykes such as forestation of mangroves, construction of sea-wave dissipaters, etc.

Selection of the types is the most affecting factor in estimating the construction cost. If the dyke is constructed without artificial materials like concrete, the cost will be cheap; however the dyke may not be able to stand against sea-level rise and storms. On the other hand, concrete made sea dyke will stand against most of the very strong storms while such structure cannot be extended all along the seashore line since it is very costly.

In this regard, the type of sea dykes will have to be selected taking into account the local conditions, e.g., 1) foundation condition, 2) morphology of the seashore (sedimentation taking place or erosion taking place), 3) availability of local materials, etc. Therefore, this in-depth study explores the establishment best suited sea dyke types according to the local condition.

6.6.2 Components of Study

This study consists of two major components; one is computer simulations on morphology of the coastal area in the Mekong Delta and to identify characteristics of area such as sedimentation tendency or erosion tendency and indicate them on the map, the other is to prepare recommendation on the types of sea dyke along the coastal line according to the local situation and also simulation results.

1) Simulation

The simulation aims to identify potential risks of erosion and suspended material sedimentation taking into account geomorphology, geology, and hydraulics such as current shoe line shape, sediment thickness, sea current, tidal regime river hydraulic, waves, and wind.

- ✓ Simulation model covers; Taiwan for the northern boundary, Philippine islands for eastern boundary, and Singapore for southern boundary in ocean side, Tan Chau and Chau Doc are western boundary as river side.
- ✓ Bathymetry feature information is employed from data of National Oceanic and Atmospheric Administration (NOAA) of USA.
- ✓ Inland map, hydrological profile, and cross section of Mekong river are employed form data of Water Resource Department in 2009.
- ✓ Boundary conditions are given at; Taiwan Strait, Bashi Channel, Mindro Strait, Lumbucan Channel, Singapore Strait for ocean boundary, Tan Chau and Chau Doc for river boundary with hourly water level.
- ✓ Boundary condition for suspended sediment concentration in Mekong river is given at Tan Chau and Chau Doc stations' data obtained from Water Resource Department in 2009.
- ✓ Model calibrations of ocean water levels are applied by hourly data of 365days in 2009 at total 6 stations; correlation coefficient is calculated as 0.86.
- ✓ Software of Mike 21/3 FM is used to examine change of coastal line in hydraulics, wave effect, erosion/deposition formulation.

2) Sea-dike Planning for Coastal line

With reference to potential change of coastal line identified by simulation coupled with field survey result on present condition, recommendation is prepared for each Province. It is summarized in a series of maps of Provinces describing; present situation such as "erosion", "sedimentation", "mangrove", and recommendation such as "concrete dyke", "reforestation".

- ✓ A topographic map in 1965 is employed as a base map for this simulation.

- ✓ Satellite images are employed to grasp coastal line change in recent years; a series of LANDSAT information in 1989, 2001, 2006, 2008, and 2010.
- ✓ As per planning of sea dikes, simulation result of dry season is mainly used for this study because coastal line change occurs mainly in dry season
- ✓ Approximate cost of construction is also calculated and added in each recommendation map.

6.6.3 Simulation Results

Nodes for simulation are arranged on bathymetry chart and Mekong river shown in Figure 6.6.1. In Figure 6.6.1, triangle points colored by red show points given boundary condition of sea water level.

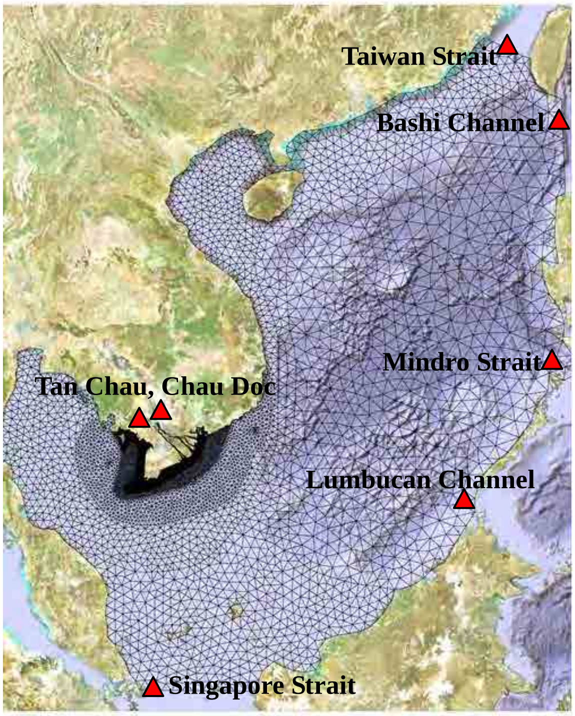


Figure 6.6.1 Node and Boundary Points Applied in Simulation
Source: ICOE and Study Team

Figure 6.6.2 Coastal Three Zones of Mekong Delta
Source: ICOE and Study Team

1) General Characteristics of Coastal Area

Coastal area of Mekong delta can be classified into four zones according to calibration survey on the simulation model and simulation results. Out of four zones, the study area has three zones. These three zones are shown in figure 6.6.2 and summarized as follows;

1.1) Can Go Zone

Can Go zone is estuary and coastal area of Ho Chi Minh city where has high tidal condition. Sediment supply from Dong Nai river is not so much. This is why coastal line of this area has an erosion tendency.

1.2) Go Cong – Tran De Zone (Zone 1: blue color belt area in figure 6.6.2)

This zone starts from Go Cong in Tien Giang Province and ends at Tran De in Soc Trang province that the provinces included are Tien Giang, Ben Tre, Tra Vinh, and a part of Soc Trang. This zone covers all estuaries of Mekong river, so that the zone has basically sedimentation tendency mainly due to sediment supply from Mekong river. Recently, it is reported that decrease of sediment load from Mekong river, then, erosion area has been increasing.

1.3) Vinh Chau – Ca Mau Cape Zone (Zone 2: light yellow color belt area in figure 6.6.2)

This zone covers three provinces such as Soc Trang, Bac Lieu, and Ca Mau. This zone is basically characterized as erosion area mainly due to strong wave energy and tidal current. This zone does not cover Mekong river estuaries so sediment load is not so much in comparison with Go Cong Tran De Zone.

1.4) Ca Mau Cape – Ha Tien Zone (Zone 3: red-purple color belt area in figure 6.6.2)

Because of calm tide and wave of the West Sea, this zone can be characterized as stable zone in comparison with other zones. At the Ca Mau cape in the West Sea side, sediment can deposit there because of weak tide and wave.

2) Tidal Regime (present)

Present tidal regime obtained by simulation is shown in the following figures;

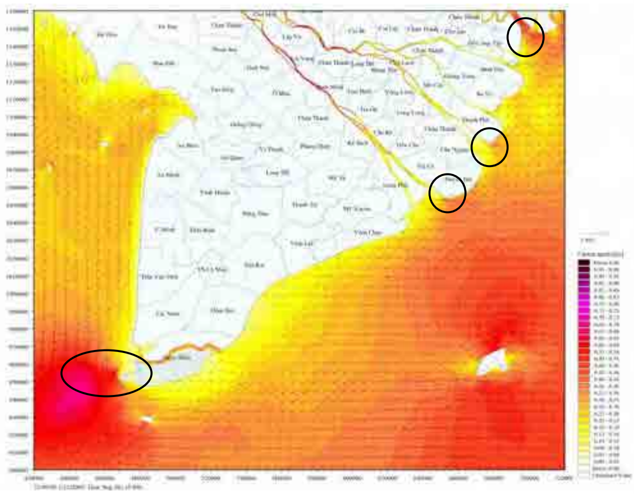


Figure 6.6.3 Current Speed of Spring Tide in Dry Season
Source: ICOE and Study Team

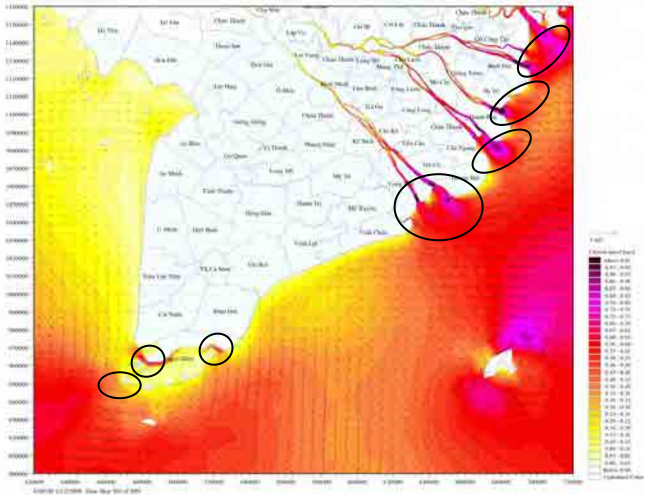


Figure 6.6.4 Current Speed of Ebb Tide in Dry Season
Source: ICOE and Study Team

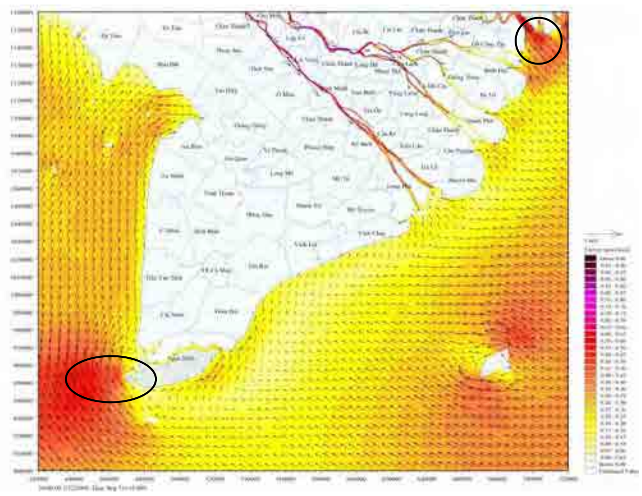


Figure 6.6.5 Current Speed of Spring Tide in Rainy season
Source: ICOE and Study Team

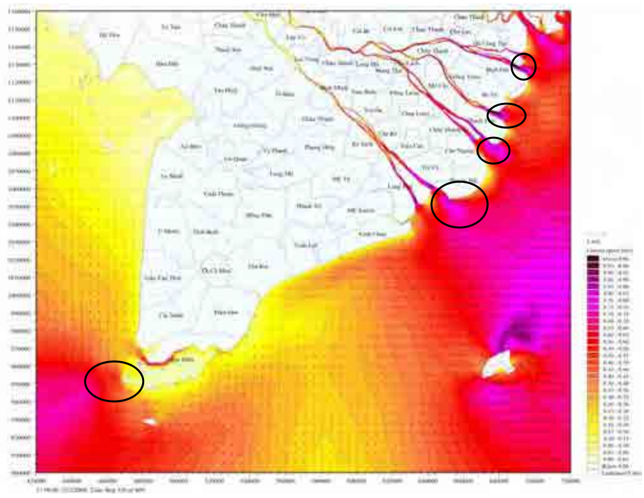


Figure 6.6.6 Current Speed of Ebb Tide in Rainy Season
Source: ICOE and Study Team

In the figures, purple and red colors indicate that tidal current speed of an area is fast, and yellow and white colors show low speed of tidal current. Circled areas are the places where erosion occurrence is expected due to fast tidal current. Except Ca Mau cape, most areas circled are located in near estuaries of Mekong delta, so that these areas also have potential of high sediment load as well. In this study, these opposite effects are finally balanced and presented as the final results. In figures, it can be seen seasonal difference; along coastal line, rainy season shows more yellowish color than dry season in both spring and ebb tides. It implies that erosion potential in rainy season is less than the potential in dry season.

3) Wave Height

Wave height shows significant change by seasons while change by tidal condition is not obviously seen in simulation results. Wave height in the East Sea is higher than the West Sea and it is higher in dry season in comparison with rainy season. Simulated wave height is summarized as follows;

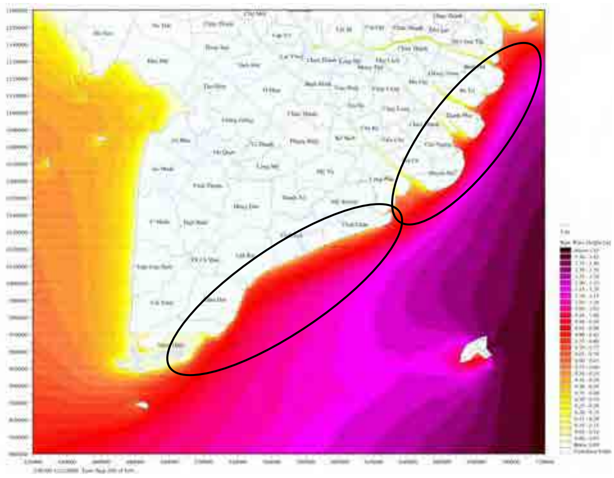


Figure 6.6.7 Wave Height of Spring Tide in Dry Season
Source: ICOE and Study Team

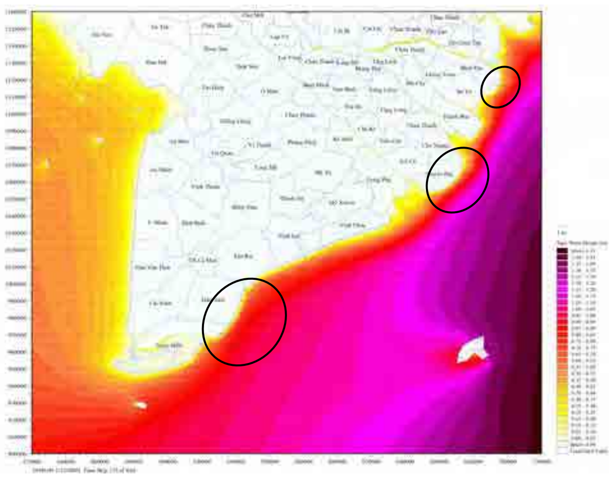


Figure 6.6.8 Wave Height of Ebb Tide in Dry Season
Source: ICOE and Study Team

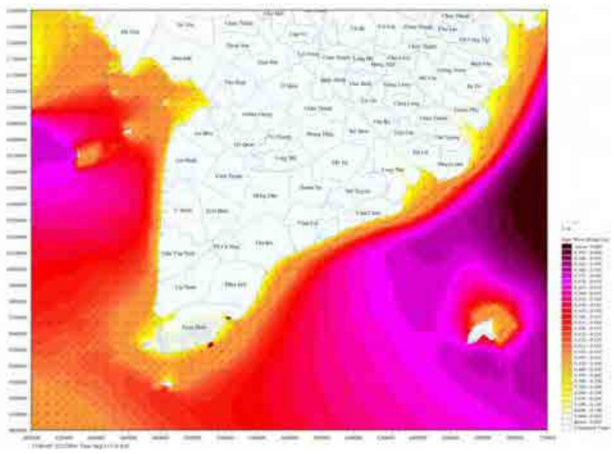


Figure 6.6.9 Wave Height of Spring Tide in Rainy Season
Source: ICOE and Study Team

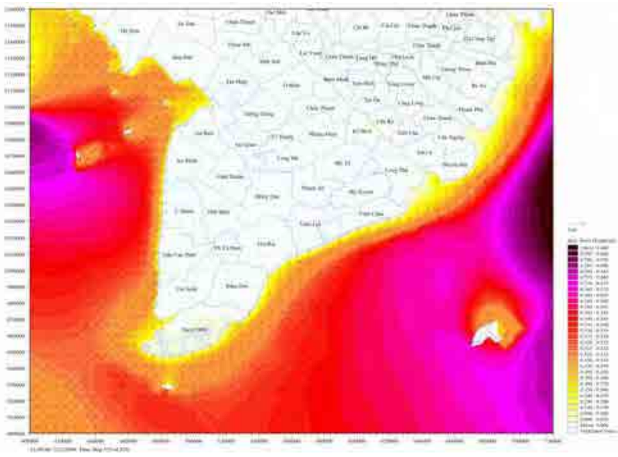


Figure 6.6.10 Wave Height of Ebb Tide in Rainy Season
Source: ICOE and Study Team

Wave height in the East Sea is generally higher than the West Sea and it appears clearly in dry season. In rainy season, yellow color surrounds coastal line not only along the West Sea but also in the East Sea during spring and ebb tides. It means rainy season wave height is not so high in comparison with dry season. Some points can be identified having potential high wave circled in figures of dry season.

4) Orientation of Erosion/Deposition

Based on the simulation results described above and climate change scenario in 2050 (sea level rise of 30cm), orientation of coastal line is examined and summarized that whether a place has erosion tendency or deposition trend. Figure 6.6.11 - 6.6.18 show orientation of coastal line on toward erosion or deposition, which the area colored by blue has erosion tendency and red color places show dominant area of deposition. As for difference of seasons, blue color appears in many places during dry season in comparison with rainy season. Regarding sea level rise cases between 0cm and 30cm, obvious change cannot be found in mud case, sand case, dry season, and rainy season. Difference can be seen in materials and zones.

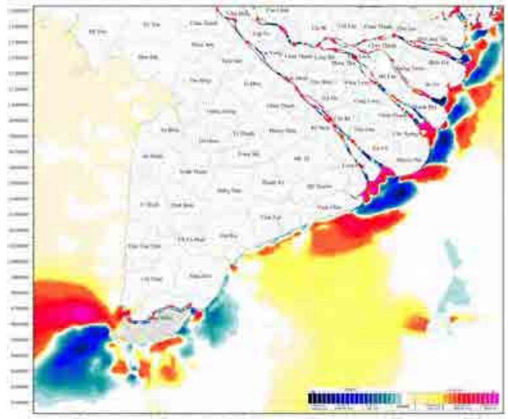


Figure 6.6.11 Mud Erosion/Deposition in Dry Season
Source: ICOE and Study Team

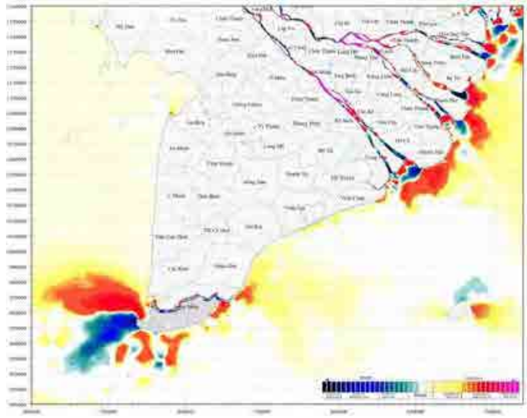


Figure 6.6.12 Mud Erosion/Deposition in Rainy Season
Source: ICOE and Study Team

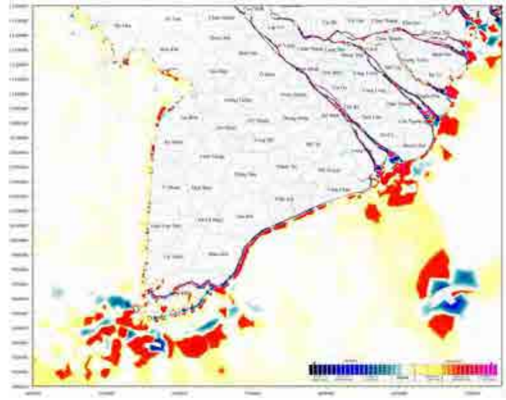


Figure 6.6.13 Sand Erosion/Deposition in Dry Season
Source: ICOE and Study Team

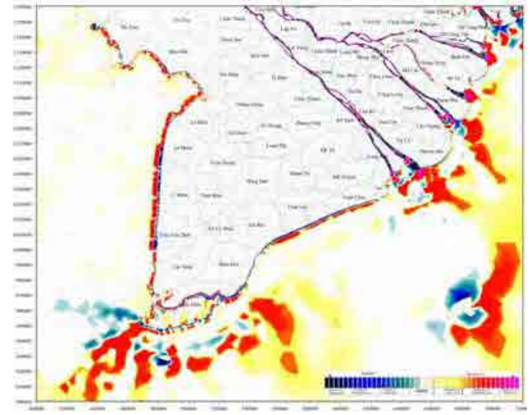


Figure 6.6.14 Sand Erosion/Deposition in Rainy Season
Source: ICOE and Study Team

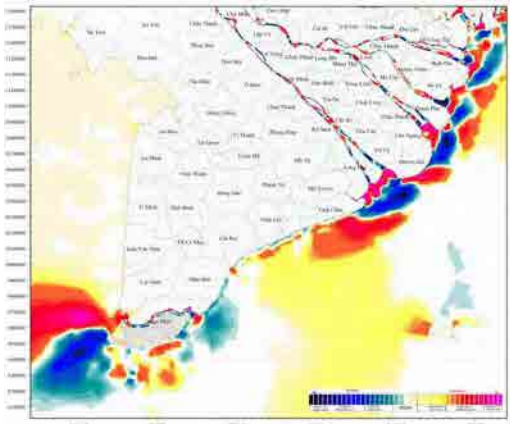


Figure 6.6.15 Mud Erosion/Deposition in Dry Season (SLR30)
Source: ICOE and Study Team

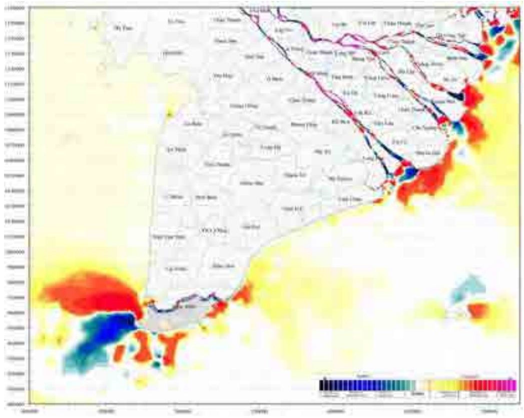


Figure 6.6.16 Mud Erosion/Deposition in Rainy Season (SLR30)
Source: ICOE and Study Team

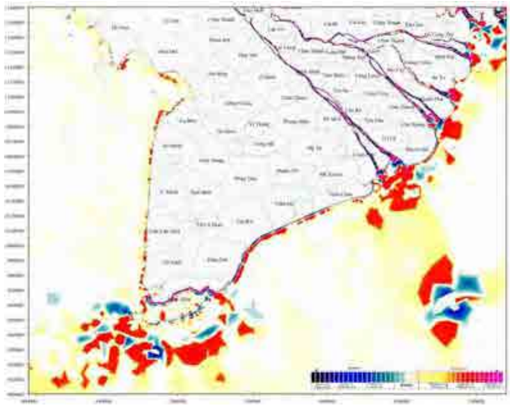


Figure 6.6.17 Sand Erosion/Deposition in Dry Season (SLR30)
Source: ICOE and Study Team

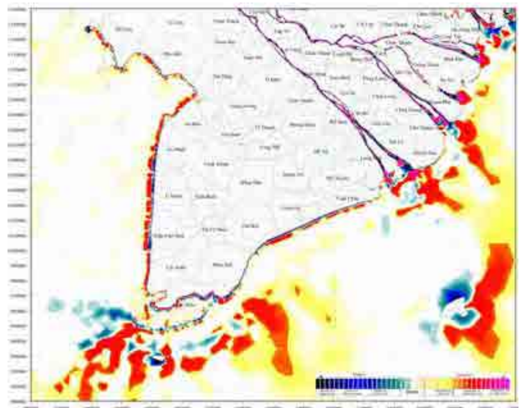


Figure 6.6.18 Sand Erosion/Deposition in Rainy Season (SRL30)
Source: ICOE and Study Team

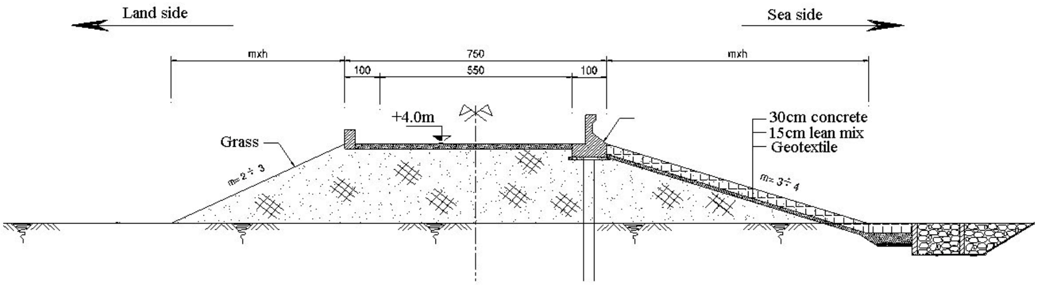
Table 6.6.1 Characteristics of Erosion/Deposition Tendency of Coastal Area

Material/Zone	Zone 1	Zone 2	Zone 3
Mud (Dry Season)	Deposition / Erosion	Erosion	No-significance
Mud (Rainy Season)	Deposition	No-significance	No-significance
Sand (Dry Season)	Erosion	Erosion	Erosion
Sand (Rainy Season)	Erosion	Erosion	Deposition (CM cape) / Erosion

It is clear that sand is not tolerant against erosion especially in zone 1 and zone 2. Sand deposition can be seen only at the area near Ca Mau cape in the West Sea. There is no significant mud erosion in the West Sea (zone 3). Mud erosion will occur mainly in dry season in zone 1 and zone 2 but it turns to tendency of deposition or no-change in rainy season. It can be said that sandy coast has much erosion risk in comparison with mud coast or mud terrain, and the erosion will be accelerated during dry season.

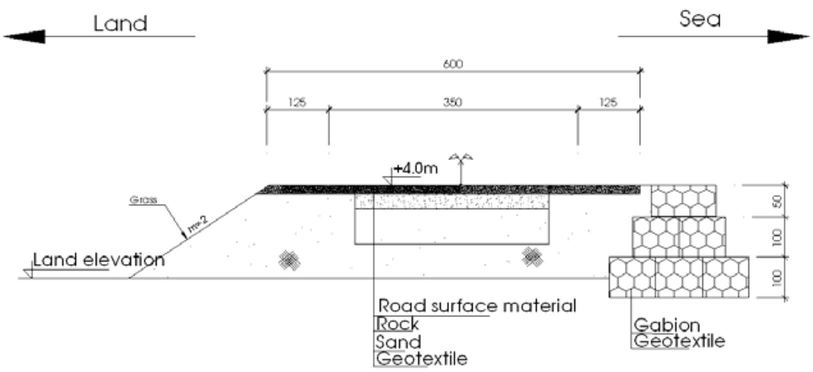
6.6.4 Sea-dykes for Coastal Line Protection

Based on field observation and simulation results, recommendable sea-dykes are considered for coastal line protection. Recommendable sea-dykes are composed of four major types such as concrete dyke, riprap (on embankment), mangrove forest protection, and reforestation as follows.



Reference for Riprap (Source: ICOE)

Reference for Reforestation (Source: ICOE)



Reference for Mangrove Protection: Gabion (Source: ICOE)

MAP OF SHORELINE EVOLUTION AND REAL SITUATION OF DYKE IN TIENGIANG

SCALE 1/300.000

Recommeded dyke for erosion protection cost 1.700.000 USD/km

SOIL DYKE
EROSION
SEDIMENTATION
MANGROVE FOREST
CONCRETE
RECOMMENDED CONCRETE DYKE
REFORESTATION

0 5 10 20km

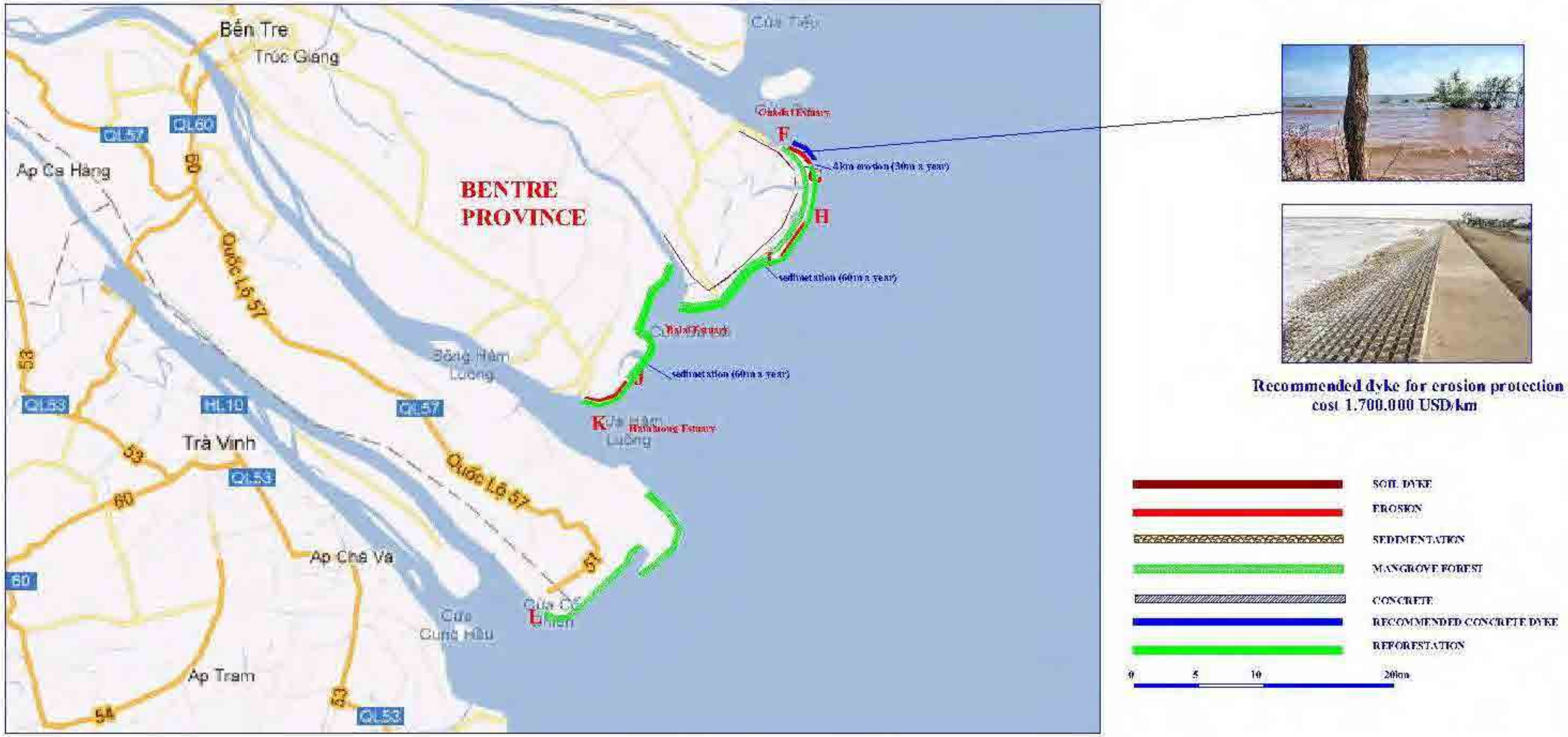
Section	A-B	B-C	C-D	D-E	E-F
Length	2km	11km	2.1 km	3.2 km	8 km
Tendency	Stable	Erosion	Erosion	Erosion	Erosion
Present condition	Loose mangrove forest	Loose mangrove forest	Concrete dyke	no mangrove forest	no mangrove forest
Recommended structure	Reforestation	Reforestation	None	Concrete Dyke	Reforestation
Length	2km	11km		3.2 km	8km
Unit price	7000 USD/km	7000 USD		1.700.000 USD/km	7000 USD/km
Sub total cost	14.000 USD	77.000 USD		5.440.000 USD	56.000 USD
Priority	IV	I	V	II	III

Figure 6.6.19 Coastal Area Morphology and Protection Plan in Tien Giang Province (Zone 1)

Source: ICOE and Study Team

MAP OF SHORELINE EVOLUTION AND REAL SITUATION OF DYKE IN BENTRE

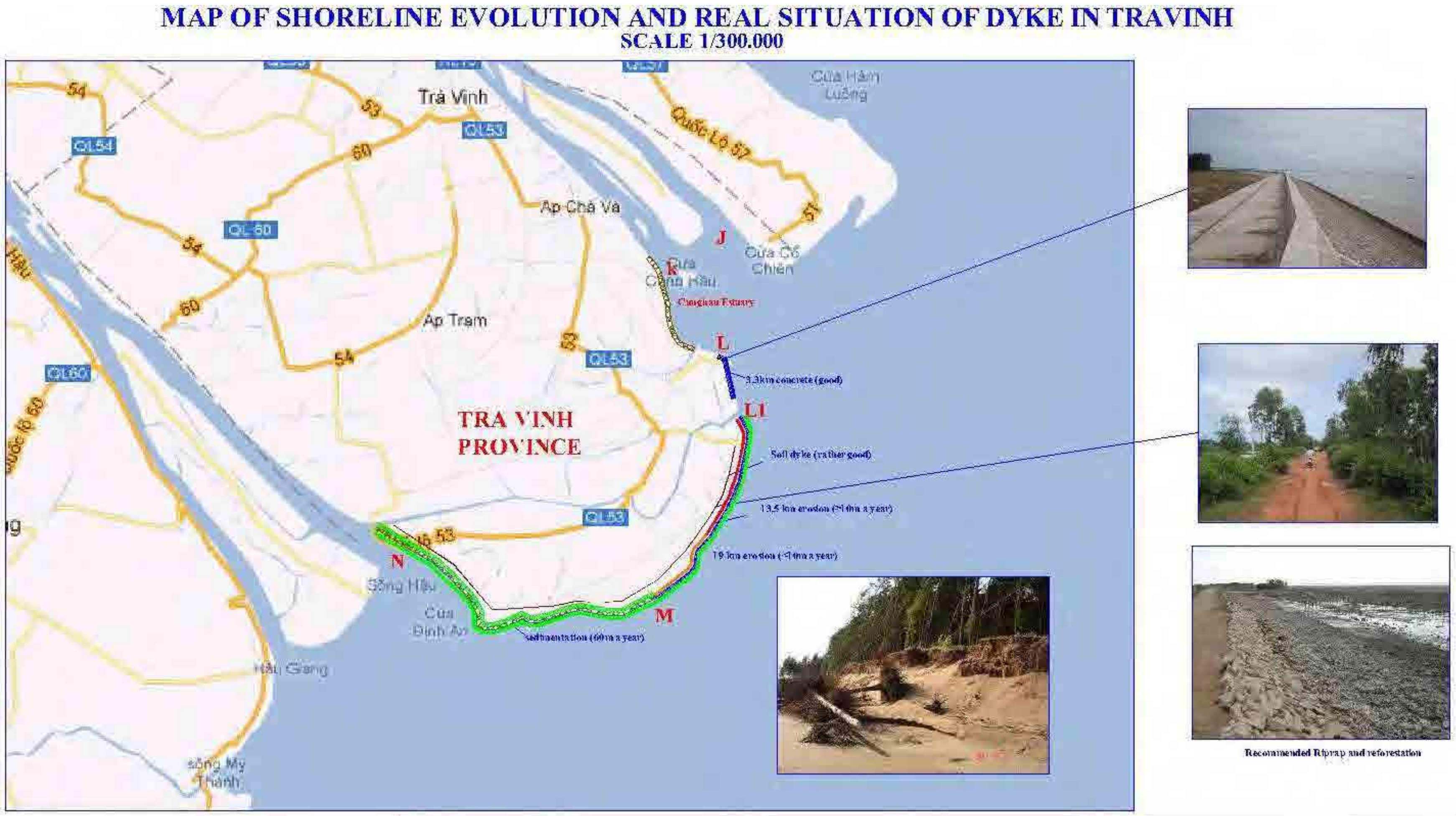
SCALE 1/300.000

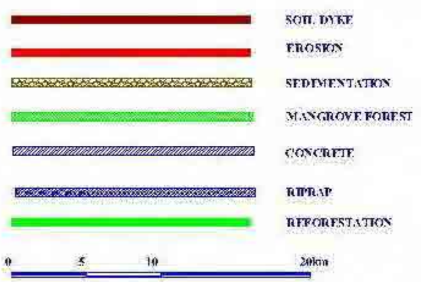


Section	F-G	G-H	H-I	I-J	J-K	K-L
Length	4 km	5 km	5 km	20 km	5 km	20 km
Tendency	Erosion	Stable	Erosion	Stable	Erosion is not very strong	Stable
Present condition	Loose mangrove forest	Loose mangrove forest	Loose mangrove forest	Loose mangrove forest	no mangrove forest	Loose mangrove forest
Recommended structure	Concrete Dyke	Reforestation	Reforestation	Reforestation	Reforestation	None
Length	4 km	5 km	5 km	20 km	5 km	
Unit price	1.700.000 USD/km	7000 USD/km	7000 USD/km	7000 USD/km	7000 USD/km	
Sub total cost	8.500.000 USD	35.000 USD	35.000 USD	140.000 USD	35.000 USD	
Priority	I	IV	II	VI	III	V

Figure 6.6.20 Coastal Area Morphology and Protection Plan in Ben Tre Province (Zone 1)

Source: ICOE and Study Team





Section	J-K	K-L	L-L1	L1-M		M-N
Length	3 km	10 km	3.3 km	28 km		20 km
Tendency	Sedimentation	Sedimentation	Stable	Erosion		Sedimentation
Present condition	No mangrove forest	Dense mangrove forest	Very good concrete dyke	No mangrove forest		Loose mangrove forest
Recommended structure	Re forestation	None	None	Riprap Reforestation		Reforestation
Length	3 km			28 km		20 km
Unit price	7000 USD/ km			7000 USD/km Mangrove	1.000.000 USD/km Riprap	7000 USD/ km
Sub total cost	21.000 USD			196.000 USD	28.000.000 USD	140.000 USD
				28.196.000 USD		
Priority	III	IV	V	I		II

Figure 6.6.21 Coastal Area Morphology and Protection Plan in Tra Vinh Province (Zone 1)
Source: ICOE and Study Team

SOIL DYKE
EROSION
SEDIMENTATION
MANGROVE FOREST
CONCRETE
RECOMMENDED RIPRAP
REFORESTATION

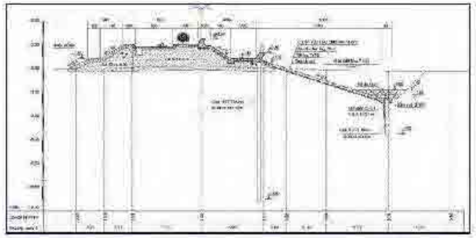
5 10 20km

Section	N-O	O-P	P-Q	
Length	12 km	22 km	32 km	
Tendency	Sedimentation	Sedimentation	Erosion	
Present condition	Dense mangrove forest	Dense mangrove forest	Loose mangrove forest	
Recommended structure	None	None	Riprap Reforestation	
Length	12 km	22 km	32 km	
Unit price			7000 USD/km Mangrove	1.000.000 USD/km Riprap
Sub total cost			224.000 USD	32.000.000 USD
			32.224.000 USD	
Priority	III	II	I	

Figure 6.6.22 Coastal Area Morphology and Protection Plan in Soc Trang Province (Zone 1/Zone 2)
Source: ICOE and Study Team

MAP OF SHORELINE EVOLUTION AND REAL SITUATION OF DYKE IN BACLIEU PROVINCE

SCALE 1/300.000



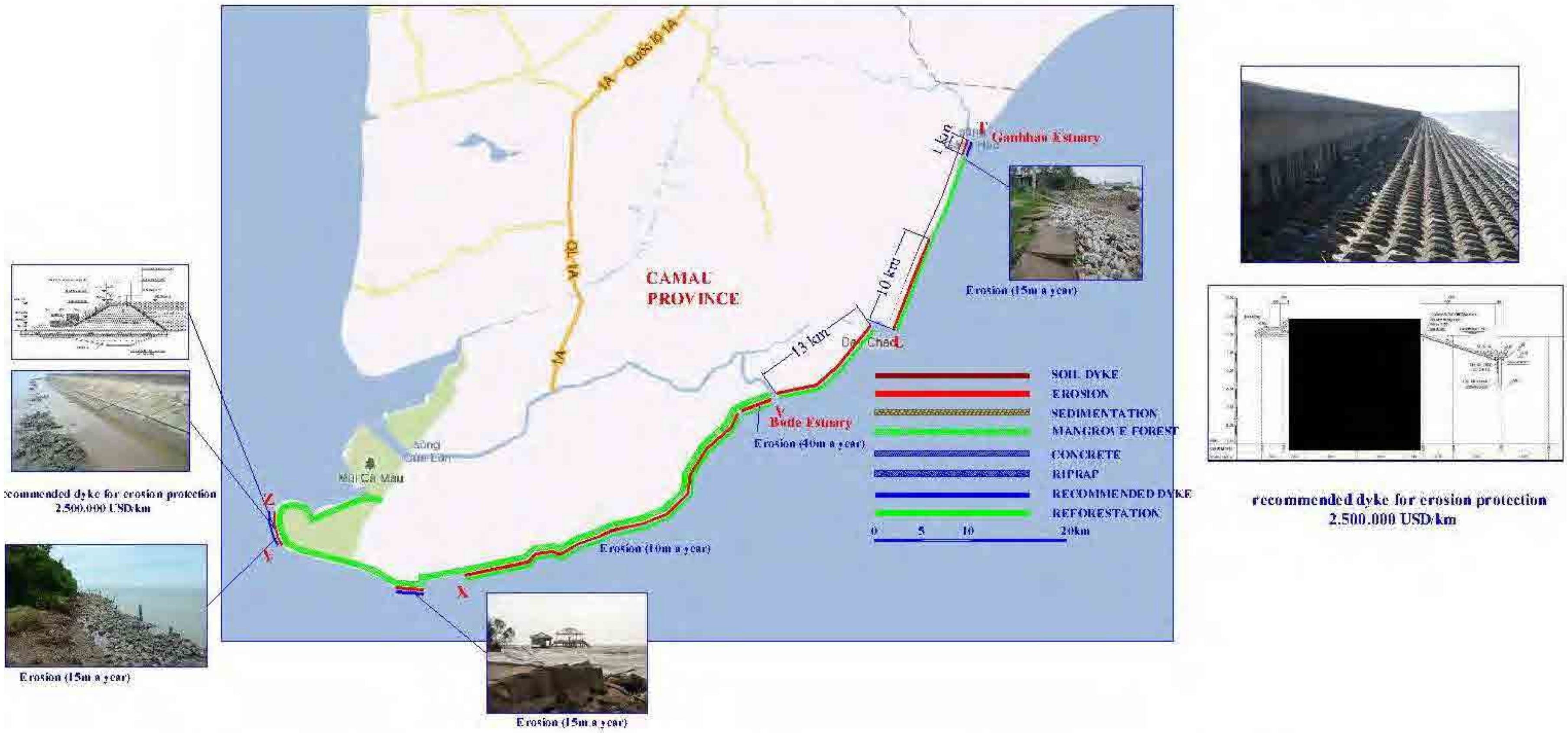
recommended dyke for erosion protection
2.500.000 USD/km

SOIL DYKE
EROSION
SEDIMENTATION
MANGROVE FOREST
CONCRETE
RIPRAP
RECOMMENDED CONCRETE DYKE
REFORESTATION
0 5 10 20km

Section	Q-R	R-S	S-T
Length	10 km	27.5 km	7 km
Tendency	Erosion	Sedimentation	Erosion
Present condition	Loose mangrove forest	Dense mangrove forest	1km concrete dyke Loose mangrove forest
Recommended structure	Reforestation	None	Concrete Dyke
Length	10 km		7 km
Unit price	7000 USD/km		2.500.000 USD/km
Sub total cost	70.000 USD		17.500.000 USD
Priority	II	III	I

Figure 6.6.23 Coastal Area Morphology and Protection Plan in Bac Lieu Province (Zone 2)
Source: ICOE and Study Team

MAP OF SHORELINE EVOLUTION AND REAL SITUATION OF DYKE IN EAST CAMAU PROVINCE
SCALE 1/400.000

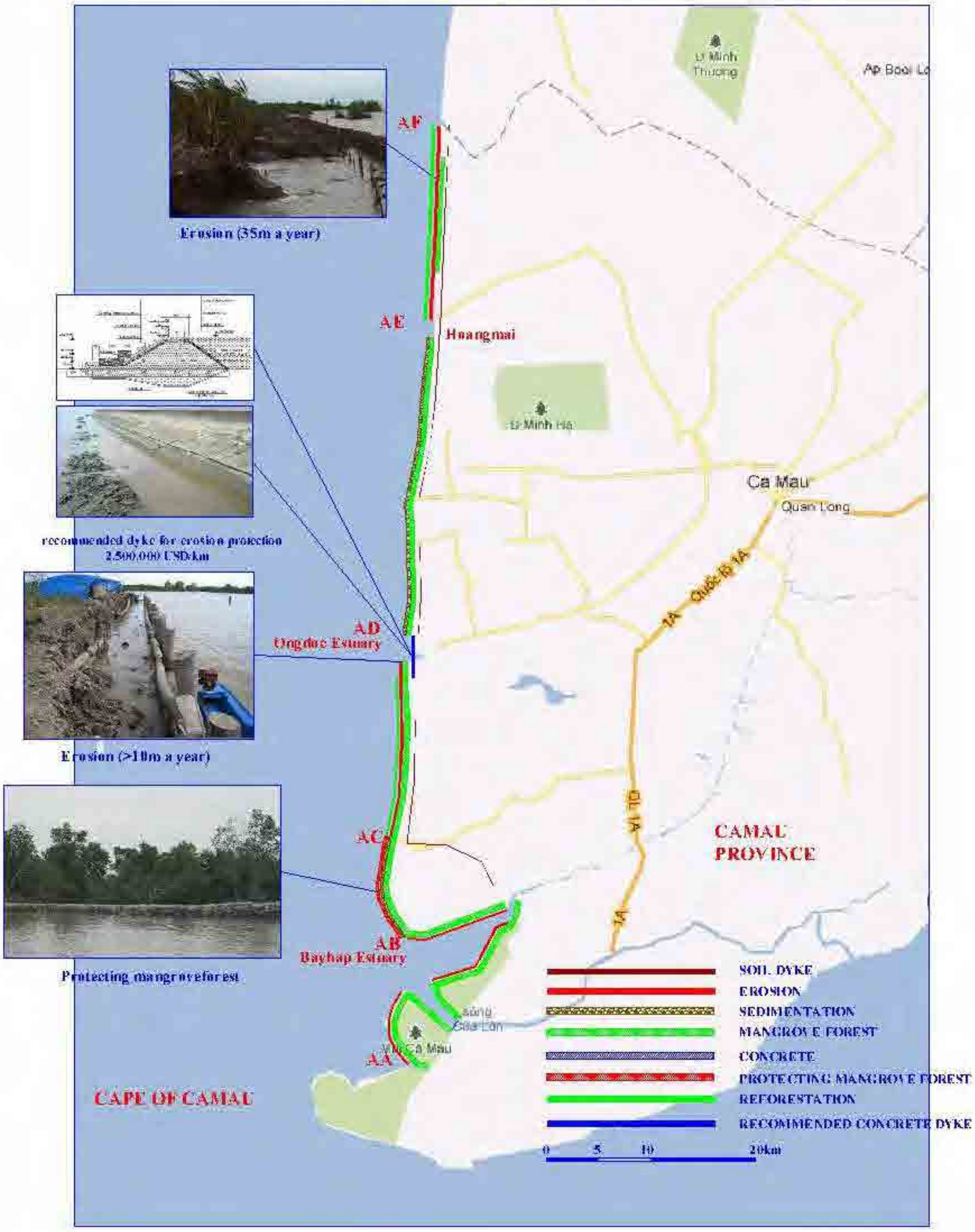


Section	T-U		U-V	V-X	X-Y	Y-Z
Length	25 km		13 km	35 km	10 km	6 km
Tendency	11km Erosion		Erosion	Erosion	1km erosion	Erosion
Present condition	Dense mangrove forest		Dense mangrove forest	Dense mangrove forest	Dense mangrove forest	Dense mangrove forest
Recommended structure	Protecting mangrove forest 1km Concrete Dyke		Reforestation	Reforestation	Concrete Dyke	Concrete Dyke
Length	24 km	1 km	13 km	35 km	1 km	6 km
Unit price	7000 USD/km Mangrove	2.500.000 USD/km Dyke	5000 USD/km	7000 USD/km	2.500.000 USD/km	2.500.000 USD/km
Sub total cost	168.000 USD	2.500.000 USD	65.000 USD	245.000 USD	2.500.000 USD	9.000.000 USD
	2.168.000 USD					
Priority	I		V	VI	II	III

Figure 6.6.24 Coastal Area Morphology and Protection Plan in Ca Mau Province, East (Zone 2)
Source: ICOE and Study Team

MAP OF SHORELINE EVOLUTION AND REAL SITUATION OF DYKE IN WEST CAMAU PROVINCE

SCALE 1/400.000



Section	AA-AB	AB-AC	AC-AD		AD-AE	AE-AF
Length	35 km	11.5 km	27 km		21 km	20 km
Tendency	Erosion	Sedimentation	Erosion		Sedimentation	Erosion
Present condition	Dense mangrove forest	Dense mangrove forest	Dense mangrove forest		Loose mangrove forest	Loose mangrove forest
Recommended structure	Reforestation	Protecting mangrove forest	Concrete Dyke Reforestation		Reforestation	Reforestation
Length	35 km	11.5 km	Reforestation 25 km	Concrete Dyke 2 km	21 km	20 km
Unit price	5000 USD/km	100.000 USD/km	7000 USD/km	2.500.000 USD/km	7000 USD/km	7000 USD/km
Sub total cost	245.000 USD	1.150.000 USD	175.000 USD	5.000.000 USD	147.000 USD	140.000 USD
			5.175.000 USD			
Priority	III	V	II		IV	I

Figure 6.6.25 Coastal Area Morphology and Protection Plan in Ca Mau Province, West (Zone 3)
Source: ICOE and Study Team

MAP OF SHORELINE EVOLUTION AND REAL SITUATION OF DYKE IN KIENGIANG PROVINCE

SCALE 1/400.000

<table>
<tr><td>Section</td><td>AE-AF</td><td>AF-AG</td><td>AG-AH</td><td colspan="2">AH-AI</td><td colspan="2">AI-AJ</td><td>AJ-AK</td></tr>
<tr><td>Length</td><td>22 km</td><td>12.5 km</td><td>25 km</td><td colspan="2">29 km</td><td colspan="2">38 km</td><td>21 km</td></tr>
<tr><td>Tendency</td><td>Erosion</td><td>Sedimentation</td><td>Erosion</td><td colspan="2">Stable</td><td colspan="2">7.8 km of Erosion</td><td>Light Erosion</td></tr>
<tr><td>Present condition</td><td>Loose mangrove forest</td><td>Loose mangrove forest</td><td>Loose mangrove forest</td><td colspan="2">Loose mangrove forest</td><td colspan="2">Loose mangrove forest</td><td>Loose mangrove forest</td></tr>
<tr><td>Recommended structure</td><td>Reforestation</td><td>Reforestation</td><td>Reforestation</td><td colspan="2">Concrete Dyke
Reforestation</td><td colspan="2">Concrete Dyke
Reforestation</td><td>None</td></tr>
<tr><td>Length</td><td>22 km</td><td>12.5 km</td><td>25 km</td><td>Concrete Dyke
10 km</td><td>Reforestation
19 km</td><td>Concrete Dyke
8 km</td><td>Reforestation
30 km</td><td></td></tr>
<tr><td>Unit price</td><td>7000 USD/ km</td><td>7000 USD/ km</td><td>7000 USD/ km</td><td>2,500,000 USD/km</td><td>7,000 USD/km</td><td>2,500,000 USD/km</td><td>7,000 USD/km</td><td></td></tr>
<tr><td rowspan="2">Sub total cost</td><td rowspan="2">154.000 USD</td><td rowspan="2">87.500 USD</td><td rowspan="2">175.000 USD</td><td>25,000,000 USD</td><td>133,000 USD</td><td>20,000,000 USD</td><td>210,000 USD</td><td rowspan="2"></td></tr>
<tr><td colspan="2">25,133,000 USD</td><td colspan="2">20,210,000 USD</td></tr>
<tr><td>Priority</td><td>IV</td><td>V</td><td>III</td><td colspan="2">II</td><td colspan="2">I</td><td>VI</td></tr>
</table>

Figure 6.6.26 Coastal Area Morphology and Protection Plan in Kien Giang Province (Zone 3)

Source: ICOE and Study Team

6.6.5 Discussions

Potential area of erosion is located in throughout coastal line of the study area, and erosion potential varies by season, by locations, and by materials at seashore. This study has revealed that erosion in dry season is more serious than which is in rainy season; the West Sea shows less erosion potential than the East Sea; sand is more erodible than mud. Erosion protection in coastal lines has to be considered these features.

In zone 1, it is estuary area of Mekong delta, erodible places and sedimentary places appear one after the other and current speed during ebb tide is quite high around the places near estuaries. Erosion protection in these areas shall have conditions to be stable and strong against current and also be able to support sedimentation phenomenon and vegetation growth. A combination of concrete structure and mangrove forestation is recommendable but location shall be selected by careful field observation.

In zone 2, the coastal line shows basically erodible features and supply of sediment is quite limited. It is remarkable that places of erosion risk continue along this zone especially in dry season. Artificial structures such as concrete dyke or riprap will be the main countermeasures as coastal area protection except places of thick mangrove forest area.

In zone 3, tidal current and wave height are calm but sediment supply from Mekong river is quite limited. In this area, bed material of sand shows erodible features but mud is quite stable against hydraulic phenomenon at seashore. In order to keep and help growing mud sedimentation, vegetation will be the best way as coastal area protection except some places where erosion is in progress. Mangrove protection and mangrove reforestation will be major countermeasures in this zone.

6.7 Study on the Sustainability of Extensive to Semi Intensive Shrimp Cultures

6.7.1 Rationale

As sea water comes in, brackish shrimp culture has become popular in the coastal areas of the Mekong delta. There are several types of shrimp culture, firstly divided into 1) mono-shrimp culture and 2) rotational shrimp culture between shrimp and paddy. Further, such shrimp culture is divided into categories as; 1) extensive culture, 2) semi-intensive culture (or family level intensive culture), and 3) commercial intensive culture. Note that rotational shrimp culture can be found only in extensive and improved extensive culture.

Though the shrimp culture brings about a lot of income, i.e. a lucrative business for farmers, it entails high risk of shrimp diseases. Once the farmers are hit by a virus disease, he/she may get total loss which is sometimes known in the coastal area. Since shrimp culture (here means brackish shrimp culture) is already a part of very important livelihood for those farmers living in saline intrusion area, there should be a need to identify a sustainable way of raising brackish shrimp.

This in-depth study therefore examines the current practices for brackish shrimp culture whereby identifies some key issues in order to make the culture highly sustainable. In addition, water quality test will be carried out at 2 collection points where water is circulated and where water is very dormant. Note that this in-depth study excludes commercial base intensive culture, which is highly regulated by the Government regulations.

6.7.2 Components of Study

This study consists of two components; one is interview to coastal shrimp farmers about circumstances of their shrimp cultivation, the other is water quality test in two places in order to grasp water circulation condition which may affect occurrence of shrimp diseases.

1) Interview

Interview and questionnaires survey have been carried out to total 281 farmers in 6 villages in Ca Mau province, Soc Trang province, and Bac Lieu province. Their shrimp farming types are; 90 samples for extensive shrimp farming, 100 samples for semi-intensive shrimp farming, 90 samples for paddy-shrimp rotation farming.

Table 6.7.1 Interviewees for Questionnaire Survey on Shrimp Farming in Three Provinces

No.	Samples	Type of Culture	Planned Province
1	30 samples for extensive 40 samples for semi-intensive	Shrimp mono culture	Phu Tan, Phu Tan,Ca Mau
2	30 samples for extensive 31 samples for semi-intensive	Shrimp mono culture	Tan Phong, Gia Rai, Bac Lieu
3	20 samples for extensive 30 samples for semi-intensive	Shrimp mono culture	Ngoc Dong, My Xuyen,Soc Trang
4	30 samples for paddy-shrimp	Paddy-shrimp	Phu My, Phu Tan,Ca Mau
5	30 samples for paddy-shrimp	Paddy-shrimp	Phong Thanh A, Gia Rai, Bac Lieu
6	30 samples for paddy-shrimp 10 samples for extensive	Paddy-shrimp	Hoa Tu 1, My Xuyen,Soc Trang

2) Water Quality Test

Water quality on some items have been carried out in Ca Mau and Soc Trang, which tested items are; *pH, temperature, EC, DO, BOD, SO4, SS, PO4, NH4, NO2, and NaOH.* Based on the data obtained from water quality test, water circulation conditions in 2 places are examined.

6.7.3 Results of Interview

It is found that interviewees have about 13 years shrimp farming experiences in average so it can be said that interviewees have enough experiences for this study purpose. Average shrimp farming area (pond) is about 1,8ha; the maximum one is 5.9 ha with paddy-shrimp type, and the minimum is 0.075ha with extensive shrimp farming. Shrimp farmers usually divide these areas into 1 to 3 plots, which each area has been arranged to be nearly the same size for easy and simple management.

In 2011, about 30% of interviewees have faced deficit balance in shrimp farming, which includes total loss farmers by 5% (15 farmers). They consider that these losses were caused by virus, low quality of post larvae, water pollution, or weather change but they did not know exact reason of shrimp loss. There are many larvae ponds in and around interviewees' commune but they do not know whether the post larvae are certified one or not. Most of farmers consider that water quality in their shrimp pond is generally good and they mostly use $CaCO_3$ for water treatment.

Multiple regression analysis was carried out on data obtained from interview. In this analysis, shrimp yield is set as dependent variable and other factors, such as shrimp density and fertilizer, are set as independent variable; the result is summarized as follows;

Table 6.7.2 Correlation Coefficient between Shrimp Yield (kg/ha) and some Factors

Factors (dependent variable)	Extensive farming	Semi-intensive farming
Intensity of larvae (nos/m^2)	r = -0.02	r = 0.25
Fertilizer (X1,000VND/ha)	r = 0.43	r = 0.25
$CaCO_3$ (X1,000VND/ha)	r = 0.29	r = 0.56
Food (X1,000VND/ha)	r = 0.07	r = 0.86
Medicine (X1,000VND/ha)	- (no use)	r = 0.38
Water Quality (4 grades)	r = 0.28	r = 0.19
Use of Certified Larvae	r = 0.06	r = 0.19

Source: JICA Project Team

It is obvious that food supply is the key for good shrimp yield in semi-intensive shrimp farming.

Similar tendency can be seen in extensive shrimp farming because fertilizer shows higher correlation with shrimp yield than other factors even though correlation coefficient of each factor with shrimp yield is not so high. $CaCO_3$ is used for water cleaning up and it may relate to a factor of “water quality”.

According to correlation analysis, some factors are selected for multiple regression analysis and the result of it is shown as follows;

<Extensive shrimp farming>
Shrimp yield (kg/ha) = 320.9 + 0.040A + 0.160B + 1.92C
A: cost of CaCO3 by 1,000VND/ha
B: cost of fertilizer by 1,000VND/ha
C: Intensity of Larvae (nos/m^2)
n = 80, R^2 = 0.32, under 5% significance level

Result is that coefficient of determination is less than 0.5 (R^2 = 0.32), and therefore it is difficult to explain correlation between shrimp yield and these factors.

<Semi-intensive shrimp farming>

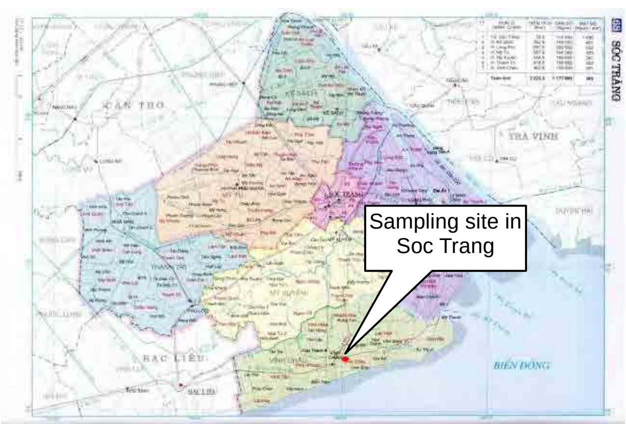
Shrimp yield (kg/ha) = 48.3 + 9.08A + 0.00997B + 0.00372C + 0.0206D

A: intensity of larvae (nos/m^2)
B: cost of food by 1,000VND/ha
C: cost of medicine by 1,000VND/ha
D: cost of $CaCO_3$ by 1,000VND/ha
n = 79, R^2 = 0.77, under 5% significance level

From the analysis mentioned above, yield of semi-intensive shrimp farming depends on four major factors; larvae intensity, cost of food, cost of medicine, and cost of $CaCO^3$.

6.7.4 Results of Water Quality Test

Basically, shrimp ponds fetch the water from irrigation canals. Temperature, pH, EC, DO, BOD, SO4, SS, PO4, NH4, NO2, and NaOH of canal water at one site in Ca Mau and another site in Soc Trang were monitored from February to June 2012. Sampling sites in each province are shown in Figure 6.7.1.



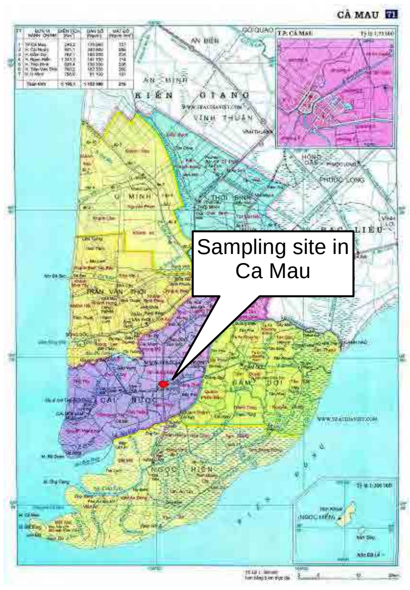


Figure 6.7.1 Sampling sites of the Water Quality Monitoring

As a result, low density of dissolved oxygen (DO) was confirmed at almost all the sampling points. According to the "Standards of Fishery Water, the 2005 Edition" published by Japan Fisheries Conservation Association, more than 6 mg/l of DO is required and crustaceans start suffering from a negative impact when DO is lower than 4.29mg/l. As shown in Figure 6.7.2, all samples show a value of DO lower than 6mg/l. Further, water at all sampling points was found enriched particularly with nitrogen. While the standard level of NO4-N should be less than 0.01mg/l and NO2-N be less than 0.03mg/l, water at most of the sampling sites showed more than that of the standard level (refer to Figure 6.7.3 and Figure 6.7.4).

From the viewpoints of DO level and nutrients, it seems that quality of canal water is not much suitable for rearing shrimps. It is recommended to take some measures to improve the quality of canal water, or otherwise close monitoring of shrimp culture should be carried out in order to detect any loss of shrimp as early stage as possible.

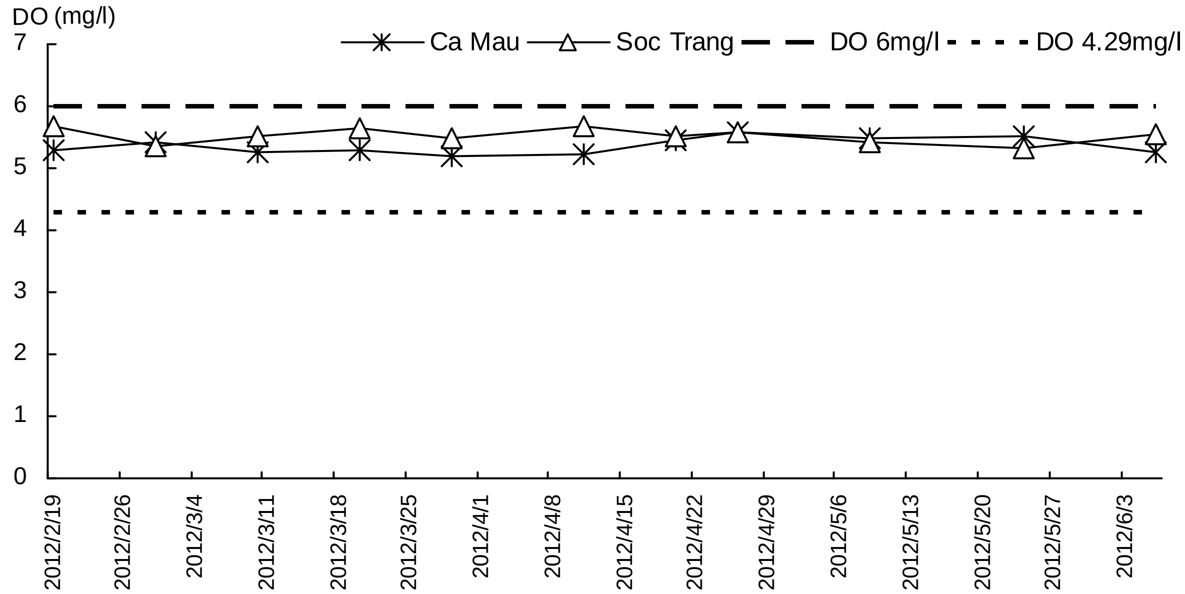


Figure 6.7.2 Trend of DO in Canal Water

Source: Water Quality Survey (JICA Study Team)

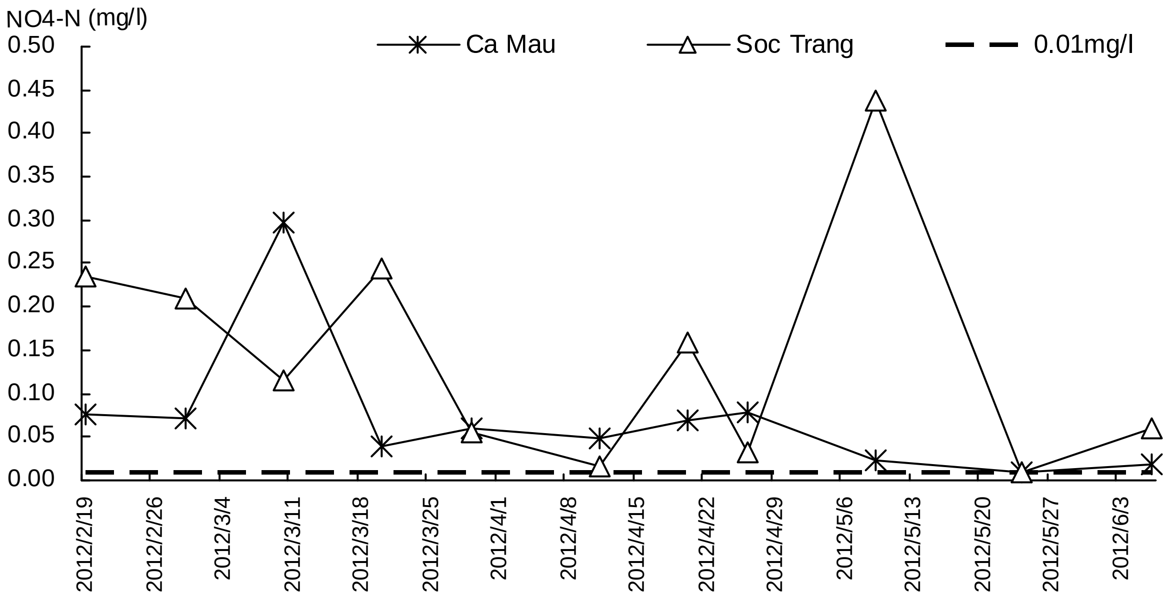


Figure 6.7.3 Trend of NO4-N in Canal Water

Source: Water Quality Survey, JICA Study Team

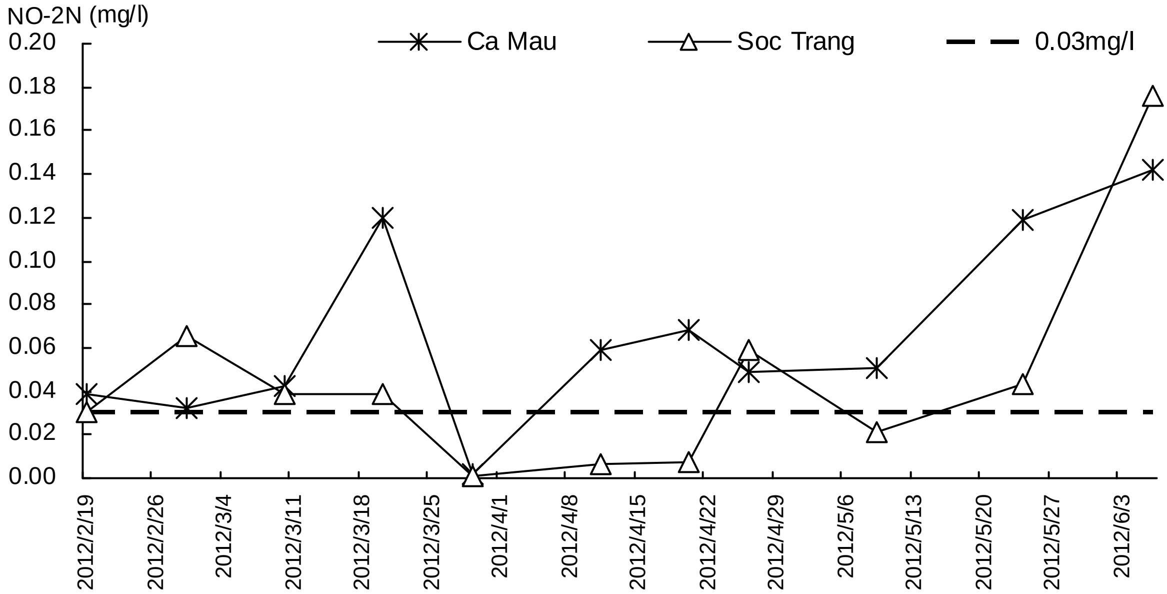


Figure 6.7.4 Trend of NO2-N in Canal Water

Source: Water Quality Survey, JICA Study Team

6.7.5 Sustainable Shrimp Farming

Shrimp cultures in Mekong Delta Area are divided into intensive / semi intensive and extensive farming. As summarized in Table 6.7.3, sustainability of intensive and semi intensive culture is relatively lower than extensive culture taking into account high disease prevalence, negative impacts to water environment, etc. all of which are well associated with the intensive and semi-intensive culture.

In contrast, impact of disease on extensive culture is lower than intensive / semi intensive culture though the disease (AHDNS) cases are also taking place even in this category of extensive framings. In any case, however, extensive culture shows less negative impact to environment i.e. low water pollution and opportunities of replanting of mangrove under mangrove – shrimp farming. In consideration of the situation, it is recommended that extensive culture is more sustainable than intensive and semi intensive culture.

Table 6.7.3 Comparison of Impacts between Intensive / Semi intensive and Extensive Shrimp Culture

Particulars	Intensive / Semi intensive	Extensive
Productivity	Higher.	Lower.
Operation Cost	Higher.	Lower.
Target group	Companies and investors.	Artificial farmers and fishers.
Disease Prevalence (AHDNS)	Higher.	Lower than intensive & semi intensive.
Impacts to water environment	Higher negative impacts to water environment due to discharge of enriched rearing water causing high rearing density and feeding.	Less negative impacts to water environment due to low rearing density and no feeding.
Impacts to forest	Possibility for trimming mangrove in the economic zone.	Same as on the left. In contrast, positive impact is also expected through the reforestation by mangrove-shrimp farming.
Impacts by Climate Change	Need to rise up the embankment of pond when sea level rises.	Same as on the left.
Sustainability	Lower	Higher

Source: JICA Study Team

It is also recommended that extensive culture which requires lower initial investment and running cost is more appropriate cultivation method for small scale farmers and fishers than the intensive / semi intensive culture. Though productivity of intensive / semi intensive culture is in fact higher than that of extensive culture, initial investment and running cost is also very high which can easily go beyond the financial capacity of small scale farmers. Therefore, it is recommended that extensive culture is much appropriate for promotion activities by the Government.

CHAPTER 7 GUIDELINE OF FORMULATING CLIMATE CHANGE ADAPTATION MASTER PLAN

This Master Plan Project aims at, as its first objective, formulating climate change adaptation master plan. The master plan (draft version) was presented in Chapter 4 'Master Plan Formulation Planning'. With reference to the process of formulating the master, this Chapter summarizes the approach and methodologies of the formulation of master plan which is adaptable to and/or able to cope with climate change.

7.1 Overall Approach of Formulating Master Plan

Overall approach of formulating the master plan is illustrated in Figure 7.1.1. First step is to identify climate change issues with prioritization, which shall be done through a series of participatory workshops. This process is illustrated at top most part of the Figure 7.1.1. There much be already existing development plans/projects formulated by different cadres of offices, e.g. national level, provincial level, district and commune levels. These plans and projects should, of course, be referred to in formulating the master plan since they must represent the area's priorities. This process is illustrated in the left most position of Figure 7.1.1.

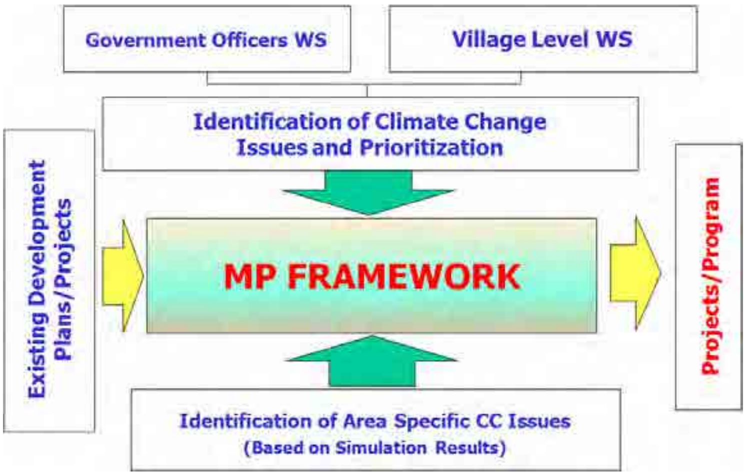


Figure 7.1.1 Overall Approach of MP Formulation

There are institutes and organizations which can carry out climate change related simulations. Required simulation for climate change prediction is, for example, temperature prediction, rainfall prediction, sea-level rise prediction, and saline intrusion if coastal areas are targeted and also flooding. These simulations can identify which area will be affected by specific issue, e.g. by saline intrusion, at how much level. The simulation result gives us specific areas to be affected by climate change issue and the magnitude as well. Based on the simulation, therefore, we can know what projects should be implemented in which area. This process is illustrated at the bottom of Figure 7.1.1. Taking all aforementioned practices into consideration, framework should be established, from which concrete ideas of projects/programs are to come.

7.1.1 Participatory Workshops for Government Officers

A government officers workshop should be held as the entry, and thereafter series of village level workshops should follow at different places of the project target area. During the workshops, the participants are requested to identify Climate Change issues by province and prioritize them. The methodology of the workshop should be of group work, presentation by group leaders, open-forum discussions, etc., which are all supported by participatory approach.

For the session of 'Climate Change Issue Identification and Prioritization', the participants are divided into groups by area where they are from. The groups are requested the following work; 1) identify all the issues/constraints/problems in the sector of agriculture and rural development by the area, 2) prioritize all of the listed issues by placing the severest issue at the top of the issue list, 2nd severest issue at the second place from the top, and alike, 3) mark those issues which are related to climate change or caused/worsened by climate change, and 4) mention the places where the issues are taking place, 5) how sever the issues are, etc. Table 7.1.1 shows an example where climate change issues were identified and prioritized from top to the bottom of the table;

Table 7.1.1 Issues with Priority Order related to Climate Change identified by 7 Provinces

No.	XXX XXX	Ben Tre	XX XX	XXX	Kien Giang
1	Saline intrusion	Saline intrusion	Drought, saline intrusion, lack of fresh water	Sea-level rise (saline intrusion, lack of fresh water)	Drought
2	Sea dyke breach	Lack of fresh water	Shoreline erosion	Temperature rise (drought, forest fire)	Saline intrusion
3	Shoreline erosion	Shoreline erosion	Flood-tide increasing (sea dyke breach)	Storm and tropical low pressure	Forest fire
4	Flood	Livelihood and health of farmers	Epidemic disease for fruits and livestock	Depletion of ground water resource	Sea-level rise
X	Inundation	Decreasing of mangrove forest		Rainfall pattern (uneven distribution)	Shore line erosion
XX	Change of the ecosystem	Storm/ Tropical low pressure			Inundation (flood)
XXX					Rainfall pattern (uneven distribution)

Source: JICA Project Team, based on the 1-day workshop held on October 27, 2011

After having finished the presentation of the issues by group, next step for the participants is to discuss and agree overall priority order on the issues reviewing across the issues identified by province. As example done in this Master Plan Project was; saline intrusion being the first priority, followed by drought and/or lack of fresh water, erosion and damage of sea dyke, frequent storm, inundation and flood, rain in dry season, and then forest fire.

7.1.2 Participatory Workshops for Villagers

Upon completion of the government officers workshop, there should be village level workshops which should try to identify the villagers issues relating to climate change. Methodology can be same as the one for the government officers workshop or can be modified. One of ideas of letting the villagers identify climate change issues easily may be to apply Problem Analysis. The Problem Analysis is a classical tool adopted by ZOPP of GTZ (GIZ) and Project Cycle Management (PCM) of JICA. Problem Analysis is a tool to find causes (problems) facing the people, and prioritizes them.

Use of the Problem Analysis for formulating a master plan is a little different from the usage for typical classical development projects. For project planning, we need to find out a specific problem to solve so that a project can complete the mission in a pinpoint manner. For master plan formulation, however, we need to find out all the major issues and prioritize them as alternatives. That is why the scope of the Problem Analysis for project planning needs to be specific, while the scope for regional program planning, say this kind of master plan formulation in the context of climate change, needs to be general.

The core problem for formulating the plan needs to be a wide one so that all the major problems identified can be covered. We suggest that “Living standards of the people are low” would better be employed as the core problem for the master plan formulation, because it can cover broad spectrum of issues of income, health, crop, aquaculture, food production, etc. which can be worsened by the impact of climate change. With the procedure briefed in the box, the Problem Analysis establish so-called problem tree. An example is shown

How to develop a problem tree using cause-effect relations;

- Identify existing problems, not theoretical, imaginary or assumed problems (**Good:** Many rice farmers don’t do line transplanting. **Bad:** Farmers are lazy).
- Write one problem on one card (**Good:** Our income is low. **Bad:** Our income is low because there are few jobs.).
- Write in negative and descriptive form (**Good:** We are drinking unclean water. **Bad:** Water issue.).
- Avoid writing absense of solutions (**Good:** We cannot get proper medical care. **Bad:** There is no hospital). Hospital is one of the solutions, but there could be other solutions such as mobile clinic, community pharmacy and community health workers.
- Note that higher position in the problem tree does not mean that the problem is more important than lower ones.

below;

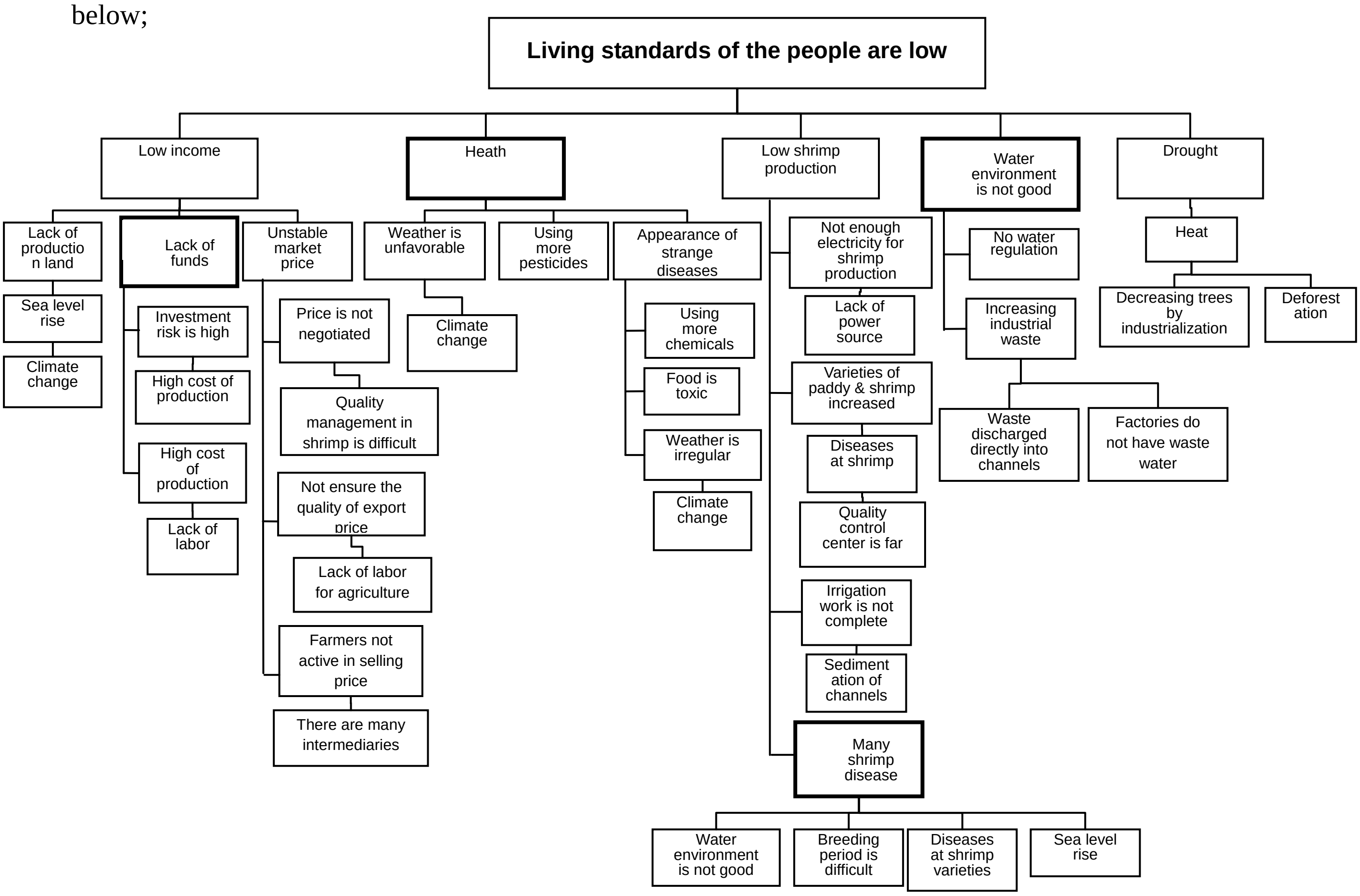


Figure 7.1.2 Problem Tree in Tran Thoi commune, Ca Mau Province

Problem analysis further continues, during which issues related to climate change should be separately picked up and discussed. All the climate change related issues are now summarized as in the following table by village where the workshop was held. In most cases, climate change related issues can be; drought, saline intrusion, inundation, flood tide and heavy rain as exampled in the following table. By simply count the climate change related issues for the villages, we can know what issues are more prevalent at the village level, whereby prioritization can be done.

Table 7.1.2 Climate Change Issues Identified in the Problem Tree of Each Commune

Commune	Thuan Dien	An Binh Tay	Huyen Hoi	Vinh Hai	Phuoc Long	Tran Thoi	Nos.
Province	Ben Tre	Ben Tre	Tra Vinh	Soc Trang	Bac Lieu	Ca Mau	
Drought	●	●	●		●	●	5
Saline intrusion	●	●	●	●			4
Inundation	●				●		2
Flood tide	●			●			2
Heavy rain	●				●		2

Source: JICA Project Team, based on the Problem Analysis

Summing up all the works done through the workshops, and in addition with the review of existing plans/projects, a prioritized development framework should be presented together with project/program description in a simplified project design matrix (PDM).

7.2 Establishment of Development Framework

Development framework can be a guide for the Vietnamese government and also all the development stakeholders because the framework provides with concrete development components, those priorities by issues related to climate change and by area (province) at which what projects should be carried out.

In addition, any organizations which work in the target area can refer to the framework, with which they can know where to carry out their development intervention with what priority.

Development framework shows climate change issues prioritized and strategies sought to achieve the development vision, as well as intervention activities that are called development project or development program. The framework has the priority at different levels of, e.g. issue, strategy, project/ program, with which we can consider that which development intervention should be put in implementation first taking into account limited resources.

Target area usually covers certain extent, and in case of this Master Plan Project, it covers 7 coastal provinces. Therefore the framework should also relate those projects/ programs with the specific area (or province/district). Given the relationship we can know which project/ program should be implemented in which area (or province/district) with the top priority, 2nd priority, and son on, making development intervention sound according to the nature of the area (or provinces/districts) and increasing the efficiency in fund allocation as well. An example of the framework is shown below;

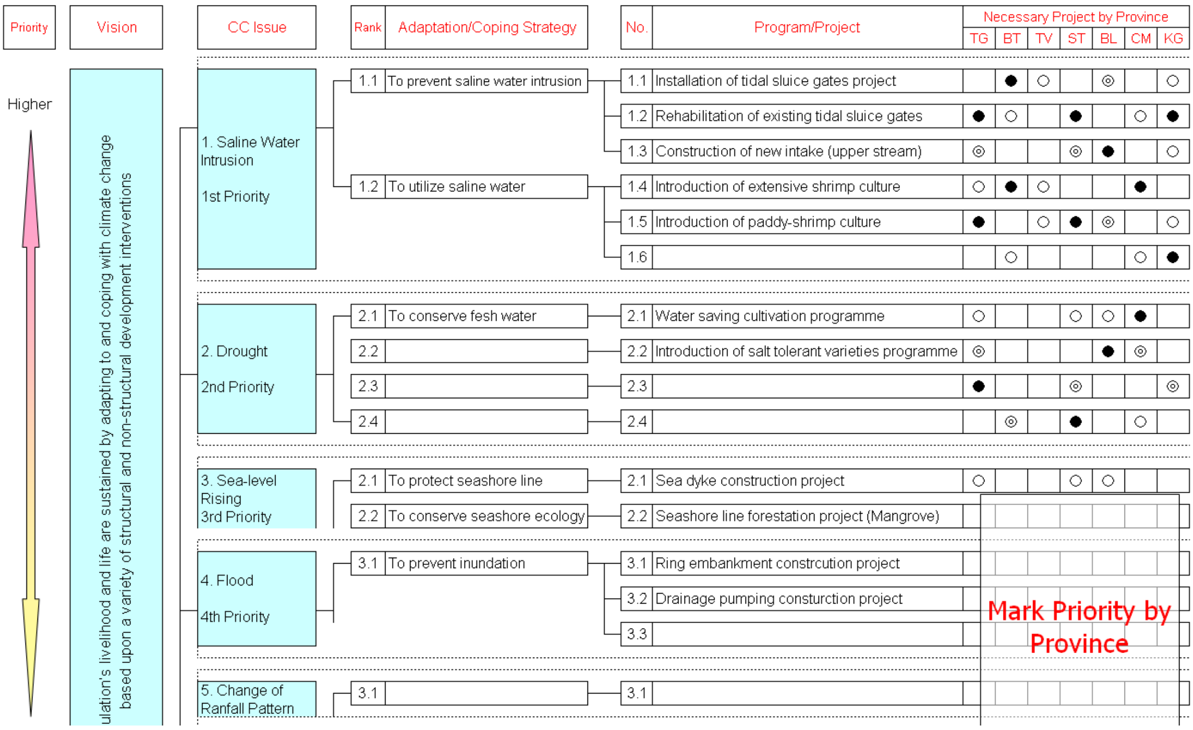


Figure 7.2.1 An Example of Development Framework

Framework recommended here is a tree structure which starts with development vision at the right most position, and is cascaded to climate change issues prioritized adaptation and/or coping strategies and finally down to the project/ program. The climate change issue should of course refer to the aforementioned prioritization practices given by the government officers' workshop, at the village workshops, and based on the existing projects by the government offices and/or development partners.

In formulating master plan in the context of climate change, there is usually simulation to know future trend in saline intrusion, flood happening, etc. These simulation can identify which area will be the most affected, whereby what intervention should be brought about in to which areas. As an example, Figure 7.2.2 shows saline intrusion in April for Mekong Delta area. One may notice Ben Tre province and Ca Mau province is hardest hit by the saline intrusion. Therefore, measure(s) to prevent saline intrusion should be brought in those provinces with higher priority than others, or otherwise adaptation measures to the saline intrusion should be sought, e.g. introduction of brackish shrimp culture.

In fact, at the right side from the list of the programs/projects, there is a matrix table having such symbols as ●, ◎, ○. This matrix shows the guidance of which projects/ programs should be carried out in which province with how much of priority according to the result of simulations. The prioritization in the matrix can be done by cross cutting from top to bottom by the province, for example 1) half of the projects/ programs in each province are prioritized with the symbol of ○ (high priority), out of which again half are prioritized with the symbol of ◎ (higher-priority), and further out of which half are prioritized with the symbol of ●, the highest (top) priority.

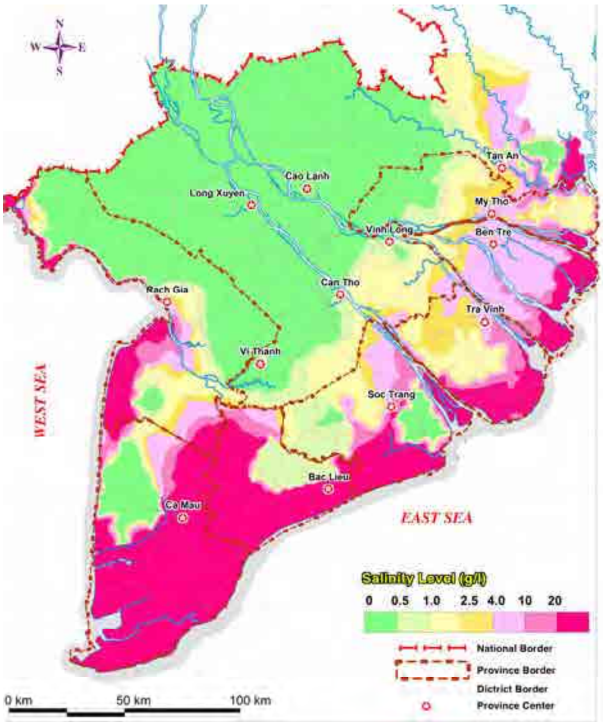


Figure 7.2.2 An Example of Saline Intrusion Simulation

7.3 Project Description

Projects/ programs summarized in the Development Framework should be elaborated in a simplified project design matrix (PDM). The PDM constitutes of project title, priority in province, target group, implementing agency, collaborators, objectives, rationale why the project is in need, implementation period, expected outputs and relevant activities, cost and expected fund source, project risk and environmental assessment in for example three levels of; A (highly expected), B (little expected), and C (not expected). Example is shown below;

Table 7.3.1 Simplified Project Design Matrix for a Priority Project

Programme No. 3	Title: Sluice Gate Construction Project				
Climate Change Issues	Saline Intrusion, top priority				
Priority division(s)	District 1	District 2	District 3	District 4	District 5
	○	●	●	◎	●
Target groups	Common Interest Groups, Women groups, and any interested individuals				
Implementing agency	Ministry of Agriculture, and Rural Development				
Collaborators	Donors				
Objectives	To prevent saline intrusion to inland areas				
Rationale	Describe why the program needs to be implemented?				

Project Implementation	Yr 2013	Yr 2014	Yr 2015	Yr 2016	Yr 2017	Yr 2018	Yr 2019	Yr 2020
	■ ■ ■ ■	■ ■ ■ ■	■ ■					

Expected Outputs:	Development Indicators	
1.	Group Nr.	
2.	Technologies adopted	
3.	Post harvest loss	
Major activities (corresponding to the number under Expected Outcomes):	App. Cost, VND	Expected Source
1. Identify and organize common interest groups		GOV
2. Disseminate improved farming skills		DARD
3. Disseminate post harvest handling skills and storage facilities		DARD
Total of the cost, VND	XXXX VND	
Project Risks (External factors which may affect the project success, but beyond the project management):		
Environmental Consideration (environmental consideration is described here, and in case extended environmental impacts are expected, scoping shall be mentioned here.		

CHAPTER 8 CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

Taking into account the points outlined below, this Master Plan project concludes that the implementation of the Master Plan presented in this Report would be the most appropriate comprehensive approach in coping with and adapt to the climate change taking place in the Mekong Delta, especially for the coastal seven provinces thereof in the sector of agriculture and rural development. The Government should therefore embark on the development for the coastal provinces guided by the Master Plan.

1) The Development Plan has incorporated voices of the concerned stakeholders such as provincial DARD officers, provincial people’s committee members, and community members and leaders, local authorities, etc. The stakeholders have worked not only in analyzing the area’s situation but also through the process of planning, exercising consensus making at different issues such as identification and prioritization on their confronting difficulties, identification of climate change related issues, and the prioritization thereof, etc. Situation analysis was also carried out mainly from quantitative point of view where data were available. Then, the results facilitated the stakeholders to well understand where and how the Project Area stood and how it looked like in comparison with other parts of Mekong Delta as well as with other regions of Vietnam. Exercising the participatory approach has contributed to making the Development Plan comprehensive and also responsive to the needs from the stakeholders.

2) Development framework presented in this Report can be a very guide when the concerned central and provincial offices try to carry out development activities in the coastal provinces of Mekong Delta because the framework provides with concrete development components, those priorities by climate change issues and by area (province) at which what projects should be carried out with what levels of priority. In addition, any organizations which work in the coastal areas of Mekong Delta can refer to the framework, from which they can know where to carry out their development intervention with what priority. In this way, the frameworks can also work as a development platform where all the concerned development partners can make concerted efforts. The framework guides the development stakeholders to the most needy people as prioritized and leads to avoidance of misallocation of funds to activities that are not a priority, thereby accelerating the development as a whole.

8.2 Recommendations

During the process of undertaking this Master Plan establishment project, the JICA Team encountered a number of issues that lead to the recommendations presented below. However, as is the case with continuous processes, these recommendations are by no means exhaustive and may need to be changed or modified, depending upon the prevailing condition. Nevertheless, it is believed that the ones covered here constitute a broader spectrum on which the implementation of the Master Plan will have to be pursued:

1) The central MARD together with SIWRP should introduce the Master Plan to other provinces/regions in Vietnam, especially to other coastal provinces/regions facing the threats by climate change. This is because the JICA team thinks that the other provinces/regions would also benefit from this Master Plan by introducing a new approach of formulating the development plan centering on how to adapt to and/or coping with climate change impacts. In fact, one of Vietnam’s characteristics is its long coastal line stretching over 3,400 km, implying that lots number of provinces must be affected by climate change impacts e.g. sea level rise. As this Master Plan project shows concrete way of formulating a development plan in the context of climate change, the approach should be introduced to such provinces/regions whereby they can improve the

present development plans/activities.

2) There should be a coordinating committee in the process of putting the Master Plan into actual implementation, composed of all the seven coastal provinces together with SIWRP being the coordinator. In fact, project proposal in Vietnam is usually prepared at provincial DARD individually, and submitted to the central government through the provincial people's committee. From the view point of balanced development fund allocation among the concerned provinces, coordination should start from the project proposal preparation stage. One example is saline intrusion prevention sluice gate construction project, which is given the highest priority in the Master Plan framework. There are number of sluice gate construction plans across the seven coastal provinces, and without coordination among them, first priority gate may not be necessarily implemented as is the priority. To avoid this, coordination committee should be established, at which they meet and refer to the Master Plan whereby priority across the provinces could be realized.

3) Though the Mater Plan provides the concerned offices with concrete development projects/ programs with timeframe when to implement, the implementation itself should always be flexible. The Master Plan was prepared taking into consideration the impacts of climate change to take place in future, which itself includes uncertainty by nature. In fact, even for the climate change scenarios, there are primarily 4 scenarios presented in the IPCC Fourth Assessment Report (2007). It is hard to forecast which scenario could come the most, since it is dependent on many factors such as population growth, economic growth, structure of governance, social values, and patterns of technological change, etc. There is thus uncertainty in the forecast of future climate change, and therefore the Master Plan should be reviewed every year with reference to the magnitude of climate change to come, based on which the Plan should be modified accordingly.

4) In conjunction with above No. 3) issue, future discharge of Mekong River is also with great uncertainty. There are completed and on-going hydropower dam construction works in the upper catchment area and also number of development plans including hydropower dam construction (in China territory only, 4 large scale dams constructed and more than 10 dams planned as of 2011). The development in the upper catchment area will greatly influence the flow regime of lower part of Mekong River, especially by hydropower dam construction. The dams store flood water during rainy season aside from generating power while release stored water during dry season for the generation whereby dry season flow of the Mekong River would increase. Increased Mekong River discharge will push back sea water intrusion whereby saline damage may not take place as forecasted. Given this picture, the Master Plan should be reviewed with reference to not only the magnitude of climate change but also the change of Mekong River discharge regime.

5) NO Regret Investment is therefore always pursued in the development under climate change. As aforementioned, future status of the Mekong River flow entails uncertainty. Sea level rise will be happening with certain level of accuracy, causing salinity intrusion into the Mekong River. However, the saline intrusion depends more on the flow regime of the River. Therefore, should the development in the upstream riparian counties work in the direction of augmenting dry season flow, saline intrusion may not become severe even under sea level rise. Given this uncertain future, if once a large scale investment were made, for example, in putting up tidal prevention barrage at the estuaries of Mekong River, the investment might become worthless. Therefore, from this point of view, large scale investment at one place at once is not recommended as it might result in 'regret' investment. The Master Plan was thus prepared not including such large scale investment, whereby the Plan itself is composed of number of small and medium scale projects including non-structural measures. The structure of the Plan itself therefore entails flexibility able to be modified/changed.