Flood Control in the Mekong Delta

To Van Truong[1]

[1]*Sub-Institute of Water Resource Planning, 253A An Duong Vuong Street, Ho Chi Minh City, Vietnam*

ABSTRACT: In the Mekong Delta, flooding is a severe problem as well as a beneficial environmental functio n. It causes devastating loss of life and damage to property while also providing essential nutrients, habitat and water resources that are necessary for the development of agriculture and fisheries. Therefore management and control of flooding in the Delta faces the difficult task of minimising the damages whilst maximising the benefits. In 1998 the Sub-Institute for Water Resources Planning completed a document titled "Flood Control Planning for the Inundation Areas of the Mekong Delta in Vietnam" that proposed a strategy for flood control planning in the Delta. The strategy combines the idea of "living with the floods" with flood control. The Government of Vietnam approved this document. Based on this document the flood prone areas of the Delta are divide d into two categories for flood control. In "Shallow Flood" areas flood waters are to be fully controlled while in "Deep Flood" areas flood control will attempt to protect against the early flood while allowing flooding of fields during times of high flow.

1 INTRODUCTION

Annually, between 1.4 and 1.9 million hectares is inundated in the Vietnamese Mekong Delta for periods of between 3 to 6 months and with depths between 0.5 and 4 m. While water resources and flood control development of the Mekong Delta over the past two decades has seen great improvements to agricultural production and lead to the Delta becoming the "Rice Bowl" of Vietnam, flooding still represents the most common and devastating natural disaster to occur in the country. Flooding results in loss of life and damage to property and production. It also represents a hindrance to industrialisation and modernisation.

The Ministry of Agriculture and Rural Development (MARD) was assigned the task of producing a flood control plan for the Mekong Delta, which, after consultation with a number of sectors, such as transportation, construction, marine, environment as well as with the provinces, it completed in December 1995 giving rise to Decree 99/TTg (9 Feb 1996). One of the main ongoing tasks of th is plan is the study of hydraulic scenarios for flood control in the Delta. In 1998, after extensive consultation, conferences and workshops, the results of this work were detailed in a document titled "Flood Control Planning for the Inundation Areas of th e Mekong Delta in Vietnam". This paper will summarise the findings of this document.

2 BACKGROUND

2.1 Natural Characteristics

The Mekong River originates in the mountains of the Tay Tang area of Tibet and has a length of 4,200 km running through China, Myanmar, Thailand, Laos, Cambodia and Vietnam, as shown in Figure 1. The total catchment area of the Mekong River is 795,000 km^2. The Mekong Delta, defined by its low-lying topography, begins downstream of Kratie and consists of 55,000 km^2, 16,000 km^2 in Cambodia and 39,000 km^2 in Vietnam.

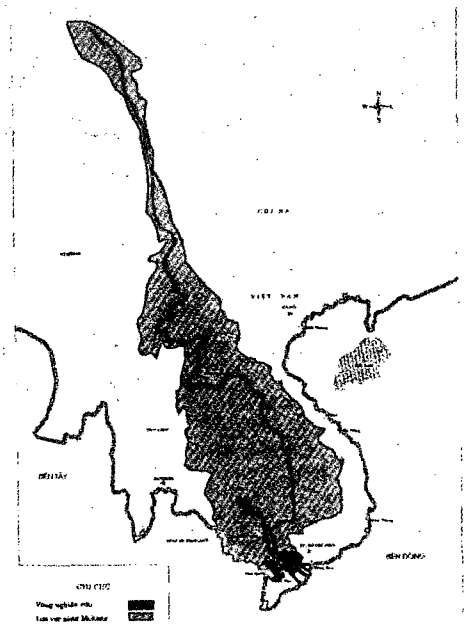

Figure 1. Mekong River Catchment

A total annual volume of 432 billion m^3, or 13,700 m^3/s in terms of average discharge is estimated at Kratie. Flows are distinguished into the rainy season and the dry season. In the Rainy season, between June and November, flows account for 90% of the total annual volume. The Great Lake has a large impact on the flow regime of the Mekong river downstream of Phnom Penh because during the flood season there is a reversal of flow in the Tonle Sap River, from the Mekong to the great Lake, which provides regulation of the flood flow. This results in the flood season occurring a month later (July to December) downstream of Phnom Penh, compared to locations upstream. Tide levels in the South China Sea also have a large influence on the hydrological regime of the lower basin.

The Mekong Delta in Vietnam is approximately 5% of the entire Mekong River Catchment. The topography of the catchment is flat, typically between 0.5 and 1.5 m above sea level, with levels generally declining from North to South. The climate of the Mekong Delta in Vietnam is tropical Monsoon with an annual average rainfall of 1,700 mm, varying between 2,400 and 1,200 at different locations. 90% of the rainfall falls during the rainy season (May to December).

The flow regime of the Mekong Delta in Vietnam is strongly influenced by tidal fluctuations in the South China Sea and to a lesser extent, the Gulf of Thailand. The tide of the South China Sea is diurnal with amplitudes between 3.5 and 4 m. The tides in the Gulf of Thailand are semi-diurnal with amplitudes of 0.8 and 1.0 m. Due to this strong influence there are large areas, approximately 1.7 million hectares, of the Mekong Delta that are affected by salinity intrusion. Mekong River fresh water flows are important to push back this intrusion. The fresh water flows are also important to the Mekong Delta in Vietnam for irrigation, fisheries, domestic and industrial use and the creation of freshwater habitats. The Mekong River also brings large amounts of sediment that are important for replenishing nutrients on agricultural land.

Inundation areas of the Mekong delta in Vietnam were generally formed by Kanozoi sedimentation. Bedrock is located between 100 and 1000 m below ground level with sediment layers at downstream locations deeper. Soils are generally fluviogenic and marine alluvial soils and weak in structure. There are also large areas of acid soils, which are prevalent due to the annual wetting and drying of inundation areas.

The Mekong Delta river system is dominated by the two main (dis)tributaries of the Mekong River, namely the Mekong and the Bassac River. The Mekong carryies most of the flow until its confluence with the Vam Nao River, which diverts water from the Mekong to the Bassac, after which flows in the two channels are similar. Other large rivers include East and West Vam Co Rivers, Cai Lon Cai Be River system and Giang Thanh River. In addition to this there is an extensive and dense man-made canal system, developed over a century, which affects flow regimes in the rivers and connects river systems, farms and seas in a complex pattern.

Water Quality in the delta is seasonally variable and is high in silt particles. Major water quality issues include acidity from leachate draining from acid sulphate soils, salinity intrusion, pesticide and nutrient loads from agricultural practices and human and animal waste. Natural vegetation is scarce and only eucalypt forests in the high acid sulphate soil areas remain. The rest of the Delta has been transformed by agricultural practices. Fisheries remain important and diverse.

2.2 Flood Characteristics

Flooding in the Mekong Delta in Vietnam is influenced by flooding from the upper-catchment, regulation of the great lake, tides of the South China Sea and the Gulf of Thailand and locally generated runoff as well as human influence.

Floods are moderate in the Delta, when compared with areas upstream. Amplitudes at the border sites of Chau Doc and Tan Chau of between 3.5 and 4 m, with maximum rates of increase of 20-30 cm per day and speeds between 1.5 and 2.0 km/hr. Flood hydrographs generally have two peaks, with the maximum peak in September/October and another in August.

The inundation area of the Mekong Delta in Vietnam can be divided into 4 distinct areas based on topography, climate, hydrology, canals system, roads and economic development. They are: The Long Xuyen Quadrant, The Western areas of the Bassac River, The Plain of Reeds and the areas between the Bassac and the Mekong Rivers. In a high flood year 40,000-45,000 m^3/s crosses the border of which 80% flows in the main stream, and 20% (12,000m^3/s) is overland flow, of which 2,000-4,000 m^3/s flows into the Long Xuyen Quadrant and 6,000 – 9,000 m^3/s flows into the Plain of Reeds. Floods have increased in the Long Xuyen Quadrangle and Plain of Reeds over recent years due to intensification of the canal system, which has not been designed for flood flows, bringing more overland flow into these areas.

Flood levels are higher in the Mekong and so flow is from the Mekong to the Bassac through interconnected canals and rivers. Most flow is to the South China Sea, with a small portion discharging to the Gulf of Thailand through the canals system. Flooding in the Delta is mainly caused by out of bank flow from the main rivers. Flooding is not greatly influenced by local runoff generation however rainfall contributes a large amount of water to in-farm floods resulting in larger and longer flood seasons. Tides are also not the major factor with regard to flooding however, tides tend to increase towards the end of a flood season, therefore if the flood peak is later than average, then it will coincide with higher downstream water levels resulting in longer periods of flooding due to the difficulty of drainage. Construction of the canal system and other hydraulic structures over the past two decades, while improving drainage, has also contributed to flooding of farm areas, especially near the border with Cambodia. Recent large floods have occurred in 1961, 1966, 1978, 1991, 1994 & 1996.

2.3 Socio-Economy

The Mekong Delta of Vietnam has been transformed over the past few decades as it has been possible to develop the deep flooded areas, such as Long Xuyen Quadrant and the Plain of Reeds, due to the improvement of impoundments and drainage. Due to this, agricultural production has increased rapidly. However the agricultural economy is still

underdeveloped with low levels of mechanisation, infrastructure and urbanisation. Flood inundation is a big constraint on the economic development of the area. Other areas of economic development in the Delta include fisheries, forestry, animal husbandry, industry, handicrafts, trades and services.

In the inundation area (8 provinces) of the Delta there are approximately 10 million people, 81.4 % of whom live in rural areas, and 18.6 in urban areas. The population density is 481 people/km^2, however populations are not evenly distributed. The average GDP per capita is approximately 300USD/year.

Flooding is slow to occur however it covers a large area and lasts for a long period. This provides constraints to agricultural production, settlement and development of infrastructure as well as disruption to people's lives, transportation, education and health services. Floods also result in the loss of life (217 in 1996, 199 in 1995, 407 in 1994), damage to infrastructure and erosion of riverbanks. Benefits of flooding include deposition of silt on farm soils, cleansing of fields (including eradication of vermin), remediation of acid soils and fisheries.

Socio-economic development objectives are for annual growth of between 8-10% GDP to the year 2010. To meet this, the target for agricultural growth is 5% per year through diversification and increased cropping area, industrial growth is to increase at a rate of 14%, especially through increased foodstuff processing, and trades and services at 13%. Other areas to be developed include fisheries (especially aquaculture), roads, and urbanisation (to 24-27% by 2010).

3 FLOOD PLAN FOR THE MEKONG DELTA

In order to meet socio-economic development objectives improved flood control and management is necessary.

3.1 Long-Term Flood Control Plan

The long term objectives for flood control planning in the Mekong Delta of Vietnam are:

- Create conditions for comprehensive socio-economic development
- Protect the ecological environment
- Develop rural areas, especially in terms of industrialisation and modernisation

The methodology to achieve these objectives have been identified:

- Together with protection of people, infrastructure and inhabited areas it will also be necessary to exploit the benefits of floods to increase silt amounts, fisheries, remediation of acid soils and cleansing of fields. The Plain of Reeds and the Long Xuyen Quadrant are the two main acid sulphate areas in the inundation areas of the Delta. Therefore flooding in these areas is still greatly beneficial and these areas will "live with the floods". To "Live with the floods" means to control floods by diverting to Vam Co River and Gulf of Thailand, whilst ensuring continued flooding to provide silt. The main idea is to reduce the duration of flooding to allow two crops per year.
- Flood control planning must consider other water resource issues such as fisheries, agriculture, water supply and drainage, salinity intrusion and navigation.
- Flood control planning must also consider non-construction methods such as flood forecasting to mitigate against flood damages.
- Monitoring of changes to the hydrologic and hydraulic regime of the Delta is necessary and continual upgrading of mathematical models is required.
- Environmental impacts of flood control planning need to be made.
- Selection of flood control plans needs to consider: objectives, economy, engineering, society and environment.

Having looked at various options SIWRP recommend that flood control planning should provide year around flood protection for the urban areas, main transportation system, "shallow" inundation areas, fruit and industrial tree areas. Modelling suggests that this does not affect flood levels at Tan Chau and Chau Doc on the border with Cambodia. Also there should be early (August) and late (November-December) flood protection for stable production of double rice in the "deep" inundation areas. This will result in fewer impacts on flood levels and less impact on the ecological environment. Figure 2 shows the inundation area of the Mekong Delta in Vietnam.

3.1 Shallow Flood Areas

The objectives for "Shallow flood" areas are to actively prevent floods, divert and drain floods through suitable areas to reduce the level and duration of floods in order to protect lives, infrastructure (such as roads) and property, protect production year-round and meet demands of steady and stable socio-economic development and the environment. Specifically: a complete hydraulic works will be completed to prevent flooding while considering other water resource issues.

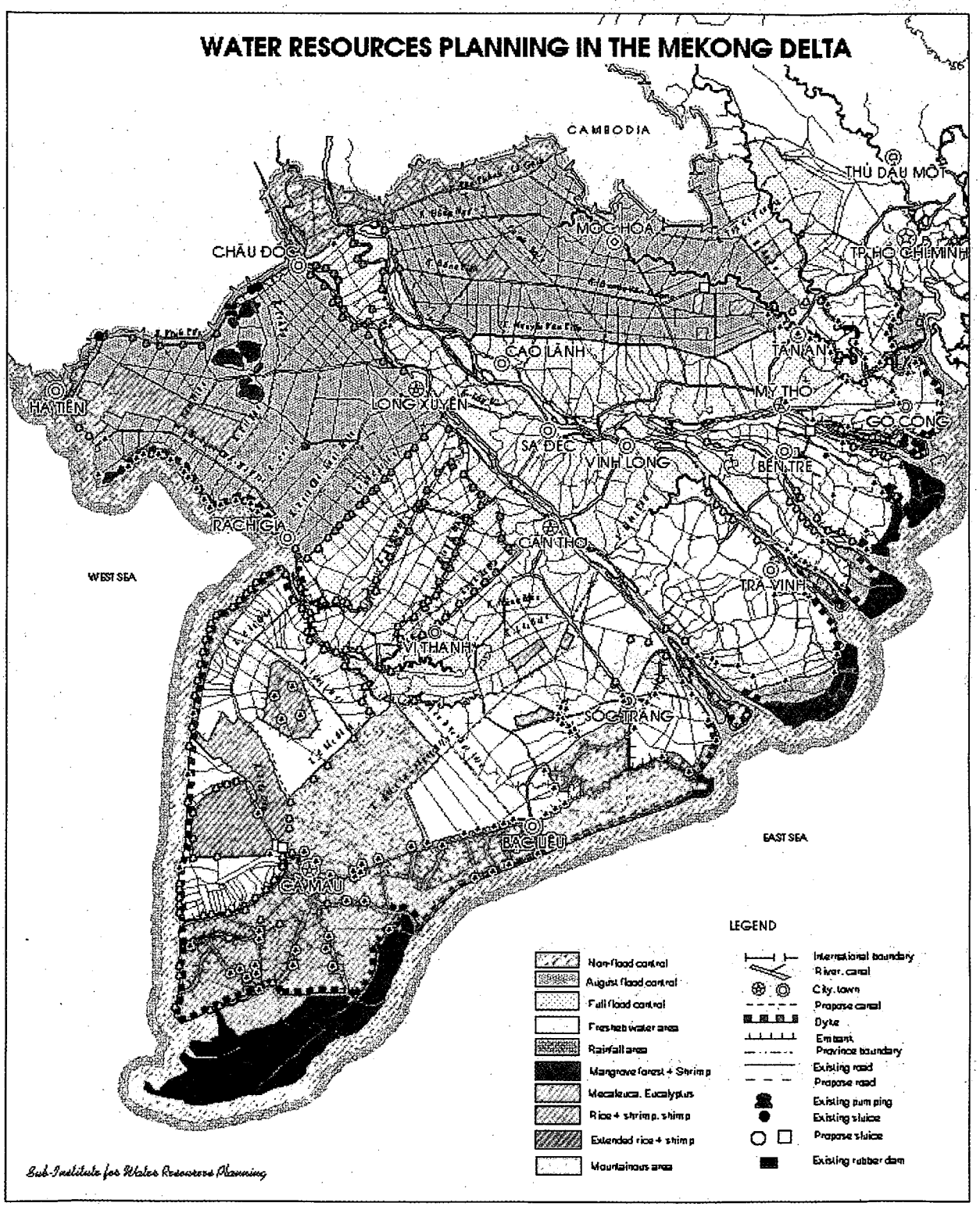

Figure 2: Shallow and Deep Flood Areas

3.1.2 Deep Flood Areas

The objectives for "Deep flood" floods are to control floods in a timely manner (which means to actively control early floods (August) for harvesting and late floods (Nov and Dec)), reduce loss of life and damage to property and mitigate difficulties to meet demands of steady and stable socio-economic development and the environment. In these areas National roads will be constructed above the 1961 flood level, while lesser roads may be flooded from time to time. Towns (and other inhabitant centres and lines), schools and infirmaries are to be protected.

3.2 Short-Term Flood Control Plan

Short Term flood control planning is to determine the essential, pressing and clearly efficient, practical constructions that need to be implemented first in order to protect the lives and properties of the local people. These measures should:

- contribute to stable socio-economic development of agriculture and rural areas;
- consider national foodstuff security;
- meet demands of national security;
- environmental conservation;
- no contradiction with long term development;
- suitable to mobilising capacity of integrated sources; and
- Implementation in short period

The preferred option for short-term measures includes:

- Long Xuyen Quadrant: Constructions to control flood from border areas and Bassac River, construct drainage canals to the Gulf of Thailand to control early flood, construct dikes and sluices for salinity intrusion prevention;
- Plain of Reeds; Constructions to control flood from border areas, construct drainage canals to the Mekong and Vam Co River to control early and late floods.
- Flood control system along Road 80
- Dredging flood canals to the Cai Lon River and including sluices for salinity prevention and year round flood protection;
- Full flood protection for southern areas of the Vin An Canal
- Constructions to protect urban areas.
- Build main roads over 1961 flood level.

3.3 Regional Flood Control Plans

Several scenarios have been investigated to determine the optimum flood control strategy. Below the flood control plans are detailed by regional location. As described before the inundation areas can be divided into 4 distinct areas: Long Xuyen Quadrant, Western Areas of the Bassac River, The Plain of Reeds and the areas between the Bassac and Mekong Rivers.

3.3.1 Long Xuyen Quadrant

Engineering measures planned for this region are:

- Control Floods from the border to the Long Xuyen Quadrant and drain floods to the Gulf of Thailand.
- Build up flood drainage construction to the Gulf of Thailand.
- Build up salinity prevention construction and keep fresh water in the coastal areas of the Gulf of Thailand.
- Build up flood control construction from the Bassac River to the Long Xuyen Quadrant.

3.3.2 Western Areas of the Bassac River

Engineering measure planned for this region are:

- Construct a flood control line under the Cai San Road to control floods from the Long Xuyen Quadrant through 4 sluices.
- Dredge main and primary canals connecting Bassac river to the Cai Be and Cai Lon Rivers.
- Build Sluices at the Beginning and end of canals KH1, KH6, KH7, KH8, KH9 and secondary canals.
- Enclose small areas along secondary canals in the area from Xa No canal to Lai Hieu and the area along the Bassac River for flood protection of farms.

3.3.3 The Plain of Reeds

Flood control in the Plain of Reeds is difficult due to the large flows, limited drainage capacity and location of densely populated areas in drainage paths. Engineering measure planned for this region are:

- Build flood control line (dike) with 10 sluices along the south bank of the Tan Thanh Lo Gach canal and dredge canal.
- Enlarge 3 gates on the Nam So Thuong Road to drain floods to the Mekong River.
- Dredge 4 flood drainage canals along the Mekong River, enlarge the Song Trang Canal and connect to the Ca Rung ditch and Ca Gua canal, enlarge canal 28.

- Dredge and enlarge and improve part 2 of the Hong Ngu canal and canal 79 in order to drain floods to the West Vam Co River.
- Dredge, enlarge and improve Dong Tien-Lagrange canal and An Phong-My Hoa-Nam Ngan-Bac Dong canal.
- Build Salinity and tide prevention sluices and Lagrange drainage sluice along the Vam Co River
- Dredge and Enlarge 21 canals connecting Nguyen Van Tiep canal to the Mekong River
- Build Tide prevention and drainage sluices along the Mekong from Cao Lanh to My Tho.
- Dredge and Enlarge Bo Bo canal, and canals connecting the two Vam Co Rivers and form small enclosed areas for industrial trees.
- Protect 12 towns and communal centres.
- Build three ecological reservoirs (Lo Moi, Lang Sen and Tram Chin) to conserve nature and the ecology of the Plain of Reeds.

3.3.4 The Area between the Bassac and Mekong Rivers

Engineering measure planned for this region are:

- Build dikes and sluices along secondary canals to form closed areas in area north of Vinh An canal.
- Build dikes, sluices and pumping stations to protect Tan Chau and An Phu Town.
- Maintain roads over 1961 flood level in area north of Vinh An canal.
- Dredge the Than Nong canal and primary canals, build flood prevention and drainage sluices and build a dike system along the Mekong River, Bassac River and Cai Tac ditch in Than Nong area.
- In the Cho Moi Area Build a dike system and sluices to form 3 closed areas, dredge the Ca Mau canal and primary canals, maintain dikes and flood control sluice in combination with rural roads.
- Building sluices along the Mekong River, and improving heights of roads with flood control sluices in the Bac Lap Vo Area.
- A system of sluices under Road 80 in the Nam Lap Vo–Muong Khai area
- Build Closed dikes in small and medium scale and dredge canals in the Area fro Muong Khai canal to Mang thit River.
- Build closed dike system on small scale in Ben Tre.

4 CONCLUSIONS

Recent data shows the frequency of large flood events in the Mekong Delta of Vietnam to be increasing. Measures are required to control flooding to allow for the development of agriculture, protect property and lives as will as to allow for the industrialisation and modernisation of the region. A flood control strategy has been proposed by SIWRP and adopted by the government of Vietnam.

The implementation of the proposed works is estimated to cost 21,900 billion VND ($1.43 billion US) and have an NPV of 8,422 billion VND ($550 million US) which includes benefits due to reduction in damages, improvements in agricultural productivity, fisheries (natural fisheries will decline, however aquaculture will be increased and the total fishery production is expected to increase) and savings in transportation and other infrastructure (investment cost and annual operation and maintenance will decrease).

The main environmental impacts of the scheme will be to limit the natural fisheries and silt sediment in the year round flood control areas of the "shallow flood" areas. However the benefits to the socio-economy and stability of the population, the strengthening of acid water drainage, the improvements to fresh water supplies and improved hygiene are seen to by far outweigh the negative impacts.

5 REFERENCES

Sub-Institute for Water Resources Planning (1998). *Flood Control Planning for the Inundation Areas of the Mekong Delta in Vietnam – Main Report,* Ho Chi Minh City, Vietnam