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Dyke System Planing:

Theory and Practice in Can Tho City, Vietnam

Pham Cong Huu, Eckart Ehlers, Saravanan V. Subramanian

Abstract

Dyke system planning has emerged as a technical solution to the natural occurring floods in many parts of the developing world, such as the Mekong Delta. The paper applies the theory of integrated flood management to understand the inherent planning process in the system, the established institutional structures and the social perceptions of the dyke system. The paper draws on personal interviews and secondary documents to understand the dyke system planning taking Can Tho City as a case study. The paper discusses the dyke system planning to understand its social reflections in the shallow – average flooded areas in Can Tho City to address contradictory perceptions between techno-centric planners and livelihood-centered local people in flood control to improve life of rural people. The paper reveals the neglectfulness of the social aspects such as participation, local knowledge and experiences of local people in the dyke system planning. The dyke system planning has mainly focused on hydrological and technological aspects to control floods, to protect and develop agricultural production rather than to meet the livelihood needs of rural people. The dyke systems have produced disadvantages for water environment while advantages of floods have been gradually disappeared overtime.

Keywords:

Planning, Integrated flood management, participation, social reflection and perception

1. Introduction and general problem statement

Can Tho city has to adapt to new problems and challenges that have been generated by dyke works in recent years. In the last 30 years, floods greatly damaged both the lives and property of the people of Can Tho city. The government of Vietnam has invested VND 1000s billion to build dyke works with the aim of controlling floods, exploiting the maximum available potential and benefits of floods and reducing the negative impact of floods for agricultural production and the lives of people. Thus, a series of dyke works has been implemented in recent years in order to control flooding levels between sub-areas, drain acid water, floodwater and protect even against floods in agricultural production activities (such as summer-autumn rice crop protection in inundated areas of Can Tho city). There is a series of new rice seeds with short growth duration and advanced agricultural techniques which have been applied to change the seasonal farming calendar in order to increase agricultural production in the inundated plains of Can Tho city. A remarkable agriculture farm model conversion from single farm models into integrated agriculture farm models has been applied in the enclosed dyke areas. A shift from one rice crop to two-three rice crops per year with higher yields (from about 8.6 thousand tons of rice produced in 1976 up to 11.56 thousand tons of rice product in 2006 (GSO, 2006)). These imply that there was a great change in agricultural production thanks to a contributive part of dyke works to ensure national food security strategy and the livelihood of people. Unfortunately, these dyke works have produced new challenges for ecology and people's lives at present time and also for the future (besides the short-term benefits and achievements). In addition, the progress of industrialization, modernization and ubanization is also leading to additional problems apart from the dyke works. The dyke works still contain implicit problems that have not been addressed in the dyke system planning in the averagely protected flooded areas of the Mekong Delta. In recent years, most research on floods and dykes has been implemented in deeply flooded areas such as An Giang, Dong Thap and Long An provinces while there still has been almost no research on averagely flooded areas such as Vinh Long, Hau Giang provinces and Can Tho city. Thus, this study aims to understand the existing problems of dyke system planning in averagely flooded areas.

This study intends to understand and address the existing problems and differences between planning theory and practice of dyke system planning in averagely flooded areas. The study tries to compare the theories of governmental dyke system planning under the theory framework of integrated flood management that has been promoted by the Associated Programme on Flood Management (APFM)[1]. Can Tho city was selected to implement this study. The main question of the study is: "How is the theory degree of the dyke system planning applicable to the realities of life and the necessities of people in the flooded areas of Can Tho city?" To answer this question, the study will begin from sub-questions: (i) How was the dyke system planning formulated?; (ii) What are the priorities of the planners? and (iii) What are the existing problems of the dyke system planning for the life of local people?

The study applied personal interviews and observation methods to collect information and data during the implementation process of the study. Secondary data and personal interviews were collected and implemented from Southern Institute for Water Resources Planning (SIWRP) and Southern Institute for Water Resources Research (SIWRR) of the Ministry of Agriculture and Rural Development and various organizations within Can Tho City. The study expects to provide necessary information for planners and policy-makers to improve the current dyke system planning in averagely flooded areas such as Can Tho city.

The following parts of this study include three sections. The first section will present a brief theory applied to discuss and analyze the dyke system planning. The second section will describe and discuss the current dyke system planning. The last section will discuss the existing problems of the dyke system

[1] Associated Programme on Flood Management (APFM) is a joint initiative of the World Meteorological Organization (WMO) and the Global Water Partnership (GWP). It promotes the concept of Integrated Flood Management (IFM) as a new approach to flood management. The programme is financially supported by the governments of Japan and the Netherlands.

planning from social reflections and provide an outlook into the future of dyke system planning in flooded areas and for the development of Can Tho city.

2. Can Tho City: Theory and practice of dyke system planning

2.1 Integrated flood management theory

Integrated Flood Management (IFM) is a process promoting an integrated-rather than fragmented– approach to flood management. It integrates land and water resources development within the context of Integrated Water Resources Management (IWRM), and aims at maximizing the net benefits from flood plains and minimizing loss to life from flooding (WMO, 2004).

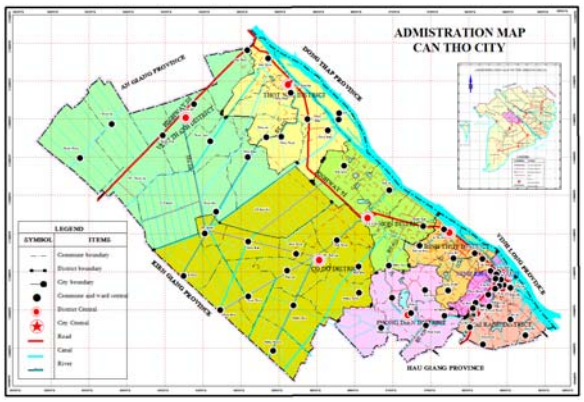
Thus, IFM is very close to the concept of Integrated Water Resources Management in terms of land and water resources benefitting from exploration and management. Both IFM and IWRM are two concepts that are very closely combined to maximize economic net benefits, social welfare and environmental protection from available natural resources use and exploration such as land and water resources. However, IFM aims at maximizing the net benefits from flood plains and reducing negative impacts of floods for life and livelihoods of humans in the flood plains. In the IFM, therefore, the flood control measures should consider negative impact reduction of floods and effective use of available natural resources in an integrated approach for flood plains. Both arable land and water resources are scarce, and most productive arable land is located in flood plains. Thus, flood control measures need to maximize the efficient use of these available resources and efforts should be made to maintain or augment the productivity of flood plains. On the other hand, economic and human life losses due to inundation should not be ignored. Treating floods as problems in isolation almost necessarily results in a piecemeal and localized approach. Thus, IFM´s aim is not only to reduce the losses from floods but also to maximize the efficient use of flood plains - particularly where land resources are limited. However, while reducing loss of people's lives should remain the top priority, the objective of flood loss reduction should be secondary to the overall goal of optimum use of flood plains. In turn, increases in flood losses can be consistent with a parallel increase in the efficient use of flood plains.

IFM is based on the principle of reducing vulnerability through building resilience and developing a culture of prevention through preparedness rather than reactive responses alone. The multidimensional nature of flood management options owing to constraints, risks, uncertainties and conflicting objectives poses challenges and opportunities for the participatory approach towards decision-making, as such options should not only be technically appropriate but should also address broader socio-political issues. The need to deal with social concerns and involve experts and civil society in the decision-making process is a main key to IFM. These concerns can be qualitatively incorporated through the active participation of all stakeholders, including civil society at various decision-making levels and stages and through the implementation of flood management measures. Multi-stakeholder engagement is the key to the success of IFM as it ensures strong stakeholder support and is a catalyst for proactive engagement in flood issues.

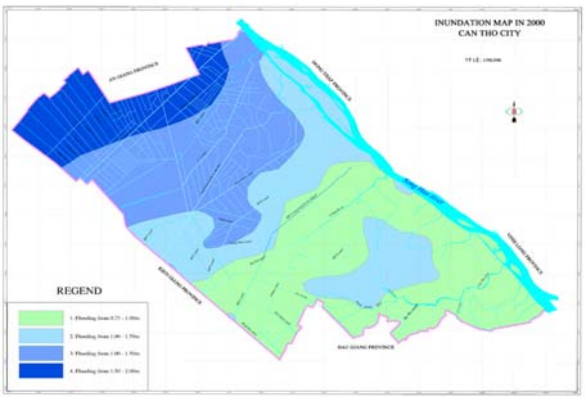
The paper applies this theoretical framework to examine the dyke system planning in Can Tho City in Vietnam to understand the integration of various sectors and its ability to address the social needs of the people. The study will analyze rationales and participation of organizations in the process of dike system planning and outcome of the dyke system planning to maximize benefits and reduce damages of floods for to life and agriculture production of people in the protected flooding areas. In addition, advantages and disadvantages of the dyke system planning are analyzed in three aspects: economy, society and environment in the protected flooding areas. Finally, opportunities and new challenges for development of Can Tho city will be addressed in this study.

2.2 Floods and their hinterland

Can Tho city is located in the centre of the Mekong Delta. It is low-lying and fairly flat with an average altitude of 0.6 – 0.8 m above sea level. It is bordered by four provinces: Hau River to the Northeast, Kien Giang province to the West, Hau Giang province to the South and An Giang province to the Northwest (SIWRP, 2005). Total natural area is 140,200 ha with an population of 1,139,900 residents (GSO, 2007). It is divided into 8 administrative units in which there are 4 inner districts within the city such as Ninh Kieu, Cai Rang, Binh Thuy and O Mon and 4 rural districts such as Thot Not, Vinh Thanh, Co Do and Phong Dien (See Figure 1).



Source: SIWRP, 2005
Figure 1: Administration map of Can Tho city



Source: SIWRP, 2005
Figure 2: Inundation situation in the 2000 flood

Can Tho city is a flood plain. It is defined as an averagely flooded area located in mid stream of the Mekong Delta. Its average flooding level fluctuates from 0.6 to 1.5m (SIWRP 1998a, 1998b, 2005a and 2005b). Generally, almost all areas of Can Tho City are flooded at an average level of 0.6 to 1.6 m with the exception of 15,843 ha of the northern Cai San which are more deeply floodedwith flooding levels reaching 1.2 to 1.8 m (SIWRP 2005 and Sub-NIAPP 2006). The flood season lasts 3 to 4 months from August to December annually. The flooding depth level of Can Tho city is dependant on the annual floods and flood flows from the Long Xuyen Quadrangle as well as rainwater. According to an hydraulic calculation done by SIWRP (1998b), the flood flow varies with 86 percentage flood volume at Can Tho city along road 80 and the Long Xuyen Quadrangle and 14 percentage at the Bassac river (See Table 1 and Figure 2). Thus, the flood volume from Bassac River is lower than that of the Long Xuyen Quadrangle along road 80.

Table 1: Extent and percentage of flooded areas in Can Tho City at 2000 flood[2]

No	Items	Lower 0.5m	0.5- 1.0 m	1.0-1.25 m	1.25-1.50 m	>1.5 m
1	Area (ha)	77,957	129,350	69,200	17,000	2,750
2	%	25	43	23%	7%	2%

Source: SIWRP, 2005

As for flood related disasters, floods cause damages to agricultural production activities and rural infrastructure and irrigation systems (see Table 1). According to summarized data of SIWRP (2005), floods led to damages of VND 100,000s billion to agriculture production and infrastructure every year from 1991 to 2001. However, flood damage declined from 1991 to 2001 except for the 2000 flood which caused more extensive damage because it had a higher flooding level in comparison to the normal years prior (See Table 2). In recent years, floods have not had such disastrous an impact on Can Tho city.

[2] The 2000 flood was an exceptionally big flood by historical standards that occured in the Mekong Delta in 2000

Table 2: Damages of flood in Can Tho City from 1991 to 2001

Unit: VND billion (USD1 = VND 15,000)

No	Items of damages	1991	1994	1995	1996	2000	2001
1	Agriculture production	38,700	52,181	7,000	27,20	86,25	21,50
2	Vegetable and industrial	13,710	15,500	2,000	5,00	15.60	4,60
3	Fruit tree	147,500	242,65	28,800	60,06	206,40	58,65
4	Fishery	6,500	8,200	2,160	0,03	1,25	0,50
5	Transport and irrigation	72,500	38,322	26,250	40,40	138.60	38,28
6	Education	3,500	8,462	0,150	2,90	6,90	2,6
7	Health care	1,700	1,500	0,030	0,14	1,50	0,7
8	Housing and others	35,000	21,372	1,200	65,80	145,80	55,20
	Total				201,53	602,30	182,03

Source: SIWRP, 2005b

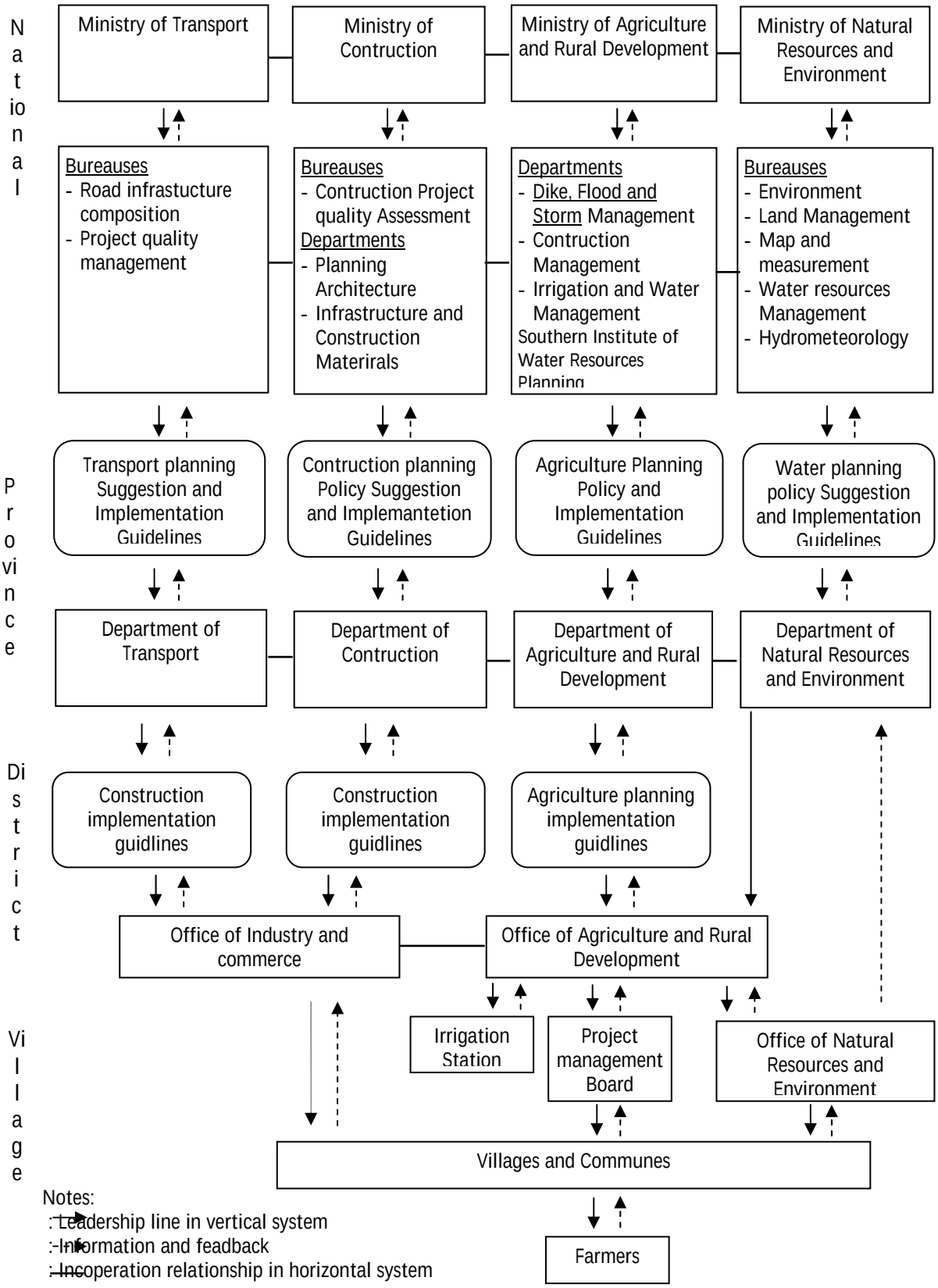
To sum up, Can Tho city is faced with recurring inundation and flooding. Floods mainly cause damages to agricultural production activities and the infrastructure base. These factors basically explain why the Dyke systems have been implemented in recent years. Thus, the system dyke planning was formed to control floods and protect agricultural production and infrastructure in the flooded areas of Can Tho city. The dyke system planning of Can Tho city is presented in the following sections.

2.3 Dyke system planning in Can Tho City

2.3.1 Organization mapping of dyke system planning

Recognizing the huge impact of flooding on the life and property of people in the Mekong Delta, the protection of said life and property has been prioritized in the flood plains. In addition, national food security is an important task for the development of Vietnam. Thus the Prime Minister of Vietnam issued Decree 99/TTg dated 9 February 1996 for “the long-term oriented flood control planning and five-year plan 1996-2000 on development of hydraulic works, transportation and rural development in the Mekong Delta in Vietnam.”

Figure 3: Relation between organizations in administrative structure in the dyke system planning



Per this Decree, a series of plans were set up to control floods in the Mekong Delta such as flood control, irrigation and dyke system planning. An important measure of this plans was dyke system planning. Can Tho city was involved in this planning because it is a flood prone area often afflicted by floods. In addition, the agriculture production of Can Tho city has contributed greatly to the national food security and also is the cultural center of the Mekong Delta. Thus, it needs to be protected effectively.

Dyke system planning is a difficult and complex matter. Therefore, it must be thoroughly studied and set up step by step in the process of dyke system planning formulation. Therefore, the dyke system planning requires an interdisciplinary cooperation between Ministries and professional sections from Central to local levels. Thus, the participation of organizations and local people is very important and needs to be involved in the process of dyke system planning. As Article 7 of Decree 99/TTg dated 9 February 1996 states, the Ministry of Agriculture and Rural Development (MARD) has been assigned by the Prime Minister to be in charge of implementing the organization and cooperation with other Ministries and with provinces to set up the dyke system planning. One of the most important tasks which has been proposed in the Decree is to study and implement hydraulic works for the strategy of flood prevention in the Mekong Delta. To carry out this task, MARD has continuously studied the flood control planning in Mekong Delta in Vietnam in reference to the floods of 1994, 1995 and 1996 putting a special focus on transportation, resettlement and marine plans (SIWRP 1998b).

MARD has an important role in combination and cooperation with other Ministries in the dyke system planning. In the last 15 years, MARD has cooperated with other Ministries in the process of dyke system planning such as the Ministry of Transportation, Construction and Water Resources and Environment, Finance, and finally the Ministry of Planning and Investment. It has also cooperated with the respective provinces involved – all with the aim to study and to set up the dyke system planning for the flooded areas in the Mekong Delta (See Figure 3). Each Ministry has functions, tasks and administrative systems related to the dyke system planning connecting all echelons from Central to local levels (See Table 3 and Figure 3). Thus, cooperation between Ministries is very important to formulate the dyke system planning. However, coordination between Ministries, agencies and local authorities is weak. Further policy and legislation need to be developed under the umbrella of the Law in order to fully implement its general provisions (ADB, 2001).

Table 3: Functions and tasks of organizations relating to the dyke system planning

Name of organizations	Level	Functions an tasks
Ministry of Contruction	National	- Infrastructure and construction management and planning
Ministry of Agriculture and Rural Development	National	- Dam and dyke system management and planning - River and irrigation system management and planning - Agriculture and Rural development management and planning
Sub-National Institute of Agriculture Planning and Projection	National	- Zoning, planning and design of the agricultural projects - Development planning of sub-sectors of the agriculture including different types of crops and animals - Planning of high-tech agricultural zones
Southern Institute of Water Resource Planning	National	- Irrigation and flood planning and management to Southern provinces and city of Vietnam
Ministry of Transport	National	- Rural and city road infrastructure and waterway management and planning
Ministry of Water Resources and Environment	National	- Water and land management - Land use and water resources planning
Deparment of Agriculture and Rural Development in Can Tho city	City	- Irrigation system management - Agriculture and Rural development management
Deparment of Transport in Can Tho city	City	- Rural and city road infrastructure and waterway management and planning
Deparment of Construction in Can Tho city	City	- Infrastructure and construction management and planning
Deparment of of Water Resources and Environment in Can Tho city	City	- Water and land management - Land use and water resources planning

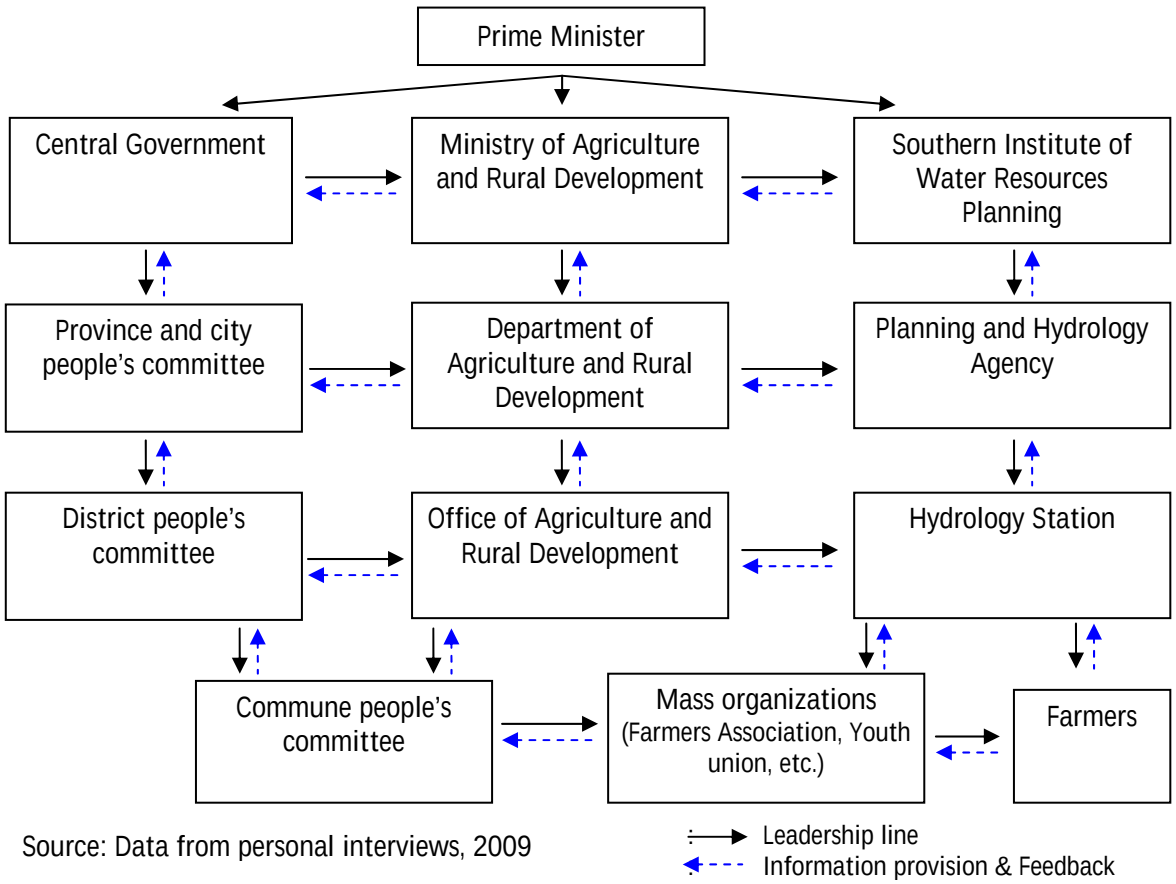
Source: Electronic websites of Ministries: http://www.isgmard.org.vn/; http://www.mt.gov.vn/ http://www.moc.gov.vn/ and http://www.monre.gov.vn/

In essence, MARD assigned the Southern Institute of Water Resources Planning (SIWRP) to set up the dyke system planning for the entire Mekong Delta. During the process of the dyke system planning, SIWRP has cooperated with local organizations in Can Tho city to collect information and data for said planning (See Figure 4). During the study, a total of 40 official participants from universities, Ministries and local organizations of provinces and cities were involved to form the dyke system planning in the Mekong Delta (SIWRP, 1998a). In addition, meetings, conferences and workshops were organised to discuss and gather the ideas of participants to build up the dyke system planning at the central and local levels. The contributive ideas and feedbacks of various organizations and individuals were collected and summarized in the process of the dyke system planning formulation. Hence, MARD and SIWRP have received lots of precious personal and organizational ideas from central to local levels. All of these ideas have been selected, analyzed, evaluated and reflected upon, with the aim of improving the quality of the dyke system planning. Therefore, a reasonable level of agreement amongst authorities and scientists and amongst locals of the flooded areas was reached . After local authorities expounded the study, MARD evaluated and then completed it on 17 and 18 December 1998.

To understand the participation of organizations and individuals in the dyke system planning, we conducted personal interviews and collected secondary data from the Southern Institute of Water Resources Planning and the Southern Institute of Water Resources Research (SIWRR) of MARD as well as local organizations within Can Tho city. Based on the analyzed results, the organizations and individuals participating in the dyke system planning was divided into two groups: (i) The first group including staff of SIWRP and participating directly in the dyke system planning. They are experts related to hydrology,

environment, construction and economy. These people form a planning group of SIWRP to take charge of the planning tasks for the Mekong Delta. Thus, the purpose of these people is to directly set up the dyke system planning. (ii) The second group is comprised of non-planners who participate indirectly in the dyke system planning. According to the official report of SIWRP (1998a and 1998b), SIWRP officially cooperated with four major organizations including the Southern Sub-National Institute of Agriculture Planning and Projection of MARD, the Southern Transportation & Economy Science Centre of Ministry of Transport, the General Construction Consultant Company of the Ministry of Construction and the Southern Economy Center of the Ministry of Planning and Investment as well as hundreds of other organizations in the whole country – all in order to organize the dyke system planning. However, the participatory level of these cooperation organizations proved inadequate during the process of the dyke planning. They only contributed consultant opinions in seminars and workshops or made minor individual contributions to improve the dyke system planning. Local organizations at city and district level mainly provided information and secondary data for the planners and organized seminars and workshops to collect contributive opinions of different sections and organizations within Can Tho city. Most of the contributing opinions were collected from leaders and managers of organizations while professional staff, local researchers and local people had no real room to contribute their own ideas with regards to dyke system planning. On the other hands, no studies were implemented to understand livelihoods and needs of local people in the flooded areas of Can Tho city during the process of dyke system planning formulation. Thus, voice and empirical knowledge of local people and beneficiaries in the flooding plains were not collected and were ignored in the dyke system planning. To sum up, state agencies play a major role in the dyke system planning formulation while local profession agencies and local people are not

Figure 4: Relation between MARD and local organizations in the dyke system planning



Source: Data from personal interviews, 2009

really involved in the process. This implies that a top-down approach was applied in the dyke system planning. Nevertheless, the dyke system planning is filled with implicit risks for life and livelihood of the people in the flooded plains.

To sum up, the dyke system planning is a complex and long process with the aim to ultimately reach an agreement between planners and local authorities. MARD has tried to build up a close cooperation with

Ministries and professional sections to form the dyke system planning. However, combination and cooperation amongst Ministries and local organizations and city is incomplete in the process of dyke system planning. Collaboration of organizations and individuals is missing vigor with regards to said system planning. Agreement among and between Ministries and local authorities to meet the practical needs of local people is questionable because academic knowledge and experiences of planning experts dominate and are consequently applied while local knowledge and the empirical experiences of local people are ignored.

SIWRP is the organization tasked with setting up the dyke system planning for Can Tho city. In the process of the dyke system planning, the planners have been divided into professional groups. Each professional group specialized on studying an individual subject and to formulate a professional report about it. Finally, these subjects were evaluated and synthesized into an official report for the dyke system planning. The implementers of the dyke system planning were a group of planning experts of SIWRP with different professions in terms of hydrology, economy, information technology, agriculture and environment. Thus the nature of the dyke system planning is dependent on the perspectives, professional knowledge and experiences of this expert group while social and empirical knowledge and experiences of local people have no room in the dyke system planning.

2.3.2 Objective of the dyke system planning

According to SIWRP (1998a, 1998b, 2005a, 2005b), general objectives of the dyke system planning are to:

- Ensure safety for inhabitants in towns, urban and rural areas and infrastructure in terms of main roads, houses and schools;
- Control year-around floods to protect fruit trees areas and double-triple rice crops for most of the areas;
- Take silts in inside farm areas to increase fertility for land and field hygiene; and
- Combine with hydraulic works to form an enclosed flood control system for the flooded areas in order to develop agriculture production and rural road system to meet the development of Can Tho city.

2.3.3 General measures for flood control

Can Tho City has an important position in the western region of Bassac river because structural flood control measures of Can Tho city will influence other provinces such as Kien Giang, Hau Giang, Soc Trang and Bac Lieu provinces as well as Ca Mau province in terms of changes of flood regimes, inundation and salinity intrusion. Thus, the dyke system planning in Can Tho City has to be combined closely with all western sub-regions of Bassac River. In Can Tho city, floods normally cause different inundation between sub-areas. The deep flooded area is located in the North of road 80. The shallow-average flooded area is located in the South of road 80. Thus characteristics of floods are difference between sub-areas. Floodwater resources of the northern areas flowing into the South area of road 80 can obtain 86 percent with low contents of silt and cause inundation for this area while floodwater sources flowing in the western areas of Bassac river only is about 14 percentages with higher salt contents. To utilize advantages and reduce disadvantages of floods, the planners of SIWRP divided Can Tho city into sub-areas. The general idea of flood control is to prevent the floods with low silt content from the Long Xuyen Quadrant flowing along to road 80 into Can Tho city. On the other hand, floodwater sources with high salt content along Bassac river are taken inside the farming fields (SIWRP 1998a and 1998b). Thus, alternatives of dyke system planning need to be designed appropriately to meet these purposes and the development need of each sub-area. Thus, the ideas and purposes of planners are to utilize floodwater sources with high silt content to provide for the farming fields. On the other hand, floodwater sources have been allocated to control the inundation level of the southern areas of road 80. Floods can be controlled actively and allocated appropriately between sub-areas to utilize the advantages of floods to improve soil fertility for the farm fields in the interior. However, the planners have predicted that flow velocity can increase and lead to erosion along Cai San canal and other areas. In addition, it is predicted

that these intervention alternatives lead to a change in the flood regime such as the flooding level to the Northern areas of road 80 being higher in the fields. Thus, these ideas and purposes are questionable for the livelihood of local people and the future development needs of Can Tho city. These dyke planning alternatives not only aim to meet these purposes, but also to take in to account to influence future destinations to control their negative impacts for life and livelihood of local people and exhausted natural resources in terms of land and water.

2.3.4 Dyke system planning and alternatives in Can Tho City

According to the flood control planning of SIWRP (1998a and 1998b), the basic foundation of the Can Tho dyke system was based on hydraulic calculation, the crest of the 1961 flood, the tide regime in 1994 and frequent rain (P = 10%). Can Tho city was divided in two flood control areas. The first area is a deep flooded area located north of road 80. Floods are controlled timely by the August flood control[3]. The low dyke system[4] has been built to timely control floods. The second area is the rest of Can Tho city located south of road 80. This is a shallow – averagely flooded area. Thus, the high dyke system[5] was designed to control floods entirely and actively to ensure the safety of agricultural production and the lives of local people.

a. Dyke system planning north of road 80

The area north of road 80 is the most deeply flooded area in Can Tho City (See Figure 2). Total natural area is 15,843 ha of which 12,100 ha is agricultural land. The average elevation is 0.5 to 1m above sea level (SIWRP 2005 and Sub-NIAPP 2006). Flood season goes from August to December with the depth of floods ranging from 1.2 - 1.5 m. However, the flood level can be up to 2 m in the big floods (See region II in Figure 5). This region is directly influenced by floods from the Long Xuyen Quadrangle (SIWRP 1998a and 1998b). The low dyke system there has been designed along the secondary canals to protect the summer–autumn rice crop before harvesting.

b. Dyke system planning alternatives south of road 80

This is a shallow-averagely flooded area. Most land elevation ranges from 0.6 to 0.8 m except areas along the Bassac River which have elevations ranging from 1.00 - 1.50 m. The central areas slope from the North to the South and from the West to the East with elevations ranging from 0.5-1.00 m. The flood season lasts 1 - 4 months and goes in the middle of August to December with inundation depths of 1.0 - 1.5 m. According to SIWRP (1998b), the dyke system planning was set up in sub-areas to control floods. There are four dyke system alternatives set up to select an optimum alternation to control floods in this area (See Box1).

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[3] The August flood control is a measure to prevent and to reduce the impact of floods that inundate early and damage the Summer-Autumn rice crop in August.

[4]The Low dyke system is a system of dykes that have their peak lower than the crest of an average flooding level. Floods can flow over the dikes in September and October.

[5] The High dyke system is system of dykes that have their peak higher than the crest of the 1961 flood. Foods cannot flow over the dikes even in September and October. They are actively controlled and deepened if the need arises.

Box 1: Dyke system planning alternatives south of road 80 of Can Tho city

Alternative A_0: Without the dyke systems.

In this alternative, the main canal system is only dredged to connect with Bassac river to irrigate water for agriculture production in the dry season and drain off floodwater during the flood season. The irrigation system can be used to control floods and allocate water between areas. Agricultural production activities can be influenced by floods. This is a control alternative to compare with other alternatives.

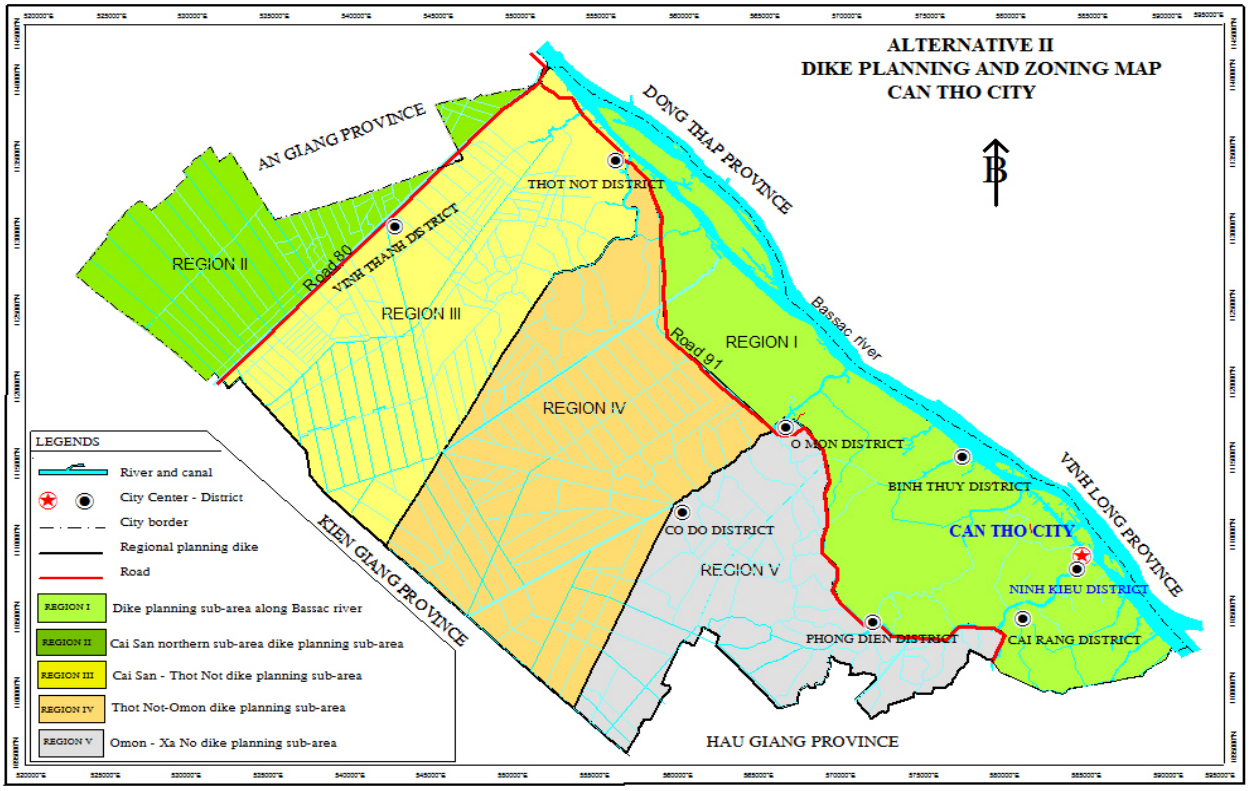
Alternative I: Control floods over road 80 (or Cai San canal)

This alternative has a few differences in comparison with alternative Ao. Road 80 and 91 are used as dykes to prevent floods from the Long Xuyen Quadrangle and take floodwater into the farm fields in the hinterland of the Bassac River. A sluice system is built along the road 80 and 90 to control the inflow and outflow of floods to the farm fields. The high dyke system is built along primary and secondary canals to form enclosed dyke areas. Floods are actively controlled to protect agricultural production activities in the enclosed dyke areas.

Alternative II: floods are controlled in sub-areas

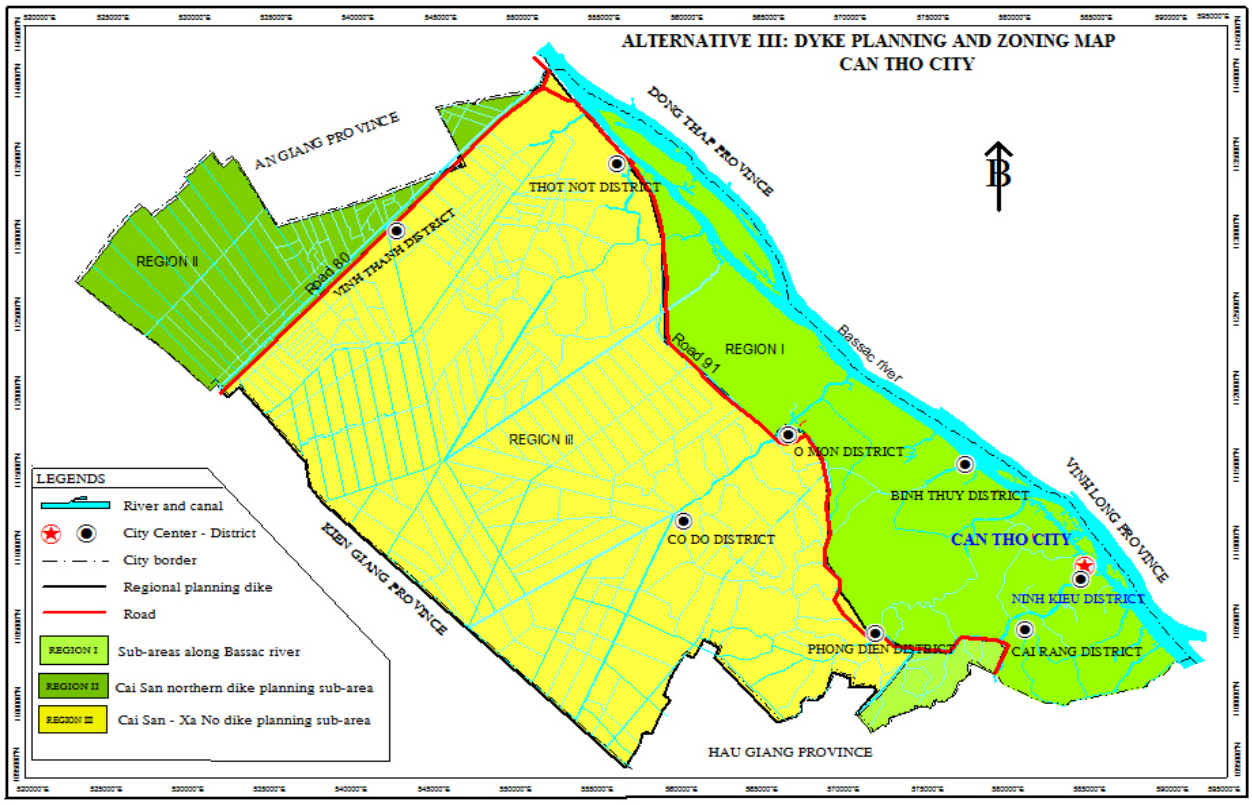
Here the primary difference to alternative I is that the areas south of road 80 are divided into two sub-areas to form smaller enclosed dyke sub-areas. The first sub-area is located east of road 91 along the Bassac River. It is enclosed by a high dyke system with enclosed dyke areas to protect fruit tree areas. The second sub-area is located west of road 91 and divided into three enclosed dyke sub-areas such as Cai San - Thot Not, Thot Not – O Mon and O Mon – Xa No (See Figure 5). In this alternative, floods are actively controlled to protect agricultural production activities in the enclosed dyke areas.

Alternative III: Control floods for the whole area of Cai San - Xa No
The contents of alternative III are the same to those of alternative II. A different point in comparison with alternative II is the three sub-areas: Cai San – Thot Not, Thot Not – O Mon and O Mon – Xa No are designed as one Cai San – Xa No enclosed dyke sub-area (See Figure 6). In this alternative, floods are actively controlled to protect agricultural production activities in the enclosed dyke areas.



Source: Author, 2009 (data source from SIWRP)

Figure 5: Dyke system planning in alternative II



Source: Author, 2009 (data source from SIWRP)

Figure 6: Dyke system planning in alternative III

2.3.5 Selection of alternatives for dyke system planning

The alternative selection the dyke system planning is a long process and complex. This study only presents the analyzed results of each alternative and explains reasons why the planners selected this alternative, but nothing more. According to the results of personal interviews and the official report on flood control planning of SIWRP (1998a and 1998b), the evaluated results of each alternative is presented as follows:

Alternative Ao: acid sulfate soil, agrochemicals and toxicity in the field are cleaned by floods. Floods are not influenced by hydrology systems. Natural resources such as fish and salts are protected and maintained during the flood season. The waterway is convenient. Costs for construction work are lowest in comparison with other alternatives. However, agricultural production models are not safely protected and can be damaged by floods.

Alternative I: According to the hydraulic calculation results, water levels in the alternative I can be reduced by about 0.6 - 1.0 m in the Cai San-Thot Not dyke sub-area, by about 0.1 - 0.4 m in the O Mon - Thot Not dyke sub-area, and by about 0.05 - 0.1 m in the O Mon – Xa No dyke sub-area. The water levels at the end of November are reduced to the same levels while the southern sub-area of Xa No canal is not influenced. In this alternative, the dyke system can safely protect urban areas, main roads and some agricultural farming areas. Floods are controlled partly to ensure safety for the farming areas in the interior and the lives of the people. Agriculture farming models can be influenced in a few places within the flooding areas.

Alternative II: the evaluation results of the alternative II are similar to alternative I. The highest flooding level in the western sub-areas of the Bassac river will be reduced in the sub-areas from 0.4 – 1.3 m in Cai San – Thot Not dyke sub-area; 0.3 – 0.7 m in Thot Not – O Mon dyke sub-area and 0.2 – 0.4 m in O Mon – Xa No dyke sub-area. The flooding level in the southern sub-areas of Xa No will not be changed. The triple rice crop can be produced safely. The rural roads are improved rapidly in comparison with alternative I. However, the rural waterway system can be limited because of sluices and dyke systems. Floods can be prolonged because of dyke systems near farm fields. Construction costs are more expensive in comparison with alternative I.

Alternative III: According to the results of hydraulic calculation, the flooding level can change from 1 to 1.2 m. Agricultural activities and rural road systems are protected. The waterways in inside the enclosed fields are not obstructed. The rural roads are improved. However, this alternative can cause obstacles when boats move outside of the enclosed dyke areas because of sluices and dyke works. Construction costs for this alternative are lower than alternative II.

The planners organized 100s of seminars and workshops with international and national experts and leaders of local organizations taking part to evaluate the feasibility of each alternative. At the same time, different researches were implemented to address disadvantages and advantages of each alternative in terms of economic benefits, environment and effective flood control. Finally, alternative II and III have many advantages in comparison with alternative Ao and I in terms of agricultural production development and main road protection. By comparison between alternative II and III, construction investment costs of alternative III are lower than alternative II, but alternative III needs to be simultaneously implemented. Finally, alternative III has more advantages than alternative I, but it was rejected because the entire budget would have to be provided at the same time while alternative II can be implemented step by step. Thus, alternative II was proposed to be implemented in Can Tho City.

2.3.6 Dyke system planning zoning and practice

Dyke system planning divided Can Tho City into five sub-areas to control floods of which one sub-area is located north of road 80 and the other four sub-areas in the South. The dyke planning for all sub-areas is presented as follows (See Figure 5):

(i) The northern dyke sub-area of road 80: low dyke system planning has been built along to secondary canals to control timely floods. Currently, the dyke systems have been completed to

about 90% along with secondary canals in cooperation between local authorities and local people.

(ii) The eastern dyke sub-area of road 91 along the Bassac River: The dyke systems here were mainly implemented by local people and local authorities. The main activities of this area are aquaculture, fruit trees, fishery and agricultural processing enterprises and industrial zones. Thus the dyke system was built to protect production activities.

(iii) Cai San – Thot Not dyke sub-area: the governmental high dyke system planning has not yet been implemented. However, local people and local authorities have undertaken local measures to protect agriculture production activities and the rural road system. Most of them are low dyke systems to protect the Summer-Autumn rice crop in August.

(iv) Thot Not – O Mon dyke sub-area: the low dyke systems have been built in this area to actively produce agricultural yields while the high dyke planning of the government has not been implemented yet.

(v) Mon – Xa No dyke sub-area: This is a representative area for the shallow flood plains of the Mekong Delta. The high systems have been in operation since 2005. The rest is located in the inner city. The dyke system planning is mainly built along primary and secondary canals and depends on the appropriate condition of each area. It was built mainly by local people and local authorities.

In summary, the dyke system planning is mainly used to control floods and allocate floodwater between the flooded areas of Can Tho City. The general effect of the dyke system is to transport silts into the farm areas in the hinterland of the Bassac River and to control the flood level between sub-areas. This approach is questionable when considering the practical conditions of Can Tho city. It needs to be propagated in society to receive contributions of local people and classes in the society. Currently, the planners mainly focus on the hydraulic calculation to select an appropriate alternative while other important aspects such as rural socio-economic development and the long-term impact of the dyke systems on the rivers´ environment and the development of Can Tho city have been ignored. Disadvantages of the dyke system planning have not been evaluated adequately to address problems related to water pollution, changes of livelihood, culture, customs, and the social life of the local people.

2.3.7 Combining dyke system planning and other activities

The dyke system planning has created five flood control sub-areas in Can Tho City. This planning has supported other professional organizations to engage in their respective activities to fix each sub-area such as agricultural planning, aquaculture planning and road transport planning. There is a close combination between dyke system planning and other activities in Can Tho city.

a. Combining dyke system planning and agricultural planning

In the sub-areas, domestic animal and plant systems have been designed and arranged appropriately in the dyke sub-areas. Agriculture farming models have been transformed from simple farming to integrated farming. Mono-rice farm crops have been transformed into rice – cash crops and rice – fish, fruit tree – fish, special intensive fruit trees and special intensive fish farming. Thus, farming activities have been diversified in the protected flooding areas to increase the effectiveness of land and water use. According to the complement agriculture planning of Sub-NIAPP (2006), the agriculture system planning of Can Tho city was implemented based on the zoning base of the dyke system planning as follows:

Sub-area I (along Bassac river): Total natural area is 37.549 ha. Alluvium soil with light acidity is convenient for agriculture farm models. The main agriculture farming models include fruit trees, rice-cash crops, vegetables and aquaculture. special rice crop farming has been transformed into fruit tree-fish farming or special aquaculture.

Sub-area II (the North of Cai San): this is a deeply flooded area with an average flood level of 1.2 - 1.5 m. Total natural area is 15,843 ha. The land contains silt with light acid soil. Thus, the land of this area is appropriate for double rice crop farming, rice-fish/shrimp and special shrimp farming. Double rice crops

and rice-fish can be developmeed in this area. Double rice crop farming will be transformed into rice-fish and rice – shrimp farming.

Sub-area III (Cai San-Thot Not): Total natural area is 30,346 ha. This is an averagely flooded area with a flood level of 0.5 – 1.0 m. This sub-area has light acid suphate soil and available water. Double rice crop farming has been transformed into two rice crop – one cash crop farming and intensive fish culture. Current double rice crop farming in the fields can be transformed into triple rice crop farming, double rice crop – fish/shrimp farming and double rice crop – cash crop farming.

Sub-area IV (Thot Not - O Mon): This area has low terrain, light acidity, alluvium soil and a low flooding level of about 0.5 m. Total natural area is 35,084 ha. Quality of water environment is low in comparison with sub-areas II and III. Current farms are high quality rice, natural fish culture in the field and special fish culture to the North. A rice crop can be trasformed into double and triple rice crops, double rice crops - single cash crop, double rice crops – one fish.

Sub-area V (O Mon – Xa No): total natural area is 21,272 ha. This area has low terrain, alluvium soil, ligh acidity, actively water control for agricultural production. The quality of water environment is inferior in comparison with other sub-areas. Natural conditions are suitable for fruit tree cultivation, natural fish culture and tourist development. Double rice crop farming will be conversed into fruit tree-fish farming, special fish cultivation, triple rice crop farming and cash crop farming.

b. Combining the dyke system planning and aquaculture planning

Aquaculture development and planning is dependent on the quality of the water environment and the flood level and time of each sub-area. According to the general report of the Southern Aquaculture Planning Sub-Institute (2007), Can Tho City was divided into two aquaculture areas. Sub-area I is located along the Bassac river to the East of road 91 (national highway 91) stretching from the Vinh Thanh and Thot Not district to the Cai Rang district. Sub-area II is located in the western area of road 91 including the Thot Not - O Mon dyke sub-area, O Mon – Xa No dyke sub-area and the rest of Can Tho City.

Sub-area I (along the Bassac river): Total natural area is 94,150 ha. Land and water is appropriate for fish and shrimp culture because the water is directly taken from the Bassac River. Almost all aquaculture activities are concentrated in this area. Aquaculture models include intensive fishpond, cage fish culture, rice-fish/shrimp, fruit tree - fish, rice – fish, fish culture in the rice fields.

Sub-area II (the West of the Bassac River): Total natural area is 45,946 ha. The terrain of this area is low and swampy. Fish culture models are mainly semi-intensive cultures. Fish culture models include fishponds, fruit tree - fish, rice - fish/shrimp and special fish cultures in the fields during the flooding. In addition, intensive fishpond cultivation has been implemented in O Mon, Thot Not and Vinh Thanh districts by rural households.

c. Combining the dyke system and rural socio-economic development

The high dyke system planning has contributed positively to rural road and resident development in the flooded areas of Can Tho city. High dykes along with primary and secondary canals were used to form rural roads in the flooded areas. Road 80 with 30 km stretching from Lo Te to Kien Giang, Road 91 with 50 km long stretching from Can Tho to An Giang province, road 921 with 25.53 km stretching from O Mon to Vinh Thanh district were raised higher than the crest of the 1961 flood to connect with other provinces. In Can Tho city, the high dyke systems in the flooded areas have been used to build rural roads to connect different communes and districts and rural areas and cities. In addition, some main canals and rivers along the dyke systems were excavated to enhance the waterways such as Cai San canal and Can Tho River. Furthermore, the high dyke systems used to build dyke and resident clusters aim to move people who wereexposed to the impact of floods to these clusters for their security. These clusters were mainly built in rural areas. Thanks to the high dykes, there are product exchanges between cities and rural areas. Agricultural products such as vegetable, fruits, rice, fish and pigs are transported to cities. The products of cities such as family furniture, agriculture materials are transported or moved to rural areas to serve the local needs there. Therefore, services in rural areas have been developed rapidly to meet the needs of local people. To sum up, the high dyke systems have contributed positively to rural

socio-economic development in which rural road systems are improved rapidly to meet the development needs of Can Tho city.

3. The dyke system: pros and cons

Dyke system planning has produced both advantages and disadvantages for flood protection and the livelihoods of local people in the flooded areas of Can Tho City. There are different opinions about the negative impact of dyke planning system for floods and livelihood activities of local people. The dyke system planning can produce new challenges for people and the environment in the long-term. Currently, there is a lack of studies to address these problems. In this section, the study would present a general impact analysis of the dyke system planning in the protected flooding areas of Can Tho city. Personal interviews were implemented at the Southern Institute of Water Resources Planning, the Southern Institute of Water resources Research and various organizations within Can Tho city. In addition, secondary data, reports and the published journals were collected and involved in this study. The detailed contents of these reflections are presented in the following sections.

3.1 Advantages of dyke system planning

According to an official report of SIWRP (1998a and 1998b) and personal interviews, dyke system planning has some advantages as follow:

Agricultural production activities and the lives of people are safely protected during the flood season. Floods are actively controlled and used to enhance agricultural production and the rural road system. In fact, dyke systems have actively contributed for agricultural and rural road system development till now. Agricultural production activities are produced unhindered and are not influenced by the impact of floods on the summer-autumn rice crop of the protected flooding areas.

Livelihood activities and the lives of the local people are safely protected in the flood plains. Floods are actively controlled to create favorable conditions for the agriculture farming activities of local people in the flooded areas. Agriculture and aquaculture farming models have been diversified to generate more income for said people. Thus, local people have many different income sources to improve their lives.

Agricultural farming systems have been transformed from mono-rice farming into integrated agriculture farm models such as rice-upland, rice-fish, rice-shrimp, fruit trees - fish, rice – livestock – fish, and intensive fish culture in the fields. These models have advantages for the development of Can Tho city. Firstly, integrated agriculture farm models have diversified income sources for the local people; Secondly, both land and water resources are used effectively and especially floods are also used to raise fish; thirdly, thanks to changes of the agricultural farm structure, pests and diseases can be controlled on rice and vegetables; and fourthly, soil fertility is stable, and water quality is improved in the integrated agriculture farm models. Thus, the integrated agriculture farm models are seen as an advantage that has is encouraged to be implemented in the protected flooded areas to reduce risks for the local people.

Local people can actively control floods to undertake agriculture production activities. Annually, floods normally cause inundation in August and influence the summer – autumn rice crop. Thanks to the dyke systems, local people can pump water out to produce the Winter-Spring rice crop about 1 – 2 months earlier (before the floods recede). Thus the summer – autumn rice crop can be protected to avoid negative impact of early floods in August. Fruit tree gardens are protected in the enclosed sub-areas by the high dyke system.

The high dyke system has created favorable conditions for socio-economic development in Can Tho city as presented in section c in 2.4.6. Rural roads and dyke-resident clusters can be developed along canals to support agricultural production and the protection of the local people´s lives. Some high dykes are used to build rural roads. Thanks to these roads, the children in rural areas have opportunities to access schools. Local people have opportunities to access services within rural areas and cities and exchange

agricultural products between rural areas and cities. In addition, rural an electricity system along dykes and resident clusters has been built to improve the lives of local people.

3.2 Disadvantages of dyke system planning

In this section, the disadvantages of dyke systems are summarized based on personal interviews with local organizations and local people in Can Tho City. In addition, this section presents the disadvantages of these systems derived from scientific reports related to the disadvantages of dyke systems in the Mekong Delta. The disadvantages of these systems are presented as follows:

Natural fish resources have been reduced rapidly after the dyke system was constructed in the flood plains because of the following reasons: (i) The dyke systems have prevented migration of natural fish from rivers and canals into the protected flooding plains; (ii) The main gates of sluices along the dyke systems hinder the fish from migrating and are closed during the flood season; and (iii) Triple rice crops have been implemented in the protected flooding areas. Thus, fish have lost their habitats during the flood season. Thus, the dyke systems as direct and indirect causes lead to the reduction of fish. According to the research results of Duong Van Nha (2006) and Tran Nhu Hoi (2005), fish productions in the dyke system at two Vinh Loi and Vinh Hau communes of An Giang provinces were 533.2 kg and 1,126 kg per year respectively. This yield fell to 230.96 kg per year in Vinh Loi and 472 kg per year in Vinh Thuan in 2005. Both authors conclude that fish sources are exhausted in the high dyke systems. In contrast, fish sources have not been reduced in the low dyke systems because this system allows direct exchange with floods and rivers and irrigation systems.

The dyke systems have changed the inundation levels between regions. According to results of personal interviews, the inundation time has been prolonged in the flood plains protected by the dyke system. Floods have increasingly come sooner and receded later in recent years. The main reasons for this are that the sluice systems under the dyke systems fail to completely to discharge water timely into the fields. Thus, the fields are normally flooded earlier and the flooding time is prolonged at the ending of the wet season. Thus, the flooding time has been prolonged in recent years. According to Le Thi Viet Hoa et al (2008), the dyke system has changed the flood regime and inundation in the recent years. She studied infrastructure effects on floods in the Mekong River Delta. She found out that infrastructure changes during the period 1996–2002 had a massive effect on the flood regime. Such infrastructure changes as dredging the canals, raising the embankment systems along canals, upgrading roads to protect residents' lives, and protecting crops can prevent floods by slowing flood propagation to paddy fields early in the season, but cause inundations to last approximately 5–10 days longer and to be 0.2–0.3 m deeper in some regions near or between high embankment systems. In addition, the dyke system in the upstream provinces decreases the overbank inflow to Vietnam and increases the water flow to the canals. This is consistent with the above analysis of varying trends based on the flood data from 1961 to 2004: flood peaks tend to increase with progression downstream. Thus, the dyke system is one of causes effecting to flood regime and inundation levels between different regions in the Mekong Delta.

The dyke systems are one of the causes that lead to water pollution and soil fertility reduction in the protected flood plains. Agricultural production activities have been engaged in intensively in the protected flood areas. Farming three rice crops is one of the causes of the development of pests and diseases in the protected flood areas. Thus, agrochemicals have been used without reservation which has lead to water pollution. In addition, the high dyke systems have limited the water exchange with rivers and canals during the flood season which results in silt reduction in the fields. On the other hand, toxicity and agrochemicals have accumulated and remain in the fields and have not been cleaned by floodwater. According to the research results of Duong Van Nha (2006) and Tran Nhu Hoi (2005) at An Giang and Tien Giang provinces, the proportion of silts were lesser in the protected flooding areas when compared to the unprotected flooding areas. In addition, they found that BOD5 and COD volumes in the protected flooding areas were 4-5 times (BOD5) higher than those in the unprotected flooding areas- a full 6 – 8 times (COD) to the standard allowance of Vietnam´s case study in Tien Giang province and 2 times in in An Giang province. They concluded that the dyke systems are an indirect cause which leads to water pollution in the protected flood plains.

Dyke systems lead to the erosion of rivers and canals. According to the experiences of rural people, the flow velocity in the rivers and canals has increased during the flood season in comparison with the period before the construction of dyke systems. It has caused erosion on both sides of the rivers. In recent years many river and canal segments have been eroded. Thus, the dyke system is one of the causes of said erosion. The engineering structures in the delta increase the flow velocity in the rivers and canals, increasing bank erosion along the rivers and canals. The risk of catastrophic failure of the dykes in the protected areas has increased (Le Thi Viet Hoa et al., 2007). The other causes for the erosion of the dyke system are to waves and rainfall. The wet season in Can Tho city normally occurs during 5 to 6 months. During the wet season, heavy rainfall and waves normally cause dyke erosion. On the other hand, the dyke systems were built temporarily by using soil. Thus, they are easily eroded by rain and waves. Besides, the dyke systems are often broken because of the low awareness of people. Most of these people rely entirely on floods to catch the fish for their daily lives. A few of them actually destroyed the dyke system to find fish. There were many segments of the dyke systems broken in rural areas. Thus, maintenance of the dyke systems is a difficult task in the protected flooding areas.

Annual upkeep for the broken dykes is a heavy burden for the local people. The main income of said people is rice production. This income is low and does not suffice to pay for repairs of broken dykes. In addition, local authorities do not have enough budgetary means to repair these broken dykes themselves. This is a challenge for both the local people and local authorities.

The use of fertilizers and agrochemicals has increased in the protected areas. The fertility of soil has declined due to lack of silts provided by floods. Most of the respondents acknowledged that silt levels had fallen in farming areas protected by the high dyke systems. They have to invest more fertilizer to compensate for the loss of natural silts and use greater amounts of agrochemicals to prevent pests and diseases.

3.3 Social reflections on dyke system planning

In this section, this study focuses on presenting social reflections from personal interviews with representative people of local organizations. In addition, reflections from newspapers of Vietnam are also presented in this section. The Content mainly relates to dyke system planning in Can Tho city.

In Can Tho City, O Mon – Xa No project sub-area, a representative shallow flooded sub-area (See figure 5), was selected. It has been under development since 2005. There are currently different reflections related to disadvantages and existing problems of this project made by various organizations and local people. Based on the analysis results of interviews, opinions were divided into two groups. The first group includes people who support the construction of the dyke system in Can Tho City. They are planners, hydrologic specialists and leaders of political and professional organizations. Similarly, the second group includes people who only partially support or do not support at all the construction of the dyke system in Can Tho city. They are mainly researchers etc. With fields of expertise related to water environment, aquaculture, animal husbandry and natural resources management.

The first group reports that the flood control dyke system is an appropriate solution for the development of the Mekong Delta and especially for Can Tho City. The dyke systems have brought more advantages than disadvantages for the local people in the flood plains. The dyke systems have safely protected both the double rice crop harvests and lives of the inhabitants in the flood plains. Mono-agriculture farming models have been transformed into the integrated agriculture farming models such as rice-fish, rice-vegetable, garden-fish, special fish culture, fish culture in the protected farming areas. The dyke systems have created many employment opportunities and income sources for local people thanks to agricultural farming model diversification. The high dyke systems have been used to improve rural road systems and build rural electricity systems along the high dykes to meet the development needs of Can Tho City. Thus, people in this group are interested in flood control, water management and economic development while the negative consequences of the dyke systems with regards to the water environment and exhaustion of natural resources are ignored.

On the other hand, the opinion of the second group is totally contradictory to that of the first group. People in this second group state the dyke system planning should carefully consider its negative

consequences in the long-term (with the aim of sustainable development). Currently, the dyke system has produced disadvantages for the lives of the inhabitants and agricultural production (examples being water pollution, erosion, change of flood regime and employment for the poor). Most of local researchers have addressed these problems in O Mon – Xa No dyke sub-areas and other protected areas in Can Tho city. In recent years, inundation has increased in the downstream provinces and especially in areas located along the Bassac River. A typical example is that inundation has also increased within Can Tho city

Local dyke systems have changed the natural rule of floods. The current dyke systems were built locally and depended on the needs of each community, commune and district. Most communes and districts set up the dyke plans and implemented them themselves – all to meet the practical needs of the community. A few dyke plans of certain communes and districts have not been connected to the general flood control planning of the government. Thus, these have changed or broken down the natural regime of floods and lessened the advantages of floods. In recent years, it has become difficult to predict and control the inundation levels within Can Tho city.

There are contradictions between planners and local people relating to the low and high dyke system. The planners want to build high dyke systems to control floods while local researchers and some local people do not entirely support this idea. Most opinions of researchers presented that the high dyke system has changed natural rules, characteristics and advantages of floods as presented in the above sections. They only support the construction of low dyke systems in the flooding condition of Can Tho city because these dyke systems do not produce water pollution, change the flood regime and inundation levels between regions. According to Duong Van Nha (2006) and Tran Nhu Hoi (2005), the high dyke systems have produced disadvantages for water environment, changes of flood regimes, inundation between regions. Thus, the low dyke systems should be considered for construction in the current flooded conditions.

Regarding existing problems in the dyke system planning, most opinions of respondents reported that local organizations and especially non-planning organizations participated inadequately or did not contribute any opinions to formulate dyke system planning in Can Tho City. Contents and decision-making of the dyke system planning were dominated by higher ranking organizations while opinions of local organizations were ignored in the dyke system planning.

The objectives of dyke planning mainly focus on the protection of local peoples´ lives, flood control, water allocation and economic development while livelihood activities and customs of local people in the flood plains are not considered adequately or worse are simply ignored. Social research on dyke system planning was not found. Thus, dyke system planning has produced long-term disadvantages for the inhabitants´ lives. To sum up, dyke system planning prioratizes hydrological technique aspects over social aspects and livelihood needs of local people in the flooded areas of Can Tho City.

The collected information and data to set up the dyke planning is also not adequate. Most information and data were collected from secondary data at city and district level to formulate the dyke planning. Primary data and information from local communities was not collected and found in the official reports of the dyke system planning. In addition, research on socio-economic research and practical surveys were not implemented to address the needs of local people and mitigate the short and long-term negative impacts of dyke system planning on the lives of local people. Thus, the dyke system planning has had a negative impact on the practical condition in Can Tho City. These can lead to conflicts of interest and needs between local people with planners.

The flood control dyke system planning has not been propagated popularly in society. Therefore, there are currently very few people who know the contents of this planning at city, district and commune levels. Thus, local knowledge and experience contributions of local organizations, local people and especially academic knowledge of researchers were not involved in the dyke system planning. Unpredictable short and long-term negative impact of this dyke system planning in the protected flooded areas of Can Tho city is inevitable.

4. Vision for the future

The transformation from a rural society living with the natural rules of floods to one living with floods under human control has produced new challenges for the inhabitants of Can Tho city. Dyke system planning can obtain foreseeable benefits in short term, but can also lead to unpredictable negative impacts on the long – run. It changes the flood regimes and inundation levels between sub-areas within Can Tho city. Existing problems of dyke system planning have not been addressed adequately (such as water pollution, land fertility decline and fish reduction which have lead to disadvantages for the lives of local people in the protected flooding areas). The natural rules of floods have been changed and are now under human control. The natural advantages of floods are gradually disappearing and are replaced by new disadvantages for the lives and livelihoods of local people in the long-term.

Dyke system planning merely focuses on hydraulic and technological aspects to control floods and protect agriculture activities in the flooding plains while social aspects are ignored. Knowledge and experience of local professional agencies and researchers are not involved adequately in dyke planning formulation. Vital livelihood activities of the local people in the flooded areas are not considered, studied or addressed in the dyke system planning. A top-down approach is mainly applied when setting up dyke system planning. New problems in terms of water pollution, flood regime changes have challenged local people in the protected flooding areas. There are great differences between theory and practice in the dyke planning and also between the ideas of planners and the practical needs of the local people. It is difficult to obtain sound theories of integrated flood management in three aspects: economy, society and environement.

In summary, there are many existing problems and new challenges beyond the dyke system planning in the practical lives and livelihoods of the local people in the protected flooding areas of Can Tho city. Adaptation of local people in the protected flooding areas has not been studied in the last years. This study will continue to address these contents in the coming reports.

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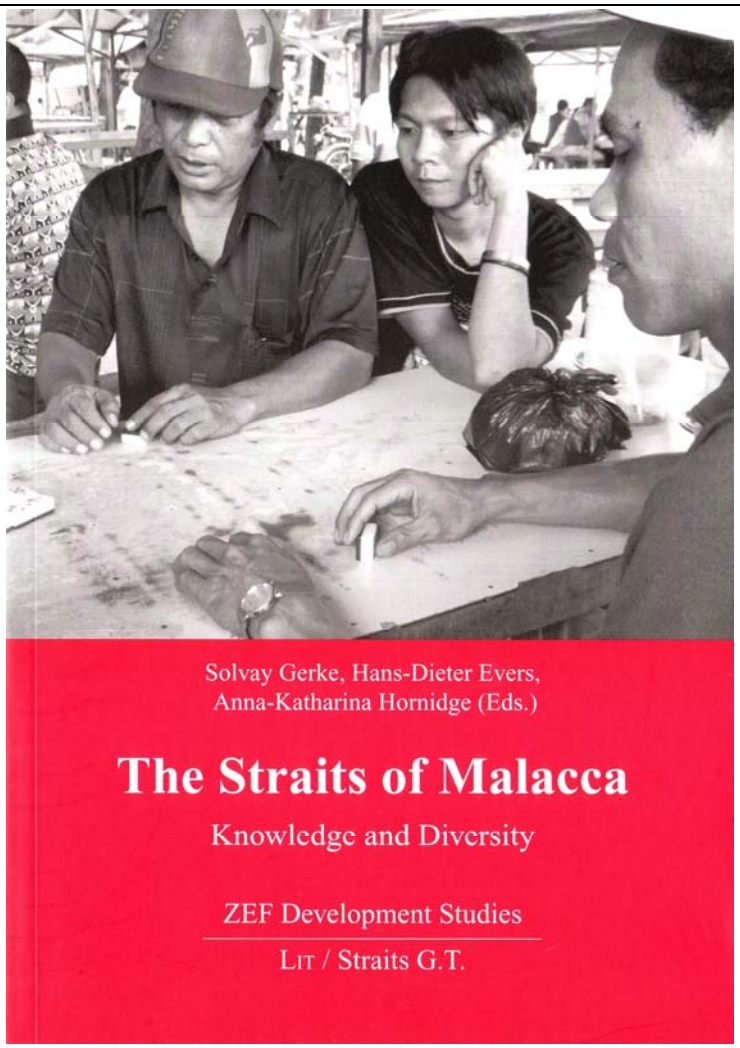

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