Kingdom of the Netherlands

Viet Nam – Netherlands Cooperation

Towards a Mekong Delta Plan

MAP
Mekong Delta Plan

Synthesis of Water Sector Assessment

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Abbreviations

ADB	Asian Development Bank
CTU	Can Tho University
DARD	Department of Agriculture and Rural Development
DWRPIS	Division for Water Resources Planning and Investigation for the South
EIA	Environmental Impact Assessment
EKN	Embassy of the Kingdom of the Netherlands
GTZ	German Technical Cooperation
HCMC	Ho Chi Minh City
IFAD	International Fund for Agricultural Development
IMC	Irrigation Management Company
IMHEN	National Institute of Meteorology, Hydrology and Environment
LWR	Law on Water Resources
MARD	Ministry of Agriculture and Rural Development
MDP	Mekong Delta Plan
MKD	Mekong Delta
MOC	Ministry of Construction
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
MOT	Ministry of Transport
MPI	Ministry of Planning and Investment
NEDECO	Netherlands Engineering Consultants
MRC	Mekong River Commission
NIAPP	National Institute for Agricultural Planning and Projection
NTP	National Target Program to Respond to Climate Change
NWRC	National Water Resources Council
ODA	Overseas Development Assistance
PvW	Partners for Water
RBO	River Basin Organisation
SEDP	Socio-Economic Development Plan
SIHYMETE	Sub-Institute of Hydrometeorology and Environment
SIWRP	Southern Institute for Water Resources Planning
SIWRR	Southern Institute for Water Resources Research
SLR	Sea Level Rise
SRHC	Southern Regional Hydrometeorological Centre
SVEC	South Vietnam Economic Studies Centre
TSS	Total Suspended Solids
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention for Climate Change
VND	Vietnamese Dong (exchange rate per 01-01-2011: 19,000 VND = 1 US$)
WB	World Bank
WUO	Water User Organisation

Executive Summary

Natural constraints and challenges

Formed by the deposition of sediments transported by the mighty Mekong River, the Mekong Delta in Vietnam comprises a vast triangular plain of approx. 3.9 million hectares. Being one of the most densely populated and productive areas in the world, it is hard to imagine that nature essentially generated a harsh environment to live in. Although deltas tend to be endowed with high fertile soils and abundant freshwater, enabling a highly productive agriculture and fisheries, actual conditions in the Mekong Delta are far from benign for its inhabitants. Each year about half of the delta is flooded by river water up to three metres in depth under extreme conditions. And after the recession of the floodwaters new problems arise. Reduced river flows cause the sea to intrude far inland, affecting over 1.4 million hectares with saline waters. Furthermore, drainage of naturally occurring acid sulphate soils, with high levels of potentially toxic aluminium and poor phosphorous availability, cause an additional problem for agricultural practices over 1 million hectares of low lying land. And the highly uneven seasonal distribution of rainfall causes temporary drought conditions in the central and eastern parts of the Delta.

Still its inhabitants managed the delta to become the number one rice producer in the country and a major producer of fruits, vegetables and aquaculture products. Especially since the early 80s the growth in agricultural production was remarkable. How can this be explained? Certainly, the economic reforms policy of Doi Moi, introduced in 1986, had a major influence on the socioeconomic development of the Delta. This shift in thinking, together with many policies to remove obstacles for development gave proper direction to investments to improve the water infrastructure, especially for irrigation development. These improvements have significantly contributed to a breakthrough in economic development of the Delta. Salinity control projects in coastal areas and reclamation of acid soils greatly enlarged the areas suitable for cropping. But also technological developments played a key role, once the appropriate mix of innovations with investments in infrastructure was implemented. For instance, although already available in the 1970s, the high yielding rice varieties only started to be effectively used after improvements in irrigation, drainage and flood control were implemented on a large scale. Thanks to these improvements in water management, the implementation of technical advances and policy reforms, the delta's rice production rose from 4.5 million tons in 1976 to nearly 21 million tons in 2008.

At the same time it must be remembered that the population of the Delta has shown a remarkable adaptive capacity to cope with difficult conditions and rapid changes. From times immemorial, people have used to live with the floods, showing a resilience towards extreme floods, while benefiting from the moderate floods that bring fertility to the fields and sustain a rich fishery. The unprecedented growth of aquaculture – for instance brackish water aquaculture production quadrupled over a period from 2001 to 2008 – also shows the capacity of the people to seize an opportunity provided by market conditions and technology.

Existing problems

Despite the great advances in socioeconomic development, the people of the Delta still face a range of problems in their daily life. Safe water supply is guaranteed only to 60-65% of the urban population and for the rural population this percentage is considerably lower. Water supply in the rural areas is based on surface water, groundwater and rainwater. Supply from surface water encounters two major problems: high salinity and aluminium contamination.

Untreated wastewater discharges, industrial pollution and limited sanitary facilities cause local problems of water quality, which, combined with insufficient water supply, create health risks. Shortage of funds for maintenance leads to reductions in overall capacity of irrigation systems. Existing water infrastructure is said to operate at no more than 55-65% of the design capacity. Drainage capacity is insufficient in many areas during periods of heavy rainfall and high river discharges, causing floodwaters to recede late. Many canals have not yet been equipped with sluices to prevent saline water to intrude from the sea. And where such sluices do exist, there is sometimes a conflict between the freshwater needs for agriculture and salt water needs for brackish water shrimp farming.

Rapid population growth and intensive agricultural and aquaculture development over the past decades have significantly reduced the natural values in the delta. Many wetlands such as mangroves, ponds, lakes, lagoons and wet grasslands are threatened by extinction through the concessions for irrigation, forest plantations, salt ponds, industrial development zones and shrimp farms. Furthermore,

overexploitation of the natural resources such as the illegal exploitation of timber and non-timber forest products, unsustainable fishing, illegal wildlife hunting and trade are a major threat for the health of ecosystems.

Growing industrial and urban development is leading to spatial conflicts. Although the Mekong Delta is defined as a focal area for agricultural production at national scale, much fertile land has recently been converted into industrial development zones. As a consequence, this results in the resettlement of a large number of households. Because there is a huge competition between provinces and cities to attract industry for their economic growth, the industrial zones in the Delta are developed randomly. Thousands of hectares along the Mekong and Bassac rivers, which have been classified as first class agricultural soils and which should have been reserved for agricultural production, have been or are planned to be turned into industrial zones. Nevertheless, presently just 30 to 40 % of the industrial zones have actually been occupied by enterprises, even just 5% at some places. The reason for this situation is the lack of basic planning studies and cooperation between municipalities and provinces.

Drivers of change

On top of the problems the Mekong Delta is already facing, the future will bring new challenges to meet. Besides the evident trends in society, such as industrial development and population growth, climate change will certainly have significant impacts on the physical conditions of the Delta. In combination with changes in river flow due to upstream water developments in the riparian countries of the Mekong River, these impacts will cause profound difficulties in the life and work of the inhabitants.

The projection of population size for the year 2050 is from the present 17 million up to around 30 million. This will fuel the urbanization trend, taking more land out of agricultural production. At the same time more people need to be provided with food and fresh water. Ongoing industrialisation will also take up more space and increase the demand for water as well as the production of wastewater. Both trends will increase the need for proper spatial planning, efficient water supply, investments in water treatment and stringent enforcement of environmental legislation.

Climate is already changing in the Delta. Despite a limited record of meteorological and hydrological data in the Mekong Delta, some trends in temperature, rainfall and sea level are noticeable. From 1970 to 2007 average temperature and rainfall increased 0.6°C and 94 mm, respectively. Predictions of climate change in Vietnam are carried out by the Vietnam National Institute of Meteorology, Hydrology and Environment (IMHEN), which has developed three scenarios for the country: Low emission (B1), Average (B2) and High emission (A2). According to scenario A2 the temperature in 2100 will increase in the rainy period with 2.9^0C. This value is two times higher than that of scenario B1. In all scenarios rainfall tends to decrease in the dry period and to increase in the wet season. December-February rainfall is computed to reduce with 10 to almost 20 % in scenario B1 and A2, respectively. September – November rainfall averages are projected to increase with 8 to 16% for the same scenarios.

The impact of climate change on the river discharges is likely to be complex, and the response may vary across the river basin. Climate change will result in change of rainfall pattern and streamflow which can cause severe floods in the rainy season (especially in Ben Tre province) and low flows in the dry season. It is estimated that in the delta maximum monthly flows will increase by 16–19% and minimum monthly flows will decrease by 26–29%, compared with 1961–1990 levels.

The three scenarios for sea level rise in 2100 are 65 cm, 75 cm and 100 cm, corresponding to the Low, Average and High emission scenarios, respectively. Together with the temperature rise and changing

rainfall patterns, sea level rise is expected to have a huge impact on the physical conditions of the Mekong Delta, leading to a range of effects on people, their health, livelihood and prosperity. In the flat areas of the delta, the predicted sea level rise can result in large areas of permanent and more frequently inundated coastal plains. Depending on the scenario the percentage of inundated delta ranges from 12.8 to 37.8%. Rice production will be affected through excessive flooding in the tidally inundated areas and longer flood periods in the central part of the delta. These adverse impacts could affect all three cropping seasons.

Furthermore, a rise in sea level will increase salinity levels in the Delta rivers and its water network. An 1 m SLR would increase the area of 4 g/l salinity with 334,000 hectares in relation to the benchmark year of 2004, a rise of 25%. Deep salinity intrusion is occurring already during dry seasons, giving rise to significant crop losses. Its extent and frequency is likely to increase due to climate change, giving rise to even higher and more frequent economic losses.

Hydropower development and several other upstream developments, such as water diversions and irrigation schemes in Thailand, Cambodia and Lao PDR will also have an impact on the future hydrology of the Delta. Depending on the scale of these projects and their operation regime, dry season discharge of the Mekong River to Vietnam could be significantly reduced which will increase salinity intrusion.

Responses

Evidently, these drivers of change do not cause isolated impacts. Instead, there will be complex interactions that could result in cumulative and non-linear impacts on the human-environment system of the Delta. Possibly also some effects may be cancelled out against each other, but it is safe to say that the overall impacts of these changes will surely require an active management response.

Partly these responses consist of measures, policies and plans that are already under study or implementation. For instance the improvements of the water supply system and salinity barriers along canals are urgently needed now and continue to require upgrading to solve future demands. But besides these so-called no regret measures and actions also some more fundamental strategic decisions are needed in the near future on how to meet the combined impacts of all these changes. An example for a more radical intervention in the water infrastructure is a plan to construct large salinity barriers across the main estuaries. A fundamentally different strategy would call for adapting to the changing salinities by radically shifting cropping patterns to more salt-tolerant crops such as shrimp and fish culture.

But many questions remain to be answered before such decisions can be made. For instance, in view of sea level rise and flood risks a potential response would be to opt for full flood control. However, this would deny people the present benefits of the floods and would completely eliminate the accumulation of silts brought in by the floods, annihilating aggradation of the soils and causing the delta to sink relative to the sea level. More detailed measurements of actual sedimentation patterns, compaction rates and sea level changes are needed to get a more quantitative insight in these processes.

Hence, more research, studies and projections are needed both in the magnitudes of change as well as in the efficiency and side-impacts of all possible alternative measures. But equally important are mechanisms to work together to formulate plans and implement measures in a coherent and harmonious way. This requires sound planning and good governance.

Planning and governance

Vietnam has a strong experience in preparing plans for economic sectors. The central government has initiated a number of studies to deal with planning challenges and collect sectoral data (agriculture, construction, aquaculture, water resources planning). Increasingly, the interdisciplinary nature of the issues and interests of various stakeholders create difficulties in information exchange, matching sectoral interests. Consequently, truly integrated spatial planning remains difficult. Not only multiple ministries, agencies and planning branches are involved but also multiple levels of government (central, provincial, district, city and local people' s committee's).

The *'Master Plan for Socio-Economic Development until 2020 for the Mekong Delta'* plays a very important role and should be the foundation for other sectoral plans. However, this Master Plan has not yet been approved by the Government. It is evident that spatial planning is strongly determined by (central) socio-economic planning.

Water governance in the Mekong Delta has been improving over the years to meet the needs for managing its dynamic development. There is a well-defined legal framework for water management (i.e. the Law on Water Resources) and a network of institutions for water management. Besides the various ministries, there are both national and international river basin organizations (i.e. the Mekong

River Commission). Furthermore there are research and education institutes, public and private companies, dealing with water infrastructure. On the ground there are many irrigation management organizations at grassroots level.

Despite this dense network of institutions and organized stakeholders there are still many challenges for the government at all levels to improve water governance. There are overlaps in responsibilities and tasks, leading sometimes to conflicts between and among the agencies. There is weak collaboration among sectors and the various administrative layers. Provinces have a relatively large autonomy, which sometimes result in sub-optimal solutions at the larger Delta scale. And finally, human resources in water management are relatively poorly developed compared to the country's standard, both quantitatively and qualitatively.

Preface

In 2010 the Prime Ministers of Vietnam and The Netherlands have signed a Strategic Partnership Arrangement for co-operation on climate change adaptation and water management. As part of this partnership, the Vietnamese government has requested the Netherlands Government to support a process to develop a Delta Plan for the Mekong Delta (MDP), based on the experiences of the Dutch Delta program. In earlier workshops the specific objectives and initial activities of the Vietnam-Netherlands Mekong Delta Plan project have been formulated. One of the preparatory activities of this project is a set of Water Sector Assessment Studies that aims at the collection and review of reliable data and information, which supports a more precise formulation of the overall problems and constraints in the Mekong Delta. As presented in the overview below, eight sector studies were conducted by selected Vietnamese institutes with pertinent expertise on the subject and for the Mekong Delta (see Table 1).

Table 1: Assessment Studies by Vietnamese institutes

	Subject	Institute	Topics
1	Climate change	SIHYMETE	Climate scenarios, sea level rise, other effects, adaptation and mitigation options
2	Water resources	DWRPIS	Surface water, groundwater, water quantity and quality, data available, modeling research, water balance, MRC, inter boundary issues, salinization
3	Water infrastructure	SIWRP	Dams, dikes and barriers, flood protection measures, existing master plans, salinity control
4	Water and environment	SIHYMETE	Living environment, eco-systems, mangrove, nature preservation
5	Water for food	SIWRP	Agriculture, land use, trends, potential production capacity, crop varieties, upstream developments
6	Water supply and sanitation	SIWRP	Drinking water and waste water treatment, industry water use, hydropower demands, also upstream developments, demand management
7	Spatial planning	SIWRP	Demographic growth, industrial developments, food security, preservation of ecological system, not yet considered with climate change.
8	Water governance	CTU	Institutional setting, Human resources development, legislation, capacity strengthening, financing, stakeholder analysis

This synthesis document presents a summary of each of the eight Assessment Study reports. It also includes an Executive Summary with a synopsis of the main current water management issues and future challenges in view of climate change and development of the Mekong Delta. The report does not pretend to be complete or conclusive, but should be seen as a starting point for further analysis and study. Assistance and financial support for compiling the Assessment Reports and this Synthesis Document was kindly provided by Partners for Water, the Embassy of the Kingdom of the Netherlands and the Water Mondiaal programme (The Netherlands). The support from the Ministry of Natural Resources & Environment, as well as the Ministry of Agriculture & Rural Development from Vietnam and from The Netherlands' Ministries of Infrastructure & Environment and of Economic Affairs, Agriculture & Innovation is thankfully acknowledged.

1

General description of the Mekong Delta

1.1 Basic characteristics of the Mekong Delta

Land of the Nine Dragons

The Mekong River Delta was formed by the deposition of sediments transported from the Mekong River, which flows through six countries: China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam (see Figure 1). From a geomorphological viewpoint the delta starts at Phnom Penh in Cambodia, where the river divides into its two main distributaries, the Mekong (or Tien river in Vietnamese) and the Bassac (Hau river in Vietnamese). The Tien river subsequently divides into six main channels and the Hau river into three branches to form the nine "dragons" of the outer delta in Vietnam.

The delta comprises a vast triangular plain of approximately 5.5 million ha of which the Vietnamese part constitutes 3.9 million ha. It extends for about 270 km from its apex at Phnom Penh to the coast, and has a coastline of about 600 km. The average elevation of the Vietnamese part of the delta is about +0.8 m above sea level.

Living with floods

Floods play an important role in the life of people living in the Delta. Each year floodwaters inundate 1.9 million ha and affect the lives of more than 2 million people. Normally, these floods are essential to food security and biodiversity and people have a tradition in living with the floods. However, extreme mainstream flood events can be destructive and cause enormous damages.

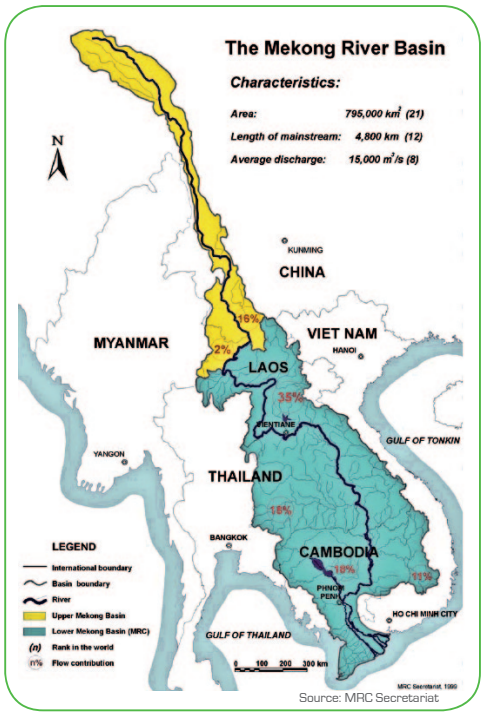

Figure 1: Map of the Mekong Basin

Figure 2: Map of the Mekong Delta

Population and income

The Mekong Delta is one of the most densely populated areas on earth. Around 17 million people (22% of the Vietnamese population) live in the Mekong Delta of which nearly 85% are rural. It is also one of the most productive areas. Large parts are used for rice cultivation, highly productive shrimp farms, orchards and vegetable crops. With an annual production of more than 16 million tonnes of rice, the delta accounts for half of the nation's rice production and contributes to Vietnam's place as the second largest rice exporter in the world.

Per capita income in the Mekong Delta averaged in 2008 around 14 million VND (about 730 US$). The difference between the highest and lowest income groups increased from 6.5 times in 2004 to 7.5 times in 2008. The percentage of poor households is still fairly high, especially in remote and border areas the percentage may reach 20 to 25%.

Administration

The Mekong Delta includes 13 provinces (see Table 2). Presently, in the Mekong Delta there are 132 municipalities, including: 1 city under Central Government (Can Tho), 12 provincial cities, 7 provincial towns, 98 district townships, and 14 district towns.

Table 2: Provinces and capital cities in the Mekong Delta

No.	Provinces	Capital
1	Can Tho	Can Tho City
2	An Giang	Long Xuyen
3	Bac Lieu	Bac Lieu
4	Ben Tre	Ben Tre
5	Ca Mau	Ca Mau
6	Dong Thap	Cao Lanh
7	Hau Giang	Vi Thanh
8	Kien Giang	Rach Gia
9	Long An	Tan An
10	Soc Trang	Soc Trang
11	Tra Vinh	Tra Vinh
12	Tien Giang	My Tho
13	Vinh Long	Vinh Long

1.2 Current climate patterns

Climate and rainfall

The Mekong Delta has a tropical monsoon climate with a seasonal distribution of dry and wet months depending on the monsoon. The dry season usually coincides with the North-East monsoon that lasts from November to April, and the weather is characterized by dry heat and little rain. The wet season coincides with the South-West monsoon that lasts from May to October, and the weather is characterized by high temperatures, high humidity and rainfall.

The yearly average rainfall in the Mekong Delta is 1733 mm and is mainly concentrated in the rainy season. The highest average rainfall (2200-2500 mm) occurs in Ca Mau and Kien Giang provinces. Provinces with the lowest rainfall, ranging from 1300-1500 mm, are Dong Thap, Tien Giang and Ben Tre. The difference between highest and lowest annual rainfall amounts up to 1200 mm.

Table 3: Average rainfall in Mekong Delta (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9	5	15	58	187	233	235	246	264	295	143	43	1733

October has the highest rainfall and it is the period of flood peaks in the Mekong Delta and also of water level rise due to *strong* winds. From January to March, average rainfall in this area is very low. Sea water level rises due to wind surges during this dry period can lead to salt intrusion that may severely affect agriculture. The combination of heavy rainfall, drought and water level rise due to wind and the occurrence of flood peaks are important issues which need special consideration in climate change coping and adaption strategies for the Mekong Delta.

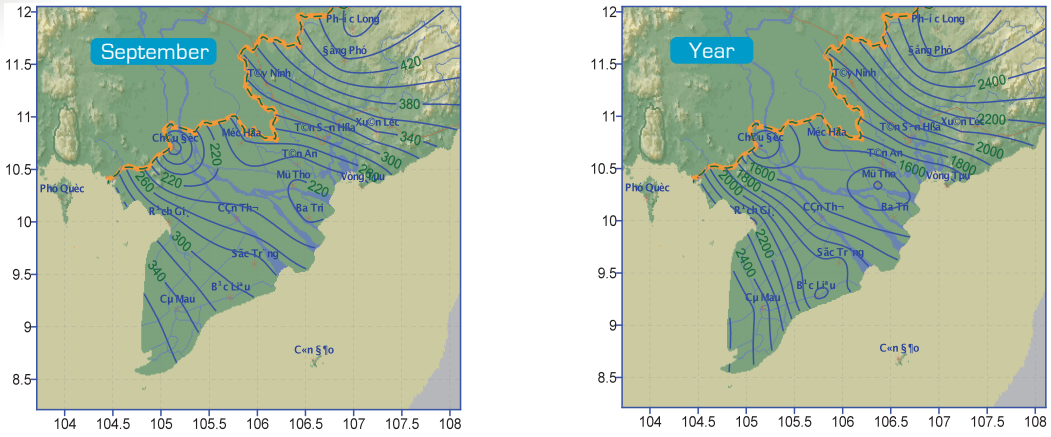

Figure 3: Average rainfall of September and year (mm)

Evaporation and drought

Total evaporation in Mekong Delta measured by PICHE instrument is 1095mm/year. Months with highest evaporation are from February to April, which are also the months with low humidity and high temperature. During the rainy season the evaporation is low, due to high air humidity and lower temperature, with values ranging from 2.2 to 2.6 mm.day^{-1}.

Table 4: Average evaporation (mm.day^{-1})

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
3.4	3.8	4.1	4.0	3.0	2.7	2.6	2.6	2.3	2.2	2.7	3.0	3.0

Spatially, Kien Giang and Dong Thap provinces have the highest evaporation with average values ranging from 3 to 4 mm.day^{-1}. The East-coast provinces including Ca Mau, Soc Trang, Bac Lieu and Tra Vinh have the lowest evaporation with values from 2.6 to 3 mm.day^{-1}.

The drought index for the Mekong Delta is presented in Figure 5. This index is calculated as the ratio of evaporation over rainfall. The yearly average drought index in the Mekong Delta ranges from 0.5 to 0.9, indicating a water surplus. The distribution of drought index indicates that Dong Thap, Tien Giang and Ben Tre provinces are most prone to drought. On the other hand, Ca Mau, Bac Lieu, Soc Trang and Hau Giang provinces are rather wet.

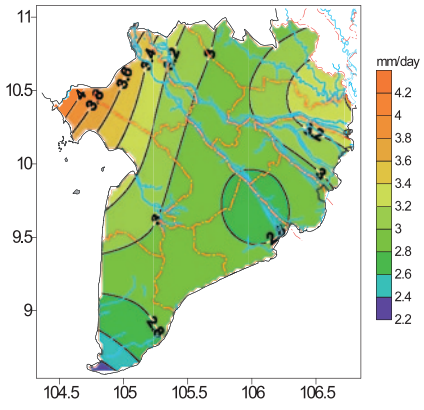

Figure 4: Average evaporation in the Mekong Delta (mm.day^{-1})

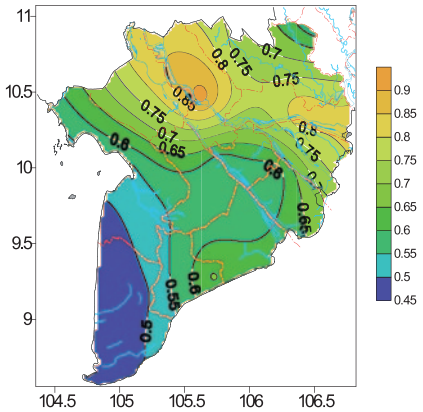

Figure 5: Drought index in the Mekong Delta

2

Climate Change

2.1 Observations of climate change and sea level rise

Despite a limited record of meteorological and hydrological data in the Mekong Delta, some trends in temperature, rainfall and sea level are noticeable. From 1970 to 2007 average temperature and rainfall increased 0.6°C and 94 mm, respectively. Although the Mekong Delta is not very large, there are distinctions in climate change between the various sub-areas. The southeast experienced the highest rainfall increase and the farther inland, the more distinct the change in temperature (Figure 7).

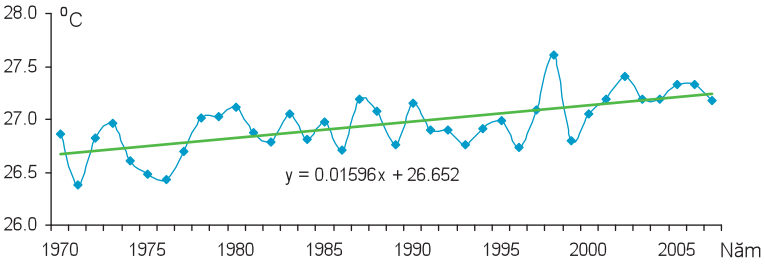

Figure 6: Mean temperature trend in the Mekong Delta

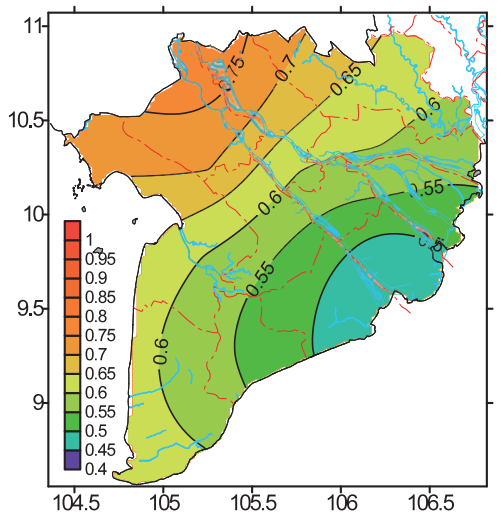

Figure 7: Trend of mean annual temperature change (°C) in the period 1970 – 2007

Monitoring data from marine stations along the coast of Vietnam indicate that the speed of mean sea level rise in Vietnam is currently approximately 3mm/year (period 1993 – 2008), which is nearly equal to the average sea level rise worldwide. In the past 50 years, the sea level in Hon Dau station has risen about 20 cm (Figure 8).

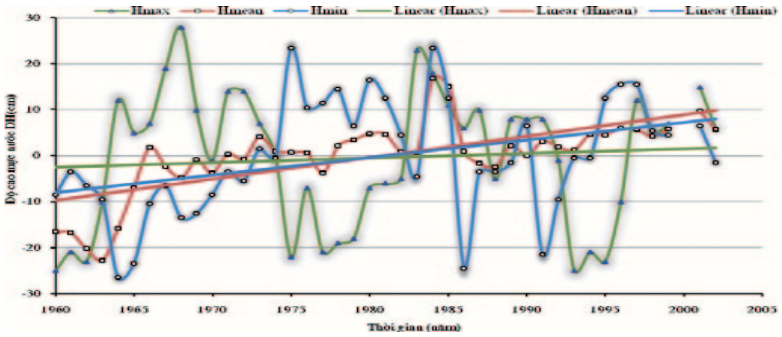

Figure 8: Sea level trend at Hon Dau station

In the period 1980 – 2007, data at Vung Tau station show that the highest, average and the lowest sea level increases are 14 cm, 13 cm and 12 cm, respectively (Figure 9). Stations on the river belonging to Sai Gon – Dong Nai river system and stations at estuaries in the Mekong river system proper also have recorded a mean sea level rise of 9 – 13 cm during this period.

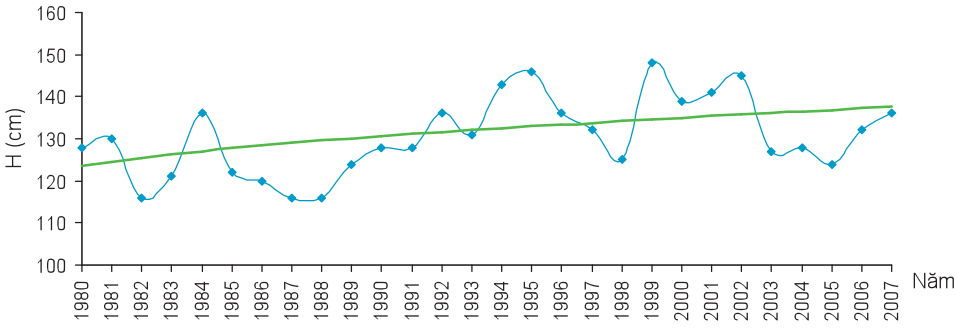

Figure 9: Trend of highest water level in the period 1980 – 2007 at Vung Tau station

2.2 Climate change scenarios and impacts

The prediction of climate change in Vietnam was carried out by the Vietnam National Institute of Meteorology, Hydrology and Environment (IMHEN). The first official report was presented in 2009. Three climate change scenarios for Vietnam were built: Low emission (B1), Average (B2) and High emission (A2).

The model used for building the climate change scenarios was MAGICC/SCENGEN. MAGICC/SCENGEN is the integration of MAGICC model (for assessing climate change – caused by greenhouse gases) and SCENGEN (for building zonal climate scenarios). These scenarios and reports were elaborated for 7 areas of Vietnam including the North West, North East, North Delta, North Central, South Central, Central Highlands and the South. The time frame used in the climate change reports and scenarios are decades from 2020 till 2100.

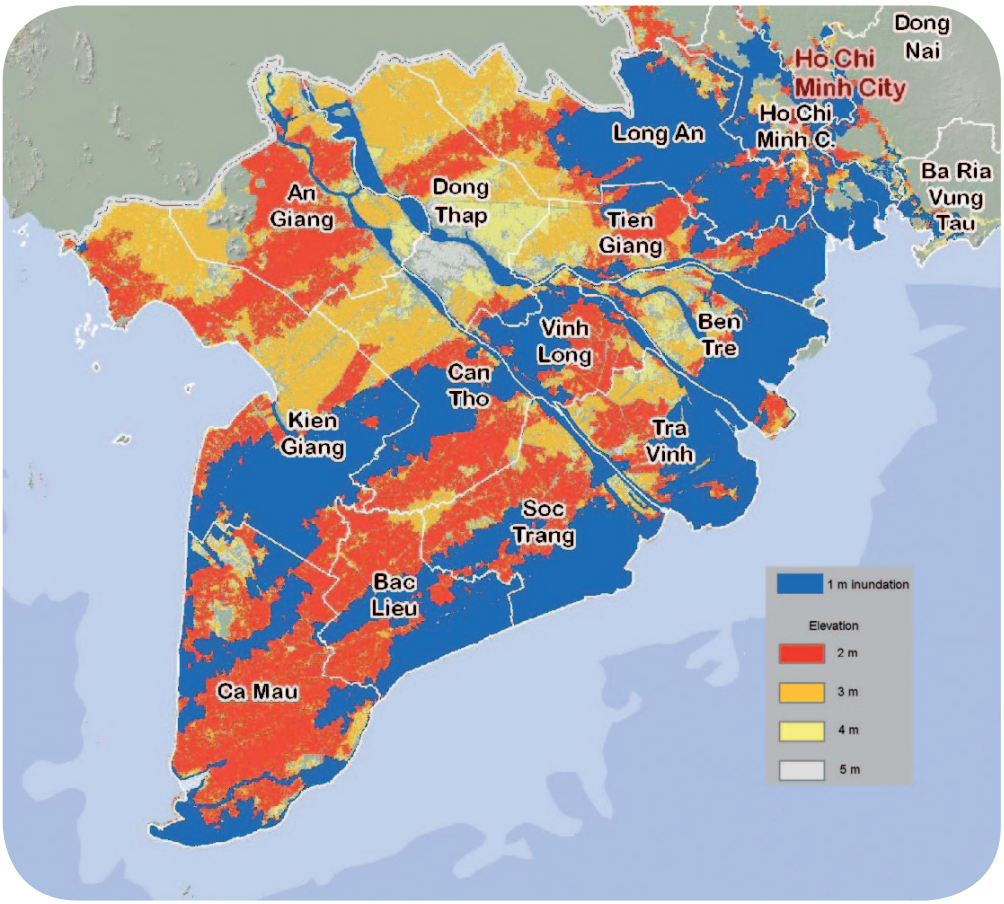

Figure 10: Impact of a 1m sea level rise on the Mekong Delta (Source: Carew-Reid, 2008)

According to these scenarios, temperature rise in the rainy season will be higher than in the dry season. This conclusion is radically different compared to the increasing trend recorded in the period 1970 – 2007. In 2100, the temperature increase compared to the period 1980 – 1999 in scenario A2 in the rainy season is 2.9^0C. This value is two times higher than that of scenario B1.

In all scenarios rainfall tends to decrease in the dry period and to increase in the wet season. December-February rainfall is computed to reduce with 10 to almost 20% in scenario B1 and A2, respectively. September – November rainfall averages are projected to increase with 8 to 16% for the same scenarios.

The three scenarios for sea level rise in 2100 are 65 cm, 75 cm and 100 cm, corresponding to the Low, Average and High emission scenarios, respectively. Together with the temperature rise and changing rainfall patterns, sea level rise is expected to have a huge impact on the physical conditions of the Mekong Delta, leading to a range of effects on people, their health, livelihood and prosperity. In the flat areas of the delta, the predicted sea level rise can result in large areas of permanent and more frequently inundated coastal plains. Depending on the scenario the percentage of inundated delta ranges from 12.8 to 37.8% (Figure 10). Rice production will be affected through excessive flooding in the tidally inundated areas and longer flood periods in the central part of the delta. These adverse impacts could affect all three cropping seasons.

Furthermore, a rise in sea level will increase salinity levels in the Delta rivers and its water network. A 1 m SLR would increase the area of 4 g/l salinity with 334,000 ha in relation to the benchmark year of 2004, a rise of 25%. Deep salinity intrusion is occurring already during dry seasons, giving rise to significant crop losses. Its extent and frequency is likely to increase due to climate change, giving rise to even higher and more frequent economic losses.

2.3 Responses, strategies and adaptations

The Government of Vietnam ratified the United Nations Frame Convention (UNFCCC) in 1994 and the Kyoto Protocol in 2002 and subsequently stipulated a number of policy documents to enable the implementation of national commitments to address climate change issues. The first communication to UNFCC was submitted in 2003 (MONRE, 2003). Many ministries, branches, and local authorities have deployed research programs on the progress and impacts of climate change on the resources, environment and social – economic development, and proposed and implemented initial coping plans.

One of the most important recent developments was the establishment of the Vietnam National Target Program to Respond to Climate Change (NTP). The NTP serves as a national climate change strategy framework and will involve all relevant ministries, sectors, provinces and local governments. Both MONRE and MPI have key roles to play in the implementation of the NTP.

The NTP aims to communicate priority activities addressing the urgent and immediate needs and concerns of the country, relating to adaptation to the impacts of climate change. The NTP is proposed to be integrated into future national, sectoral and local socioeconomic development strategies and international commitments. The strategic objectives of the NTP are to assess climate change impacts on sectors and regions, to develop feasible sector action plans to effectively respond to climate change to ensure the sustainable development of Vietnam, to take opportunities to develop towards a low-carbon economy, and to join the international community's efforts in mitigating climate change and protecting the climatic system.

In the Mekong Delta, there are many organizations and agencies active in climate change themes. In 2008 the Institute of Climate Change Research – Can Tho University (DRAGON – Mekong – CTU in short) was established. The ability and specialty of the institute can be described as follows:

- Studying and building programs on climate change.
- Integrating analysis of social economic information, vulnerability and adaptation to climate change.
- Proposing coping and adapting solutions for adverse impacts of global climate change and sea level rise in the Mekong Delta. Integrating vulnerable factors and possible adaptation strategies into development programs.
- Training the people in the provinces of the Mekong Delta how to cope and adapt to climate change.

3

Water Resources Assessment

3.1 Hydrology

The river system

The Mekong Delta consists of a dense network of river courses and canals. The main river branches are the Tien and Hau rivers, being the continuation of the Mekong and Bassac rivers coming from Cambodia, respectively. These rivers are wide and deep, with an average width of about 1000 – 15000 m and an average depth of 10-20m (up to 40 m locally). The rivers have many elongated islands and their complex flow patterns cause erosion and sedimentation processes. The rivers flow to the sea via nine estuaries: Tieu, Dai, Ba Lai, Ham Luong, Co Chien, Cung Hau, Dinh An, Ba Thac and Tranh De. The total annual flow volume of both rivers is around 400 billion m^3, which is about four times as much as the Netherlands for an area that is similar in size. The fluctuations in discharge are considerable and may vary between 366 and 448 billion m3 in dry and wet years, respectively.

During the period of high discharges, the banks of the Mekong river system are overtopped on a large scale and the land is inundated. Inundation usually starts in July/August and ends in November/December. The considerable drop in water levels further down the river system and the progressive increase of the capacity of the rivers reduce the occurrence of river inundations downstream. Flooding in the north is aggravated by high rainfall. In the south, excess rainwater also leads to large-scale inundation of land outside the river flooding zone, particularly in the southwestern part of the Delta where drainage is poor.

In the northern part two separate rivers can be found, the Vam Co Dong and Vam Co Tray. Both rivers have much smaller catchments than the Tien and Hau rivers. The tidal influence on these rivers is large and because their dry season flows are much reduced, salinity intrusion is high.

There are several local rivers, such as the Cai Lon and Cai Be, flowing from the centre of the Ca Mau Peninsula to the sea through the Cai Lon river mouth.

Groundwater

In the Mekong Delta groundwater is an important water source, especially in the Ca Mau peninsula, coastal areas and Long An. The groundwater resources have not been evaluated on safe exploitation reserves for each area and the whole region. According to results of hydrogeological studies in the delta, groundwater can be exploited from sedimentary deposits of Pleistocene, Pliocene and Miocene age, and from at least 4 different aquifer levels:

- Aquifer A at the depth of 50 - 130 m (upper Pleistocene age)
- Aquifer B at 170 - 200 m (lower Pleistocene age)
- Aquifer C at 250 - 300 m (Pliocene age, Hau river right side)
- Aquifer D at >450 m depth from Miocene age (in the Soc Trang, Ben Tre, Tien Giang, Vinh Long areas).

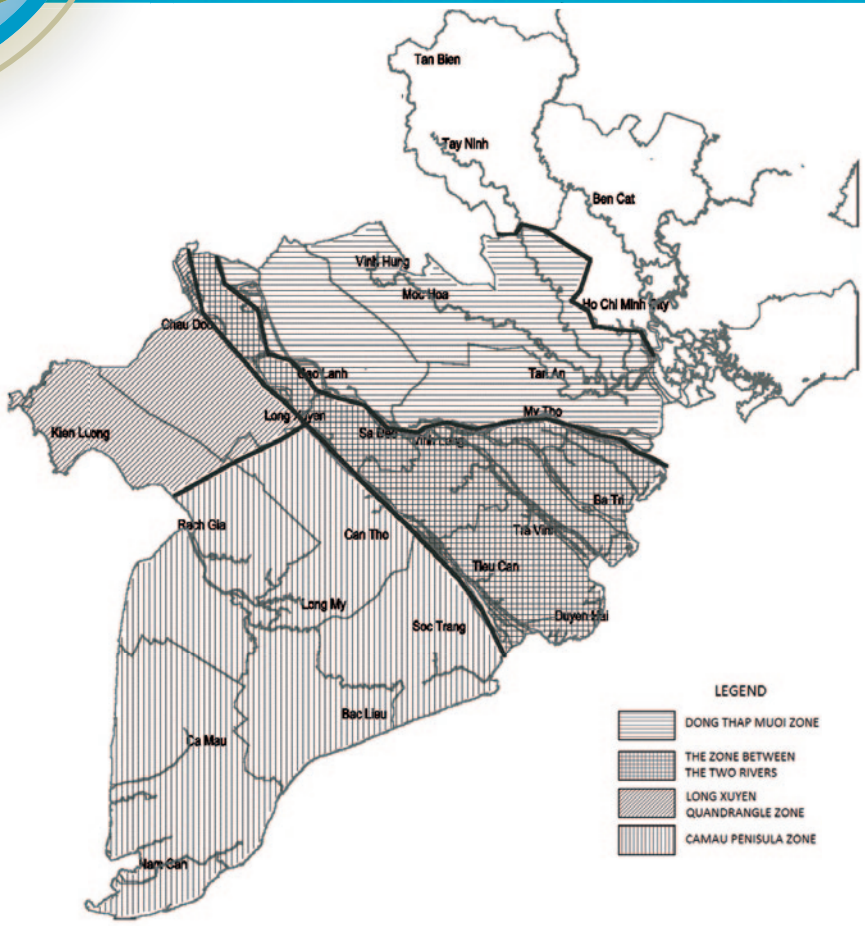

Figure 11: Groundwater zones

Groundwater reserves have been assessed for four regions in the Delta (Figure 11):

- Dong Thap Muoi zone from the boundary of the Tien River up to the end area of Long An.
- The zone between two rivers, including the area between the Tien River and Hau River.
- Long Xuyen quadrangle zone, including the area from the Hau river Rach Gia-Ha Tien and the Gulf of Thailand.
- Ca Mau Peninsula zone.

Table 5: Groundwater reserves of the Mekong Delta

Zone	Fresh (M<1g/l)	Brackish (1<M<3g/l)	Salt (3<M<10g/l)	Very salt (M>10g/l)	Total
Dong Thap Muoi	10.621.984	6.008.983	5.231.636	1.704.815	23.567.418
Zone between two rivers	5.760.993	5.055.436	5.405.275	4.555.217	20.776.921
Long Xuyen Quadrangle	904.429	3.284.246	1.819.926	253.447	6.262.048
Ca Mau Peninsula	26.556.846	7.828.737	696.737	283.227	35.365.547
Total	**43.844.252**	**22.177.402**	**13.153.574**	**6.796.706**	**85.971.934**

Unit: m^3/day

From the Table 5 above it can be concluded that the Dong Thap Muoi and Ca Mau Peninsula possess rich groundwater resources with a large exploitation potential. At the other side of the spectrum Long Xuyen Quadrangle can be found, which has the lowest fresh groundwater reserve; most of the groundwater being brackish or saline.

3.2 Freshwater demand and water balance

Water demand

Based on data of land use in 2005 and assumptions on water demand for crops, livestock, fisheries, domestic and industrial uses the total water demand has been calculated on a time step of 10 days. For this calculation the Delta is divided into 120 irrigation areas. The results show that with 68% the rice sector is the largest consumer of water, followed by 15% for other crops. January and February are the months with the highest water demand (Table 6).

Table 6: Monthly water demand in the Mekong Delta

Month	Monthly water demand (million m^3)						
	Rice	Other crops	Livestock*	Fishery	Forestry	Population & Industry	Total
Jan	2,048	347	7	85	142	51	**2,680**
Feb	2,020	390	6	77	86	46	**2,625**
Mar	1,399	468	7	85	52	51	**2,062**
Apr	1,167	421	7	83	50	49	**1,777**
May	1,180	171	7	57	70	51	**1,535**
Jun	1,027	64	7	-	187	49	**1,334**
Jul	603	83	7	-	231	51	**974**
Aug	231	54	7	-	220	51	**563**
Sep	88	11	7	-	137	49	**292**
Oct	43	37	7	-	170	51	**307**
Nov	286	145	7	26	164	49	**678**
Dec	998	291	7	72	152	51	**1,572**
Average	11,089	2,483	79	487	1,663	597	**16,398**
Ratio	68%	15%	0%	3%	10%	4%	**100%**

* NB: direct water consumption only

Water balance

When comparing with the annual average inflow from the Mekong River of about 400 billion m^3, the water demand of 16,398 million m^3 amounts to only 5% of the inflow. Even in the month of lowest flow (February) in dry years the supply is around 9,500 million m^3, which is still much higher than demand (2,625 million m^3). However, this does not imply that there is no freshwater problem. Most of the river water flows directly to the sea. Water shortages do occur in the dry months in certain delta areas because of insufficient supply systems and salinity intrusion.

3.3 Water quality

Since 1999 SIWRP is implementing a surface water quality monitoring programme on behalf of MARD. In 2007 this water quality monitoring programme included 12 stations in the Delta. Samples are taken on the 15th of each month at two moments: during high and low water level of the day. Water quality

parameters include physical and chemical characteristics, nutrients and organic pollution. Based on the results of this programme the following summary comments can be made:

- Salt water intrusion in 2007 was not high. Of recent years, the year 2004 had the highest salinity intrusion.
- At some locations with aluminium concentrations (e.g. the channel in Nguyen Tan Thanh) relatively low pH values are measured.
- Silt content in the main stream and internal canals tends to increase during the period 2002-2007. The highest concentration of silt in major rivers was approx. 500 mg/l.
- In the period 2002-2007 nitrogen tends to increase whereas phosphorous decreased, although differences are not significant.
- Organic matter measured as BOD5 is quite low, but COD component (chemical oxygen demand) tends to increase in the period 2002-2007. In the dry season dissolved oxygen levels in the channels were low.
- In some locations the water was polluted by acid water leaching from acid soils early during the rainy season.
- Total coliform and E.coli concentrations are low because of large flow conditions in rivers and canals where the measurements have been taken.

In areas where people use surface water for domestic uses (e.g. cooking), problems arise with high turbidity (total suspended solids or TSS), especially during the flood period (a TSS of <20mg/l is required but often exceeded).

Industrial pollution is locally affecting the water resources that are used by people living concentrated along canals and rivers. Aquaculture activities are also a source of water pollution, due to the production of sludge waste from ponds and wastewater carrying chemicals used in aquaculture. Also the agricultural production is a source of water pollution by its annual use of 2 million tons of chemical fertilizers and considerable amounts of pesticides and herbicides.

3.4 Salinity intrusion

The situation of salt intrusion in Mekong Delta is complex. Each year the situation is different, depending on the magnitude of the last year flood, the ability to supply fresh water upstream in the dry season, the production level of Summer-Autumn paddy and the onset of the rainy season. Salinity can intrude far inland when rains start late, as happened for instance in 1977, 1993, 1998 and in 2004-2005.

Highest salinity levels are reached at the end of the dry season, usually in April, but when rains are late sometimes even into early May. The 4 g/l isoline can extend 4- 50 km inland (Figure 12). The flood season pushes the salinity wedge back to the estuary.

In the Plain of Reeds salt intrusion occurs through the Tien River and Vam Co Tay Rivers. Because the Vam Co Tay has no resources upstream, the salt water intrudes far. In the Ca Mau Peninsula the salt water intrusion is extremely serious and most complex of the Mekong Delta because it is bordered on two sides by the sea. The East and West Sea each have different tidal regimes which makes the river flow in the canal system rather complex. The Long Xuyen Quadrangle area is directly affected by salt water from the West Sea. The main canals in the Long Xuyen quadrangle from Tri Ton to Cai San take water from the Hau river out to sea. Most of them have salinity control gates, except Vam Rang and Ha Giang channels, causing saltwater intrusion.

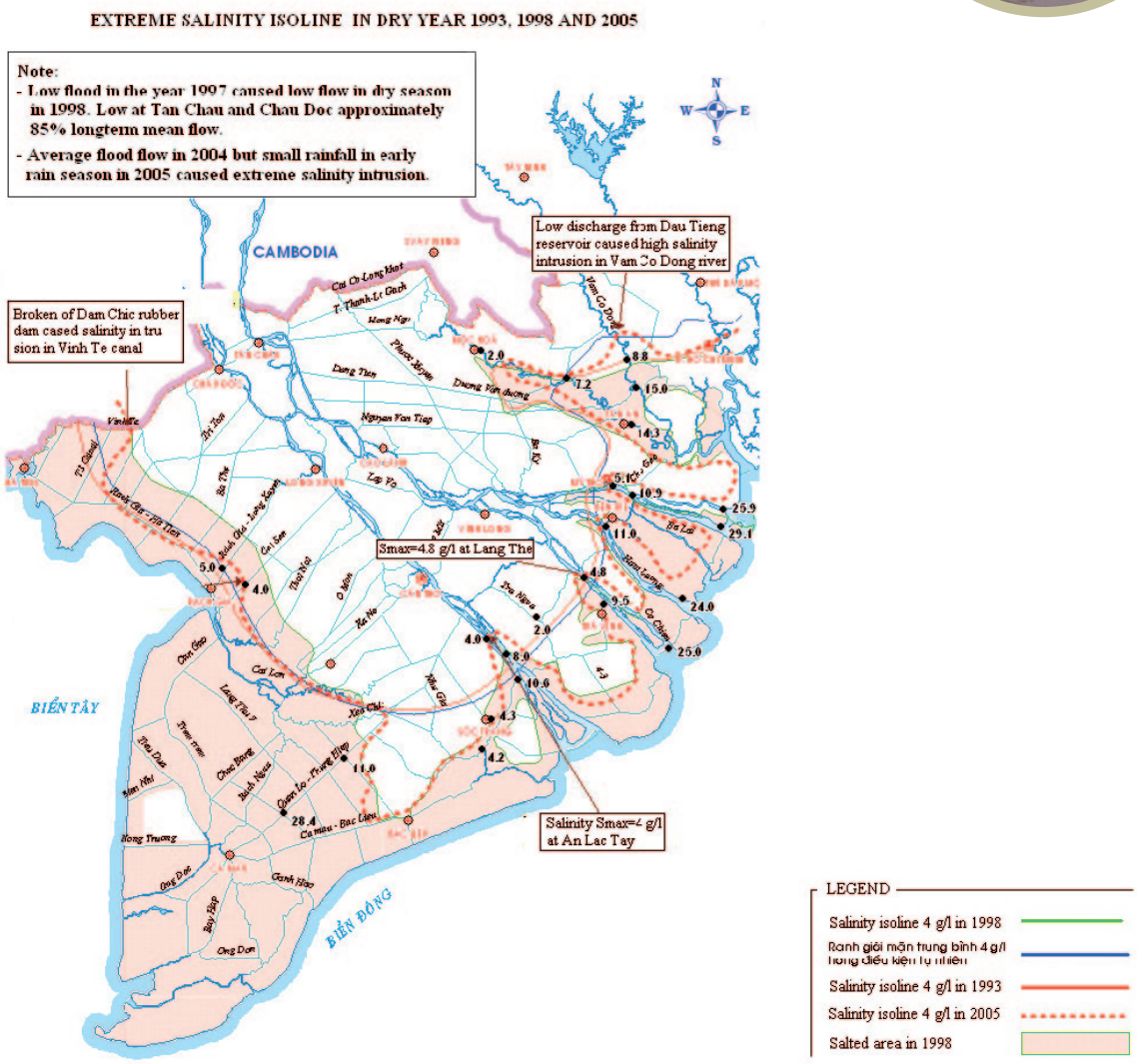

Figure 12: Salinity intrusion in the Mekong Delta

3.5 Hydrological impacts of upstream developments

Before 1990 there was only one hydropower station in the Mekong River Basin, Nam Ngum, with an active volume of 4700 million m^3. From 1991 to 2003 four large hydropower reservoirs were constructed, with a total active volume of 1926 million m^3. More than ten hydropower projects with dams in the Mekong River itself are currently on the drawing table or in the pipeline in China, Lao PDR and Cambodia.

Flow data analysis shows a significant increase in dry month flows in recent years. This is a logical effect of storage reservoirs operated for hydropower during normal years. However, the situation may be different in dry years when there is shortage of reservoir water. This may lead to significant changes of the downstream flow regime. Another side effect is the deposition of silt in the reservoirs, leading to reduced sedimentation of silt in the Mekong Delta.

Besides hydropower dams, several other upstream developments will have an impact on the hydrology of the Delta. For instance, the Thailand Government has made plans for water diversions from the

Mekong Basin for irrigation purposes. This would amount to 15.2 billion m^3 per year. Also the Lao PDR and Cambodia are planning irrigation development projects. If these projects and plans mentioned above are implemented, the dry season discharge of the Mekong River to Vietnam would be reduced and saline intrusion becomes more serious. Some research predicts that discharge will be reduced by 24% in April and the area affected by saline intrusion may increase with 7%.

3.6 Integrated water resources planning and adaptation measures

In 2005 MARD executed a master plan study on integrated water resources planning for the Mekong Delta to promote local socio-economic development. The Study proposed a long/term development plan to adapt to critical dry season situations caused by upstream developments. A number of possible measures were identified, such as changing cropping patterns, increase of water storage in canals and storage basins and the construction of large sluice gates in the main estuaries. Also a water resources planning study was executed by MARD for adapting to climate change and sea level rise. A number of proactive adaptation measures especially with regard to salinity intrusion were recommended, including improvements in sea dikes, water diversion channels and large sluice gates at the river mouths (Figure 13).

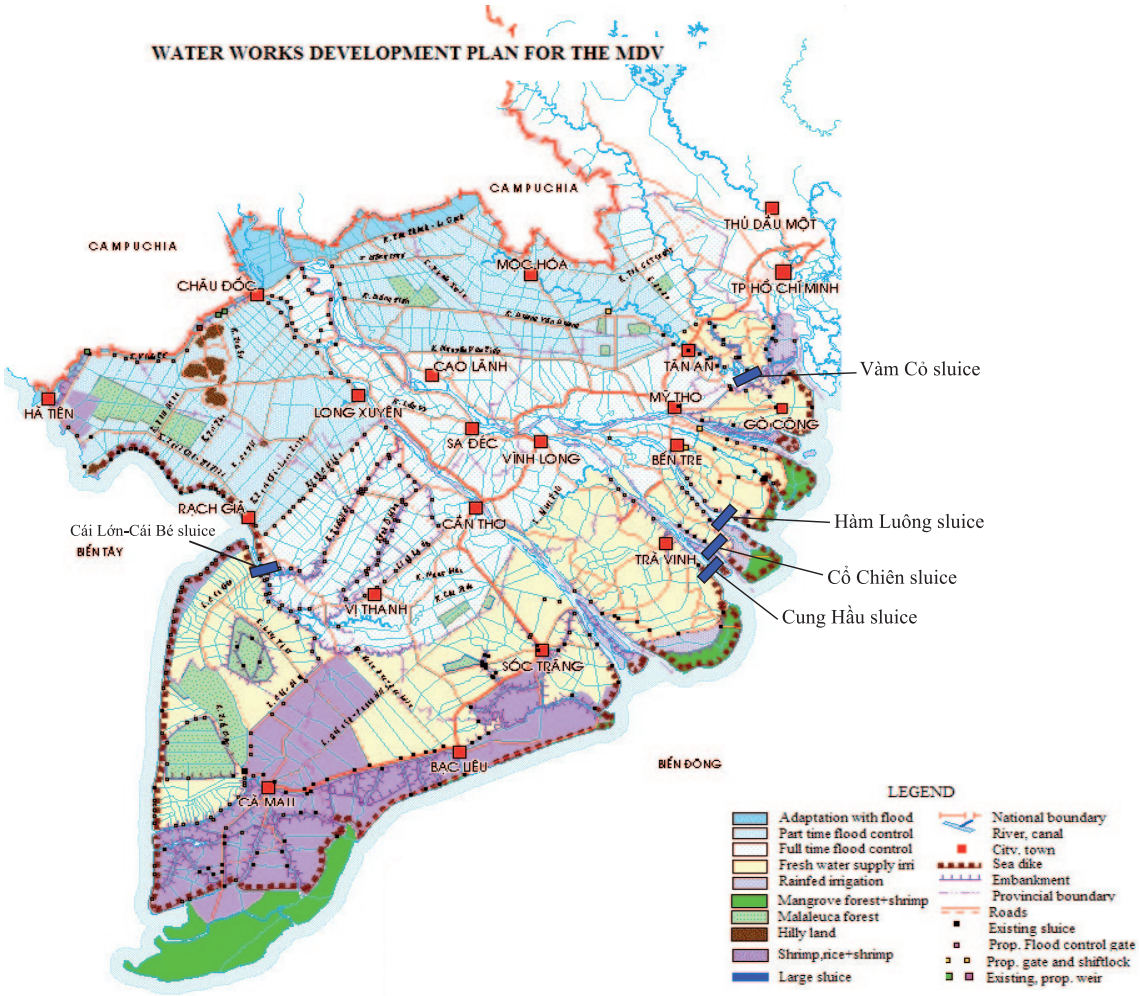

Figure 13: Water works development plan for the Mekong Delta

4

Water Infrastructure

4.1 Challenging natural constraints

A fine meshed water infrastructure

The canal system of the Delta has been developed in more than a century with the main purpose to enhance agricultural production and transportation. Today the system comprises over 15,000 km of main and primary canals, nearly 27,000 km of secondary canals and about 50,000 km of tertiary canals. These canals, together with sluices, numerous culverts, dykes and pumping stations, form the basis of the water resources infrastructure in the Delta (Table 7 and Figure 14). The result is a fine meshed pattern of canals attaining a density of 80 – 100 m per ha.

Table 7: Statistics of main hydraulic infrastructure in the Mekong Delta

Structure	Whole Delta		Plain of Reeds		Long Xuyên Quadrangle		Ca Mau Peninsula		Trans Basssac	
	Project	L (km)	Project	L (km)	Project	L (km)	Project	L (km)	Project	L (km)
Main Canal	133	3,190	45	1,068	64	1,056	36	633	32	1,039
Canal-Level I	1,015	10,961	343	3,116			428	5,294	200	1,945
Canal-Level II	7,656	26,894	2,187	6,742	2,313	7,374	3,297	13,689	1,072	3,363
Canal-Level III	36,853	50,019	3,400	7,200			7,467	16,692	24,773	21,853
Large Sluice	984		169		38		322		455	
Small Sluice	20,517		2,491		1,915		6,000		10,111	
Flood control		13,332		7,099		4,485				1,748
River dyke		281								281
Sea dyke		523		21		63		306		133
Pumping station	1,151		338		319				494	

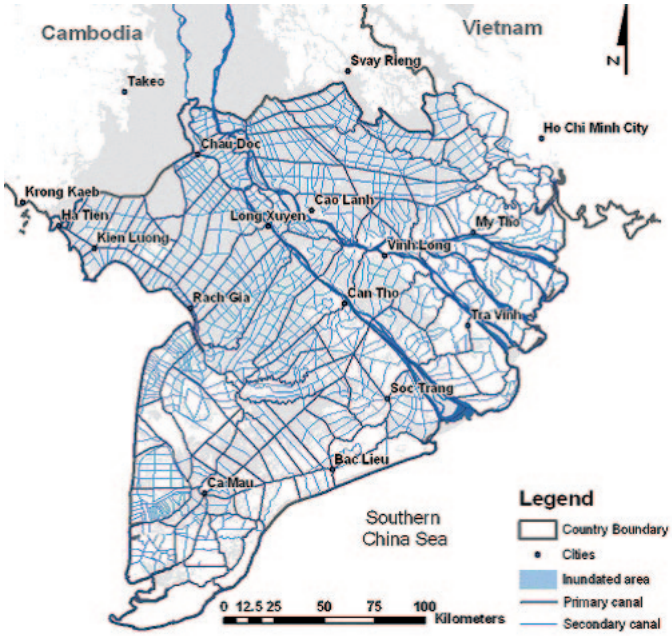

Figure 14: Surface water network of the Mekong Delta

In addition to the canal system, the Mekong Delta also has an extended system of embankments and dikes with a total length of 13,000 km, including 7,000 km of embankments for flood protection for the Summer-Autumn rice fields, and over 500 km of sea dikes.

The reason of developing this massive infrastructure was and is the need to overcome a number of natural constraints of the delta. The most important constraints are:

- The regular and sometimes extreme floods over 1.9 million ha in the upper part of the Delta;
- Salinity intrusion over 1.4 million ha along the coast;
- Acid sulphate soils over 1 million ha of low land areas and
- Seasonal shortage of freshwater for agricultural and domestic use over an area of about 2.1 million ha.

Removing these constraints requires a complex hardware system for irrigation, drainage, flood and salinity control as well as a fine tuned management of water flows. Sometimes the demands on the water management are contradictory, for instance the need to maintain a certain dry season freshwater discharge to the sea to control salinity intrusion against the agricultural demand for freshwater in the same season. Also the need for keeping acid sulphate soils saturated in the dry season draws heavily on the already limited freshwater resources during the low-flow season. Hence, optimizing the current water management and its future development requires an integrated approach in which the water demand of all sectors is balanced against the enabling natural conditions of each delta region combined with the potential for upgrading and improving the water infrastructure performance.

Historical development

The Mekong Delta has a long-standing history of agricultural development which goes back many centuries. Rapid development took place since the eighteenth century and especially during the period from 1860 to 1930. This is the period that the canals were built and cultivated land area developed rapidly. However, the development of the Mekong Delta has faced many setbacks due to both natural and social conditions, especially during the first 50 years of the twentieth century.

Over the last decades a series of studies and research activities was performed to improve the infrastructure in a planned and coordinated way. Examples are the UNDP / World Bank funded *Mekong Delta Master Plan* (1993), assisted by NEDECO, *Control and planning of flood water in the Mekong Delta* (1994-1999), *Planning of sea dikes and river dikes* (1999) and the *Integrated water resources planning in the Mekong Delta* (2002-2006). The execution of these plans has greatly improved the water resources situation. It brought greater efficiency in salinity control, dry season water supply, flood control and the drainage of acid soils. Together with the introduction of high yielding varieties, this led to a significant increase in agricultural production (see Section 6.1). Nevertheless, improvements are still possible and necessary, not only in the field of construction but also in operation and maintenance.

4.2 Current water resources infrastructure and bottlenecks

Irrigation

About 1.4 ha (over 90% of the Winter-Spring and Summer-Autumn crop) is actively irrigated with canals and sluices at all levels. Thanks to the irrigation system large areas of alkaline soils have been reclaimed for rice production, enabling two to three crops per year.

Still, shortage of water is encountered in certain remote areas and synchronization between pumping stations, canals, sluices and dams is sometimes lacking. Sedimentation of canals locally causes a reduction in irrigation and drainage capacity (e.g. in the Plain of Reeds).

Flood control

Flood control has achieved significant results, partly through state investments, but also by local people themselves. The main idea is not to completely eradicate floods, since 'normal' floods also provide benefits to the people and their crops. Many embankments have been erected to avoid flooding during the harvest month of August.

Still flooding may cause serious problems. For instance in the Plain of Reeds summer-autumn rice crops, high value fruit trees and infrastructure suffer from damages from floods.

Drainage

In normal years the drainage system functions well on about 80% of agricultural land enabling two crops a year. Especially in years of heavy rainfall and high river discharges, floodwaters recede late and cause difficulties for farmers.

Sea dikes

Sea dikes have been constructed along estuaries and coasts in Tien Giang, Tra Vinh, Soc Trang, Bac Lieu, Kien Giang, Ben Tre and Ca Mau provinces. In the latter two provinces, however the sea dike system is not closed, and only gives partial protection. Both the height and strength of the dikes need upgrading.

Salinity control

Saline water is prevented to enter the canals by the construction of sluices that can be closed when the seawater rises with the tide above river water levels. However, many canals do not have such sluices. Where sluices do exist, there is sometimes a conflict between the freshwater needs for agriculture and salt water needs for brackish water shrimp farming and shrimp-rice farming. For instance along the coastline of the Long Xuyen Quadrangle and Ca Mau peninsula, sluices consist of only one-way gates to let fresh water out and prevent salt water to enter. There is no management system to demarcate the salt-fresh interface based on the needs for agriculture and aquaculture.

4.3 Developments in water resources infrastructure

For each sub-region of the Delta targets and specific measures have been formulated to improve the water objectives and measures infrastructure. Although varying in importance for each region, the following targets are mentioned:

- Flood protection for residential areas, towns and cities;
- Reduction of flood levels in early and late season to ensure the production of two spring-summer-autumn paddy;
- Improvements in water management to reduce problems with acidic soils (e.g. in Ha Tien quadrangle) in order to use them for agriculture and aquaculture;
- Combination of flood control projects with irrigation works to form a complete irrigation system, combination with water storage and traffic infrastructure.
- Improvements of irrigation capacities by dredging canals and improvements the links between canals and the various rivers.
- Improvements in drainage pumping capacity for areas that cannot be drained by gravity (e.g. the fruit tree areas).

4.4 Institutional arrangements

By Decree No. 01/2008/ND-CP the Ministry of Agriculture and Rural Development (MARD) has overall guidance on the implementation of strategies on hydraulic structures for irrigation, flood and salinity control and on the implementation of strategies for prevention and mitigation of natural disasters including flood control. At the provincial level these activities are coordinated by the Departments of Agriculture and Rural Development (DARD). DARD coordinates, with districts and cities, the construction and management of the dikes and dams, inspection of irrigation works and the removal of obstacles in rivers and canals. Furthermore, together with provincial People's Committees they coordinate activities from provincial to grassroots level to carry out protection and maintenance measures for dikes, dams and irrigation works. The exploitation and daily management of irrigation areas is the responsibility of either a company or a provincial irrigation agency.

5

Water and the Environment

5.1 Diversity in landscape ecological zones

Notwithstanding the absence of any major relief, the Mekong Delta consists of a number of fairly distinct landscape ecological zones. Differences in soil texture, salinity and micro-topography have resulted in a variety of ecosystems with different natural vegetation and agricultural opportunities and land use. Figure 15 shows a map with nine ecological zones. Below the zones are briefly described.

Alluvial floodplains and **High coastal plain:** The floodplains along the banks of the Tien and Hau rivers cover an area of 1,201,861 ha. The region consists of recent alluvial soils that are only slightly acidic (pH values of 4.5-6.5). These areas with freshwater are the most suitable for agriculture, especially rice cultivation.

Dong Thap Muoi and **Long Xuyen quadrangles**: these closed floodplain systems are situated at both sides of the river and together cover an area of 510,027 ha. Dong Thap Muoi includes the vast Plain of Reeds. The agricultural potential is very low because soils in these regions have very high concentrations of sulphates (low pH values ranging from 2.26 to 3.54). Moreover, these areas are deeply flooded from August to November and have insufficient fresh water during the dry season. In the higher parts of this region, one or two rice harvests can be produced each year, but this entails a considerable amount of drainage and irrigation. The most appropriate forms of land use would be retaining the wetlands in their natural state for nature conservation, management of the *Melaleuca* forests for timber production, and management for fisheries production.

Ca Mau Peninsula includes large areas of saline and non-saline acid sulphate soils originally covered with forests. The area near Ca Mau town has extremely difficult soils and water levels should remain high to prevent acid formation.

The U Minh *Melaleuca* forest covers an area of 189,358 ha. The main soil types are peat and sulphate, and the agricultural potential is low. Large tracts of the forest were destroyed by toxic chemicals and napalm during the war and forest fires continue to destroy large areas; fires during the dry season in 1982-83 and in 1987 were particularly damaging.

The Tidal Floodplain includes swampy tidal areas along the entire Delta coast and covers an area of 215,974 ha. The main soil types are salty soils. Most of the intertidal zone was formerly covered by mangrove forest.

Chances Mountain and **Terrace Alluvium**: Chances Mountain is a small area with relatively high elevation within the Long Xuyen quadrangle. It has rocky soils and is only marginally flooded. The Terrace Alluvium area in the extreme north of the Delta consists of grey soils and is most suitable for the cultivation of upland crops, although soil fertility is low.

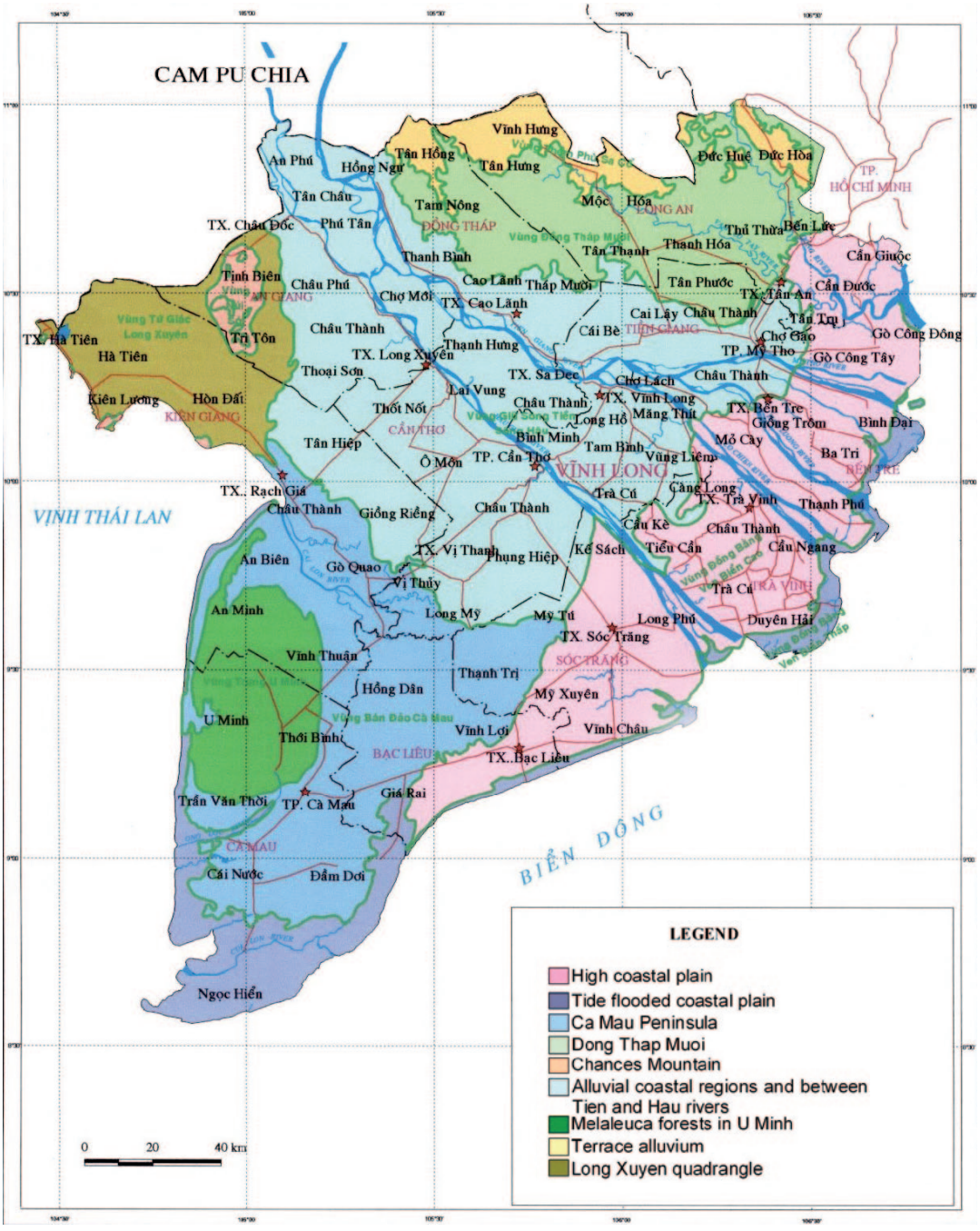

Figure 15: Map of ecological land use zones

5.2 Nature values and protected areas

Despite the huge population density of the Mekong Delta it still harbours significant nature values. The mangrove and Melaleuca forests constitute an important forestry resource, potentially capable of meeting the local demand for construction materials, firewood, fodder for domestic animals and other forest products. In addition, the Melaleuca forests provide a valuable harvest of honey from wild bees' nests, amounting to five or six litres of honey per ha per year. The mangrove forests also play a very important role in coastal protection and land reclamation.

The Mekong waters host over 1,300 fish species, one of the highest species counts of any river system in the world. One of the most important wetland habitats contributing to this high fish diversity is the seasonally inundated riparian forest found on the gently sloping plains adjacent to lakes, rivers and tributaries. More than 360 fish species use this habitat as a feeding, breeding and nursery ground. Furthermore these wetlands are vitally important for breeding colonies of large water birds. Bird species are concentrated in the few remaining natural wetlands and number approximately 350 species. A total of 256 bird species have been recorded at Tram Chim wetlands in the Plain of Reeds alone, including the world's largest flying bird the sarus crane *(Grus antigone sharpii)*.

At least six nature reserves have been established to conserve the wetland ecosystems and their wildlife (Table 8). In many areas, policies have been developed for the conservation and management of wetland resources and considerable effort has been made in some areas to restore wetlands to their natural condition. For instance, between 1975 and 1985 almost 30,000 ha of mangrove forest and 20,700 ha of *Melaleuca* forests were replanted.

Table 8: Nature Reserves and protected areas in the Mekong Delta

Name	Area (ha)	Province
Tram Chim Sarus Crane Reserve	9,000	Dong Thap
Vo Doi Protected Forest	3,945	Minh Hai
Nam Can Mangrove Reserve	7,547	Minh Hai
Bac Lieu reserve	40	Minh Hai
Cai Nuoc reserve	20	Minh Hai
Dam Doi	119	Minh Hai
Mui Ca Mau National Park	41,862	Ca Mau
U Minh Ha National Park	8,528	Ca Mau

5.3 Delta wetlands: a dwindling resource

Rapid population growth and intensive agricultural and aquaculture development over the past decades have significantly reduced the area of natural wetlands in the delta. Many wetlands such as mangroves, ponds, lakes, lagoons and wet grasslands are threatened by extinction through the concessions for irrigation, forest plantations, salt ponds, industrial development zones and shrimp farms. For instance the area of shrimp farming increased from practically zero in 1965 to over 200,000 ha in 2001 in Ca Mau province alone. Simultaneously, the forest area has reduced from more than 90,000 to less than 40,000 ha in that province. Furthermore, overexploitation of the natural resources such as the illegal exploitation

of timber and non-timber forest products, unsustainable fishing, illegal wildlife hunting and trade are a major threat for the health of ecosystems.

Proposed upstream developments along the Mekong River are in potential conflict with wildlife and fisheries interests in the Delta. These include large-scale irrigation schemes, hydro-power projects, flood control projects and industrial developments. Dam construction will likely change the hydrology of the delta, reducing seasonal flow peaks and the extent of flooding. This is likely to have significant effects not only on the waterfowl populations, but also on those fish species that utilize the floodplain wetlands for spawning. Changes in water quality and the timing of the peak flows are likely to have adverse effects on fish migrations and spawning, and dams will create barriers for long distance migrating fish species. The dams will reduce sediment flow and thereby affect the nutrient regime in the delta. The water quality in the lower Mekong has been affected already by domestic waste and agricultural runoff, carrying pesticides and fertilizers downstream. Though localized at present, such problems are expected to increase. Industrial activities, such as pulp and paper mills, textile mills and chemical factories are increasing within the basin. Together with increased waste from shipping, these activities are likely to create a serious pollution problem in the future.

The introduction of exotic rice varieties, especially hybrids with a high productivity, has led to a decrease in both the area and gene source of native plants. This has impoverished native gene resources and already several cropping varieties were regretfully lost.

Climate change will no doubt put additional pressure to the already endangered natural values of the Mekong Delta. The ecological consequences will largely depend on the rate and magnitude of change of mainly three critical environmental drivers: temperature, freshwater availability and sea level rise.

5.4 Major problems in environmental management

Currently, industrialization and urbanization has been rather limited in most of the Mekong Delta and thus have had little impact so far. But this is rapidly changing and the negative consequences of deforestation, inappropriate agriculture, road construction and other forms of development are already evident. This will pose a great challenge to the environmental management capacities in the delta.

Despite certain progress made in reaching the national environmental policy goals, several problems in management still exist, such as:

- Inconsistent and insufficient legislation for biodiversity protection. Many important issues are not yet included in current legislation such as genetic access and benefit sharing, biodiversity exploitation and utilization.
- Inadequate community participation in biodiversity conservation leads to poor law enforcement in general. Deforestation and wildlife trade are still going on.
- Lack of professional agencies capable to manage biodiversity resources based on innovative approaches and methods.
- Investment for biodiversity is limited and untargeted; usually focusing on infrastructure construction rather than on scientific research, management and protection activities.
- Fragmented environmental monitoring and assessments. Improved monitoring programmes for both water quantity and quality and the effects on ecological health and livelihoods need urgent attention.

6

Water for Food

6.1 Current agricultural situation and trends

Main crops and cropping patterns

With a total of around 1.8 million ha (2008), rice is the main crop in the Delta. Fruit trees are the second crop with a total area of about 0.54 million ha. Aquaculture comes third in terms of area with 0.53 million ha (see Table 9). Aquaculture has grown significantly over the past decade, mostly at the expense of rice fields, forests (mangrove) and wasteland. Overall agricultural land is fairly stable over the past decade after a significant increase since the 1980s, while rice and upland cropland reduced somewhat (see Figure 16).

Table 9: Changes in land use from 2005 to 2008 in the Mekong Delta

No	Items	Year 2005 (ha)	Year 2008 (ha)	Difference 2008/2005
	Total area (*)	**4,049,953**	**4,051,854**	**1,901**
I	**Agriculture, Forestry and aquaculture**	**3,444,221**	**3,424,265**	**-19,956**
1	Agriculture land	2,579,352	2,550,657	-28,695
1.1	Annual crops	2,044,702	2,009,448	-35,254
	Rice	1,908,431	1,873,727	-34,704
	Other Annual crops	135,592	134,912	-680
	Pastures	679	809	130
1.2	Perennial crops	522,500	541,208	18,708
2	Forests	219	219	0
3	Aquaculture	501,404	530,746	29,342
4	Salt pans	4,417	4,687	270
5	Miscellaneous crops	4,019	6,694	2,675
6	Forestry land	355,029	331,480	-23,549
II	**Non-agricultural land**	**561,682**	**591,932**	**30,250**
2.1	Residential land	107,966	111,592	3,626
2.2	Land of Special use	218,482	241,152	22,670
2.3	Religious land	2,856	2,886	31
2.4	Graveyards	6,645	6,678	33
2.5	Rivers and water surface	225,094	228,807	3,713
2.6	Non-agricultural land	639	816	177
III	**Waste land**	**44,050**	**35,657**	**-8,392**

Source: Statistical Book 2008 of 13 Mekong Delta provinces; (*) excluding islands Phu Quoc and Kien Hai (Kien Giang)

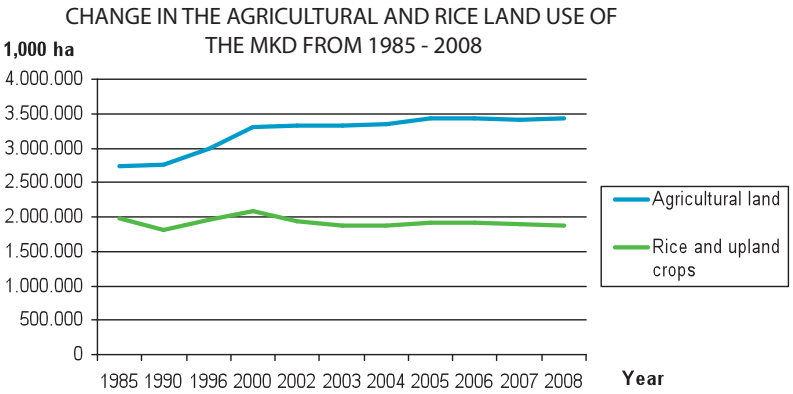

Figure 16: Change in agricultural land and rice fields from 1985 to 2008

Yields and production

Yields per ha in rice production have increased greatly over the last decades. In 2008 the average rice yield was 5.36 ton/ha, an increase of 3.1 ton/ha compared to 1976. Although introduced as early as the 1970s, high yielding varieties only started to become effectively used after improvements in irrigation, drainage and flood control were implemented on a large scale. Also the use of fertilizers, pesticides and herbicides greatly contributed to the increasing rice yields. Currently, more than 1.5 million ton of fertilizer and considerable amounts of pesticides and herbicides are used annually in the Delta. The main cropping schemes are Winter-Spring rice and Summer-Autumn rice. Traditional rice is now being cropped over an area less than 400,000 ha, from 1.4 million in 1976 (Figure 17). Likewise, the total rice production in the Delta has increased year by year to a total of more than 20 million ton (Figure 18).

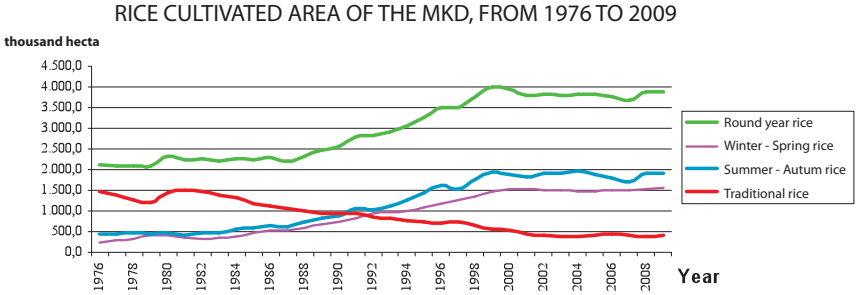

Figure 17: Area of rice cultivation from 1976 to 2009

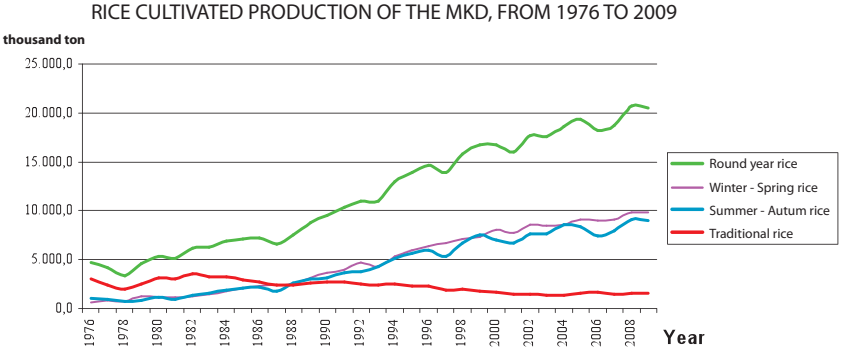

Figure 18: Rice production from 1976 to 2008

Not only rice but also fruit is a main product of the Delta. During the 2000 decade, fruit increased both in area and in production. Comparing the year 2000 with the year 2008, area and production increased with 73,888 ha and 602,739 ton, respectively. In terms of production also vegetables (3 million ton) and sugarcane (5 million ton) are of great significance. Vegetables show a doubling of cropped area since the year 2000.

Aquaculture is no doubt one of the fastest growing sectors in the Delta. After the year 2000, the area of brackish and freshwater farms increased enormously, particularly in Ca Mau, Bac Lieu and Kien Giang provinces. Shrimp farming has replaced rice in some areas (South Ca Mau, Quan Lo – Phung Hiep, Soc Trang, Tra Vinh, Ben Tre).

Brackish aquaculture production more than quadrupled from 365,141 ton to 1,838,640 ton. Not only brackish aquaculture developed rapidly, but also fresh water aquaculture. The Delta harbors a typical fresh water fish (Cavefish/Basa) that is cultured in the river in floating cages, or in closed ponds. The area of fresh water aquaculture increased from 94.639 ha in 2001 to 137.110 ha in 2007 and its production rose from 238.258 to 1.168.623 ton.

6.2 Limitations to agricultural production

Soils

Soils in the Delta can be grouped into 5 classes, of which the acid soils are dominant with an area of about 1.4 million ha (approximately 35% of the entire Delta). Saline and alluvial soils occupy nearly an equal area of about 1.2 million ha (28%) each.

In the 1980s a total of about 1 million ha of acid sulphate soils could not be used for cultivation. Thanks to developments in water management most of these soils have been reclaimed for cultivation. There are still affected zones belonging to the Plain of Reeds (Bac Dong, Bo Bo) and Ca Mau peninsula (Upper and lower U Minh), with a total area of about 100,000 ha that are not yet reclaimed.

Run-off water from the acid sulphate soils at the beginning of the rainy season may reach high acidity levels of pH ranging from 2.5 to 5 in many parts of the Delta.

Freshwater and salinity

Most of the water for agriculture comes from surface water. Water for irrigation normally takes about 80-85% of the total water use in the Delta, of which about 25% is returned to the canals or rivers. Groundwater is used in small areas for upland crops. Salinity intrudes into the Delta through the river

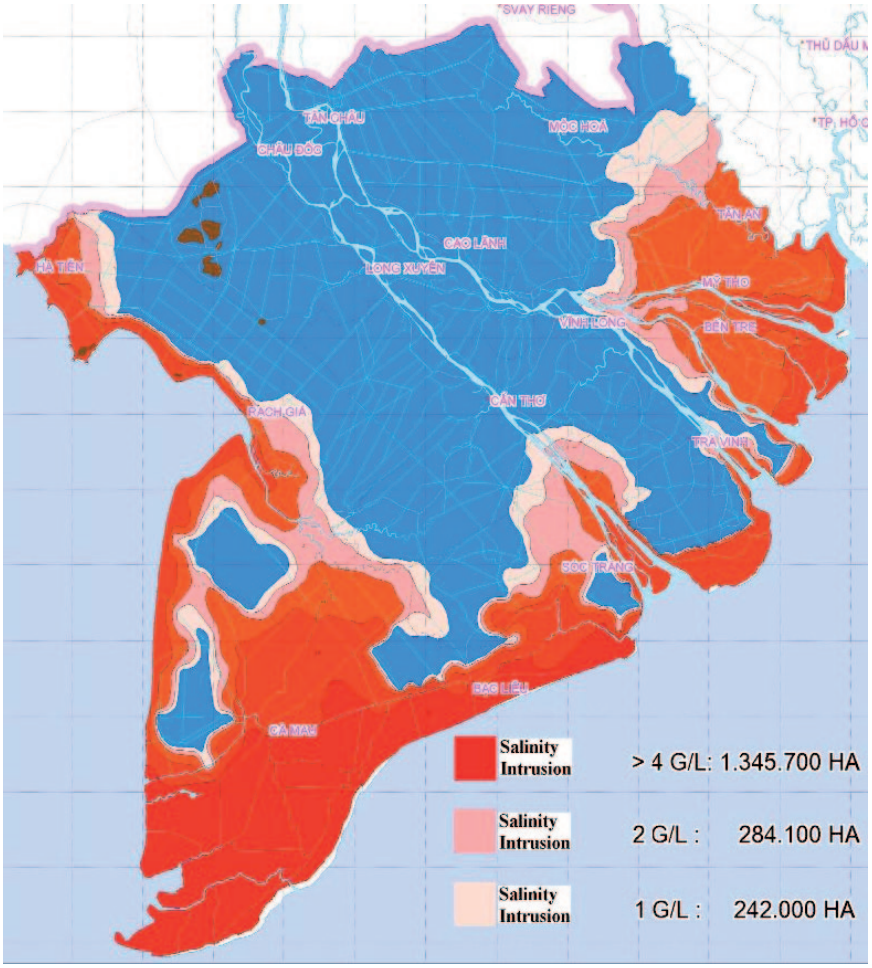

Figure 19: Areas affected by salinity intrusion

mouths with maximum lengths in the dry season up to 60 km. The total area affected by salinity levels of more than 4g/l reaches 1.3 million ha (Figure 19).

Flooding

Each year approximately 1.2 - 1.9 million ha of the Delta is affected by floods with an inundation depth of 0.5 to 4.0 m and a duration of 2 to 6 months (depending on the floods/years). The deepest inundated areas are located along the border with Cambodia, where water depths can reach 1.5 to 3.5 m. In deeply inundated areas double crop patterns are encouraged to develop and in shallow inundated areas triple crops are applied.

6.3 Development scenarios and impacts of climate change

The Mekong Delta is considered as an important area for the food security of the country. Therefore, the Vietnam Government has put special attention to the development of the region. Food production targets have been formulated for the years 2020, 2030 and 2050. Rice production is targeted at a relatively constant level of 22 to 23 million ton, whereas both fruit and vegetable production are projected to

increase over the period 2020 – 2050 from 3.7 to 5.0 million ton of fruit and 4.4 to 6.3 million ton of vegetables. However, sea level rise and changed dry season flow of the Mekong River due to both climate change and upstream developments could significantly change this picture. Three scenarios have been analysed (Table 10).

Table 10: Scenarios for agricultural development

	Sea level rise	Dry season flow	Extreme conditions
Scenario I	30 cm in the year 2050	Higher than annual average	Unusual
Scenario II	30 cm in the year 2050	Equal to annual average	Unusual
Scenario III	30 cm in the year 2050	Lower than annual average	Similar to 2010 with serious saline water intrusion

Under these three scenarios different cropping patterns and seasons have been identified. For Scenario I the area of triple crops per year are maximized, including 3 rice crops per year. Under Scenario II only a moderate development of areas with triple crops per year are assumed. Limitations are expected in zones affected by saline intrusion. Under Scenario III a substantial rearrangement of scale and space of cropping patterns is expected. More efficient water use is required to reduce the damage from droughts and saline intrusion. Areas with triple crops would be significantly reduced.

7

Water Supply and Sanitation

7.1 Current supply levels and problems

According to the report of the Southern Institute for Urban and Rural Planning, around 60-65% of the urban population in the Delta receive water from the existing supply systems. For larger cities such as Can Tho and Vinh Long the percentages are 70 to 90%. For the rural population these percentages are considerably lower. Industrial water demands are satisfied for around 40 to 50% by water supply systems. The remainder is coming from local wells or surface water from channel networks.

There are several shortcomings in the water supply systems in the Mekong Delta. The systems cannot meet the current demand because of out-of-date water treatment technology, except in Can Tho and Long Xuyen. In many areas, such as Ca Mau, Bac Lieu and Soc Trang water is used without treatment, so water quality is below the required standards. Water supply systems were built many years ago and many pipes are getting old. Some were built 50 years ago. Breakdown of pipes and sedimentation have caused pressure loss and water leakage. Maintenance and replacement has not taken place due to lack of budget.

Main sources for urban domestic and industrial water includes surface water from rivers and canals and groundwater through wells. Water supply in the rural areas is based on surface water, groundwater and rainwater. Supply from surface water encounters two major problems: high salinity and aluminium contamination. The salinity limit for industrial and domestic use is 0.4 g/l and is now approaching 50 to 60 km in the Hau and Tien river branches at the end of the dry season. In the flood season the salinity intrusion is pushed back to the river mouths but still reaches 5 to 20 km inland. Due to a considerable presence in the delta soils aluminium is flushed to the surface waters under conditions of excess rainfall and irrigation. It flows into canals and ditches and contaminates the surface waters of the Vam Co Dong, Vam Co Thay and Dong Thap Muoi. Furthermore, the Mekong River and its branches have a high total organic carbon content in the order of 250-1,000 mg/l. Locally the water is also moderately to heavily contaminated with bacteria and polluted from acid-sulphate soils, leading to high acidity in canal waters.

The groundwater has been exploited for industrial use since 1941. Up till now, there are about 200 large wells to provide water for urban areas and over 25,000 small-scale drilled wells to provide water for rural areas. The current total exploited groundwater amounts in the order of 480,000 m^3/day. There are four major aquifers in the delta originating from sedimentary deposits of the Pleistocene, Pliocene and Miocene. Groundwater is also exploited from shallow aquifers in sand dunes along the coast and from higher terrain in the interior part of the delta, although not very abundant, the quality is said to

be good. In some areas groundwater can be pumped and used directly without treatment. Especially for the people living in the coastal areas where freshwater is scarce, this groundwater resource is very important.

Rainwater is an additional and valuable water source for domestic use by people in the coastal areas as well as in regions where aluminium contamination is severe. Traditionally, rainwater is stored in big ceramic jars to be used in the dry seasons, but the amount of water stored in this way is usually not enough for the demand.

7.2 Plans for water supply improvements

To address the problems in the water supply a National Target Program for Rural Clean Water and Environmental Sanitation was formulated. This program aims to achieve, through consecutive 5-year plans, that all rural population can use clean water (a minimum of 60 l/day/capita), and has access to proper sanitation facilities. Program components include specific approaches and targets for rural, urban and industrial water supply. The Ministry of Agricultural and Rural Development (MARD) is responsible for the implementation of the program.

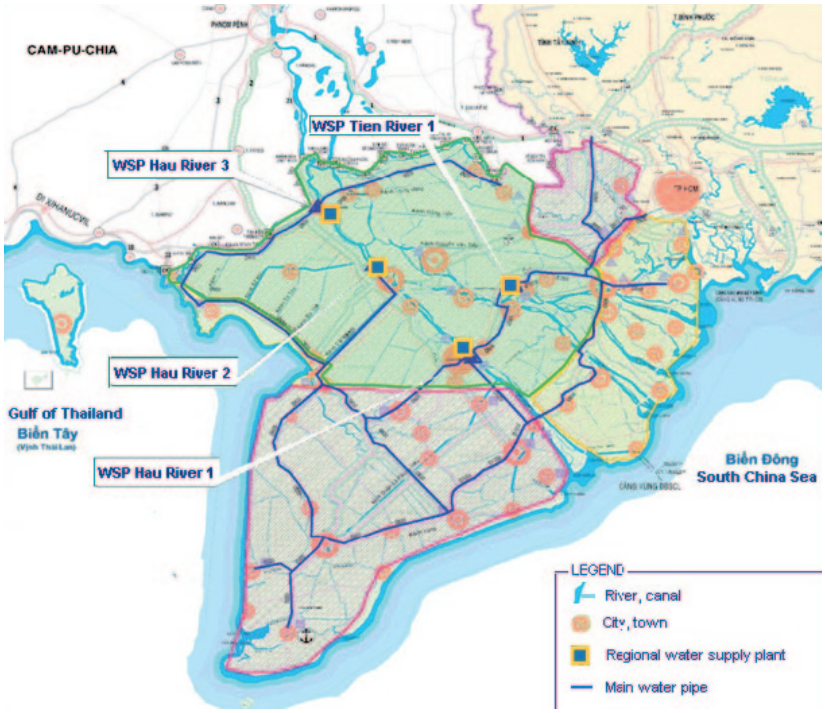

Figure 20: Location of major planned water supply plants (headworks) in the Mekong Delta.

The water supply plan for the Mekong Delta was prepared in 2000 and is currently outdated. Two approaches are anticipated for meeting the demands of the Delta:

- **Piped water supply:** for residential areas and town centres serving about 500 to 3000 people. Each commune should have water supply from 1 to 2 stations based on the spatial planning of residential areas of the commune.
- **Non-piped water supply:** for residential areas located separated or along canals and ditches. This includes a combination of manually drilled or UNICEF wells serving 1 to 5 households each, water filters to purify the water and eliminate the aluminium and water jars to store the water.

Overall, the piped water supply target for cities and industrial parks for 2020 reaches some 3,5 - 4.0 million m^3/day (from a current 650,000 - 700,000 m^3/day). To achieve these goals a number of centrally located water supply facilities would be developed (Figure 20). Existing water supply facilities will continue to operate normally. However, the intake of groundwater will be reduced when the proposed water supply facilities are operational, in areas with limited groundwater resources (see section 3.1). Smaller surface supply plants (with a capacity less than 10,000 m^3/day) that cannot meet the technical requirements will be replaced by the new main water supply systems.

Plans also include the construction of a water delivery network to supply the water to the domestic consumers and industry. In due time households in the region will be connected to the network and all users will be fitted with water consumption meters.

7.3 Water and sanitation

The total amount of wastewater in the delta is estimated to be millions of m^3/day of which approximately two-thirds is domestic and one-third industrial. Most of this water is discharged untreated in rivers, canals and ditches. In many residential areas the drainage system for rainwater and wastewater is incomplete and under-designed, leading to local flooding during heavy rains.

Also for wastewater treatment and environmental sanitation ambitious targets are set under the National Program, viz. 85 % of wastewater from domestic and animal husbandry should by hygienically collected/treated, and 60 % of solid waste. The use of pesticides and fertilizer in agriculture will be regulated. For urban and concentrated industrial areas wastewater treatment facilities are projected. This will require a substantial financial investment for many years to come.

8

Spatial Planning

8.1 Current spatial patterns in the Delta

Although its landscape is still dominated by agriculture, industrial development and accelerated urbanization are increasingly taking up space in the delta. Industrial development (processing of agricultural products is a key branch) is concentrated near the major cities of Can Tho, Long An, Ca Mau and My Tho. This sector is regarded as key to future economic growth, so integrated industrial zones near cities are expanding significantly. These developments will have a major impact on population distribution and densities in the delta (more urbanization).

In the central delta area people are concentrated along roads and rivers. The closer to the river or road, the higher the population density becomes. This linear form has become point-linear with many concentrated population centres in towns and commune centres. Social welfare centres such as schools and hospitals are rather regularly distributed at reasonable spacing. In the coastal area a different spatial occupation pattern may be found. For instance in the areas where Khmer people live on sand dunes in their villages.

The municipal network is distributed rather regularly which is characteristic for an area depending largely on agricultural production. Presently, there are 132 towns and cities. Small towns usually have their economic base in agriculture, are rural and the home of farmers. The larger municipalities have important regional functions. Can Tho City has become the service, commercial, educational, health, science and technology centre for the whole delta. Can Tho City has branches and representative offices of companies and corporations and it has an international airport. However, the influence of the city on the Ca Mau peninsula and the southern part of Long Xuyen Quadrangle is still minor. Most coastal towns are relatively marginally developed due to bad infrastructure and poor access from the sea due to siltation of estuaries.

8.2 Conflicts over space and other problems

Although the Mekong Delta is defined as a focal area for agricultural production at national scale, much fertile land has recently been converted into industrial development zones. As a consequence, this results in the resettlement of a large number of households. Because there is a huge competition between provinces and cities to attract industry for their economic growth, the industrial zones in the Delta are developed randomly. Thousands hectares along the Mekong and Bassac rivers, which have been classified as first class agricultural soils and which should have been reserved for agricultural production,

have been or are planned to be turned into industrial zones. Nevertheless, presently just 30 to 40 % of the industrial zones have actually been occupied by enterprises, even just 5% at some places. The reason for this situation is the lack of basic planning studies and cooperation between municipalities and provinces.

Besides this conflict over space, the socioeconomic development in the delta is also faced with limitations in the natural conditions, especially for agriculture and livelihood. The main bottlenecks are:

- Prolonged flooding of 1.9 million ha in the upper part of the Delta Vietnam-Cambodia border area;
- Salinity intrusion in an area of about 1.2 to 1.6 million ha in the coastal zones (salinity levels of 4 g/l);
- The presence of acid sulphate soils with a low pH and the spread of acid drainage water in an area of about 1.2 million low-lying ha;
- Problems with the timely supply of sufficient and good quality freshwater for agricultural production and domestic needs in an area of about 2.1 million ha;
- River bank and coastal erosion and loss of natural ecosystems (mangrove forests, wetlands).

These problems may increase due to climate change effects and water management challenges.

8.3 The spatial planning system

Spatial planning goals are based on governmental master plans. The 'Master Plan for Socio-Economic Development until 2020 for the Mekong Delta' plays a very important role and should be the foundation for other sectoral plans. However, this Master Plan has not yet been approved by the Government. It is evident that spatial planning is strongly determined by (central) socio-economic planning.

Figure 21: Map of Spatial Development Orientation in the Mekong Delta to 2020

The overarching spatial vision for the delta may be summarized as: a coastal and riverine agricultural region with multipolar (major cities) development hubs (Can Tho as the core municipality) and interconnecting municipal and infrastructure corridors. The geographic distribution of municipal network is strongly determined by the river network. This vision is schematically visualized in Figure 21.

The central position and functions (central location for services, industry, commerce) of Can Tho city is elaborated and exemplary for other, smaller, regional hubs in the delta. As depicted in Figure 21, the network of main municipalities is connected through national and regional highways and waterways. The rural interior and coastal areas constitute a very different spatial image; agricultural, a dispersed population (along roads, canals and water courses) and prone to flooding.

The central government, has initiated a number of studies to deal with the planning challenges and collect miscellaneous sectoral data (agriculture, construction, aquaculture, water resources planning) (Table 11). Increasingly, the interdisciplinary nature of the issues and interests of various stakeholders create difficulties in information exchange, matching sectoral interests; consequently, truly integrated spatial planning remains difficult. Not only multiple ministries, agencies and planning branches are involved but also multiple levels of government (central, provincial, city, district and commune).

Table 11: List of institutes participating in spatial planning for the Mekong Delta region.

No	Plan	Institutes
1	**Master plan for socio-economic development**	Development Strategy Institute (MPI) South Vietnam Economic Studies Centre - SVEC (HCMC)
2	**Land Use Planning**	Branch of Center for Land Investigation and Planning in HCMC (MONRE)
3	**Planning of the agricultural sector**	Sub-National Institute of Agricultural Planning and Projection (MARD)
4	**Planning of forestry**	Southern Sub-Institute of Forest Inventory and Planning (MARD)
5	**Water Resources Planning**	Southern Institute for Water Resources Planning (MARD)
6	**(Ground) water Resources Planning**	Division for Water Resources Planning and Investigation for the South of Vietnam (DWRPIS under MONRE)
7	**Construction Planning**	Southern Sub- Institute of Urban and Rural Planning (MOC)
8	**Planning for Transport**	Institute for Development Strategy and Transport (MOT)
9	**Planning for Industry**	Industrial Policy and Strategy Institute (under Ministry of Industry and Trade-MOIT)

NB: All institutes, except for the last one, are located in Ho Chi Minh City

In conclusion, spatial planning is still lacking intersectoral integration and data sharing. Existing plans are hampered by the fact that the impacts of climate change and sea level rise have not been considered. Many plans and data are still in the form of hard copies located at the organizations or agencies that prepared the plans. Exchange and supply of information is still often inadequate. Sectoral plans are often formulated with little collaboration or exchange between sectors and agencies. Furthermore, most plans do not respond adequately to the relatively new challenges of climate change, changing water regimes, increasing urbanization and industrialization.

9

Water Governance

In this assessment a definition of water governance from the Global Water Partnership (2002) is used: 'the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society'. In order to describe the water governance in the Mekong Delta both formal (e.g. laws, regulations and government agencies) and informal issues and arrangements (e.g. private sector, water user associations) are considered.

9.1 Legal framework

In Vietnam, water resources management has a history as long as the development of the country itself. However, the Law on Water Resources (LWR) has just been approved by the National Assembly on May 20th, 1998 and became active since January 1st, 1999 (LWR No 08/1998/QH10). According to Article 1 of the LWR *"Water resources are under the ownership of the entire population and uniformly managed by the state. All organizations and individuals have the right to exploit and use water resources for living and production, and are responsible for protecting water resources as well as prevent against and mitigate for any harm caused by water in accordance with laws"*. This law is the first of the policy development process, i.e. the policy formulation for water resource use and management.

After the establishment of the LWR, on December 30th, 1999, the Government enacted the Decree No. 179/1999/ND-CP to guide the implementation of the LWR in detail. These two documents are considered as a legal base for water resources management in Vietnam (Loan, 2010a). Besides, other laws (i.e. Land Law, Law on Fisheries, Law on Dykes, Law on Inland Waterway Navigation, Law on Environmental Protection, etc.) have a close-relationship with the management of water resources. The coordination for implementation of such laws, however, remains a critical case of concern. Recent studies based on the analysis of more than 300 relevant documents have shown that the legal framework in the water sector contains many overlaps, gaps, contradictions and even conflicts. Therefore, it is necessary to revise the LWR in order to solve such problems for better water resources management in the future.

9.2 Institutional framework

National government agencies and ministries

Institutional arrangements for water management in Vietnam relate to many institutions. At national level, the National Water Resources Council is considered as an inter-ministerial body that is chaired by the Deputy Prime Minister with representatives from 10 line ministries. Besides, there are numbers of related ministries involved in implementing water resources management according to the authority and assignments given by the government. Table 12 presents the key agencies and their functions for water management in the country.

Table 12: Institutional tasks, and key functions for the water sector in Vietnam

Agencies	Key functions	Reference
National Water Resources Council (NWRC)	• Advising the government on important decisions regarding water sectors • Organizing discussion among specialists, scientists for recommendations on national water resources • Solving conflicts between ministries, provinces	Decision No. 99/2001/QD-TTg
Ministry of Natural Resources and Environment (MONRE)	Overall water resources management • Directing, guiding and organizing the implementation of legal documents and policies on water resources • Appraising master plans on exploitation and use of water • Deciding on the classification and listing of water sources • Prevention of degradation and depletion of water resources • Building, managing and exploiting a network for monitoring and measuring water resources (surface water, ground water and meteorology) • Water quality monitoring and pollution control • Guiding and examining the grant and withdrawal of licenses on water resources • Proposing to the Prime Minister international cooperation in water sector • Standing member of the National Water Resources Council and the Vietnam Mekong River Commission	Decree No. 25/2008/ND-CP
Vietnam National Mekong Committee (VNMC)	• Assisting the Prime Minister in guiding and managing all cooperative activities with the Mekong River Commission (MRC)	Decision No. 860/TTg (in 1995)
Ministry of Agriculture and Rural Development (MARD)	• Guiding the implementation of strategies on hydraulic structures for irrigation, flood control and salinity intrusion prevention • Guiding the implementation of strategies on prevention and mitigation of natural disasters (including flood and storm control) • Developing policies and strategies for agriculture, forestry, aquaculture, fishery and salt productions • Protection and exploitation of aquatic resources • Responsible for rural water supply and sanitation	Decree No. 01/2008/ND-CP
Ministry of Industry and Trade	• Construction, operation and management of hydro-power facilities • Planning industrial water use	Decree No. 189/2007/ND-CP
Ministry of Health	• Water standards for drinking and domestic use	Decree No. 188/2007/ND-CP
Ministry of Construction	• Spatial planning and construction of urban water supply, sanitation and drainage facilities	Decree No. 17/2008/ND-CP
Ministry of Transport	• Planning, construction and management of waterway transport systems • Monitoring hydrographical, hydrological, and hydraulic data along Mekong delta branches • Management of marine works and ports	Decree No. 51/2008/ND-CP
Ministry of Science and Technology	• Setting of technology standards • Conducting research and environmental management through the EIA process	Decree No. 28/2008/ND-CP
Ministry of Finance	• Allocation of state budgets • Development of policies on taxes and fees for water resources	Decree No. 118/2008/ND-CP
Ministry of Planning and Investment	• Allocation of planning and investments • Coordination of international relations	Decree No. 116/2008/ND-CP

Many of these national agencies have their representatives at the other government levels, i.e. provincial, district and commune. Among the national agencies MONRE and MARD play an important role in water management. Since 2002, a number of functions and activities have been handed over from MARD to MONRE (i.e. the Standing Office of NWRC was moved to MONRE in 2003, and the Vietnam National Mekong Committee is hosted by MONRE since 2008). Besides, the involvement of various ministries and stakeholders under the NWRC is important to approach integrated water resources management. Despite certain achievements, however, there are still a number of problems and challenges in terms of institutional arrangements in the water sector (see Section 9.5).

River Basin Organisations

River Basin Organizations (RBOs) are also responsible for water management in the country. The Law on Water Resources (1998) indicates that the primary planning and management unit for water is on the level of the river basin. In 2001, the first 3 RBOs were established, being the Red River, the Dong Nai and the Mekong RBOs. In 2004, MARD created a Standing Office for RBOs as a coordinating unit. Later RBOs were moved from MARD to MONRE and MONRE has been responsible for preparing river basin plans. In December 2008, the Prime Minister approved the Decree No. 120/2008/ND-CP on river basin management. This Decree stipulates a number of general policies and responsibilities regarding river basins:

1. Water resources in a river basin must be uniformly managed without division among administrative levels, between upstream and downstream; the fairness, rationality and equality in obligations and interests among organizations and individuals in the same river basin must be ensured;
2. Ministries, branches, local administrations at all levels, organizations and individuals shall bear joint responsibility for protecting the water environment in river basins according to law, and actively cooperate in tapping benefits brought about by water resources and ensuring the interests of population communities in river basins;
3. The exploitation, use and development of water resources must be combined with the environmental protection and sustainable exploitation of other natural resources in river basins.

Although the main task of RBOs is to enable unified management of the catchment areas across the administrative borders dividing them, their functions are limited to an advisory and coordinating role and not to fulfill state management functions. Because the inter-provincial coordination is still poor, the RBOs have not been working as effectively as intended.

9.3 Other organizations and stakeholders

Mekong River Commission (MRC)

The Mekong River Commission (MRC) was established in 1995 by an Agreement between the governments of Cambodia, Lao PDR, Thailand and Vietnam. The two upper states of Mekong river basin, China and Myanmar, are dialogue partners to the MRC. The goal of the Agreement is "to cooperate in a constructive and mutually beneficial manner for sustainable development, utilization, conservation and management of the Mekong river basin water and related resources". Each country has its National Mekong Committee, the Director of which has the status of Minister.

International organizations

Many international organizations are active in the Mekong Delta, e.g. WB, ADB, UNICEF, UNDP, IFAD, GTZ, EKN, etc. These organizations are supporting many projects in the water sector. Such agencies provide not only "hard-measures" (e.g. dykes, sluice gates, and canals for flooding control and salinity intrusion prevention, urban drainage constructions, rural water supply systems, etc.) but also "soft-measures" (e.g. knowledge, approach, and concepts) support. Through those projects both the water infrastructure and human capacity has improved in the region.

Research and education institutes

Amongst many institutions related to water resources planning and management in the Mekong Delta the most important are:

- the Southern Institute of Water Resources Research (SIWRR),
- Southern Institute of Water Resources Planning (SIWRP),
- Division for Water Resources Planning and Investigation for the South of Vietnam (DWRPIS),
- Sub-national Institute of Agricultural Planning and Projection (Sub-NIAPP),
- Sub-institute of Hydrometeorology and Environment of South Vietnam (SIHYMETE),
- Southern Regional Hydrometeorological Center (SRHC), and
- Can Tho University (CTU).

Private and public companies

Business companies in Vietnam are operated under both public and private owners with profit-oriented purposes. In water-related sectors, some major companies are active. The *Hydraulic Engineering Consultants Corporation II (HEC-II)* is a previously state-owned enterprise. The company has about 300 staff and is active in engineering design, geotechnical, hydrological, environmental and social investigations etc. *Irrigation Management Companies (IMC's)* operate water distribution systems and manage operation and maintenance of irrigation works. Besides these large companies, there are numbers of smaller companies, mainly active in the environmental and irrigation construction sector.

Civic organisations

There are many irrigation management organizations at grassroots (farmers) level in Vietnam with different names (e.g. water user organizations, water user associations, water user groups). In the Mekong Delta they are often called water user organizations (WUOs). In most of the cases the Irrigation Management Companies manage primary and secondary canals while smaller canals are managed and maintained by the WUOs. The WUOs have been created spontaneously and there is no legal framework for such organizations. As a result they do not receive any capital support from the government, causing low water use efficiency and limitation of hydraulic works maintenance. Additionally, local authorities have not been properly concerned to form WUOs and farmers are not aware of their interests and duties when participating in these organizations.

9.4 Financing structures

For irrigation works in the Mekong Delta the central government ensures financing for water supply through primary canals, while the secondary canals are invested by the provincial government. Farmers are responsible for tertiary and lower level canals through cooperatives, collective and private organizations.

Most budget is allocated for new infrastructure. However, funds for operation and maintenance often fall short to prevent downgrading of the investments.

An important role in irrigation investments has the Central Office for Water Resources Projects (Central Project Office or CPO in short), under MARD. It is an investor for all irrigation projects that are funded by ODA's capital. Its main functions are mentioned in Decision No. 3239/QĐ-BNN-TCCB on October 22nd 2008 and can be summarized as follows:

- Leading relations with donors to deal with procedure, implementing and organization of projects.
- Organizing, operating programmes and projects according to the Vietnamese and ODA regulations.
- Managing international consultative activities in construction in Vietnam.
- Coordinating with Provincial People Committees where the project is implemented to solve particular issues within each project.

9.5 Bottlenecks and challenges in water governance

Water governance in the Mekong Delta has been improving over the years to meet the needs for managing its dynamic development. However, there are still many challenges for the government at all levels to improve water governance. A list of the major problems and issues is given below.

- Legal and policy frameworks contain many gaps, duplications and inconsistencies.
- Institutional arrangements suffer from overlaps and even conflicts between and among the related agencies. For instance there are several overlaps between the roles of MONRE and MARD. For example, in 2006, MONRE published the "National Water Resources Strategy towards the year 2020" while MARD also issued its own "Strategy for Sustainable National Water Resources Development and Management". In terms of water resources planning both ministries operate their own institutions, the Institute of Strategy and Policy on Natural Resources and Environment under MONRE, and the Institute for Water Resources Planning under MARD.
- There is weak collaboration among sectors and provinces. Many stakeholders and agencies at different levels may manage and exploit an irrigation work in different ways. Furthermore, management of water resources is based on administrative boundaries instead of physical water boundaries.
- Operation and Maintenance often does not get the attention it needs. Existing water infrastructure is said to operate at no more than 55-65% of the design capacity.
- Human resources in water management are poor in the Delta compared to the country's profile, both qualitatively and quantitatively. In terms of qualification, only 30% of the staff at provincial level obtained a bachelor/engineer or higher degree. This is the lowest figure among 7 regions within the country.
- The decentralization in irrigation work management has not been defined clearly (who manages what?) causing underperformance of irrigation systems. Additionally, participation of farmers in the irrigation project cycle (planning, design, implementation, operation) is insufficient. In many cases, investments in irrigation infrastructures were made but did not meet community needs.
- Irrigation management has been supplied and driven with the *'command and control'* approach to meet the requirement for rice cultivation purpose mainly, but less attention was paid to other uses as for instance aquaculture.

Colophon

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Southern Institute for Water Resources Planning (SIWRP);
- Water for food
- Water supply and sanitation
- Water infrastructure
- Spatial planning

Can Tho University - Mekong Delta Development Research Institute & Climate Change Research Institute (CTU)
- Water governance

Division of Water Resources Planning and Investigation for the South of Vietnam (DWRPIS)
- Water resources

Sub-institute of Hydrometeorology and Environment of South Vietnam (SiHYMETE)
- Climate change
- Water and environment

These reports, and for each report an Executive Summary, are available as soft copies.
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