Sub-INSTITUTE OF WATER
RESOURCES PLANNING

VIET NAM NATIONAL MEKONG
COMMITTEE

REPORT
ANALYSIS OF SUB-AREA 10V
BASIN DEVELOPMENT PLAN

Ho chi minh city, November 2003

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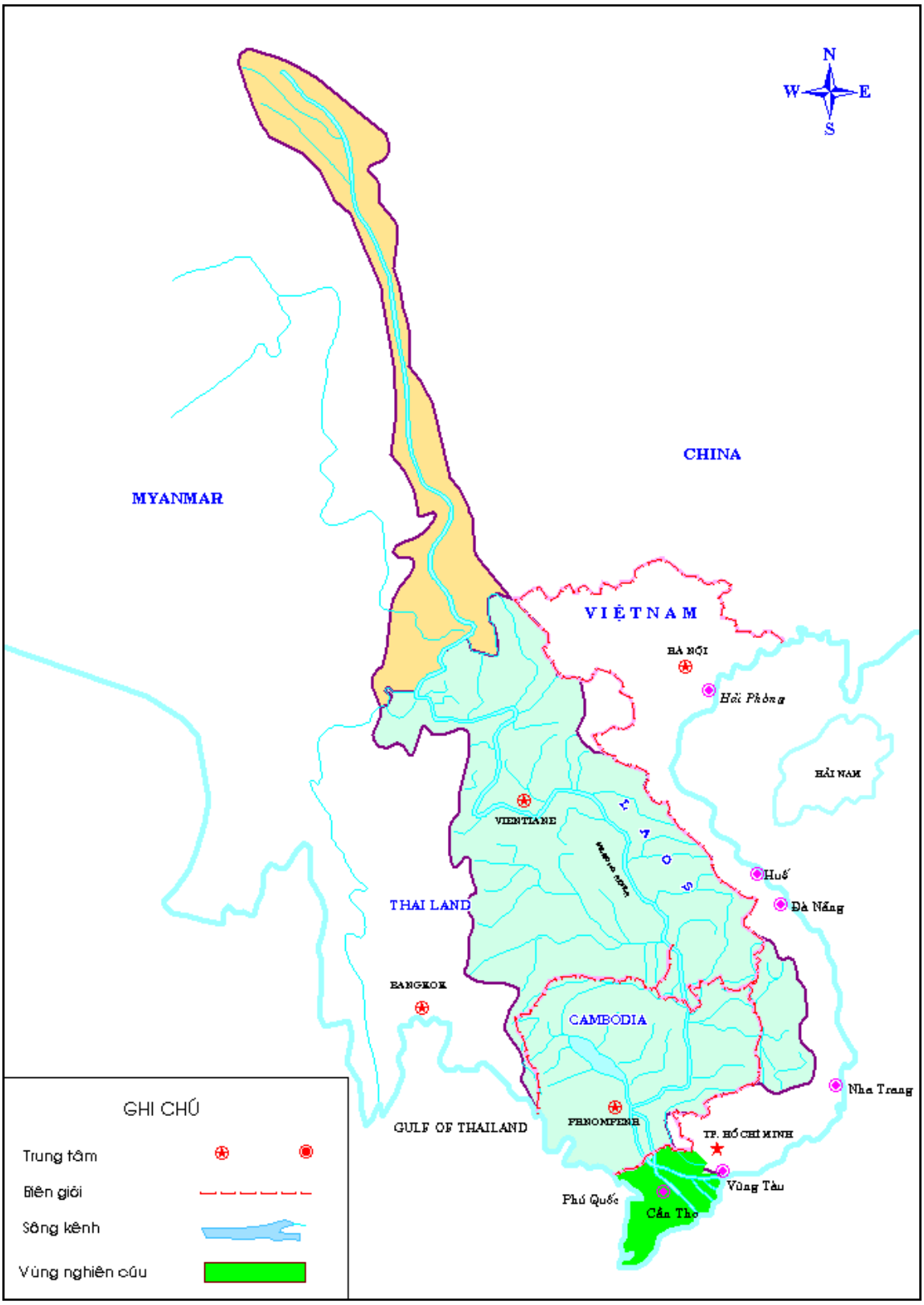
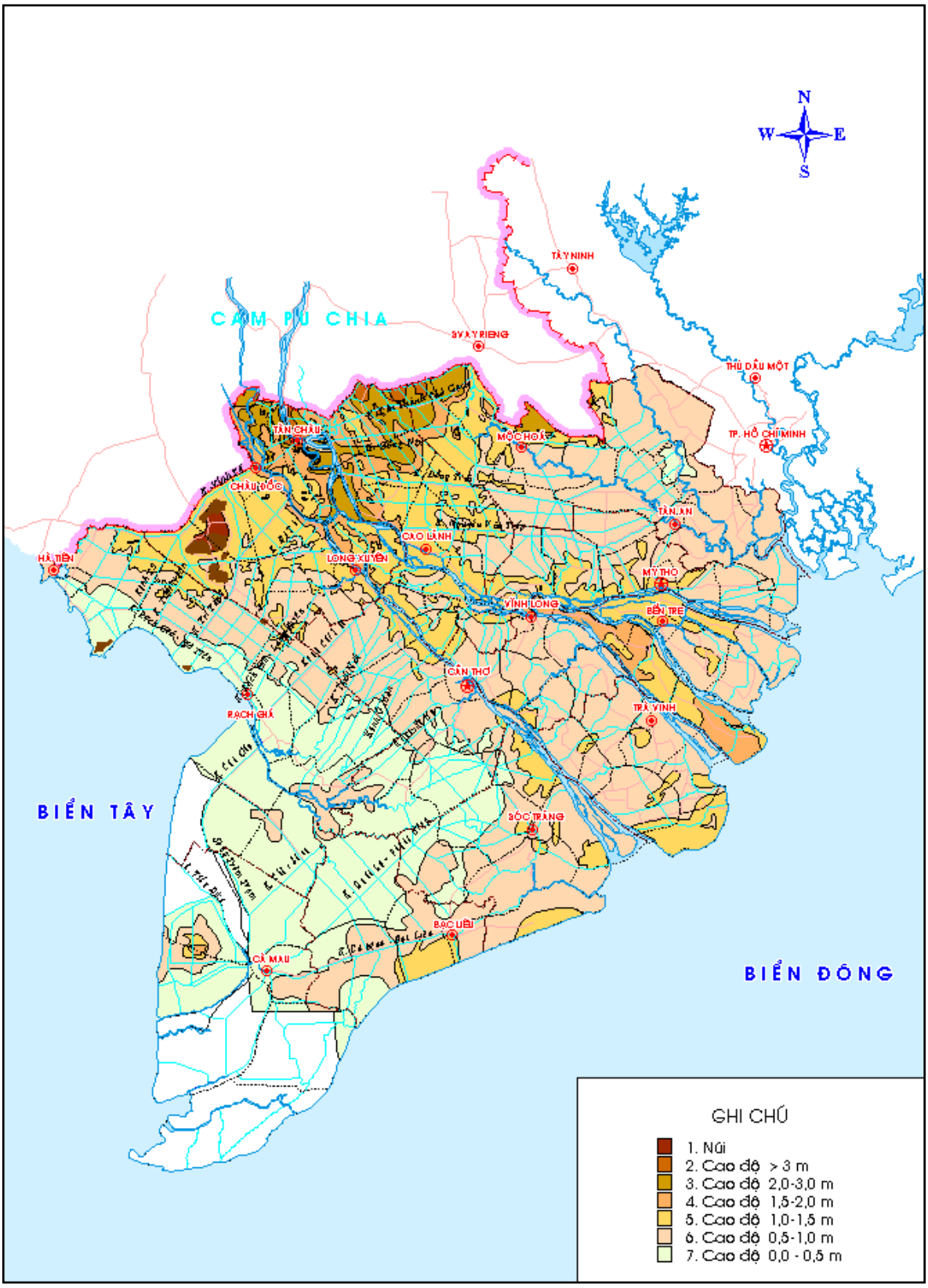
ABBREVIATIONS

10V	Sub Area 10V in Vietnam
BDP	Basin Development Plan
DANIDA	Danish International Development Agency
DARD	Department of Agricultural and Rural Development
DSF	Decision Support Frame
EVN	Vietnam Electricity Corporation
SFIPI	Forestry Investigation and Planning Sub-Institute
GDP	Gross Domestic Products
GOS	General Office of Statistics
ISD	Institute of Strategy Development
IWARP	Institute of Water Resource Planning
SIWARP	Sub-Institute of Water Resource Planning
JICA	Japan International Cooperation Agency
MARD	Ministry of Agriculture and Rural Development
MOFi	Ministry of Fishery
MOT	Ministry of Transportation
MOC	Ministry of Construction
MRC	Mekong River Commission
SNIAPP	Sub-National Institute of Agricultural Planning and Projection
VND	Vietnamese Dong
VNMC	Vietnam National Mekong Committee
EP	Environment Programme

SUB-AREA 10V IN LOWER MEKONG BASIN



topographical map of SUB-AREA 10V



I. INTRODUCTION

I.1 General introduction

The Mekong River with a length of about 4200 km runs through six countries including Myanmar, China, Thailand, Laos, Cambodia, and Vietnam. Total catchment area of the river basin is about 795,000 km^2, of which, the Mekong Delta is about 49,367 km^2. The Mekong Delta of Vietnam or the Cuu Long Delta - the end part of the Mekong Delta extends over 12 provinces including Long An, Tien Giang, Dong Thap, Vinh Long, Tra Vinh, Can Tho, Soc Trang, Ben Tre, An Giang, Kien Giang, Bac Lieu and Ca Mau with a land of about 3.92 million ha, sharing about 79 % the Mekong Delta or sharing 5% the whole Mekong River Basin. The Cuu Long Delta is quite flat area ranging from 0.3-4.0 m.a.s. The land with elevation of about 0.5-0.75m shares about 60%, therefore, floods, which originate from upstream, cause serious inundation in the low areas.

The Cuu Long Delta plays very important role in socio-economic development and is the key area for the national food security strategy. Owing to high potential for agriculture development, the Cuu Long Delta always contributes about half of the national food volume to the country (in year 2000 about 17.5 million tons), 55% of the national fishery and fruit production, 61% of the national export value, and was determined as an area for ensuring the national food security.

Since 1986, the economy of the Cuu Long Delta has been improving rapidly. With a limited investment fund, but due to the positive and prompt reaction of the Doi Moi policy (Innovation Policy) the agriculture and fishery production of the Cuu Long Delta has been quickly increased promoting the increase of processing industry sector, transportation, and national and international trade sectors. This success contributed to the national economy stability. In year 2000, the GDP per person in the Cuu Long Delta reached to 280 USD/person.

The Basin Development Program (BDP) is aimed at contributing to develop sub-areas through out the establishment a planning process and framework for sustainable investment and development. The Mekong Agreement in 1995 has identified that BDP is " the general planning tool and process that the Joit Committee of the Mekong River Commission would use as blueprint to identify, categorise and prioritise projects and programes to seek assisstance for and to implement the plant at the basin level".

- ***The objectives of the sub-area analysis is aim at***

  - Analyzing, reviewing all the existing data, information, analyzing the socio-economic situation of the sub-area, particular 8 focal economic sectors under the BDP
  - Determining “necessarily concerned issues” of the sub-area, in particular, the issues related to water utilization, and trans-boundary impacts; and determining opportunities, potentials, trends, and development related to water utilization of the sub-area
  - Determining development objectives and elements forming development scenarios.

- ***Scope of the sub-area analysis***

The analysis of the sub-area will cover the development situation of eight economic sectors including irrigated agriculture, watershed management, hydropower, fishery, navigation (water transportation), tourism, water supply, and flood mitigation and management. Other cross-cutting issues interlinked with the development including the environment, human resources development, socio-economy, and public participation will be included. The study on this sub-area analysis is concentrated on only the Cuu Long Delta, which is located in the Vietnamese territory.

- ***Cooperation among MRC programs***

  - The sub-area 10V planning, in particular, and the BDP for the Lower Mekong Delta, in general, is an important program of the Mekong River Commission (MRC). Therefore, the Sub-area 10V planning will be closely coordinated with other programs such as the Water Utilization Program (WUP), the Environment Program (EP) of MRC as well as other programs like the "*Capacity Building program for River Basin Organization of the Cuu Long Delta of Vietnam*" supported by Australia; the *"Support to Capacity Building of Water Resources Institutes"* supported by DANIDA; the Hunger Clearance and Poverty Mitigation Program of the Vietnam Government, the Sea Dikes and River Mouth Bank Plan; the Flood Damage Mitigation Program, etc... BDP will be formed based on the national policy for socio-economic development, and will support to development activities such as balancing the socio-economic development with other environmental and social issues in a reasonable manner. In addition, the implementation of BDP will consult public involvement to ensure widely agreement on the objectives set out, and other sectors' development strategies.

  - National policies and sectors development strategies, development priorities for each local will be the key issues, upon which the BDP as well as the sub-area analysis will take into consideration. Bilateral development policies between Vietnam and Cambodia on socio-economic development for areas adjacent to the border will be prioritized to take into account in the analysis and will be used to form development scenarios for the sub-area.

  - Trans-boundary impacts between sub-area 10V, 9C and 10C will also be studied and considered in the plan; current impacts will be analyzed in the analysis of the sub-area, particularly impacts on the ecosystem due to exploitation activities in the upstream as well as right in the Cuu Long Delta. Development needs, which relate to basin development plan and relate to the sub-area will be considered or supplemented to the BDP through out other programs of MRC.

- ***Approach***

  - Basin development plan concentrates on issues such as development opportunities, potentials and constraints occurring during the implementation of the water resources development of the sub-area. Consideration on the sub-area issues, sector development plans of the sub-area, national plans and programs, and other concrete requirements of the nation and sub-area will be taken into account. The approach makes sure that interlinks between the mainstream and its tributaries, the issues of the sub-area, inter-sub-area, the nation and inter-nations will be considered. The process of the plan comprises 5 stages as follows:

- ❖ Stage 1: Sub-area analysis;
- ❖ Stage 2: Development scenario analysis;
- ❖ Stage 3: Strategies formulation;
- ❖ Stage 4: Compilation of long-list of programs and projects;
- ❖ Stage 5: Compilation of Short-list programs and projects.

- Process of plan, criteria system for assessment and comparison of programs, project as well as selection of priority programs and projects will be figured out.

- ***Implementation organization***

A study team of Sub-Institute for Water Resources Planning was established to implement the Study on Analysis of Sub-area 10V. The Team has relation with and consults the National Mekong River Committee of Vietnam to implement the above-mentioned works. The Sub-Institute of Water Resources Planning are responsible for the study and joined-study organizations include Sub-NIAPP, Sub-Institute for Forestry Planning, Fishery Planning Institute, Ministry of Plan and Investment, local departments (Provincial Department of Agriculture and Rural Development, Departments of Science and Technology, Departments of Plan and Investment) of 12 provinces including Long An, Tien Giang, Dong Thap, Vinh Long, Tra Vinh, Can Tho, Soc Trang, Ben Tre, An Giang, Kien Giang, Bac Lieu and Ca Mau. Specially, the implementation of the study has been guided, and monitored by the Vietnam National Mekong Committee.

The study team includes 8 specialists from SIWRP as follows:

1. To Van Truong – Director of SIWRP.
2. Luong Quang Xo – Water resources expert, Team Leader.
3. Ho Trong Tien – Irrigation expert, member.
4. Nguyen Huu Tan- Hydraulic works expert - member.
5. Tran Duc Dong- Hydraulic model expert -member.
6. Tran Minh Khoi –Environment expert - member.
7. Nguyen Dinh Tien – Hydrology expert -member.
8. Nguyen Tan Ha – Database expert - member.

The project of BDP will contribute to strengthen the cooperation among sub-areas by establishment of a planning process and a reasonable framework for investment and sustainable development. BDP will establish a framework for water resources plan aiming at efficient use of water resources, protection of the environment, and promotion of the society equitableness.

I.2 Context and Scope of Sub-area analysis

The Cuu Long Delta is located in the southernmost Vietnam bordered with the border of Vietnam and Cambodia and Ho Chi Minh City in the north, the East Sea in the east and the south, the West Sea in the west. It covers provinces including Long An, Tien Giang, Dong Thap, Vinh Long, Tra Vinh, Can Tho, Soc Trang, Ben Tre, An Giang, Kien Giang, Bac Lieu and Ca Mau with a land of about 3.97 million ha.

In the flood season: Flooding in the Cuu Long Delta originates from two sides including (a) flows from the Hau River and the Tien River and (b) floods overflowing across the border

of Vietnam and Cambodia into the Plain of Reeds and Long Xuyen Quadrant. In the beginning of the flood season (from June to July), floods from the Tien River and the Hau (Bassac) River flow into the Plain of Reeds and Long Xuyen Quadrant through canal system. When the water level at Tan Chau is over 3.0 m (from end of July to begin of August) floods flow across the border of Vietnam and Cambodia into Plain of Reeds and Long Xuyen Quadrant that are also the main reason of inundation of the Cuu Long Delta. According to flood studies and measurements, the flood which flows into the Cuu Long Delta, through the two main rivers is about 75 %, and about 25 % through the border. On the other hand, in the years of low peak flood, but late-July and early August floods are high and early occur then the effects to the Summer-Autumn crop production is also very seriously.

In the dry season, the flow of the Tien River and the Hau River ant Tan Chau and Chau Doc is only about 2000 m^3/s resulting in salinity intrusion further inland covering an area of about 1.4 million ha. If the upstream countries increase water abstraction for winter-spring crop cultivation, the salinity intrusion from downstream happens more seriously. Therefore, the water utilization in the Cuu Long Delta, in particular, and in the Mekong Delta, in general, must have a cooperation aiming at the common vision of the whole basin. In the other words, the water resources development in the Cuu Long Delta, when development scenarios are initiated, must consider this organic relationship.

However, the Cuu Long Delta located downstream of Mekong Delta has both natural favorable conditions and constraints causing by hydrological regime, and water exploitation from upstream, and tidal fluctuation from the East Sea and the West Sea. Therefore, the Cuu Long Delta has faced to contradictions of socioeconomic development and sustainable development of the environment and the ecology.

For development, the Cuu Long Delta has encountered a number of constraints caused by the nature resulting in difficulties for agriculture development, in particular, and for socio-economic development, in general. The major natural constraints of the Cuu Long Delta include: (a) the impacts of floods over 1.9 million ha of the upper part of the Delta; (b) salinity intrusion over 1.4 million ha of the coastal area; (c) acid sulfate soils and acid water movement over 1 million ha of low land areas; and (d) shortage of fresh water for cultivation and domestic uses over area of about 2.1 million ha that are from rivers and/or near the coast.

The population of the Cuu Long Delta comprises of about 13.6 million rural people (sharing 82.9%), and 3.08 million urban people. The number of people per household averages to 5.4 people, rather high in comparison with that of the nation. The population growth rate is estimated at about 2,4%/year, with a density of about 412 people/Km^2, which unevenly distributed over the area. The highest population density is concentrated in the provinces along the Mekong River and the Bassac River, and the lowest is located in provinces which are far from freshwater-sources like Ca Mau, Bac Lieu, Kien Giang and Long An. The population in labor age is about 9.7 million people.

The education level of the sub-area is considered as low level in comparison with that of the nation. The percentage of the people, who are not graduated primary school, is 32,8% (the nation 15,8), high school 7,9% (the nation 16,5%). As well, non-specialist is at 90,2% (the nation 80,8%), the rate of graduated-primary-school or over is 6,7% (the nation 11,2%). Therefore, to develop the Cuu Long Delta in general, and the inundation area, in particular, a policy for education and improvement of technical knowledge, etc..., is needed.

Poverty and hunger: In comparison with the nation, the rate of hunger and poverty of the Cuu Long Delta is still high with a figure of 17.5%. This rate concentrates to groups of people, who have less land and lack of food, and concentrates on people, who live in remote areas where infrastructure and services are lacked.

The opportunities and challenges of the sub-area are:

- Changes in economic structure in the sub-area, particularly changes in agriculture production, of which the government promotes in trend of industrialization, modernization, and commercialization, have increased the water demands.
- Growth of population, increasing urbanization, increasing uses of agro-chemical substance, that affect to ecology and increasing of pollution of water sources.
- High poverty and hunger rate in most of the rural areas, remote areas as well as the un-balance between the rural areas and urban areas, un-reasonable uses of land, shortage of technical knowledge, and insufficient infrastructures and public services have contributed to the increase of the hunger and poverty
- Rise of sea water level as well as the increase of water abstraction during dry season has increased salinity intrusion further inland affecting to production and living condition.
- The planning for socio-economic development is revealed as perplex, non-concentrated, weakness in coordination among sectors.
- The investment is non-synchronic between development of water resources, fishery with transportation, electricity network, food production areas and forestry.

II. GENERAL ECONOMY OF THE NATION AND THE MEKONG DELTA OF VIETNAM

II.1 Economic growth and structures

During the last five years, the economy of the world and the Southeast Asia countries has grown slowly, while Vietnam has a growth rate of economy rather high. For instance, GDP reached a rate of 7.04% in 2002 and 7,2% in year 2003, ranking the second in the region after China. The Cuu Long Delta has a progress of improving economy frame at a low level and unstable in comparison with other areas of the nation. The rate of agriculture, forestry and fishery production decreases from 62.1% in 1995 to 50.9% in 2002. Correspondingly, the rate of the industry and the construction increases from 14,1% to 19,8% at the same time, and the service production from 23,8% to 29,3%. The service sectors, particularly agriculture, forestry and fishery services are still weak. The rate in terms of "content of science" in each product is still low. Urbanization rate of the sub-area 10V increased from 15.7% in 1995 to 18.1% year 2001 is quite lower than that of the whole nation (from 20.7% to 24.8% at the same time).

Table 1 Growth rate and economic structure

Index	Growth rate %		Economic structure %	
	1996 - 2000	2002	1995	2002
Nation	6.82	7.04	100	100
Agriculture, forestry and fishery	4.0	4.1	36.1	24.6
Industry-Construction	10.5	9.4	26.9	39.2
Services	5.7	6.5	37.0	36.2
Sub-area 10V	5.5	6.34	100	100
Agriculture, forestry and fishery	3.8	4.35	62.1	50.9
Industry-Construction	9.1	11.56	14.1	19.8
Services	5.6	6.48	23.8	29.3

Source: Institute of Strategy Plan – Ministry of Plan and Investment

The above table shows that the growth rate of the Sub-area 10V is lower than that of the nation but in comparison with itself from 1996 to 2000, the sub-area has increased in all three sectors as follows:

- ***Agriculture, forestry and fishery:*** The value of the sector production in 2001 and 2002 has grown at high rate due to changes of agriculture cultivation to fishery culture. In economic structure aspect, GDP of agriculture, forestry and fishery sectors still has contributed to a high rate. Recently, decreasing Catfish (Basa) consumption as well as no consumption markets for agriculture and fishery products has obstructed the progress of development of the sub-area. In the year 2003, GDP of agriculture, forestry and fishery sectors is shared of 73.5%, 1.5% and 25% respectively.
- ***Industry and construction:*** The production value of industry and construction sectors has increased ***only*** at a rate of 11.56%, at the same time, GDP of industry production shared only 19.8 %. In comparison with that of the nation, this growth rate is still low. The increase is mainly due to the effort applying the law of business and policies of mobilization of interior investment capital.

- ***Services:*** In year 2002, the service sector has prosperity. The value of trade, hotel, restaurant, transportation, telecommunication, tourism has increased at rather high rate (6.48%). Particularly, GDP of service sector has reached a rate of 29.3%. However, this is still low in comparison with that of the nation. It is necessary to speed up urbanization and kind of ecological tourism in near future.

II.2 Economic sectors

II.2.1 Agriculture

Agriculture production of the sub-area 10V has developed rapidly and steadily in trend of diversification of cropping. It shares a high rate in terms of agricultural products in comparison with that of the nation as follows:

- Yearly agriculture GDP reached 5.8% in period of from 1990 to 2000 and 5.18% from 1996 to 2000.
- Economic structure of the sub-area, particularly in recent years, has changed in trend of increasing fishery production. Within the agriculture sector, the cultivation has decreased from 77% in 1995 to 73% in 2000 (and 73.7% in 2003), the breeding increased from 19.6% in 1995 to 21.3% in 2000 (and 20.4% in 2003), and service from 3.5% to 5.7% (5.9% in 2003).
- Having formed specialized cultivation areas, where have high potential in comparison with other areas of the nation, and shared high rates in terms of agriculture products such as over 50% rice production, over 60% of fruit and coconut, about 40% of sugarcane, 20% of meat production and 60% value of fishery production.

However, agriculture production has encountered a number of difficulties in terms of consumption markets, particularly changes in export markets. While agriculture production of the Cuu Long Delta has carried out at small farming scales with the limited possibility of support of the economy to exported agriculture product.

The sub-area 10V produces a diversified agriculture product sharing about 40% the value of the agriculture-forestry-fishery production of the nation. Of that value, rice production (17.4 million tons of rice in 2002) took over 50% the total production and 90% exported value of rice of the nation; fishery shared 55% in terms of production and 61% in terms of the exported value of the nation.

Table 2 Cropping areas in 2002

Crop	2002 (1000 ha)		Ratio (%)
	Sub-area 10V	Nation	
Rice	3814	7,484.6	50.9
Maize	25.8	726.9	3.5
Cotton	0.4	27.3	1.4
Fruit	223.2		

The change in agriculture structure was in trend of decrease of agricultural weight, increase weight of the value of the breeding and service sectors, although the target has gained at a low rate. In comparison with that of the nation, yield of cultivated crops and the value of agriculture production in each land unit have increased. Income of agriculture labor has increased correspondingly (from 6.95 to 10.83 million VND /labor /year). A number of

specializing crop areas like special rice, sugarcane, fruit, etc. have been formed initiating an important basic condition for development of commercial agriculture production in connection with processing industry, improving local people's lives.

However, a number of potentials of the sub-area 10V in terms of agriculture production are not yet explored reasonably. Rate of area of high quality rice, which needs for export, is still at low, and post-harvesting technology needs to be improved. In the sub-area 10V, the growth rate of pigs and poultry averages to 4.5 – 4.8%/year, cattle decreases at rate of about 11%/year that needs to be improved. On the other hand, due to slow improvement of socio-economic, and culture situations, a number of ecosystem problems have occurred at a extremely rate. Particularly, change of mangrove forest for shrimp culture in the coastal area affecting to the coastal ecosystem, water pollution, salinity, acidization,... needs to be studied in the plan.

II.2.2 Forestry

The sub-area 10V is the rice bow of Vietnam but often affected by floods and salinity. In this area, forestry sector shares a low rate in compare with other economic sectors and is in trend of decrease. The area of forest has decreased from 348,700 ha in 1990 to 273,000 ha in 1998 and slightly increased to 333,800 ha in 2002 due to the policy of reforestation of bared land and hills. The coverage rate at this time is about 8.4%. Due to fire disasters at the beginning 2002, there remain only 51400 ha of the natural forest. The reason of decrease of the forest area is due to lack of synchronous development policy such as reclaim policy, a policy on encouraging food crop cultivation, fishery culture …

Table 3 Forest area in 2002 (1000ha)

Forest	Nation	Sub-area 10V	Rate %
Total area	11,523.8	333.8	2.9
Natural forest	9,586.5	51.4	0.5
Replanted forest	1,946.3	282.4	14.5
Un-used land	7,699.4	247.3	3.2

Source: Sub-Institute of Forestry Investigation and Planning No 2

II.2.3 Fishery

Fishery capture: In 2002, 8 coastal provinces in the sub-area 10V had captured 1,035,388 tons sharing 65.3 % of the total capture production of the nation. Inland production of fish capture of the sub-area was 50,000 tons/year, of that figure; river fish was about 30,000 tons/year.

Aquaculture: Aquaculture area in the sub-area 10V is about 571,700 ha sharing 70% of the aquaculture area of the nation. It is different from traditional ways of fishery capture in large lakes, pond aquaculture, and cage fishery, which limit to supply for inner/local needs of the Central Highland area, the potential of large water surface area of the Sub-area 10V has been used efficiently for a decade ago. The fishery production of the sub-area 10V in 2002 was 1,327,437 tons, increasing 2.7 times, and sharing over 60% of the exported fishery production of the nation.

Particularly, there was a change of rice cultivation to shrimp/fish culture (about 200,000 ha) in year 2000 and 2001. Main product was catfish with high value contributing to the export.

Table 4 Present situation of fishery production

Items	Nation	Sub-area 10V	
		Production/area (ton/ha)	Rate compared with that of the nation (%)
Total production in 2002 (ton)	**2,578,500**	**1,327,437**	**51.4**
Marine fishery capture	1,797,100	848,651	47.2
Aquaculture	781,400	478,786	61.2
of which: Shrimp	186,700	144,849	77.6
Aquaculture Area, ha	**819,800**	**571,700**	**69.7**

Source: Sub-Institute of Economy and Fishery Planning

Owing to large fishery production and developed infrastructure for fishery processing, the total fishery export value of the sub-area 10V has contributed 51.4% to the national export fishery value. However, situation of uncontrolled fishery development in the sub-area is a reason, which affects to the fishery environment such as degradation natural sources for fishery, pollution of aquaculture environment, degradation of aquatic environment.

II.2.4 Water transportation

Vietnam is the nation with high potential for water transportation. River networks of the Red River Delta in the North and the Mekong Delta in the South cover almost fields of economic, political, culture, science, and population of the nation, creating a favorable navigation system for socio-economic development.

Table 5 Main navigation routes of the sub-area 10V

Navigation line	**Length** (km)
National Lines (Ship 300 DWT, Barge 1000DWT)	
Ho Chi Minh City – Ca Mau	356
Ho Chi Minh City – Kien Luong	319
Ho Chi Minh City – Plain of Reeds – Long Xuyen Quadrant	288
Line in Mekong River and Bassac River (ship 3000-5000 DWT)	
Mekong River from Tieu River Mouth to Vietnam – Cambodia border	227
Bassac River from Dinh An River Mouth to Vietnam – Cambodia border	228
Lines linked with harbors	
Line linked Kien Giang with Ca Mau	
Line linked Dai Ngai – Bac Lieu - Ca mau	
Line linked Quan lo - Phung Hiep	

Source: Southern Transportation and Construction Consultation Company

Navigation network of the Sub-area 10V is the most enormous and diversification one of the nation with an approximately 13,000km, which can be used for transportation (of which about 5000Km for ship/boat of about 30 - 50T). At present, about 2,312 km of the Mekong River, the Bassac River and main routes from Ho Chi Minh City to Ca Mau, Kien Luong

sharing 20% of the total length of the whole sub-area are managed by the central government.

Because of under developed road network; without railways, and due to high potential for navigation, investment for development of navigation network of the sub-area during the past years has shared a high rate in transportation development. In year 2002, transportation volume of the river transportation of the sub-area was 21,385 thousand tons/km.

Table 6 Comparison volume of freight of water transport with total volume of freight in the sub-area 10V

Items	1994		1995		1996		1997	
	1000T	Mil.TKm	1000T	Mil.T.Km	1000T	Mil.T.Km	1000T	Mil.T.Km
Volume of freight	11997	1274	13406	1472.5	14831	1636	16299	1769
Of that, water transport	7433	954.6	8247	1096	9150	1193	10102	1318
Rate (%)	62	74.9	61.5	74.4	62	72.9	62	73

Source: Southern Transportation and Construction Consultation Company

Together with navigation network, system of harbors and stations has been developed and diversified in terms structures, but still in poor condition in terms of technical facilities. The group of harbor system in the Mekong River, the Bassac River with Can Tho port considered as the center, is the most important. In addition, there are some other harbors such as My Thoi harbor located in the right bank of the Bassac River (1.2 mil.T/year for ship 2000 DWT); Vinh Thai harbor in the right bank of the Co Chien River (0.3 mil.T/year, for ship 1000-2000 DWT); My Tho harbor in the left bank of the Mekong River (0.7-1.0 mil T/year, for ship 1000-3000 DWT); Cao Lanh habor in the left bank of the Mekong River (0.3 mil.T/year, for ship 1000 DWT) and a number of local harbors such as Ca Mau , Dai Ngai (Soc Trang), Nam Can, Ong Doc, Hon Chong (Kien Giang) ....

However, in the water transportation in the sub-area has encountered number difficulties as follows:

- Although there are a number of navigation routes, most of these are used naturally, depending on topography of river channels, water levels (large difference by seasons), and sedimentation regime
- A number of obstacles like sunk ships, bridge pillars, underwater reefs and fail river embankment, and even structures that encroach river banks (such as houses, fish cages) are not fully controlled and managed that caused a number of problems for the navigation and polluted the environment. There are a number of low free-broad and old bridges, which have narrow width and low clearance that also limit the navigation.
- Facilities and infrastructure of harbors are in out of date condition. Ships are transported at a low speed due to capacity and limited engines. Investment for harbor development was not corresponding to the potential, which the sub-area has (about 2% of total investment of the transportation sector).
- Rate of un-educated human resources is rather high. People, who involve in navigation activities, are mainly poor people living based on rivers with low education. Therefore, their knowledge on law and technical and science are limited.
- There are many harbor and station systems but spontaneous development. They have been built but not following any integrated plan, small capacity, mainly manual loading and unloading. Therefore, management and coordination in production are

difficult. On the other hand, due to not having reasonable investment yet, there is a lack of equipment for loading and unloading.

- Transportation equipment (wood skin sharing 40-45%, steal skin of about 50%), is limited to capacity, un-safety and low speed.
- Management: At present, about 18-20% is managed by central government organizations, the remaining are managed by local authorities; therefore the management is still in poor state. In the flood season, when large inundation happens, transportation equipment could not identify routes causing difficulty for transportation and loading unloading.
- Activities of water transportation, in fact, have caused pollution for the environment such as dirty dust, chemical substance spill/scatter, oil spreading, odor, waste waters at harbor areas; accidents like oil/chemical spreading; disorder of heavy metals during dredging, which also caused problems for fauna/flora existence.

II.2.5 Tourism

The Cuu Long Delta is one of cradles of the culture of the Vietnamese communities, with many valuable cultural and historical heritages, which contribute to the sources of the diversified tourism of the area. The tourism of the area is mainly cultural, ecological and historical tourism such as ecological tourism in mangrove forest (Ca Mau), marine ecological area, coral ecology (Phu Quoc Island), swampy/wetland ecology, and famous natural beauty areas. However, tourism infrastructures, particularly hotels, restaurants, tourist services, etc., are limited. There are about 500 hotels with about 13,750 rooms in over the Sub-area 10V (sharing about 18% total hotel rooms of the nation); restaurant systems have just developed in recent years, and did not qualify to serve for high requirement tourists. Tourist services are not diversification; services activities with community participation are in poor arrangement, monotonous and un-attractive.

In order to develop the tourism of the sub-area taking advantage of the famous river and canal networks, the tourism sectors of the sub-area have implemented many studies and developed step by step. On the other hand, owing to the assistance from the government in terms of funds and technical aspect, the tourism, in fact, has became an important sector in contributing to the gross production and creating jobs for local people.

II.2.6 Power

Total installation capacity of all power stations in Vietnam is about 8,750 MW. Of which, hydropower is about 48.8%, thermal power 20.4% and gas turbine and diesel power 30.8%. Over the last 10 years, power production of Vietnam has increased at a rate of about 12% and production scale has increased 3.5 times and annually power generation is about $26{,}594.10^6$ KWh. The average power consumption per person has increased from 113 to 341 KWh/year. Structure of sources of power generation has changed dramatically such as power generation by gas turbine increased from 5.4% to 23%, power generation by hydropower decreased from 61.9% to 54.7% and by thermal decreased from 32.7% to 22.3%. The sub-area 10V only has potential for development of gas turbine and thermal power plants. The potential of these powers in the sub-area 10V is estimated at 2070 MW with 3 power plants such as O Mon I (600 MW), Ca Mau (720 MW) operated after 2005 and O Mon II (750 MW) after 2010.

II.2.7 Water supply

Up to date, 61 towns and cities have water supply systems consisting of about 241 water plants with a total capacity of 2.96 million m^3/day. Rate of clean water supply is estimated at about 50-60% (60-80litter/person/day). During the last some years, the Government has invested to construction of urban water supply system by the national funds, ODA, and other international donors. However, due to the characteristics of water sources and the water losses during the operation, there is still a lack of water supply during the dry season. At present, all cities, towns in the sub-area have about 53 water supply systems with a total capacity of about 242 000 m^3/day.

Table 7 Existing situation of water supply

Region	No. Plants	Capacity 10^6 m3/day	Standard l/person/day	Rate of accessed %	Sources
Nation	241	2.96	60-80	50-60	Surface and GW
Sub-area 10V	53	0.241	60-70	40-60	Surface and GW

The issue on drainage of wastewater and environment sanitation of urban areas in the sub-area 10V has solved reasonably. However, the state of untreated wastewater causing pollution is rather popular. Specially, there are about 40% of urban areas, where wastewater from tank latrines, two-section latrines and public toilets are not treated.

Rural population in the sub-area 10V is mainly used water from rivers, canals for domestic uses; rate of accessed clean water is very low.

II.2.8 Flood control

Eight among 12 provinces of the Cuu Long Delta have affected by floods from the Mekong River. The hydrological regime in the inundation areas has strongly affected by flows from the Mekong River, tides from the East Sea, the West Sea and inland water level regime. The flood season of the sub-area is almost the same as rainy season (from July to December). Flood flows in the sub-area originate from two sides; one from inundation areas in the Cambodia territory (about 10-15%), the other from the Mekong River and the Bassac River (85 - 90%). Most of floodwater flows out the East Sea; the remaining debouches into the West Seas and Vam Co River.

The trend of the floods from Cambodia to Long Xuyen Quadrant and Plain of Reeds has increased in terms of flow discharge but the characteristic of these floods is low in the main river and higher in the farm field. Particularly, due to the flows from Cambodia side higher than the rich-sedimentation flows from the Mekong River and the Bassac River, therefore, the sedimentation, which contributes to fertilizer for soils in this area, is reduced.

Floods flowing into the Mekong Delta bring a number of benefits such as sedimentation, extending the coastal area of the Delta into the seaside, contributing fertilizer for soil, supplying more fishery sources, improving the environment, field sanitation, and aquaculture. However, floods cause a number of constraints in exploitation of land and urbanization of the rural areas, development of rural areas in trend of civilization, and modernization. Therefore, flood control plan for the Cuu Long Delta has closely related to strategies of water resources development of the Mekong River basin and the Mekong Delta. Hence, plan of water resources development and protection has to be developed in

close coordination with other plans such as transportation plan, construction plan, fishery and agriculture aiming at civilization rural areas. The key point of the flood control plan is to find reasonable measures to drain floods from the upstream into the seas, the Vam Co River, to bring back to the Mekong River and Bassac river, and to reduce effects/impacts to the production, the population and the environment. During the floods in year 2000, the damage of properties of the whole Cuu Long Delta was estimated at about 2000 bil. VND and hundreds of people died.

Table 8 Damages caused by high floods

Item	Unit	1978	1984	1991	1994	1995	1996
I. Human/housing							
1. No. of death	Person	87	105	158	407	199	217
2. Damaged house	H.Hold	66010	50504	197477	505906	28240	78859
3. Resettlement household	H.Hold	245500	10744	15600	20125	11431	38735
4. Household needed to be supported	H.Hold					59262	175441
II. Production							
1. Rice area inundated reduced yield	Ha	113600	111879	88837	202189	62399	107707
- Not harvested	Ha	307100	175628	171898	26868	11101	43249
2. Upland crop area inundated reduced yield	Ha						50
- Not harvested	Ha						17466
3. Inundated fruit	Ha						76396
4. Fish pond	Pond					16336	69505
5. Death Poultry/Cattle	Head					242	18965
III. Infrastructure							
1. School classes	Room						11093
2. Pupils has to be absent	Pupil					217412	905302
3. Medical aid station inundated	Station					156	509
4. Canal inundated	m^3					5512226	4431000
5. Damaged Bridges, sluices						2722	24478
6. Inundated stores, offices, ...						372	2411
IV. Erosion land							
Eroded areas	m^2					506880	356935
1. Effected household	Household						5543
Total	10^9 VND	2469	2492	2217	2284	700.544	2182

Source: Provincial reports

- ***General analysis on development situation and issues***

  - The problem of products consumption is not yet solved resulting in difficulties for farmers in selling their production and causing loss for farmers due to price reduction from merchants.
  - The forecast of products consumption capacity is not yet well implemented resulting in unstable development and production, and causing large amount of losses. Sometime, there is no product for consumption. And sometimes; product could not be sold.

- Management task is not yet carried out well including the management of natural resources such as land, water resources, biological resources and the management of socio-economic sector, resulting in dramatically destroy of forest, exhausted fishery resources, and that policies are not fully functioned.
- Slow development of industry sector, particularly processing industry for agriculture production, which result in limitation of products consumption of farmers and consequently reduce the income of farmers because of production in raw state and having low price.

- ***The issues***
  - Road systems are under developed. This issue affects largely to rural development including economy, culture and society.
  - Living conditions of the local people are still in difficult situation due to poor environment; lack of clean water, power for domestic uses; inundation in long period of time. In annually inundated areas, a large amount of damage still happens. In high flood years, hundred of thousand households have to resettle, therefore, no sustainable living condition are existed.
  - Lack of investment capital.
  - Difficulty in production consumption

III. BASELINE STUDY OF SUB-AREA 10V

The analysis of the economy of the sub-area 10V in the national economic context shows that, the advance of the sub-area is agriculture and fishery development. However, during the development of the socio-economy of the basin, there are some issues, which need to be concentrated to solve, as follows:

- Un-reasonable land use planning, particularly the land use for agriculture and fishery. Sometimes, severe conflicts occur in production.
- Agriculture, fishery – the main economic sectors- have formed a commodity production, but spontaneous production resulting in many difficulties in terms of consumption market, price fluctuation, flooding impact, salinity intrusion, and drought.
- Unreasonable investment structure. Not much attention has been paid to applying science and new technology to production. Matters such as new seeds/breeds, new technique in cultivation and breeding, maintaining, processing have not been invested satisfactorily resulting in reduction of efficiency of large investment such as water resources development.
- Living conditions of local people are still difficult such as high hunger and poverty rate, low education level (just higher than that of the Central Highland), lack of infrastructure for socio-economic development.

III.1 Development Objective, Plan and Policy

III.1.1 General Overview for development by the next ten years

The Cuu Long Delta (the sub-area 10V) is determined as one of pivot economic center of the nation. For development, the sub-area has to exploit the potential, its advance in terms of location, land, water resources, forest, sea, and labors; and promote its advance in rice export, fishery and agricultural production. Due to having started at low level in comparison with other areas of the nation, the sub-area has to speed up the scale of production, quickly increase the production value and then improve the social quality.

The sub-area must continue to play its role in term of largest exporter of rice, other agriculture products and fishery products of the nation. The sub-area has to promote production and improve quality of foods, vegetable, fruit, and fishery commodity. It has to develop processing industry, mechanism for agriculture production, home crafts/industries and services. Taking its advance in agricultural, fishery commodity, it has to take the initiative of exchange of import/export sector and tourism with other countries particularly the Southeast Asia countries. Strongly changing economic structure, increasing rate of industrial and service labors are the things that have to be done. Promoting international cooperation in infrastructure development plan, resettlement plan, and production plan those corresponds to the floods situation and salinity constraints of the area, is also an important consideration.

III.1.2 Socio-economic development objectives

1. Economic growth

- Striving to reach the GDP growing rate of about 1.3 to 1.5 times the average national GDP is one of objectives. Forming modern agriculture, fishery production areas, which have high quality and valuable commodity, high competition capacity; ensure the national food security; and keep amount of exporting 3 million tons of rice, create

special agricultural production, larger amount of agriculture and fishery commodity in the nation, is an important objective of the economic development. The sub-area is striving for increasing industrial production at a rate of 14-16%/year, trying to reach the industrial GDP at a rate of 33-34% of the total GDP. Development of processing industry with high level and forming of large-scale industrial areas for gas-power-fertilizer combination are also the main target in the economic development of the sub-area.

- Infrastructures, which need to satisfy the development requirements; to ensure safety and sustainability for local people in the inundation area, are completed.
- It is promoting biological technology.
- Urgent issues in education, society such as living condition of the Khmer people, no-land people, un-employees, illiterate...need to be solved; step by step improving local people' lives in trend of civilization and modernization.
- The Socio-economic development in combination with national safety and security, protection of the nation's sovereignty needs to be implemented.

Table 9 Development indexes by year 2010

Period	1996-2000	2001-2005	2006-2010
Nation	6.9	7.5	7.5
- Agriculture and forestry	4.3	4.0	3.8
- Industry and construction	10.6	11.0	10.0
- Services	5.8	6.1	6.4
Sub-area 10V	5.3	9.1	9.5
- Agriculture and forestry	3.4	5.1	5.0
- Industry and construction	9.2	15.3	15.0
- Services	5.7	11.5	10.5

- Population growth rate needs to be controlled, keeping the population at 17-18 million people in year 2010. Hunger households and special difficult communes need to be cleared out by the year 2005; to ensure 100% communes having 7 kinds of essential infrastructure. Poverty is reduced to 10% (annually reducing about 18,000 households).
- Issues of society, essential infrastructure for local people, improving education standard of local people, particularly ethnic minority groups need to be solved and ensured.

2. Transition of Economic structure

Main objective of transition of economic structure identified by year 2010 is to reduce agriculture GDP to 41%. Industry contribution increases to 25% and service to 34%.

Table 10 Economic structure (%)

	2000	2005	2010
Sub-area 10V	100	100	100
- Agriculture	53.0	43.5	41.3
- Industry	17.9	24.0	24.5
- Service	29.1	32.6	34.2

Sources: Provincial plans

3. Orientation for sector development

- ***Power***

  - Development of thermal power plants O Mon 1, O Mon 2 and Ca Mau to supply for needs of socio-economic development with a total capacity of about 2070 MW.

- ***Agriculture***

  - **Rice production:** Rice production is an advance of the Cuu Long Delta. About 1.8 million ha, where have water resources for irrigation and drainage, needs to be stabilized for double rice cultivation, (of which, one million of high quality production rice for export) in order to maintain rice product at about 17-19 million tons/year. Adjustments of cropping structures, rice seeds, which are suitable for change of floods and markets, and at the same time improvement of technical knowledge, farming technique for farmers have to be done. Rice areas, where yields are low, unstable; areas along river banks; rice areas in suburban, along roads will be changed to other high valuable crops or changed for aquaculture.
  - **Industrial trees:** Enlargement of maize, soybean area, etc... in combination with application new seeds with high yield to supply raw materials for feed production is aiming at. Sugarcane area of about 90,000 ha to ensure materials for existing sugarcane factories is needed to be stabilized. Application of new advance of science, techniques of new varieties in combination with extensive farming to increase yield of sugarcane in year 2005 reaching 80 ton/ha needs to be implemented.
  - Continuation of improvement of processing technology, of which much attention have to be paid in post harvesting technology and processing of coconut, cotton, cassava,...increasing of commodity value and efficiency of land use up to as 1.5 to 2 times as that of the present has be done.
  - Based on science conclusion on efficiency of cotton development in the area, a plan as well as a measure to enlarge of cotton area with high yield in a suitable area is needed. However, the development of cotton production is necessary to be developed in trend of development of cotton rolling industry, and weave fabric as well as development of jute tree in favorable area to supply raw material for wrapping and paper industry.
  - **Fruit tree:** Development of high competition and high valuable tropical fruit like mango, longan, orange, mandarine, pomelo, pineapple, mangosteen, durian and other fruit trees with an existing area of about 240,000ha to double is needed. Area, where frequently inundated, a change of crops and seasonal structure suitable for inundated condition or a measure of food mitigation is needed.

- ***Livestock***

  - It is continued breeding such as pigs, poultry, and beef in order to supply domestic demand and export as well as rapid development of milk cow to supply materials for milk processing factories in Long An, Can Tho and other local areas.

- ***Forestry***

  - Mangrove forest in the southern area, particularly mangrove forest area in Ca Mau, Bac Lieu, Soc Trang, Tra Vinh...is protected and developed and it should be considered as vital issue of the ecology of the southern area. Combination of

protection and development of special used forest, natural protection area, and place-name forest areas as well as development of ecological tourism; as well as increasing development of reforest areas in acid sulfate soil and other suitable areas; newly reforest area of about 100,000 ha of malaleuca in low-land areas in Plain of Reeds, Long Xuyen Quadrant, Western Bassac River areas, and Southern Ca Mau Peninsula is to be carried out.

- Intensification of protection and development of forest areas in inundated ecological areas; reforestation and in combination with aquaculture, improvement of protection capacity, ensuring efficiency of forestry sector and protection of ecological environment have to be done.
- Strong development of trees, which have large branches and could be protected against waves as well as wooden trees in resident areas, along roads, canal banks, housing gardens with a target up to 2010 of coverage areas in the area over 15%, is to be implemented.

- ***Fishery***

- It is promoting the potential and advance of fishery as an largest fishery production area and largest exporter of the nation; development of aquaculture in all water bodies as fresh water, bracket water and saline water, specially development of high value shrimp, fish and other valuable mollusca. According to a general plan of the area and in each local area, a target of aquaculture areas increasing to 700,000 ha by year 2005, capture and aquaculture production of about 1.7 million tons with an export value of about 1,500 million USD is aiming at.
- Aquaculture need to be diversified as interpolated cultivation, rotational cultivation, specialized cultivation, intensive cultivation, semi-intensive cultivation, ecological culture and diversification of people involved aim at gaining high economic results, protection of ecology and environment, reducing risks, rapidly responding to the requirement of international and national markets, particularly high potential markets.
- Development of infrastructure for aquaculture, particularly hydraulic works like dike, canal, sluices, drainage facilities, electricity pumping station,...is prioritized to be implemented for forming project area with large and medium scale areas for aquaculture in order to synchronous investment, and ensure of rapid, sustainable and high efficiency fishery development.

- ***Industry***

Main industrial sectors are concentrated to develop as follows:

- Agriculture, fishery and forestry production processing industry, particularly fishery processing. Improvement of quality of fishery processing enterprises in Ca Mau, Soc Trang, Can Tho, Tra Vinh... is prioritized to be implemented for increasing processing capacity up to 250,000 tons/year by the year 2005;
- Developing mechanism for infrastructure development, agriculture and rural development.
- Producing construction materials for infrastructure and housing development. By year 2005, cement production is to increase to 4.17 million tons, of which, about 3.05 million tons is to be developed in Kien Giang province.
- Regarding to wine, beer and beverage sector, quality improvement, increasing of capacity, and rearrangement of factories in order to improve quality for consumption of the area is concentrated to be implemented. The issues such as consumption

markets, improvement of juices beverage production quality; study to build additional factories with a capacity of over 10 million litters/year to use fruit as mango, longan, orange, mandarin, rebuttal... need to be solved

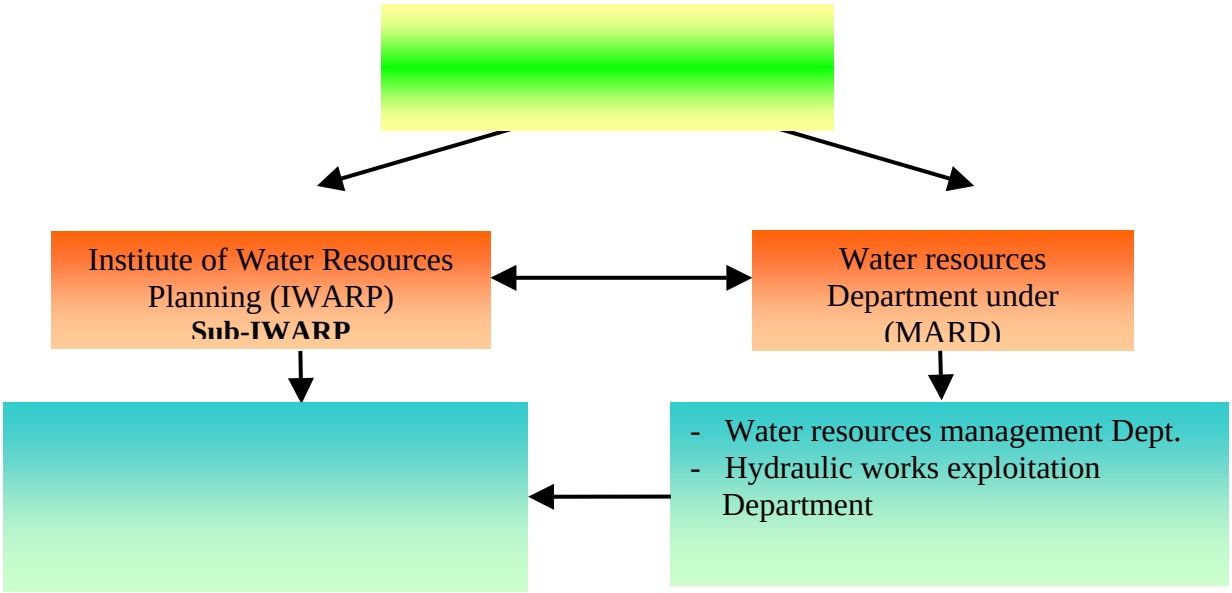
- Developing to attract investors to 6 concentration industrial areas as well as step by step planning to form other medium and small scales industrial areas.
- Continuing forming concentration industrial areas, district industrial areas in towns for demands of storing, processing agricultural products; development of industry, home craft, and handicraft villages to produce production to supply for consumptions and export in order to contribute to promote the rural industrialization process.

III.2 Organization/ Management Capacity

A flowchart for water resources management in Vietnam has shown as in figure below. Ministry of Natural Resources and Environment has a responsibility in licensing water use and wastewater release into rivers. Observing this organization chart, there are some limitations as follows:

- There is no river basin organization
- There is no integrated master plan according to basin boundary (there is only sector and field planning)
- Sector plan is not consistent with river basin plan; no unified consideration is taken into account for.
- Policies under Law on Water Resources are not yet concretization; poor consciousness attitudes of the local people in terms of implementation.

Administration and water resources management



III.3 Socio-Economic Situation And Water Resources Utilization Information

III.3.1 Social situation

- ***Population***

- Population of the sub-area 10V in 2002 was about 16.76 million, including 13.7 million rural people (sharing 82.9%) and 3.04 million urban people. The number of people in each household was 5.4 people rather higher than the average of the nation. The growth rate was about 1.55%/year, with an average density 423 people/km^2, and unevenly distributed over the area. The highest population density was concentrated in provinces along the Mekong River and the Bassac River, and the lowest is located in provinces, which are far from freshwater-sources like Ca Mau, Bac Lieu, Kien Giang and Long An. The population in labor age was about 9.7 million people. Communities living in the sub-area include Kinh people, Khmer, Hoa (Chinese). Of that, the Kinh people were about 88%.
- The education of the sub-area is considered as low level in comparison with that of the nation. The percentage of the people, who are not graduated primary school, is 32.8% (the nation 15.8%); graduated high school 7.9% (the nation 16.5%). As well, non-specialist is at 90.2% (the nation 80.8%); people graduated from primary school or over are about 6.7% (the nation 11.2%). Therefore, to develop the Cuu Long Delta, in general, and the inundation area, in particular, a policy for education and improvement of technical knowledge are needed. Moreover, rate of using agricultural labor hours is low as about 73.1 / 73.9% in comparison with the nation. Therefore, it is needed to change production structure to create more jobs for community.

Table 11 Population of the sub-area 10V in year 2002

Province	Are (ha)	Population (People)	Density (Per./km2)	Urban (people)	Rural (people)	Growth rate (%)
Total	3,962,304	16,767,238	423	3,042,941	13,724,297	1.55
Long An	435,509	1,364,355	313	224,928	1,139,427	1.68
Dong Thap	23,811	1,622,072	501	242,540	1,379,532	1.53
Tien Giang	236,663	1,648,922	697	212,117	1,436,805	1.57
Ben Tre	231,500	1,336,720	577	144,720	1,192,000	1.34
Vinh Long	148,448	1,029,710	694	152,175	877,535	1.33
Tra Vinh	222,580	996,206	448	129,898	866,308	1.35
An Giang	340,623	2,122,539	623	490,430	1,632,109	1.62
Can Tho	298,600	1,878,226	629	460,504	1,417,722	1.51
Soc Trang	322,300	1,226,667	381	226,110	1,000,557	1.75
Bac Lieu	254,188	774,395	305	188,773	585,622	1.16
Ca Mau	521,182	1,165,876	224	220650	945226	1.87
Kien Giang	626,900	1,601,550	255	350,096	1,251,454	1.84

- ***Labor, farmer household's economy and income***

- The sub-area 10V (the Cuu Long Delta) has had a large amount of labors. In year 2000, population in labor ages was about 9.7 million people, (about 4.8 million people in the inundation areas). Of which, agriculture labors shared 70 %. Most of rural population involved in agriculture production activities. Due to uneven population density, farmland for each person was different from area to area. For

instance farmland each person in riparian area of the Mekong River and the Bassac River is about 0.1-0.2 ha/person, and about 0.2-0.4 ha for each agriculture labor.

- The income of the population of the area is mainly depended on the agriculture production. Recent investigations show that other incomes of the population in the sub-area shared only about 10-30 % of the total income, and depending on areas and household. At present, GDP per person in the sub-area is about 300 USD/year, and unevenly distributed over the area, rich households shared about 30%, and about 20-30% households below poor level.

III.3.2 Economic situation

Total production of the sub-area in the year 2002 was estimated 89,089 billion VND (approximately 5.9 million USD). Growing rate in 1996-2000 averaged to 7.5% higher than that of the nation (7%). However, due to low commodity value and commodity that produced only based on the potential of the area not based on requirement of the market, thus agriculture production has faced many challenges.

Sources of the economy of the sub-area 10V, in general, and of the inundation areas, in particular, are mainly agriculture, and in addition, fishery, forestry, industry of exploitation of materials, agricultural and fishery processing industries, and services. Recently, the economy of the Cuu Long Delta and of the inundation area has developed remarkably. In the year 2000, rice production reached 11,742,808 tons; GDP per person was about 300 USD/person/year. Strong investment in water resources development and infrastructure from the government, in combination with reasonable frameworks, and policies, has created dynamic for production. However, the economy of the basin is considered, in general, as a backward agriculture economy with a low mechanization level, undeveloped infrastructure, low urbanization, naturally based production, instable living condition. Floods and inundation are major constraints to the socio-economic development of the inundated area of the sub-area. Specially, low agricultural commodity price in recent years causes much difficulty for local people; hence change in production structure is one of urgent matters for development of the sub-area.

In comparison with 8 economic zones of the nation, the economy of the sub-area in terms of agriculture, industry, and construction, is ranked the seventh, only higher than that of the Central Highland. The progressive economic zone is the Southeast Area where the rate of agriculture is account for 10%.

III.3.3 Economic sectors related to water resources

(1) Agriculture

- ***Upland crop production:***

The upland crop production is unstable, for instance, in year 1980 production of upland crops converted to rice volume was about 249,000 tons, sharing 5.1% the total food production; in year 1995 this reduced to 165,000 tons, in year 2000 only about 120,000 tons. Particularly, maize production has potential to develop fast in the future due to application of advance in seeds and high requirement from national markets. Upland crop area is reducing such as soybean decreased to 8.3%, groundnut decreased to 3.6%; and sugarcane reducing due to low price.

- ***Cultivation***

Table 12 Rice production

Items	Unit	1980	1985	1990	1995	2000	2002
1. **Cultivation area**							
Total rice area	1000ha	2263	2346	2547	3121	3924	3813
Increased rate	1000ha	210	83	201	574	803	-111
Average increased percentage	%	2.05	0.72	1.66	4.15	4.69	
2. **Yearly rice yield**							
Yield	Tons/ha	2.26	3.01	3.71	4.02	4.25	4.58
Increased yield rate	Tons/ha	0.01	0.75	0.70	0.31	0.23	0.33
Average increased percentage	%	0.13	5.90	4.27	1.62	1.12	
3. **Yearly rice production**							
Production	1000tonss	5115	7062	9459	12832	16677	17477
Increased rate	1000tons	505	1947	2397	3819	2457	800
Increased rate per year	1000tons	101	1442	450	1422	-1362	400
Average increased percentage	%	2.19	6.66	6.02	6.29	5.38	

Sources: Sub-Institute for Agriculture and Projection Planning

- ***Land use***

Table 13 Land use in 1985 - 2000 (ha)

	Items	1985	1990	1995	2000
	Natural area (12 provinces including islands)	3,965,800	3,957,606	3,956,900	3,971,232
	Agriculture land	2,441,900	2,463,472	2,498,164	2,970,316
	Ratio (%)	61.57	63.13	63.13	74.80
1	Annual crop area	2,130,900	1,970,788	1,993,613	2,226,252
1.1	Rice and upland crops area	1,973,700	1,826,535	1,837,144	2,082,663
	Triple crops	4,200	97,091	148,335	359,349
	Double crops	614,500	925,768	1,014,791	1,333,881
	Single crop	1,355,000	890,529	674,018	292,307
	Single crop + fish, shrimp				97,125
1.2	Upland crop areas	156,000	144,253	156,470	134,084
2	Perennial trees and mixed gardens	272,800	346,483	334,081	514,694
	Of that: fruit		137,492	179,957	197,320
3	Pasture area		1,260	1,035	18

Source: SNIAPP / Sub National Institute for Agriculture Projection and Planning

- ***Efficiency of land use types:***

  - Land used for only rice cultivation is less efficient than land used for other cropping structure like rice-upland crops, upland crops, fruits and rice and fishery culture. Diversification of rice cropping structure is a main focus in cultivation by the next years.
  - Land used for triple rice is less efficient than triple crops like rice - upland crops but high efficient than only double crops, therefore increasing cropping rotation is one of important measures to increase the efficiency of land use and income of local farmers. The efficiency of land used for the rice-upland crops is higher than that of land used for only rice cultivation but the difference is not large (except for land used for rice-vegetable), therefore, in order to enlarge the area for rice-vegetable

cultivation, it is needed to apply advance of technique, particularly varieties, and on the other hand, new organization for agricultural products consumption is needed to be established.

- The efficiency of the land used for rice-fishery is much higher than the land used for only rice or rice-upland crops, and suitable to ecological conditions in many areas. The rice-fishery land used type can overcome some limitations in terms of time, disaster, and market in comparison with the only rice or rice-upland crop land used types, and it has high potential in terms of enlargement. Therefore, it is needed to concentrate on investment to keep economic growing rate in the 2001-2010.
- The efficiency of the land used for intensive fruit cultivation is high. It can be continued to enlarge areas in the shallow inundation areas to contribute to increase the income of local farmers. However, it is also needed to concentrate on improvement of mixed gardens, which share high rate in total of upland crop areas of the sub-area, and needs to find out the measures to protect the gardens against floods during rainy season.
- The efficiency of the land used for only sugarcane and pineapple is low, unstable. It is needed to apply new variety with high yield in order to reduce price, increase the competition, and sustainable development in the area.

- ***Fruit tree and perennial industrial trees***

Many places in the Cuu Long Delta have favorable conditions for development of fruits and perennial industrial trees such as coconut, banana, oranges, mandarin, pomelo, mango, pineapple, longan, rambutan, durian, mangosteen, etc. Fruit area, at present, is estimated at about 205,500 ha, with a production of over 1.531 million tons; of that area of mixed gardens is remaining large area with low yields, low quality. Recently, provinces in the area have invested in improvement of mixed gardens, varieties but due to budgetary limitation the progress is still in low implementation. On the other hand, high floods in 1994, 1999, and 2000 have caused remarkable damages for many fruit gardens.

- ***Livestock***

Pigs: Pig breeding is progressed rather stably in comparison with the others. The growth rate of this breeding during 1990-2000 was about 5.98%. Of that time, the progress in 1990-1995 was stronger than that of in the rest. Average pork production increased 6.21%/year during the period 1990-2000 and the product was about 320,000 tons in year 2002. Number of buffalo decreased, cows used for cultivation was changed to cows used for meat production.

- ***Drought***

- Drought has occurred recently, particularly in 1993, 1998 and in 2003. Even in rainy season, the drought also occurs that prolongs about 7-10 days, local people called "Ba Chang" drought. Specially, serious drought occurs in coastal provinces causing shortage of water not only for agriculture development but also for domestic uses.

- ***Water requirements***

- Water requirement is mainly concentrated in months in the dry season (December to May). According to water balance study for The Mekong Delta in Vietnam, total water demand at present is about 1200-1500 m3/s (environmental flow is still not mentioned) but the probability of irrigation water is not high due to low capacity of water structures and they are not constructed synchronously. Total water requirement

by the year 2010 is higher while the average flow at Tan Chau and Chau Doc is only about 2000 m^3/s. Therefore, if the upstream countries increase using of water for agriculture development then the water supply for the Cuu Long Delta will meet many difficulties such as further salinity intrusion inland, and shortage of freshwater, particularly the freshwater for the coastal areas.

Table 14 Water demand for agriculture in the dry season (m^3/s)

Water demand	Jan.	Feb.	Mar.	Apr.	May.
Existing year 2000	1021	1235	929	644	633

- ***Existing hydraulic works***

In order to develop agriculture sector in the Cuu Long Delta, many hydraulic works have been built over the last two decades. Presently, main canals, first, secondary and on farm canals have been built with a density of about 6-10m/ha ensuring supply capacity for agriculture development, but in terms of fishery development, hydraulics works need to be improved and upgraded. According to year 2002 statistics, hydraulics works used for irrigation are as follows:

- Main and first level canal system with a total length of 4430 km, bed width 8-40m, and bed elevation from – 2.0m to – 4.0m;
- About 105 pumping stations, with a total designed irrigation capacity of 81,620 ha, but the actual irrigation areas about **23,377** ha. In general, these pumping station systems are not suitable to the real situation of the Cuu Long Delta so far. Presently, the measures to take water from canals to the fields are mainly used small pumps for irrigation with irrigated area for each pump of about 0.2 – 0.5 ha;
- Sluice systems used for salinity prevention, drainage and drainage of acid water comprised of about 153 sluices systems, with a dimension of about 2-84 m. These sluice systems have proved their efficiency in reality. It needs to continue to use this kind of hydraulic structures with a large numbers by the next years. In addition, there are a number of culverts for irrigation and drainage;
- Low embankment systems for early flood control at the beginning of August and protection of summer-autumn crops with a total length of about 7000 km.

During the last five years, hydraulics works has progressed rapidly due to the implementation of pivot plan programs such as: Quan Lo Phung Hiep program, Plain of Reeds, Tu Giac Long Xuyen, South Mang Thit, sea dikes and river embankment, and flood control program. Many hydraulics works for irrigation have been built but their efficiencies are not high due to:

- Management, maintain and operation activities are not well implemented, particularly small-scale projects managed by districts and communes levels, not to be repaired correspondingly due to budgetary limitations.
- Backward irrigation techniques.

- ***Constraints on uses of land and water***

- Unused lands and unstable production share with a high rate, most of these are acid sulfate soils, saline soil, and far from fresh water sources. These areas can be continued to reclaim but a large amount of investment and synchronous are needed.
- Efficiency of land uses is not high, and is in unstable manner due to not combining with other purposes. Spacial integrated exploitation is not well implemented, therefore, that do not take advantage of high potential in each area
- In many areas, farming intensity and investment for cultivation are low, particular to fishery culture and upland crop cultivation.
- There is no close coordination between sector and sector and among local authorities in the orientation planning process of strategic land use.
- Yield and quality of the products are low, poor competition. Processing and post harvesting technologies are limited. Product outputs are only in raw materials, difficult for consumptions.
- Infrastructure for agriculture development of different type of cultivation is limited, particularly hydraulic works does not meet production requirement yet.
- Abundant water resources but concentrated only in the six-month rainy season, on the other hand, floods, salinity, acid water and acid sulfate soils have caused a lot of difficulties.
- Changes in land uses due to fishery development that are not followed by the set-up planning resulted in changes in water demand difficulty for water resources planning and management processes.

(2) Forestry

- ***Forest area***

According to an inventory study on the forest, the present total forest area in the Cuu Long Delta is 280,484 ha, of which, natural forest is 58,136 ha and planted forest area is 222,344 ha. Coverage rate was about 7.1% (year 2001). Total forest production was about 6.71 million m^3, sharing about 0.8% total national forest production. The coverage rate of the Cuu Long Delta is the lowest in comparison with the whole nation (33.2%).

- ***Forestry existing planning and activities***

- Planning special used forest areas is about 67,364 ha, of which about 50,704 ha have forest. Important special used forests in the Cuu Long Delta of Vietnam include Tram Chim National Park (in Dong Thap province), U Minh Thuong natural preservation area (Kien Giang province), Vo Doi natural preservation area, Dat Mui natural preservation area (Ca Mau province), and Thanh Phu natural preservation area (Ben Tre). In addition, there are some areas preserved for birds with about ten or more hectare areas in Ca Mau, Bac Lieu, Ben Tre and Dong Thap. There are some special used forests, which are now in progress of implementation like Lung Ngoc Hoang (Can Tho), Tra Su and Ha Tien (in Kien Giang province). These areas are precious ones remained in the Cuu Long Delta.
- Under Forestry Planning, economic forest area is about 268,867 ha, of which about 147,759 ha have forest. Plant varieties planted in these areas is malaleuca planted in the acid sulfate soils; mangrove, cypress, etc. planted in estuarine areas.

Table 15 Existing forest and other forestry areas

No	Forest types	Total	An Giang	Bac Lieu	Ben Tre	Can Tho	Ca Mau	Dong Thap	Kien Giang	Long An	Tien Giang	Tra Vinh	Soc Trang
	Forestry area	527832	18401	24782	14032	4443	194325	16034	145000	60095	8077	26238	16405
I	Land having forest	280480	9176	6480	3451	2043	101714	9059	80732	47047	4282	8019	8477
1	Natural forest	58136	573	778	994	0	9753	0	40637	1553	368	1794	1686
1.1	Mangrove forest	15281	0	778	994	0	7852	0	1809	0	368	1794	1686
1.2	Forest inundated with acid water	7758	0	0	0	0	1365	0	4840	1553	0	0	0
1.3	Wide-leaf forest	35097	573	0	0	0	536	0	33988	0	0		0
2	Planted forest	222344	8603	5702	2457	2043	91961	9059	40095	45494	3914	6225	6791
2.1	Mangrove forest	73249	0	1599	2451	0	56609	0	1782	330	1653	6145	2680
2.2	Forest inundated with acid water	114103	3200	4103	0	2043	35352	8912	10097	44032	2253	0	4111
2.3	Mangrove forest	34992	5403	0	6	0	0	147	28216	1132	8	80	0

Source: Sub-Institute for Forestry Inventory and Planning No 2

- Protection forest area is 191,601 ha, of which about 82,017 ha have forest. Protection forest area is the mangrove forest along the coast in Ca Mau, Kien Giang, Bac Lieu, Soc Trang, Tra Vinh, and Ben Tre. Newly formed coastal protection forests are progressing in Kien Giang, An Giang, Dong Thap and Long An. Protection forests are planned but not yet implemented, hence much attention needs to be paid by the next years.

- Regarding to scattered forest/trees, annually locals have grown about from 15 to 20 million trees. Scattered trees are abundant and diversified about 30 varieties.
- On the management and forestry assistant aspect, ten of twelve provinces have their management system from provincial forest protection department to district levels. Frameworks and functionaries of these departments are overlapped. The conditions for operation, exchange of information, facilities, and information update are poor.

- ***Forest ecosystems***

Mangrove ecosystem

Cajuput ecosystem: cajuput forest is located in almost lowland areas, acid sulphate soil areas, and peat soil areas like Plain of Reeds, Long Xuyen Quadrant and U Minh.

Table 16 Mangrove forest area over the period of time

Year	1950	1983	1988	1995	1998	2001
Area (ha)	250,000	126,000	93,000	72,000	73,000	88,530

Natural preservation wetland areas: Due to the importance of the mangrove forest, 11 natural preservation wetland areas have formally established with a total area of about 40,000 ha in the Cuu Long Delta. Of these preservation areas, there are national parks, which characterize for flood plain area including Tram Chim National Park, U Minh Thuong National Park in peat soil area. In addition, there are some wetland areas, which are proposed for establishment of national parks as Xeo Quyt (Dong Thap), Hon Dat (Kien Giang), Bird garden in Binh Dai (Ben Tre).

(3) Fishery

- ***Aquaculture***

Table 17 Aquaculture results

Items	Unit	1996	2000	Increases
Total area	Ha	315819	431147	+115328
Development index	%	100	137	
Of that: Shrimp	Ha	188486	285854	+ 97368
Development index	%	100	151,6	
Product	Tons	284141	351553	+ 67412
Development index	%	100	123.7	
Of that: Shrimp	tons	25677	70651	+ 44974
Development index	%	100	275.1	

Source: Sub-Institute for Economy and Fishery Planning

- ***Fishery capture***

Table 18 Fishery captured volume results

No	Items	Unit	1991	1996	2000
1	Ships	number	7915	15683	17788
	Development index	%	100	198	225
2	Total capacity	Cv	188172	778071	1417349
	Development index	%	100	413	753
3	Product	tons	182709	496106	796641
	Development index	%	100	272	436

Source: Sub-Institute for Economy and Fishery Planning

- ***Fishery processing and consumption***

Table 19 Result of aquaculture production

No	Items	Unit	1991	1996	2000
1	Total frozen fishery processing enterprises	enterprise	45	46	55
	Development index	%	100	102	122
2	Total exported volume of frozen fishery production	Tons	31600	73889	99215
	Development index	%	100	234	314
	Of which: Shrimp	Tons	26800	57633	60319
	Development index	%	100	215	225
3	Total exported fishery value	Million USD	120	307.4	717.34
	Development index	%	100	256	598
4	Average export price	1000	3.80	4.16	7.23
	Development index	%	100	109	190

Source: Sub-Institute for Economy and Fishery Planning

Table 20 Rate of Exported fisher production according to the market (%)

Market	1997	1999	2000	2001
Japan	50.27	40.80	31.75	26.14
United State	5.15	13.85	20.38	27.81
Europe	9.87	9.58	4.85	5.9
Asia (excluding Japan)	31.06	29.08	27.89	17.32*
Others	3.65	6.69	15.13	22.83
Total	**100**	**100**	**100**	**100**

Source: Institute for Strategic Planning – Ministry of Plan and Investment

- ***Fishery Infrastructure and Services***

  - Fish harbors: Until year 2000, there are 14 fish harbors located in the coastal provinces. The fewest provinces have one fish harbor (Ben Tre, Tra Vinh), and there are some under construction harbors in (Soc Trang, Bac Lieu). Tien Giang province has two fish harbors; Ca Mau province has 3 harbors; and Kien Giang has 5 harbors (2 harbors inland and 3 harbors in islands).
  - Fish stations: In the Cuu Long Delta, there are 75 fish stations. Of which, coastal provinces have 51 stations. Fishery mechanism: there are 141 small and medium scale enterprises, which repair, and create new ships/boats and other fishery equipment for fishery production; mainly concentrated in 7 coastal provinces (110 enterprises). There are 72 fishery markets, where fishery productions are selling.
  - Fishery species production enterprises: In year 2000, there are about 465 enterprises which produce marine shrimp species with a total number of about 2,500 million species.

- ***Contribution of fishery sector***

Table 21 Result of fishery production activities in 1995, 2000, 2001

Items	Total product (Tons)	Index (%)	Marine Capture (Tons)	Index (%)	Inland capture and aquaculture (Tons)	Index (%)	Average fishery production (kg/person)	Export value (10^3 USD)	Index (%)
1995									
Cuu Long Delta	685,979	52.47	415,350	43.85	270,629	58.84	35.7	261,469	40.5
The Nation	1,407,130	100.00	947,180	100	459,950	100	14.7	645,316	100
2000									
Cuu Long Delta	1,144,987	52.65	796,641	54.76	348,226	48.36	66.02	717,34	48.51
The Nation	2,174,815	100.00	1,454,814	100	720,001	100	25.89	1,478,609	100
2001									
Cuu Long Delta	1,260,315	52.25	812,425	53.32	447,890	50.92	77.94	837,404	47.56
The Nation	2,403,238	100.00	1,523,690	100	879,548	100	31.71	1,760,600	100

Source: Sub-Institute for Economy and Fishery Planning

- ***Fishery organization and management***

- Apart from fishery processing and export activities, in which the state fishery enterprises are dominant in production, other activities are responsibility by non-state enterprises. Private and farm-based economies play a decidable role in production of fishery materials for fishery sector.

(4) Transportation

- ***Navigation***

- The sub-area 10V has high potential for navigation development with two main routes from Ho Chi Minh City (HCMC) to Ca Mau and from HCMC to Kien Luong with a navigation density of about 0.68 km/km^2, higher than many areas of the nation. Main goods, which are transported by navigation routes are rice, construction materials, and agriculture materials; and shared about 90% total navigation transportation. Particularly, the two main routes share about 70-80% of the total.
- In order to support for navigation activities, a network of harbor from provincial centers to district centers have been formed. The main harbors include Can Tho, My Thai (An Giang), Cao Lanh (Dong Thap), Vinh Thai (Vinh Long), My Tho (Tien Giang), Dai Ngai (Soc Trang), Bac Lieu, Ca Mau, Rach Soi, Kien Luong, Hon Chong (Kien Giang). Of that, there are six harbors, which located in main rivers incluidng Vinh Thai, Cao Lanh, My Tho (in the Mekong River), Can Tho, My Thai, Dai Ngai (in the Bassac River); and international harbors including Can Tho, Vinh Thai, My Thai, Nam Can, Hon Chong. In particular, Can Tho has been identified as an international harbor from 1992, and can allow 5-10 thousand tons ships moored. The major limitation to the navigation network and harbors is sedimentation in main rivers, in harbors and bank erosion, which result in high cost for dredging and maintaining the system.

(5) Tourism

- ***Kinds of tourism***

Vietnam, in general, and the Sub-area 10V, in particular, has a many kinds of the natural environment and that are precious natural resources for tourism development. Kinds of tourism include:

- Mangrove ecosystem: the mangrove forests are located along the coast of Vietnam but mainly located in the South, particularly in the Ca Mau Peninsula. This ecosystem is the environment of many kinds of saltwater inundated trees, fish, shrimp, crab, and birds, paricularly big bird varieties. If these mangrove forests are invested for development these will promote ecological tourism in the area, particularly in combination with the Mekong River Basin.
- Coral ecosystem remains in some areas of the Vietnamese Sea. There are about 95 coral varieties in the North and about 255 coral varieties in the South. Coral ecosystem is the high potential resources for tourism development like in the Con Dao Island, and Phu Quoc Island.
- Marine ecosystem: with a length of about 3,200km, Vietnam has about 600,000 ha of beaches for tourism development.
- Wetland ecosystem (swamp): This is mainy concentrated in the Mekong Delta of Vietnam. This kind of ecosystem attracts many varieties of birds and it can be developed an unique kind of tourism.

- The diversification object-cutural kind in Vietnam includes cultural heritages such as temples, pagodas like Ba Chua Su, Bay Nui temple.... This kind of object culture is precious sources for tourism development.
- The non-object culture kind is charaterized as the culture of 54 Vietnamese comunities through out achitecure patterns, dancing, music, tradition, usages and customs and traditional festivals. The Mekong River Basin from the northwest, central highland to the delta has many minority communities lived, therefore there are many kinds of non-object cultures which can be developed in terms of tourism in combination with cultures of minority groups.
- Traditional trade villages: handicraft, pottery, bamboo and rattan, etc., are the kinds of special cultures attracting tourists.
- Museums are important measures to disseminate aspects of the cultures including geography, history, art and culture of a particuar area, and are preciuous not only in introduction to foreign tourists but also attracting domestic tourists.
- Drinking and eating art: The art of eating and drinking of Vietnam becomes wellknown, diversification with high quality that could attract tourists. Apart from many kinds of vegetable, fruits, many kinds of sea foods, the culture of eating and drinking of Vietnamese has also herigiated cultures of eating and drinking of South of Asia countries like China, Thailand as well as the art of eating and drinking of the western countries as France, therefore the art of eating and drinking of Vietnamese is wellknown and esteemed.

- ***Tourism infrastructure and services***

- Airlines: The airline is a main measure to support for foreigners to Vietnam. At present, there are 3 domestic airports in the Cuu Long Delta including routes from Ho Chi Minh City (HCMC) to Can Tho, Ca Mau, Kien Giang. Presently, newly established airlines include HCMC-Xiem Riep (Cambodia)-Hue; Ha Noi-Seoun; Ha Noi-Bejing...which are cultural centers of the Asian area.
- Roads: Cars, means of transportation can reach 12 provinces in the Mekong Delta. The quality of road system is in rather good condition.
- Navigation: Marine and river transportation are becomming important means for international and domestic tourism. Particularly, in the Cuu Long Delta, with 11 river harbors of the total 18 harbors of Vietnam, the navigation routes can linked with all urban centers of the Mekong Delata and of Cambodia and can develop ship tourist services.

(6) Power sector

Presently, there are 1,025 communes in a total of 1,318 communes of the sub-area that are supplied power. Provinces, which supplied for all communes, include: Tien Giang, Can Tho, An Giang, Dong Thap, Vinh Long, Soc Trang. All inland districts with a total of 1.2 million farmer households, which has accessed power network, have linked with national grid.

By 2003, all communes are strived to supply power for over 80% of households and by 2005 all households are used power for their needs. That supplies basic power need for socio-economic development of the sub-area.

The Cuu Long Delta is a center of high power load and in the future, when gas sources in the Southwest shelf is exploited; the power plant used gas sources would be implemented.

In the period of 2005-2006 there will be two power plants used gas resources including O Mon 1 - 600 MW and Ca Mau - 720MW depending on capacity of gas exploitation in the future and it would be became a center of gas power plants with a thousands of MW.

(7) Water supply

Due to investment from the Government and support form international agencies, it is primarily to solve the fresh water and sanitation problems in some resident areas. Until now, there are about 30% of households using hygienic latrines and about 15% breeding households, who have hygienic facilities. However, over 60 - 65% rural population are not accessed to clean water, even when the pollution is increasingly over 70% rural households do not have hygienic latrines that are one of fearful problem. Many water-related and sanitation diseases such as diarrhea, worms, etc... have occurred, and of that, rural population takes high rate.

Presently, over 50% rural households use shallow wells, 25% use water from rivers, ponds without any treatment, 10% households use rainfall stored in tanks, the remaining use water from drilled-wells and small scale water supply systems, which supply for communes, hamlets, etc.

In urban areas, water supply for industry is normally shared with domestic water supply systems, in some few large industrial zones, there are private water supply systems for industrial uses. Sources of industrial uses are mainly from surface water.

Table 22 Existing urban water supply plants in the sub-area 10V

Urban towns	Urban popula-tion	No. of water supply plants	Capacity (m^3/day)		Sources		Length of pipeline (100m)
Sub-area 10V	**2,593,007**	**53**	**241,960**	**196,360**		**(well)**	**468,041**
Long An	108,000	10	18,200	13,100	Canal	10	
Dong Thap	586,675	7	14,500	7,280	Canal	5	
An Giang	349,500	5	19,900	24,000	Canal		33,330 (ϕ100-400)
Tien Giang	189,933	9	51,500	45,600	Canal	14	40,800 (ϕ100-500)
Ben Tre							
Ben Tre town	110,000	Son Dong	7,200	3,000	Canal		27,000
Vinh Long	148,500	3	16,100	4,950	Canal		36,620
Vinh Long Town	137,000						
Tra On town	11,500						
Tra Vinh	163,400	3	8,560	4,550		6	33,118
Can Tho	392,000	6	54,400	48,480	Canal	4	195,813
Soc Trang	126,932	4	12,200	10,600		8	37,300
Kien Giang	161,000	3	19,000	16,500	Canal	4	33,060
Minh Hai	257,067	2	20,400	12,300		20	31,000

Source: Institute for strategic planning – Ministry of Plan and Investment

Drainage systems are commonly used for domestic wastewater, urban wastewater, rainwater, wastewater from tourist and services enterprises and directly release into canal or river systems.

At present, wastewater without treatment causes serious pollution for these own urban areas and spreading to adjacent areas.

Table 23 Existing groundwater uses in sub-area 10V in 1998

No	Province	Large capacity wells		UNICEP wells		Total Q (m^3/day)
		No. of wells	Q (m^3/day)	No. of wells	Q (m^3/day)	
1	Long An	17	14,000	6,120	33,300	47,300
2	Tien Giang	25	15,500	20,750	81,590	97,090
3	Dong Thap	19	23,700	6,100	18,300	42,000
4	Ben tre	9	6,430	4,600	13,800	20,230
5	An Giang	3	1,850	3,823	11,640	13,490
6	Kien Giang	8	8,180	40,000	120,000	128,180
7	Can Tho	11	10,020	30,731	86,056	96,076
8	Vinh Long	6	3,600	5,858	17,574	21,174
9	Tra Vinh	4	8,080	20,000	60,000	68,080
10	Soc Trang	8	7,900	46,000	165,200	173,100
11	Ca Mau	18	15,000	35,100	105,300	120,300
12	Bac Lieu	5	4,900	24,000	72,000	76,900
Total		133	119,160	243,085	784,760	**903,920**

Source: Institute for strategic planning – Ministry of Plan and Investment

Table 24 Water demand for industrial and domestic uses in 1998 and 2000 (m3/s)

Year	Month					
	Jan	Feb	Mar	Apr	May	Jun
1998	11.8	11.4	9.5	9.4	10.2	12.1
2000	11.8	11.4	9.48	9.42	10.1	12.15

(8) Flood control

- ***Flood situation***

Annually, flood season starts from July and prolongs to November, later than upstream floods about 1 month and about 2 months later than rainfall inland. Floods rise and fall down slowly, quite mildly, with a intensity of about 10-15 cm/day, the highest rate about 20cm/day, the amplitude of a whole flood levels is about 3-4m. Floods propagate slowly taking 3 days from Phnompenh to Tan Chau (200km). From Long Xuyen, Cho Moi to the sea, in case of high tide the floods propagate more slowly. Variation, in terms of time and peak floods between years, is not high, however due to the Cuu Long Delta is a quite flat area, if the flood is larger than the normal it causes inundation in larger area and prolongs. Normally, floods in the Mekong Delta have only one peak occurred at the end of September or beginning of October but two-peak floods sill occurred as in 1978, 2000, normally appear in high flood years.

Due to over flows from the Mekong River, large area in the north of the Cuu Long Delta of Vietnam is inundated. The inundated area is about 1.4 million ha in low-flood year and

about 1.9 million ha in the high-flood year with inundated depths of about 0.5 – 4.0 m, and inundation duration of about 3 to 6 months.

Floods flow into the Cuu Long Delta through main rivers and from inundation areas in the Cambodia territory. The average flow is about 38,000 m3/s (or about 4.40m at Tan Chau, and 3.88 at Chau Doc in terms of water level), in high flood year the flood flow reaches 40,000 – 45,000 m^3/s, of which, the flow through the main rivers is about 32,000 – 34,000 m^3/s, sharing about 75 - 80%, floods flow from the border about 8,000 – 12,000 m3/s, sharing 20 - 25%, of which, floods flow into Long Xuyen Quadrant about 2,000 – 4,000 m^3/s, into the Plain of Reeds about 6,000 – 9,000 m^3/s. In the main river, the flood flow at Tan Chau is 23,000 – 25,000 m^3/s (sharing 82 - 86%), at Chau Doc about 7,000 – 9,000 m^3/s (sharing 14 - 18%). Total flood volume, which flows in the Cuu Long Delta, is about 350 - 400 billion m^3. Of which, flows through the main rivers, share 80 - 85%, through the border share about 15 - 20%. In terms of water level, there is a difference between the Tien (Mekong River) and Hau (Bassac) Rivers. At the same time, water level at Tan Chau is about 40 - 60 cm higher than water level at Chau Doc. Therefore, there is always a movement of floodwater from the Mekong River to the Bassac River through out canals, which linked these two rivers such as Tan Chau - Chau Doc, Vam Nao..... Among that, Vam Nao is the biggest. Due to the movement of water, the flows at My Thuan and Can Tho in the Mekong River and Bassac River respectively are almost balanced (51 and 49%).

Most of floodwater flows into the East Sea through the main rivers; the remaining flows into the West Sea and the Vam Co River.

Flooding occurrence in the Cuu Long Delta can be divided into three phases. The first phase is from July to August, in which floods in the main rivers rise quickly and flow into farmlands and storing in the fields. In this phase, floods carry out much sedimentation. The second phase is the time, when floods are high (water level at Tan Chau over 4m, at Chau Doc over 3.8m); floods flow through two main directions including through the main rivers and through the border of Vietnam and Cambodia, and flow into the Plain of Reeds and into the Plain of Reeds and Long Xuyen Quadrant. The flows through the border contain less sediment, and dominate the high sediment flows from the Mekong River and the Bassac River reducing the sedimentation for these areas. The third phase is the time, when floods are reducing, normally from end of October when the flow from the Cambodia side reduces, flood water level in the Cuu Long Delta gradually reduces until December and almost areas are no longer inundated. Floods cause much damage in terms of people deaths and property loss but bring much benefit such as sedimentation, farm sanitation and a good environment for fishery development.

- ***Existing flood control activities and constructions***

Construction from 1996 up to date

Long Xuyen Quadrant:

- After the study on flood control planning, and particularly the Decision 99 TTg of the Prime Minister, the implementation of flood control structures in the Long Xuyen Quadrant has progressed well. At present, the group of structures No. 1 almost finished (completed 23/23 sluices and canals). The group of structures No.2 has been built including Vinh Te Canal, flood prevention embankment from Chau Doc to Tinh Bien, rubber dam Tha La, Tra Su and completion of Xuan To bridge (viaduct). In the group of structures No.3, structures named T5, T6, T4 had completed.

- During the flood in year 2000, proposed flood control constructions have brought into operation their efficiency. However, it is necessary to improve and enlarge the width of floodgates on the Road 80, Mac Can Dung. At the same time, from Ba Hon canal to Ha Tien, along the national road 80, construction of bridges is constructed instead of sluices in order to support for fishery development activities in the coastal area.

Plain of Reeds:

- The structures have been implemented including Tan Thanh - Lo Gach canal and flood control route from Hong Ngu to So Ha-Cai Co, Sa Rai Canal, Hung Dien, Hong Ngu (Stage 2), Cai Co Long Khot and 4 canals in the south of Nguyen Van Tiep Canal such as Cai Beo, 307, Ba Ky - Ba Tra, Thanh Nien - Ong Muoi, and bridges in the National Road No1, 30 and Binh Chau. Specially, the structures to protect the resident/urban areas of Hong Ngu, Tan Hong, Tan Hung, Vinh Hung, Moc Hoa had been implemented. Experienced in the floods in year 2000, flood control structures have brought into operation their efficiency. However, there are not sufficient structures, therefore, the efficiency of flood control/protection are not high. At the same time, floods 1996, 2000 and 2001 show that the proposed flood control measures have proved their reasonable efficiency, but the selection of their dimensions and structure types is still difficult and not clear. There are many opposite ideas on the flood control sites, structure types, etc. These issues will be clearly identified in further study phase.

In addition, in order to develop agriculture, the implementation of thousands km of levees for protection of summer-autumn rice and early seeding the winter-spring rice had been carried out.

- ***Limitations on existing situation of economic sectors in the Sub-area 10V***

Limitation

- Poor resolving goods consumption, which result in difficulty for local farmers to consume their production and suffer loss of their income due to low price that set out by private merchants.
- Poor forecasting the capacity of goods consumption. Therefore, it could not create sustainable production and development causing large amount of damages. Some times, there are no goods for selling, but some times goods cannot be sold.
- Poor management including management of natural resources such as land, water resources, biological resources and poor management of socio-economic aspect. Therefore, it causes seriously deforestation, exhausted fishery and biological resources; policies, social laws, rules are not fully enforced.
- Low developing industries, particularly the agro-production processing industry. It causes limitation on goods consumption of farmers' products as well as reduces their incomes due to their products only raw products with low price.

Remaining problems

- Underdeveloped road system. It causes difficulty to rural development including economy and society aspects.
- Poor living conditions of the local people in the Cuu Long Delta due to poor environmental sanitation, shortage of fresh water, and power in domestic uses, and

prolonged floods. Annual inundation areas are largely damaged, local resident areas are flooded, and hundreds thousand of households have to be resided to other places therefore their lives are not stable.

- Shortage of fund for investment.
- Low consumption of products.

III.4 Natural and water resources Characteristics

III.4.1 Topographical Characteristics

The Cuu Long Delta is rather flat with the elevation from 0.8 to 1.2 m (above m.s.l.). The highest area is located (3.0 – 4.0 m above MSL) is along the border of Vietnam and Cambodia with elevation of about 3.0 to 4.0 m (in the left bank of the Mekong River); 2.0-3.0m (the area in between Mekong and Bassac rivers). Land elevation gradually is lower downstream direction, as from 1.0-1.5 m in central zones, 0.5-0.8 m in the coastal area. Along both side of the Mekong River and Bassac River, the high elevation land strips are formed (with the elevation of 1.5-2.0 m, isolated 2.5 m) naturally formed river banks, which can protect rice fields against small and medium floods. Sand bars in coastal zone usually are established by interactions of East Sea short & long shore currents, river sedimentation and wind. The downstream of the West Vam Co River, , the lowland zones in Cai Lon – Cai Be catchments, and Southern Ca Mau cape are the lowest area with elevation of about 0.3-0.7 m, and always inundated due to high tides, rainfall, and floodwaters.

III.4.2 Climate

Mekong Delta, in general, and the sub-area 10V, in particular, is located in the monsoon tropical region. Due to topographical characteristics, the climate is rather hot year-round, and there are two distinct seasons depending on the activity of circulation of monsoon atmosphere: wet and dry. The dry season is same as the duration dominated by the northeast moon soon current prolonged from November to next April, and characterized as dry, hot and very little rain The wet season usually starts in May and lasts until November, when the southwest monsoon current dominates, and characterized as hot, humid and high rainfall. The specific characteristics are listed as following:

Temperature

Monthly average temperature varies from 27 to 28^{o}C. The lowest temperature appears in January (25.5oC) and the highest temperature appears in June (28^{o}C). The difference among months in a year is about 3-5^{o}C. The highest value of average temperature is approximate 32^{o}C and the lowest is about 23.5^{o}C.

Generally, high temperatures usually can be met from April to June, whereas low temperatures are in December and January. Differences in spatial distribution of temperature are not much.

Evaporation, humidity and wind velocity

Evaporation: Lower Mekong basin entirely lies on the monsoon tropical region of Northern hemisphere, extending in 13 latitudes (from 8^{o}7’ to 21^{o}3’). As a result of complex topographical characteristics as well as under the condition of a region in the low latitude,

the climate of the Lower Mekong Basin, in generally, is sunny and hot, and distinguishes between dry and wet depending on the activity of annual monsoon current.. Average temperature varies from 27 to 30^{o}C. Therefore, evaporation ratio is high. Especially, evaporation in surfaces of hydropower-reservoirs, irrigation canals and even in the natural rivers is very high. This is a main reason causing water loss in the basin.

The evaporation regime varies in space and time. During a year, , evaporation reaches the maximum values in March, April and May. The maximum value is usually reached from 180 to 220 mm. In August and September, evaporation still reaches 100-150 mm. The yearly average evaporation is from 1500 to 1800 mm. There is a trend, that evaporation ratios increase from upstream to downstream and from East – West direction . The below table shows evaporation values in some stations in the Lower Mekong basin.

Humidity: Humidity reaches the max values in wet season and gradually decreases till dry season. Average humidity values in August, September and October are in range of 84-89%, wherein February, March and April are 67-81%.

Wind characteristics: Average wind speed is approximate 2 m/s. In coastal zones (Sub-area 10V), max speed can be met in February and March. The wind speed exceedence frequency of 5% is estimated at about 15-18m/s. In October, November, wind speed is small except for some specific situation. In the Great Lake, there are some places where the average wind speed is lower than 1 m/s.

Sunny characteristics: The whole basin is located in the rich radiation area. In one day, sunny period lasts for more than 6 hours (and about 2000-2500 hours per year). In February and March, there are 8-9 sunny hours per day, whilst in August and September; there are only 4.6-5.3 hours per day.

Rainfall characteristics

The rainfall in the Cuu Long Delta is not evenly distributed in time and space. Western zone of the sub-area 10V has the highest rainfall, about 1800-2400mm per year. Rainfall in eastern zone of the sub-area 10V is approximate 1600-1800mm. The central zone (from Chau Doc – Long Xuyen – Can Tho – Cao Lanh to Tra Vinh- Go Cong) has the smallest rainfall , about 1200-1600mm per year. About 90 % of yearly rainfall falls in wet season while about 10% in the dry season. In January, February and March, there is almost no rain, causing severe drought periods. In the wet season, heavy rainfalls often fall causing inundation but there are some periods when there is no rainfall prolonged from 10 to 15 days and even 20 days causing damages for cultivation. There is no large difference among years in terms of rainfall, but the change of rainfall between the beginning and the end of rainfall season is high. Wet (rainy) season starts in May and ends in November, but as observed, in June there can be no rain, but in December there is still heavy rd rain. The change of rainfall patterns causes difficulties for agricultural activities.

However, long-lasting showers (3-5 days) can cause the severe inundation problems in the study area in rainy seasons. There is no rule for the distribution of 1-day, 3-day and 5-day max rainfall. Generally, 1-day max rainfall is in 3-day max rainfall, whilst 3-day max rainfall is in 5-day max rainfall. The 1-day, 3-day and 5-day max rainfall has been used as the typical and the worst conditions for rainfall in the Cuu Long Delta. The below tables present some characteristics of rainfall in the study area.

Table 25 Average monthly rainfall distribution (mm)

Stations	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Vinh Long	9.1	0.1	9.2	30.4	139	171	180	176	214	273	131	30
Long Xuyen	8.3	2.6	11.7	66.5	147	152	209	174	214	260	131	42
Can Tho	8.9	2.3	9.7	43	170	195	212	209	250	271	146	32
Ttan An	6.9	2.3	7.2	35.6	187	222	204	187	245	261	136	40
My Tho	5	2.5	4.5	38	149	188	186	171	233	267	104	35
Rach Gia	8.9	6.8	33.4	88.8	240	259	292	334	305	277	171	38
Ca Mau	16.4	7.6	34.1	101	270	323	324	365	349	331	190	64

Table 26 Average drought period in wet season in the sub-area 10V

Station	V			VI			VII			VIII		
	7 days	10 days	15 dyas	7 days	10 days	15 dyas	7 days	10 days	15 dyas	7 days	10 days	15 dyas
Vinh Long	1.1	0.7	0.3	1.0	0.3	0.0	1.0	0.5	0.1	0.9	0.2	0.0
Long Xuyen	1.2	0.5	0.2	0.9	0.6	0.3	1.1	0.5	0.2	1.1	0.5	0.1
Can Tho	1.0	0.6	0.2	0.9	0.2	0.0	1.0	0.3	0.0	0.6	0.1	0.0
Ttan An	1.2	0.7	0.4	0.9	0.5	0.0	1.4	0.6	0.0	1.1	0.4	0.0
My Tho	1.3	0.7	0.2	1.2	0.5	0.2	1.2	0.5	0.2	1.0	0.3	0.2
Rach Gia	0.8	0.4	0.0	1.0	0.5	0.0	1.0	0.5	0.1	0.7	0.2	0.1
Ca Mau	0.7	0.2	0.1	0.8	0.3	0.0	0.6	0.3	0.0	0.5	0.2	0.0

Table 27 Maximum Rainfall with frequency of 10% in 1-day 3-days and 5-days (mm)

Station	VI			VIII			IX			X		
	1-day	3-day	5-day	1-day	3-day	5-day	1-day	3-day	5-day	1-day	3-day	5-day
Vinh Long	77	103	127	56	79	106	78	111	144	95	138	186
Long Xuyen	73	106	118	77	114	134	76	103	131	92	153	173
Can Tho	99	137	159	72	109	138	74	117	144	98	168	227
Tan An	73	90	123	91	158	176	87	126	169	144	188	212
My Tho	93	130	155	86	111	133	73	113	147	107	155	190
Rach Gia	109	168	214	163	226	282	132	194	227	110	162	200
Ca Mau	97	150	193	109	194	252	108	185	220	99	151	185

III.4.3 Surface water resources

- ***River system affects hydrological regimes.***

  - The reach of the Mekong River from Kratie to the East Sea is about 545 km. After passing through Phnom Penh, at the confluence of the Mekong River and Tonle Sap River, the Mekong bifurcates, forming two distinct rivers, the Mekong and Bassac, which discharge into the East Sea through nine estuaries: Tieu, Dai, Ba Lai, Ham Luong, Co Chien, Cung Hau, Dinh An, Tran De and Hau. Actually, there are only 8 estuaries, as Hau was filled by sedimentation.

  - At the Phnom Penh intersection, the Mekong River is connected to the Great Lake by the Tonle Sap tributary. This tributary plays an important role for regulating water flow into the Cuu Long Delta. From Kratie, The Mekong River runs along low-lying

areas, which are affected by tidal movements. Bed level of the river varies in the 'broken line' trend as a result of interaction between river and sea. The bed level varies from 10-30 m, some places 40 m. The section from Phnom Penh to Tan Chau-Chau Doc is slightly affected by tidal movement, with amplitude of 1.0-1.5 m in Tan Chau- Chau Doc and 0.2-0.5 m in Phnom Penh. In flood seasons, tidal movement no longer affects.

- Small rivers and springs in Cambodia do not play the main role for distribution of flow, but they are important for conveying floodwater of the Mekong River or the Bassac River when it overflow.

In the left side of Mekong River, there are 6 small rivers and springs directly or indirectly connect to the main Mekong River including

- (1) The Vaico River: This is the upstream part of the West Vam Co River. It originates in the plain of Pre Veng province. Its elevation is from 10-15 m running Northwest-Southeast direction though Svay Rieng town and Long An province of Vietnam. The basin area is 1720 km^2 and the length of river is 110 km. This river is one of the main rivers to retain and convey floodwater from the Mekong River to Vietnam. There are some typical cross sections:

Location	Bed level (m)	Surface width (m)	Bed width (m)
Road 105	-1.58	50	30
Road 109	-0.13	30	10
Svay Rieng	-0.89	74	35

- (2) Prek Tate River: This is the upstream part of the East Vam Co River. It originates in low-hilly lands of Pre Veng Province. Its elevation is from 7-10 m, and it runs Northwest-Southeast direction though Kam Chaimea, Svay Rieng and Tay Ninh province of Vietnam. The basin area is 1380 km^2 and the length of river is 54 km. In the section near the border, riverbed is deep and is affected by tidal movement. There are some typical cross sections:

Location	Bed level (m)	Surface width (m)	Bed width (m)
Phum Tuon Tamoc	6.46	15	0
Phum Prey Taprum	4.77	65	40
Phum Tuon Donon	4.74	60	40
Kam Chaimia	0.90	60	35

- (3) Tonle Toch River: This river is in the West-North border zone. It connects 2 locations of the Mekong River. The inlet is in Phum Peam Prathnoud (distance 10 km from Kompong Cham town) and outlet is in Ba Nam (distance 5 km from Niek Luong ferry). In flood season, floodwater from main Mekong River goes to the Tonle Toch River, filling in swampy regions and finally runs toward downstream direction. Riverbed is deep and wide. Bed-width is about 100m, and bed-level is about 6-8 m. The basin area is 1900 km2 and the length of river is 120 km.

- (4) Tonle Prasat River: This river is in the Western border zone. Its inlet connects with downstream reach of TonleToch at Toeng Lost. It runs meanderingly North-South direction and finally meets So Thuong River in Vietnam. The basin area is 650

km2 and the length of river is 62 km. Playing the role as the river to convey water from Mekong river, Tonle Prasat river has the deep and widen cross sections and its bed slope is low but abundantly change. There are some typical cross sections:

Location	Bed level (m)	Surface width (m)	Bed width (m)
In front of Huu Nghi bridge	-6.94	102	30
Piencho Town	-5.86	125	30
Near So Thuong	-8.82	120	30

- (5) Tra Bek river: The Tra Bek links with So Ha river in Vietnam. The inlet is in Huu Nghi Bridge and it runs Northwest-Southeast direction to Trabek Bridge and change to Southnorth direction and finally joins So Ha River at Thong Binh in Hong Ngu district. The basin area is 575 km2 and the length of river is 57 km. Playing the role as the river to convey water from the Mekong River as well as receiving large effects from tidal movement, the Tra Bek River's cross sections abundantly change along the river course. There are some typical cross sections:

Location	Bed level (m)	Surface width (m)	Bed width (m)
Huu Nghi bridge	-1.76	32	9
Trabek bridge	-2.03	93	30
Near So Ha	-1.09	38	10

- (6) Prek Kongpong Chrey: It is a natural river originating from swampy areas in Mesong district, Prey Veng province. It runs North-South direction and meets Cai Co River in Vietnam. The basin area is 326 km2 and the length of river is 35 km. In dry season, it is considered as a 'dead' river.

It can be seen that all of small rivers and springs in Cambodia closely relate to rivers and canals in the border zone. In dry season, there is no area of water originated; therefore, base flow is very low. In flood seasons, these rivers and springs play a role of floodwater storage and conveyance floodwater to Vietnam and creating more complex in terms of flood regime and flood control for Plain of Reeds.

In the right side of the Bassac River, there are some small rivers that originate from Nui Ba Mountain in Ta Keo, Kongpong Spu and Kandal provinces. Some of them run directly to the Bassac River, some run toward low-land areas in the border zone then go into Vinh Te canal. The lowland areas along the Bassac River and border zone have elevation from 1.2 to 2.0 m and widths of 3-10 km. They become inundation areas of about thousand ha with depth of 0.5 -3 m.

Besides, in sub-area 10V, there is a densely canal system, including a number canals of primary/secondary and triple canals with density of 6-10 m/ha. This system makes the hydraulic regime of the study area more complicated.

- ***Hydrological characteristics of surface water***

  - The Mekong River is one of the ten biggest rivers in the world (the 10^{th} in basin area and 6^{th} in water resources). It originates from Tibetan plateau and runs through territory of China, Myanmar, Laos, Cambodia, Thailand and Vietnam. The basin area is 795,000 km2 and the length of river is 4,200 km. Water resources of the Mekong

River is supplied by 2 main sources: melting snow in upstream mountains and rainfall.

- Annually, the Mekong River conveys 441 billion m^3 water across Kratie, with the average discharge of 13,708 m^3/s, flow module of 21/l/s/km^2 and flow depth of 690mm. Wherein:

  - ❖ 18% from upstream part (24% basin area)
  - ❖ 55% from Western Truong Son (28% basin area)
  - ❖ 10% from Eastern and Northern Thailand (19% basin area)
  - ❖ 17% from remaining sub-areas (29% basin area)

- Water flow in the river basin is divided into 2 separate seasons: Flood season (from June to November with the run-off accounting for 90%) and dry season (from December to May with 10% of average flow). In June, dry flow is the lowest.
- Hydrological regime of the Cuu Long Delta is affected directly from: Water flow from upstream, tidal movement of the East Sea and Gulf of Thailand as well as rainfall in the plain. Flood season in the Cuu Long Delta starts in June or July and ends in November or December (delaying 1 month from the upstream part of the Mekong River and 2 month from rainy season). Dry season lasts for 6 months. Great Lake, its basin is 85,000 km^2 is a natural storage with the capacity of 85 billion m^3. The Great Lake surface area varies from 3,000km^2 to 14,000 km^2. It receives water flow from the Mekong River annually 60 billion m^3 in flood seasons and it plays a very important role for regulating water flow in both dry and wet season for Mekong Delta. From Phnom Penh to the sea, the Mekong River divides into 2 main branches: Mekong River and Bassac (Hau) River, and hydrological regimes of these rivers with effect of tidal movement is differ from hydrological regime in the upstream part of the Mekong River. Some information is shown in the below table.

Table 28 Average discharge and discharge in several return periods at Phnom Penh

Month	Avg. discharge	10%	20%	50%	75%	80%	85%	90%	95%
I	7786	9218	8681	7731	6935	6859	6515	6431	6104
II	4609	5517	5180	4572	4125	4019	3900	3752	3544
III	3182	3637	3471	3169	2900	2883	2790	2743	2631
IV	2736	3256	3037	2709	2465	2408	2375	2270	2134
V	3932	5347	4758	3790	3135	3086	2825	2693	2469
VI	10202	14415	12722	9875	7945	7509	6950	6417	5642

- Discharge distribution ratio from Phnom Penh to the Mekong River and the Bassac River through Tan Chau and Chau Doc plays an important role for hydraulic regime in entire Cuu Long Delta. Annual ratio is 83%/17% for Tan Chau/Chau Doc and it is a stable ratio. The ratio changes a little bit lower in flood season (80%/20%) and higher in dry season (84-86%/14-16%). However, distribution ratio between 2 branches: Mekong and Bassac at Phnom Penh is unequal. Vam Nao River is considered as a connecting river and it is a tributary to supply water for Bassac River. The role of Vam Nao River is to balance water flow between 2 branches (50% for Mekong River and 50% for Bassac River).
- Hydraulic- Hydrological regime in Cuu Long Delta also depends on tidal movement from the East Sea and the West Sea (Gulf of Thailand). Tide in the East Sea is of a

semidiurnal kind, while tide in West Sea is diurnal. Tidal movement changes in short and long-term period (daily, monthly and yearly). Therefore, the environment is plentiful to develop diversified biology system.

- Water resources in the Cuu Long Delta: Annually average water availability in the Cuu Long Delta to the sea is about 471 billion m^3, of which 23 billion m^3 are caused by rainfall in the field of Cuu Long Delta and 448 billion m^3 are from outside (upstream). Annually average water volume in Mekong Delta is near 59% of total water volume in Vietnam. Specific discharge of the Mekong River and the Bassac River is 30l/s.km^2 and that of Ca Mau peninsula is 20l/s.km^2.
- Dry flow: In dry season, discharge in the Cuu Long Delta is very low. Monthly average discharge at Phnom Penh from February to April is 2000-4000m^3/s. It reaches the lowest value of 2380m^3/s in April in medium year. In dry years, this value is under 2000m^3/s. Dry season in the Cuu Long Delta is considered from January to June (6 months). Flow regime in the dry season in the Cuu Long Delta is significantly affected by tidal movement, but the amplitude reduces quickly from the estuaries (2.3-2.8m) to transition zone-interior field (0.3-0.5m). In dry season, water level in canals is always lower than that of in the inter-fields, therefore, it causes difficulties for irrigation and the main measures for irrigation are pumps. In a 15-day tidal period, spring tide duration is the days to temporarily storage water in the interior canal systems and to raise average water level in the system and contrary.

The below table represents some data of water resources in dry seasons

Table 29 Low flow at Tan Chau and Chau Doc stations (m^3/s)

Station/ year	I	II	III	IV	V
Year 1996					
Tan Chau	6030	3530	2390	2010	3760
Chau Doc	1450	846	511	440	751
Tan Chau + Chau Doc	7480	4376	2910	2450	4511
Year 1997					
Tan Chau	8140	5330	3230	2620	2720
Chau Doc	2020	1160	661	547	551
Tan Chau + Chau Doc	10160	6490	3891	3167	3271
Year 1998					
Tan Chau	5885	3452	1762	1457	1989
Chau Doc	1604	683	418	358	435
Tan Chau + Chau Doc	7489	4135	2180	1815	2424

- Flood flow: Annually, flood season in the Cuu Long Delta starts in July and ends in November. It happens after floods in upstream basin 1 month and rainfall period 2 months. Flood levels change slowly, with the difference of 10-15 cm/day. The max difference is just 20 cm/day, and the amplitude of entire flood is about 3-4 m. Flood flows also propagate slowly. It takes 3 days from Phnom Penh to Tan Chau (200 km) and from Long Xuyen, Cho Moi to the sea. It even takes more time in the spring tide period. The differences among flood period and flood peak are not much. However, as characteristics of lowland delta, the Cuu Long Delta can suffer with large inundation area if it meets high floods. Flood in the Cuu Long Delta usually has 1 peak occurring in the end of September or at the beginning of October. However, in high- flood years, flood peak can also occur 2 times (e.g. year 1978, 2000).

- According to the classification of the Hydrometeorology Services, flood response timing and levels in Vietnam appear in 4 stages, each of them corresponds to the suitable serious stages of floods. If water level at Tan Chau is less than 4m, the flood can be considered as a small flood. If water level is between 4.0 - 4.5m, the flood is considered as a medium flood and if water level is higher than 4.5m, the flood is considered as a big flood. In the past, there are 13.2% of small floods, 46.2% of medium floods and 40.6% of big floods. Statistical data shows that within the last 60 years, every 2 years there was a flood, which exceeded waning level III (water level at Tan Chau was higher than 4.2 m). In the period of 1937-1952, water levels in every year were equal or higher than waning level III. Especially, in 4-year period 1937 – 1940, water levels in Tan Chau exceeded 4.85m and in 4-year period 1946 – 1949, water levels at Tan Chau exceeded 4.6m. In 1994, 1995 and 1996, maximum water levels in Tan Chau were higher than 4.6 m. Maximum water levels in several years are presented in the below table:

Table 30 Maximum water levels in several years in Tan Chau (m)

Year	1961	1966	1978	1984	1991	1994	1996
Hmax	5.27	5.28	4.94	4.96	4.80	4.67	5.03
Date	11,Oct	27,Sep	9,Oct	13,Oct	13,Oct	3,Oct	7, Oct

Note: Water levels are followed with Hon Dau datum

- ***Water quality***

- Rainfall: Rainfall sources in Mekong Delta is plentiful and in good quality. It can be used for domestic use as well as for irrigation.
- Groundwater: Flood prone (inundation) areas in the Cuu Long Delta have plentiful ground water resources, including groundwater in shallow and deep layers. Nowadays, groundwater in shallow layers has been polluted and it appears in bad quality. However, groundwater in deep layers is very fresh and good.
- Surface water: Rainfall sources in the Cuu Long Delta is plentiful and in good quality. It can be used directly for domestic uses as well as irrigation.
- Surface water quality in main rivers: Water is from the upstream parts of the river. Water quality seasonally varies. In dry seasons, water contains much dissolved materials. In flood seasons, water contains less dissolved materials (Table 31 & 32).

Table 31 Average main water quality index concentration at Tan Chau – Chau Doc, 1994

Station	Season	PH	EC meq/l	Ca meq/l	Mg meq/l	Na meq/l	K meq/l	Al meq/l	CL meq/l	SO4 meq/l
Tan Chau	Dry	7.69	17.48	0.86	0.41	0.47	0.04	1.22	0.20	0.39
	Wet	7.35	12.10	0.62	0.36	0.31	0.03	0.96	0.14	0.25
Chau Doc	Dry	7.43	14.32	0.70	0.47	0.34	0.04	1.05	0.21	0.27
	Wet	7.37	11.69	0.62	0.34	0.28	0.03	0.96	0.17	0.17

Water in Tien and Hau rivers contains much alluvium sedimentation. It is brought from upstream parts of the river. At Tan Chau, average content of alluvium sedimentation in flood seasons is about 800g/m^3, maximum content of more than 1000 g/$m^3$is in August and in dry season, the content is about 200 g/m^3. At Chau Doc, average content of alluvium sedimentation in the flood season is about 200-300g/m^3, maximum content is more than 400

g/m^3. After Vam Nao River, the content increases as a result of supplement from the Mekong River.

Table 32 Average concentration of nutrition at Tan Chau – Chau Doc, 1994

Station	Season	Total N (mg/l)	Total P (mg/l)	Total 02 (mg/l)	COD (mg/l)
Tan Chau	Dry	0.52	0.06	8.21	1.84
	Wet	0.61	0.18	5.69	4.35
Chau Doc	Dry	0.70	0.06	7.12	2.72
	Wet	0.58	0.14	5.68	5.17

- Quality of overflow water from border zones: Data of flood in year 1996 shows that water quality from this source is generally non-aluminous and it contains of small amount of toxic material. Maximum content of alluvium sedimentation in flood seasons is about 200g/m^3.
- Quality of water in interior field: Change of water quality is complex, depending on climate and hydrological regime. The main dissolved materials can be listed: Na, K, Ca, Mg, Fe, Al, SO4- -, Cl-, HCO3. Content of these ions seasonally varies. It is high in dry seasons and low in flood seasons and it bellows the critical condition. However, in some places (especially in high-aluminous areas), in some months, content of Fe and Al is high and it exceeds the critical condition. Content of other materials is low.

- ***Sedimentation***

There is a year-round conveyance of sediment to farm fields through canal system which link with the Mekong River and Bassac River. The period, with the highest sediment concentration is from July to September. Main conveyance direction is from the Mekong River and Bassac River, however, only areas along rivers with a width of about 20-30 km are supplied much sediment, the area located far from the river is supplied less. Recorded data from 1991 to 1997 shows that the highest sediment content at canal inlets on the canal block from Hong Ngu to Cao Lanh is about 300 - 900g/m3, from Chau Doc to Long Xuyen about 200 - 400 g/m3, but further in farm field is about 100 - 200 g/m3.

- ***Acid water***

Acid water is an issue of the Cuu Long Delta, in general, and of the inundation areas, in particular. Acid water has affected to water quality and consequently affected to production and living condition of local people. Acid water appears mainly in acid sulfate soil areas; in some area acid water appears as a result of water movement in from other area but not many. Acid water appears normally from May to July (in some places prolonged to August and September). Specially, in addition to acid water in the beginning of the rainy season, the Long Xuyen Quadrant and Plain of Reeds appears acid water at the end of the flood season, normally from December to January. Previously, in May and June, acid water area was almost over the inundation area of the Cuu Long Delta, but at present this phenomenon is concentrates only in the Ha Tien Quadrant, Bac Dong and U Minh.

- ***Salinity intrusion***

Salinity intrusion is varies very complicated depending on previous floods, fresh water from upstream, summer-autumn rice cultivation situation, climate at the beginning of the rainy season. Generally, late-rainy years, low amount of rainfall at the beginning resulting high water abstraction for summer-autumn rice cultivation, low flow from upstream cause strong salinity intrusion as appeared in 1993, 1998. In the Plain of Reeds, during the last some years, salinity has intruded further and the duration was longer. In 1993 the highest salinity index at Moc Hoa was 4.3g/l, at Tuyen Nhon 7.5g/l. In 1998, salinity in the main river, of the Vam CO River, Cai Lon River, and in the Long Xuyen Quadrant intruded stronger than that of in 1993. Area in Hon Dat - Ha Tien, Bo - Bo has both effects of salinity intrusion and acid water therefore poor water quality exists longer affected to production. Preciously, when water resources is underdeveloped, salinity affected area is about 2.1 million ha, presently; this area is about 1.4 million ha.

- ***Microbiological pollution:***

In general, surface water in the Cuu Long Delta has high microbiological pollution, average coliform concentration is about 300,000 - 1,500,000/100ml. The main reason is due to waste without treatment from humans, livestock.

- ***Pesticide pollution:***

At present, there are few studies on this matter. However, investigation documents of Sub-Institute for Water Resources Planning, Can Tho University, Environment Protection Center, Public Health and Sanitation Institute of Ho Chi Minh City show that there is no remarkable problem regarding to this issue, but in some local area this matter has affected to aquaculture of some fishery variety. In some areas, where one used pesticide for winter-spring rice, water flora and fauna are almost no longer existed.

III.4.4 Ground water resources

Groundwater is mainly contained in sedimentary layers. In the aging order, they are divided into 7 divisions:

Aquifers include
- Porous complex aquifer in the non-divided forth age sedimentary deposit
- Sedimentary deposit porous complex aquifer Holoxen (QIV)
- Sedimentary deposit porous complex aquifer Pleistoxen midle – late ages (QII-III)
- Sedimentary deposit porous complex aquifer eraly Pleistoxen (QI)
- Sedimentary deposit porous complex aquifer Plioxen (N2)
- Sedimentary deposit porous complex aquifer Mioxen (N31)
- Porous complex aquifer Mezozoi – Paleozoi (MZ-PZ)

At present, groundwater is mainly used for domestic use and in some places groundwater is used for irrigation of vegetable, fruits. Groundwater is very valuable in the dry season from December to May, however in some places, groundwater is also used in the rainy season when long drought occurs. According to geologists, groundwater in the Cuu Long Delta is only enough for domestic use and irrigation of vegetables, etc. Main irrigation sources for agriculture development are surface water.

Groundwater resources: According to the report (1998) of Vu Van Nghi, Tran Hong Phu, Dang Huu On, the ground water resources of the Cuu Long Delta: natural static reserve:

84,786,000 m^3/day, dynamic volume 6,971,111 m^3/day, and the total daily volume of 91,575,000 m^3/day

On the groundwater quality aspect, groundwater with mineralization of M<1g/l, shares 46% total groundwater volume, enough for supplying domestic uses. Groundwater with mineralization of about 1-4 g/l is about 19 million m^3/day, sharing 31%. It can used to supply for other demand such as: industry and agriculture. The remaining about 23% should not be used except when treatment is made.

III.5 Development orientation of economic sectors

III.5.1 Agriculture

Based on socio-economic development for the Cuu Long Delta for 2001-2005 and 2010 approved by the Prime Minster, in combination with agriculture and rural master plan of provinces in the region, agriculture development in the Cuu Long Delta by year 2010 will concentrate on the orientation as follows:

- Concentrate on efficient and sustainable exploitation of potential and advance in terms of geological location, land, water resources, biological resources and labors in order to continue the development of agriculture, fishery, and forestry at a high growing rate, promoting its position/advance in rice, fishery and other agro-product export to the nation. It is necessary to improve efficiency of sector production as foods, vegetable, fruit, breeding, fishery, processing industry, promoting agro-mechanism progress to create rapid movement of economic structure in trend of increasing the rate of industry and services.
- Strongly move agriculture structure in trend of improving efficiency and sustainable development, increasing value in each area unit, increasing farmer's income; concentrating on high-competition production sectors in combination with processing industry and consumption markets.
- Continue to invest on socio-economic infrastructure development including: transportation, water resources sector, healthy, education and training, building resident areas and houses in the inundated areas, in estuarine areas and in the coastal area. It is essential to intensify the natural disaster prevention capacity to reduce damage caused by flooding and natural disasters, to ensure the safe and sustainable lives for local people in inundation areas, in estuarine area and in the coastal area.

1. Land use structure

Selection for land use by year 2005 and year 2010 are as follows:

- ***Allocation of land use by sectors:***
  - Agriculture land will decrease from 2,970,316 ha in year 2000 to 2,908,637ha by 2005 and to 2,864,251ha by year 2010
  - Almost water surface area and un-used land will be exploited for forestry, fishery and agriculture development.

- ***Agriculture land use structure:***
  - Strong change in land use in trend of reducing area of annual crops, increasing area of perennial trees and aquaculture, improving mixed garden to fruit gardens:

- Changing rice area to fishery and special rice cultivation, strong movement in trend of diversification of kinds of rice growing areas

Table 33 Land use by 2010 (ha)

Items	2000	2005	2010	2005/2000	2010/2005	2010/2000
Total area	**3,971,232**	**3,976,266**	**3,976,266**	**5,034**		**5,034**
I. Agriculture land	**2,970,316**	**2,908,637**	**2,864,251**	**-61,679**	**-44,386**	**-106,065**
1. Annual crop area	*2,226,252*	*1,908,108*	*1,810,173*	*-318,144*	*-97,935*	*-416,079*
1.1. Rice–upland crop	2,082,663	1,746,679	1,631,992	-335,984	-114,687	-450,671
a. Triple rice – upland crops (UC)	359,349	308,169	564,800	-51,180	256,631	205,451
b. Double rice –upland crops	1,333,881	1,289,937	989,966	-43,944	-299,971	-343,915
c. Single crop	292,307	81,410		-210,897	-81,410	-292,307
d. Single rice + 1 fishery	97,125	67,163	77,226	-29,962	10,063	-19,899
1.2. Mountain field	9,506			-9,506		-9,506
1.3. Other	134,084	161,429	178,181	27,345	16,752	44,097
2. Mixed garden	*117,317*	*43,586*		*-73,731*	*-43,586*	*-117,317*
3. Perennial trees	*397,377*	*479,791*	*540,662*	*82,414*	*60,871*	*143,285*
a. Industrial trees	118,429	122,761	120,501	4,332	-2,260	2,072
b. Fruit	197,320	270,439	320,806	73,119	50,367	123,486
c. Other	81,628	86,591	99,355	4,963	12,764	17,727
4. Pasture	*18*	*2,315*	*4,957*	*2,297*	*2,642*	*4,939*
5. Aquaculture surface water area	*229,352*	*474,837*	*508,459*	*245,485*	*33,622*	*279,107*
a. Shrimp culture	183,999	407,039	430,149	223,040	23,110	246,150
- Shrimp-growing	176,852	242,078	248,488	65,226	6,410	71,636
- Shrimp –rice	7,147	164,961	181,661	157,814	16,700	174,514
b. Fish-growing	30,800	52,212	56,654	21,412	4,442	25,854
c. Other	14,553	15,586	21,656	1,033	6,070	7,103
II. Forestry	**337,688**	**430,770**	**438,135**	**93,082**	**7,365**	**100,447**
1. Natural forest	76,629	76,767	78,112	138	1,345	1,483
2. Replanted forest	261,059	354,003	360,023	92,944	6,020	98,964
III. Special used land	**223,516**	**262,682**	**309,846**	**39,166**	**47,164**	**86,330**
IV. Resident area	**101,313**	**122,118**	**142,254**	**20,805**	**20,136**	**40,941**

Source: SNIAPP (Sub National Institute for Agriculture Projection and Planning)

- Area of perennial trees increase from 397,377ha in year 2000 to 479,791ha by year 2005 and to 540,662ha by year 2010; the ratio of perennial tree area in total agriculture area correspondingly increases from 13.38% to 16.65% and then to 18.84%.
- Surface water area used for aquaculture (mainly shrimp culture) rapidly increases in period of 2001-2005 and slightly increases in period of 2006-2010 from 229,352 ha in year 2000 to 407,039ha by 2005 and to 430,149ha by year2010, the ratio of surface water area used for aquaculture correspondingly increases from 7.72% to 16.46% and then to 17.79%.
- On the fishery aquaculture land, the surface water area used for only aquaculture slowly increases, mainly increasing by expanding shrimp-rice cultivation.
- Land use rotation in rice growing area: this rotation ratio will increase from 2 in year 2000 to 2.32 by year 2010, due to no single crop area and about one third areas used for triple crops.

2. Agricultural development criteria

Rice production: According to estimation by the World Bank (WB) in April, 1999, in comparison with 10 Asian Countries, Vietnam has highest advance in rice export (mainly in the Cuu Long Delta) (RCA on rice export of Vietnam is 69.7; much higher than RCA of Thailand: 28.7).

In the rice production areas of the nation, rice production in the Cuu Long Delta is the most favorable and has highest advance in competition. Rice production for the next years will develop in trend of: promoting intensive cultivation, increasing yield and quality in order to reduce investment, to increase price, reduce risks in rice production. The areas having low efficiency will change to fishery culture and other crop cultivation that have market assurance, higher income and much higher sustainability. According to the agriculture development orientation, food production, particularly rice production, is a strategic objective, of that the Cuu Long Delta is the area no 1 of the nation. Two rice-growing seasons are winter-spring rice and summer-autumn rice, Seasonal rice is cultivated in accordance with rice-shrimp, rice-fish cultivation models. Most of triple rice areas changed to double rice - fishery production model. The proposed rice growing area is as follows: total year-round rice cultivation area 3,321,000ha, with a production of 16-17 million tons.

Maize production: Maize production in the Cuu Long Delta is mainly used as livestock foods. Parallel with promoting breeding and fishery development, the demand on maize product is rapidly increased in order to supply materials for livestock food processing factories and will be developed in the next years. Almost maize area will be rotated in rice areas in shallow inundated alluvial soil land in riparian areas. Total cultivation area is 136,000 ha, with a production of about 753,000 tons.

Sweet potato production and others (winged yam, taro..): all kind of common cassava (sweet potato, winged yam, taro, cassava,...) produced in the Cuu Long Delta is mainly used for inner consumption. Total cultivation is about 20,000 ha, with a production of 314,000 ton.

Soybean production**:** Soybean will be developed strongly in order to change the inner demand, this kind of demand will be increased largely in the future on one side to reduce the pressure on rice consumption, on the other side to increase the efficiency of land use and farmers income. Soybean area is expanding mainly in shallow inundated alluvial soil land in riparian areas by applying double rice+1 upland crop cultivation model. Total soybean cultivation area is 93,700 ha, with a production of about 163,600tons.

Cotton production**:** According to the orientation of the government, cotton will be strongly developed to supply inner demand, this demand will be increased higher in the future on one side to reduce the pressure on rice consumption, on the other side to increase the efficiency of land use and farmers income. Cotton area is expanding mainly in shallow inundated alluvial soil land in riparian areas by applying double rice + 1 cotton crop and single rice + 1 cotton crop cultivation models. Total cotton cultivation area is 49,000 ha, with a production of about 110,500tons

Sugarcane production: Sugarcane in the Cuu Long Delta has fewer advances in competition than that of in the Southern Area of Vietnam due to inundation situation, low sugar content, and the efficiency of sugarcane production is lower than that of fruit and cultivation of triple season of rice and upland crop. However, due to the existence of sugar

factories, it will be maintained the production with reasonable scale to supply materials for these existing factories. Sugarcane area is about 112,000ha, with a production of 8,454,200 tons.

Table 34 Existing and planed crop cultivation areas by year 2010

Area : 1.000ha; Yield : ton/ha; production : 1.000ton							
No	Items		1990	2000	2010	Average growth rate (%/year)	
						2000/1990	2010/2000
1	Year-round rice	DT	2,580	3,936	3,321	3.16	-1.68
		SL	9,480	16,881	16,360	5.72	-0.31
A	W-S rice	DT	752	1,520	1,498	6.99	-0.15
		SL	3,631	8,003	8,622	8.45	0.75
B	S-A rice	DT	908	1,881	1,532	5.85	-2.03
		SL	3,207	6,990	6,639	7.69	-0.51
C	Seasonal rice	DT	920	535	292	-7.12	-5.89
		SL	2,642	1,888	1,099	-4.74	-5.27
2	Maize	DT	11	16	136	22.47	24.12
		SL	26	48	753	30.92	31.76
3	Sweet patato	DT	20	10	20	10.72	18.28
		SL	193	146	314	0.07	19.15
4	Cassava	DT	12	8	10	-3.21	2.02
		SL	102	69	121	0.34	5.72
5	Vegetable	DT	42	96	185	12.89	6.76
		SL	659	1,185	2,620	10.93	8.26
6	Bean	DT	23	15	41	1.95	10.46
		SL	26	17	72	4.83	15.39
7	Groundnut	DT	13	9	30	5.35	12.79
		SL	23	19	72	8.10	14.04
8	Soybean	DT	17	7	94	11.00	29.25
		SL	24	16	164	16.54	26.57
9	Sugarcane	DT	53	87	112	6.62	2.57
		SL	2,510	5,171	8,454	10.79	5.04
10	Coconut	DT		112	117		0.49
		SL		659	857		2.66
11	Pineapple	DT	26	20	37	2.10	6.35
		SL	407	205	471	-0.60	8.65
12	Fruit	DT	144	206	307	6.54	4.09
		SL		1,531	3,281		7.92

Source: SNIAPP // Sub National Institute for Agriculture Projection and Planning

Pineapple production: Pineapple is considered as main fruit of the world. Pineapple production in 1992 reached 10.35 million tons, exported 568.600 tons and about 731.700 tons was canned. Total fresh pineapple export production is about 40% total production pineapple, the highest in other fruit production. Areas, where will concentrate to produce pineapple, are the riparian area of Cai Lon River, and Kien Luong - Kien Giang, Bac Dong - Tien Giang and Long An. Total area is 37,100ha, with a production of 470,000 tÊn.

***Fruit production*:** The Cuu Long Delta has advance in development of fruit and at present the Cuu Long Delta has highest area in comparison with that of other areas of the nation, with specialized cultivation area along National Road No. 1 from Tien Giang to Soc Trang, where has favorable navigation and road system, and abundant fresh water year-round. Famous fruit in this area includes mango, durian, oranges, mandarin, pomelo, longan, rambutan, which can export to Chinese markets, etc. The trend of development is to continue expanding fruit area in the non flooded alluvial land in the riparian areas, and to combine the intensification of intensive cultivation with improvement of quality, building flood protection dikes for concentration fruit cultivation area; intensification of applying new technique in variety, cultivation, and post-harvesting technology; combination fruit cultivation with fishery development in canal system in the fruit garden as well as breeding in fruit garden to ensure high and sustainable efficiency of fruit cultivation. Total area is about 306,700 ha, with a production of 3,281,000 tons.

3. Water demand

Based on agriculture development demand and other sector requirement, existing water demand in the dry season is about 909 - 1231 m3/s (details in table 14- excluding water demand for ecosystem). This water demand includes irrigation, industry and domestic uses. With the discharge of the Mekong River at Tan Chau - Chau Doc of about 2000 m3/s (in the dry season), if the upstream countries increase water abstraction in the dry season the water supply in the sub-area 10v is very difficult and salinity will intrude further inland.

4. Hydraulic works development

According to water resources development of the sub-area 10V, in order to satisfy the socio-economic development objectives for the next years, water resources sector has to improve the capacity of existing hydraulic works systems as well as has to construct new hydraulic works as follows:

- Building flood control construction to protect summer-autumn crops and early seeding of winter-spring crops safely as well as protect people in the flood season.
- Building “closed ring” embankment systems to protect fruit gardens as well as building “semi-closed ring” levee systems to protect summer-autumn rice areas.
- Building sea dikes and river mouth dikes in combination with building sluice system to control salinity, to keep fresh water for production and for supplying water to domestic uses.
- Developing in-farm water resources for serving different production models.
- Upgrading main canals, primary canal to convey water, to drain and to reclaim land in the acid sulfate soil areas.

5. Livestock

The Cuu Long Delta has advance in sources of foods and labors but limit by inundation; and the living environment is seriously affected by wastes from breeding. On the other hand, meat price is still high and export markets are not clearly identified therefore the breeding of the Cuu Long Delta is mainly to develop reasonably for supplying inner demand. Main livestock are pigs and poultry. Planed livestock is presented as in tables 32 and 33 as follows.

Table 35 Planed cattle and poultry in the Cuu Long Delta by 2010

Livestock	Unit	2000	2005	2010
1. Buffalo	Head	63,737	57,364	51,629
2. Meat cow	Head	197,210	265,928	370,343
3. Milk cow	Head	1,435	12,000	31,000
4. Pig	Head	2,976,636	3,423,134	4,001,388
5. Poultry	1000 head	44,212	53,147	63,992

Source: SNIAPP (Sub National Institute for Agriculture Projection and Planning)

III.5.2 Forestry

Forest in the Cuu Long Delta plays an important role in protection of the environment, preservation and development of the biological resources, and partly supplying wood demand in domestic used and construction; but for a long time the protection activity has not been paid attention remarkably the forest area reduce from 377,157 ha in 1990 to 309,233 ha in 1995, yearly reduction of about 13.585ha. In the period of 1996 - 2000, the reforestation and forest protection activities had been paid much attention therefore mangrove forest strip in the coastal area have been step by step recovered. The problem of destroying of mangrove forest for shrimp culture has been prevented basically. Heavy acid sulfate soil areas in the Long Xuyen Quadrant and in Plain of Reeds have replanted cajuput, and in 2000 the forestry area having forest is increased about 28,455 ha more than that of 1995, yearly increasing to 5,691 ha.

The development trend for the next years is to continue to expand the forest area in important areas (e.g. mangrove forest, cajuput forest in heavy acid sulfate soil areas, areas adjacent to the border,...), increasing forest area of 337,688ha in 2000 to 430,770ha by 2005 and to 438,135ha by 2010. It is necessary to intensify measures to protect forest, and step by step to combine the forest development with fishery aquaculture contributing to preservation of animal resources and improvement of the value of forestry economy, and contributing to beautify the scenery.

Table 39 Planed forest development in the Cuu Long Delta by 2010 (ha)

Item	2000	2005	2010
Total forest area	337,688	430,770	438,135
1. Natural forest	76,629	76,767	78,112
2. Replanted forest	261,059	354,003	360,023

III.5.3 Fishery

1. Brackish and saline aquaculture

- The planned brackish and saline aquaculture area by 2005 and 2010 is only concentrated in 8 coastal provinces in the Cuu Long Delta: year 2005: 563,636 ha increasing to 145,869 ha so in comparison with that of in 2001 (417,767 ha); by year 2010 increasing 27.436 ha in comparison with that of in 2005. The remaining area allowed to expand for development by 2010 is mainly alluvial ground in the coastal area and nearby the river mouth.

Table 40 Brackish and saline aquaculture area by 2005 and 2010

No	Province	Area (ha)				
		2001	2005	2005 compared with 2001	2010	2010 compared with 2005
1	Long An	3288	5880	2592	7820	1940
2	Tien Giang	4610	7166	2556	8570	1404
3	Ben Tre	30061	33480	3419	35300	1820
4	Tra Vinh	15091	26215	11124	27773	1558
5	Soc Trang	35856	53114	17258	60815	7701
6	Bac Lieu	83365	129313	45948	129313	0
7	Ca Mau	217898	246900	29002	249000	2100
8	Kien Giang	27598	61568	33970	72481	10913
	Total	**417767**	**563636**	**145869**	**591072**	**27436**

Source: Sub-Institute for Economy and Fishery Planning

- Proposed brackish and saline aquaculture is also only in 8 coastal provinces in the Cuu Long Delta and is as follows by 2005: 487,438 tons, increasing 296,108 tons in compared with that of year 2001 (191.182 tons) and by 2010: 759,158 tons, increasing 271,720 tons in compared with that of year 2005.

Table 41 Planning common tiger prawn/shrimp area and production in the Mekong Delta by 2005 and 2010

Province	Area (Ha)				Production (Ton)			
	2001	2005	2010	10 – 01	2001	2005	2010	10 - 01
Long An	3236	5820	7750	4514	1621	4640	8240	6619
Tien Giang	2355	4274	5000	2645	1348	4000	7054	5706
Ben Tre	26573	29922	31742	5169	9413	20609	39127	29714
Tra Vinh	12023	22215	22942	10919	3430	18715	26055	22625
Soc Trang	35870	51414	59725	23855	18968	38638	56336	37371
B¹c Lieu	82452	123313	123313	40861	27699	61204	98207	70508
Ca Mau	217898	238000	238000	20102	55330	98000	150000	94670
Kien Giang	26800	59508	68381	41581	4800	23634	45220	40420
Total	407207	534466	556853	149646	624612	269440	430238	307633

Source: Sub-Institute for economy and fishery planning

2. Freshwater aquaculture

Freshwater aquaculture appears almost all provinces of the Cuu Long Delta. The delta has large potential aquaculture area and a densely river-canal network to develop diversified aquaculture (e.g. specialized, intensive, cage, etc., and to diversify aquaculture object as freshwater fishes, shrimps, special fishery, etc. with high yield supplying for processing industries of provinces of the sub-area. The data is shown in the table 36.

Aquaculture area is distributed over 12 province; but the order (the area over 20000 ha) is as follow Soc Trang, Ca Mau, Kien Giang, Can Tho, Tra Vinh, Sac Trang by year2005. By

year 2010 these province will extend except Bac Lieu province. The Ca Mau province will maintain the aquaculture same as that of in 2005. Particularly, the Kien Giang has a remarkable growing rate of aquaculture area from 39,785 ha by year 2005 to 62,368 ha by year 2010; but due to low yield, the production is lower than that of some provinces.

Table 42 Aquaculture area of fresh water by year 2005 and 2010

No	Province	Area (ha)				
		2001	2005	2005 -2010 Compared with 2001	2010	2010 -2005 Compared with 2005
1.	Dong Thap	2330	19200	16870	29200	10000
2.	An Giang	1252	4200	2948	5200	1000
3.	Vinh Long	5000	7145	2145	11200	4055
4.	Can Tho	13910	29375	15465	45000	15625
5.	Long An	1735	5180	3445	10850	5670
6.	Tien Giang	4272	10030	5758	11430	1400
7.	Ben Tre	2201	9770	7569	14250	4480
8.	Tra Vinh	22662	21526	-1136	38394	16868
9.	Soc Trang	6061	19710	66903	29185	9475
10.	Bac Lieu	5120	3283	-1837	3283	0
11.	Ca Mau	36293	40000	3707	40000	0
12.	Kien Giang	15181	39785	24604	62368	22583
	Total	116017	209204	93187	300360	91156
	No. of Cage	5432	8412	2980	13037	4625

Source: Sub-Institute for Economy and Fishery Planning

Table 43 Freshwater aquaculture production by year 2005 and 2010

No	Province	Production (ton)				
		2001	2005	2005 -2001 so 2001	2010	2010 -2005 so 2005
1.	Dong Thap	35797	112550	76753	171250	58700
2.	An Giang	83641	84000	359	109000	25000
3.	Vinh Long	7000	23133	16133	37426	14293
4.	Can Tho	30857	59717	28860	171300	111583
5.	Long An	12906	16315	3409	23475	7160
6.	Tien Giang	14823	30967	16144	40329	9362
7.	Ben Tre	1664	42418	40754	47756	5338
8.	Tra Vinh	19520	33537	14017	73906	40369
9.	Soc Trang	4519	16103	11584	29606	13503
10.	Bac Lieu	6923	1748	-5175	2998	1250
11.	Ca Mau	32358	8000	-24358	18000	10000
12.	Kien Giang	6700	14043	7343	36837	22794
	Total	256708	442531	185823	761883	319352
	Of that, cage	52525	98862	46337	156783	57921

Source: Sub-Institute for Economy and Fishery Planning

III.5.4 Water transportation

- It is necessary to prevent degradation of navigation routes in the Cuu Long Delta, step by step to recover and upgrade priority routes such as route Ho Chi Minh City-Kien Luong, and route Ho Chi Minh City-Ca Mau, and to consolidate other routes.
- It is essential to construct Can Tho port in the Bassac River as a center of the Cuu Long Delta. Firstly, it allows for 5,000 tons access and then ship10.000 ton. The capacity of loading is about 1.5 million ton/year and then increases to 2.5 - 3 million tons/year by year 2010, to ensure the access of normal cargo and container ships of the whole Cuu Long Delta. This prospect depends on the study result of dredging the Dinh An River mouth. In addition, about 1-2 large harbors can be constructed.
- It is necessary to upgrade harbors along the Mekong River and Bassac River such as My Thoi, My Tho, Vinh Thai, Nam Can, Kien Luong, Hon Chong, to allow the access of marine ships. It should be often to dredge navigation routes, specially the Dinh An River mouth, Tieu River mouth (Mekong River), and Tran De River mouth related to Nam Can harbor.
- All roads located in the inundation areas should be designed based on flood peak of 1961 and roads located outside should be designed based on tidal level of 1994.

III.5.5 Tourism

Kinds of cultural and ecological tourism will be developed. Combination the tourism with protection of the environment, preservation of natural conservation area, and wetland area will be implemented. It is necessary to link the tourism network of the sub-area to that of the southeast area as well as other areas of the nation, specially the cooperation with Cambodia and Laos in the Mekong River. It is also necessary to upgrade existing tourism infrastructure to facilitate tourists. The most important matter is to train human resources involved in tourism sector.

III.5.6 Electricity sector

Electricity of the Sub-area 10V is mainly developed by thermal and gas-turbine power plants. According to 2010 plan, there will be 3 power plants O Mon 1, O Mon II and Ca Mau. The details are listed as in table 38 below.

Table 44 Main parameters of power plants in sub-area 10V by year 2010

Plant	Install capacity (MW)	Operation year
O Mon I	600	2006
Ca Mau	720	2006
O Mon II	750	2010
Total (MW)	2070	

III.5.7 Water supply sectors

1. Agriculture water demand

Water demand for agriculture is estimated from water demand standard and plans of main crop cultivation and breeding development of the sub-area by year 2010. The primarily result of the calculation shows that the agriculture water demand of the sub-area is about 35-40 billion m^3.

The most important factor, which needs to be considered in supply for agriculture of the sub-area, is temporal hydrological regime, and amplitude of other factor affected to water quality (salinity, acid water).

Table 45 Agriculture water demand of the sub-area 10V

	Development plan		Average Water demand
	Unit	Year 2010	
Crop			(m^3/ha/crop)
1. Rice	ha	3,800,000	9000 – 10000
2. Maize	ha	46,500	2000 – 2500
3. Vegetable, bean	ha	230,100	2000 – 2200
4. Sugarcane	ha	100,200	2500 – 3000
5. Cotton	ha	24,000	2000 – 2200
6. Fruit	ha	280,500	2000
Livestock			(litter/day/head)
1. Buffalo, cow	Head	88,300	90 – 106
2. Milk cow	Head	12,000	120
3. Pig	Head	4,022,000	50
4. Poultry	Head	63,359,000	20

Note: water demand at farm field excluding rainfall

2. Fishery water demand

Table 46 Water demand for aquaculture development

	2005		2010	
	Million m3	% compared with the potential	Million m^3	% compared with the potential
Sub-area 10V	11,984	2.7	13,339	3.0

Freshwater demand for aquaculture is roughly estimated and it is conditioning. The key factor is water quality, which is strongly affected by ways of agricultural cultivation in areas having surface water. These surface water areas are decidable to the efficiency of the fishery aquaculture but not the quantity of these surface waters.

3. Water transportation demand

On the technical respect, least available depth (LAD) in the dry season is used as a planning criterion to estimate water transportation demand. Water transportation demand in each route is presented in the table 41 below.

4. Water demand for domestic and industrial uses

Based on the growing population forecast and water supply criterion, the water demand for domestic uses of the sub-area 10V is 987.2 million m^3 by year 2010 and 1564.7 million m^3 by year 2020 (table 42).

Table 47 Water transportation demand in the sub-area 10V

Name	Route	Length (Km)	Ship (DWT)	LAD (m)
Ho Chi Minh City - Kien Luong	Through Te Canal, Cho Dem Ben Luc , East Vam Co... Rach Gia-Ha Tien canal	297.8	300	3.0
Ho Chi Minh City - Kien Luong- Ba Hon	Through Rach Ong Lon , Cay Kho canal, Rach Soi , Rach Gia - Ha Tien canal- Ba Hon canal	320.8	300	3.0
Ho Chi Minh City -Ca Mau - Nam Can	Through Te canal, Rach Ong Lon, Can Giuoc river, Ganh Hao River, Bay Hap canal, Tac Nam Can canal	393.3	300	3.0
Moc Hoa - Ha Tien	Vam Co River, Cai Bac river, Hong Ngu .... Ha Tien	183.5	200	2.5
Hieu Liem - Soai Rap River	Hieu Liem - Dong Nai river-Sai Gon River - Nha Be River- Soai Rap river	144	300	3.0
Tan Chau Hong Ngu - Cua Tieu	Vietnam-Cambodia border - Tan Chau - Dong Thap ,Vinh Long , Ben Tre ,...Cua Tieu	260.4	3000	6.0
Rach Gia - Ca Mau - Ong Doc River mouth	Rach Gia town- - Ca Mau - Ong Doc river	182.6	1000	4.0
Mekong River	From Vietnam-Cambodia border to the sea	260.4	5000	7.0
Bassac River	From Vietnam-Cambodia border to the sea	228	5000	7.0
Ham Luong River	Confluence of MK river - Ham Luong to Ham Luong river mouth	86	1000	4.0
Quan Lo - Phung Hiep	Intersection of Phung Hiep - Hau Giang - Quan Lo - Phung Hiep to Ca Mau	104.5	300	3.0
Go Dau – East Vam Co River- Soai Rap river mouth	Ben Soi – East Vam Co - Go Dau - Duc Hue - Ben Luc - Soai Rap	189	3000	6
Moc Hoa- Soai Rap river mouth	Moc Hoa –West Vam Ca to Tan An - Soai Rap river mouth	163.5	1000	4.0

Source: Southern Sub-institute for Transportation Design

Table 48 Water demand for domestic uses of sub-area10V

Sub-area 10V	2000	2010	2020
Growing population rate (million people), %	16.745*	1.8	1.1
Water demand (10^6 m^3)	495.5	987.2	1564.7

Industrial water demand: In the sub-area 10V, power plants as O Mon 1 O Mon 2 (600MW), mixed gas-turbine power plants (720 MW) will be implemented parallel with forming of industrial gas-power-fertilizer/nitrogen zone (800000 tons urea/year) in Ca Mau, Kien Giang cement factory (3.05million ton /year); 2 groups fabricate-sewing-dyeing in Can Tho and Long An; large and medium scale fishery processing enterprises in Ca Mau, Soc Trang, Can Tho, Tra Vinh (over 250000 ton/year). In addition, there are about 6 industrial zones and some additional industrial zones. Moreover, there are some medium and small scale industrial zones (30-40ha) in Can Tho, Bac Lieu, An Giang, Ben Tre, as well as enlargement of industrial zones in urban towns, where there are processing industry and post-harvesting processing enterprises, supporting trade village, etc.

III.5.8 Flood control

The requirements of the flood control activities are to:

- Control flood year-around for an area of about 910,000 ha, of which, agriculture is 693,000 ha to create condition for development of agriculture, fishery, improvement of living conditions for local people, development of infrastructure, rural development; and to reduce the magnitude of the inundation depth as well as duration to ensure the safety for summer-autumn harvesting. Taking consideration of flood control criteria, in the full flood control areas, the flood 2000 as designed; in the areas non-full flood control, the flood 2000 and inter-field rainfall with frequency 10% considered as designed one.
- Build structures to protect resident areas, main road system, and to reduce the damage caused by floods.
- Reduce flood water with less sediment from the border side flow into the Plain of Reeds and eastern areas of the Long Xuyen Quadrant; and to convey the much sediment flood water from the Mekong River and the Bassac River into the fields and to flush the acid water as well as to clean the field.
- Convey flood water to Ha Tien Quadrant to increase the sedimentation, to flush the acid water to improve the soil as well as the environment of this area.
- Build salinity prevention system in the coastal area of the West Sea that will improve the coastal area of Rach Gia-Ha Tien to create condition for increasing cropping seasons and supplying water for domestic uses in this area.
- Created more main canals that will create more inland navigation lines and take advantage of the dredging materials for road development as well as housing foundation improvement

The plan of flood control activities in the Cuu Long Delta is to build flood control structures to create safe and sustainable living conditions for the local people, to develop socio-economy, and to improve and protect the environment. To control floods year-round for southern area of Cai San canal, southern area of Vinh An canal, southern area of Nguyen Van Tiep Canal and eastern area of Bo Bo - My Binh canal; as well as control floods timely for deep inundation areas. The measures for flood control in the Cuu Long Delta are as follows:

- To build structures system to protect resident areas including urban areas, towns, commune centers, supplement areas and to resettle rural people along roads, main canals and primary canal. Additional, in combination with housing foundation embankment to resettle about 11.8 million people by year 2010 that could be adopted the size of 2000 floods.
- To build 24 main roads, which link with urban areas, and densely population areas, with a total length of about 2,266 km. These roads have level to protect the areas from the 2000 flood. Rural roads are not over the main floods and will be built with a density of about 0.42 km/km^2. In addition, in order not to obstructing the flood ways, reasonable floodgates, which are used for drain floods, must be built at reasonable locations. Taking the flood of year 1961 into consideration, an estimation of needed areas for flood withdraw is of about 37,665 m^2. At presently, Plain of Reeds and Long Xuyen Quadrant has 25,343m^2 and 12,322 m^2 respectively. In comparison with the existing, about 5459 m^2 is needed to enlarge, of which Plain of Reeds needs and Long Xuyen quadrant needs 1,548 m^2 and 3,911 m^2 respectively. If the floods of year 2000 are taken into consideration, the Long Xuyen Quadrant and the Plain of Reeds need to enlarge 5000 m^2 of the flood withdraw area, more than that of consideration in case of flood year

1996. Thus, in comparison the existing floodgates, much more floodgates need to be enlarged.
- To build structures which control floods flowing across the border to the Plain of Reeds, Long Xuyen Quadrant, and western area of the Bassac River;
- To build structures to control floods from the Bassac River and Mekong River to farm fields;
- To build structures system to drain floods inland to the West Sea, the Mekong River, the Bassac River, the West Co River; and structures to control tides from the East Sea and the West Sea
- To build structures to control flood year round for Western area of the Bassac River, southern area of Vinh An Canal, southern area of Nguyen Van Tiep canal and eastern area of Bo Bo canal.

Based on the fundamental flood control structures and the hydraulic parameters in the farm fields, the flood control area can be classified into three areas, which need to be controlled at different scale as follows:

- Non-controlled flood area is located in the north of the National Road N1 with an area of about 117,800 ha. This area is difficult to develop agriculture at high level. However, by adapting the measures of avoiding floods in combination with construction of ring embankment to protect against early floods, selecting crop calendar; thus double paddy crops of winter-spring and summer-autumn can be produced but summer-autumn crops must be harvested before 20 July annually.
- Timely-controlled flood area is limited from the south of the flood-protected site, which protect the flood flowing across the border, to the north of Nguyen Van Tiep canal, north of Cai San canal and the east of Bo Bo-Rach Tram My Binh Canal, with an area of about 859,000 ha. Due to controlling flood at the beginning and at the end of the flood season, the winter-spring and summer-autumn cropping seasons are safely produced and the highest water levels in the Long Xuyen Quadrant and the Plain of Reeds are reduced to about 20-40 cm and 10-40 cm respectively therefore large amount of money which invest in construction of infrastructure, are also reduced. On the other hand, due to construction of main roads and resident areas to adapt floods, damages caused by flooding are also reduced creating safety and sustainable lives for local people.
- Year-round flood-controlled area is the area of the remaining inundation area with an area of about 938,490 ha. In this area, due to controlling floods year-roundly, agriculture, infrastructure, civilized and modern rural area, and the environmental sanitation can be developed and improved at high level.

In addition, it can be combined with non-structure measures for flood control as flood forecasting, cropping calendar guidance, new varieties that can be adapted the inundation, growing in short duration in order to ensure the safety, and sustainability for production. Following are the descriptions of the flood control for key flood controlled areas:

1. Long Xuyen Quadrant

The Long Xuyen Quadrant is located in the northwest of the Cuu Long Delta with an area of about 490,000 ha, bordered with the Vietnam-Cambodia in the North, the West Sea in the west, Cai San Road in the east and the Bassac River in the northwest.

The objectives of flood control for the Long Xuyen Quadrant are to

- Protect resident area, town and urban areas safely;
- Ensure transportation smoothly year-round in national roads, main roads as Road 80, Road 91, National Road N1, N2 and provincial roads as Long Xuyen - Hue Duc, Long Xuyen - Tri Ton;
- Reduce flood level at the beginning and at the end of the flood season to ensure the double rice cropping in the winter-spring and summer-autumn safely;
- Reduce flood peaks in the main flood season for southern area and along the national road 80;
- Reclaim soils in the Ha Tien Quadrant for agriculture production;
- Combine with other hydraulics works to form a complete water resources construction system for socio-economic development as well as to combine with construction of transportation works, resident areas to form rural area in trend of modernization and civilization.

Flood control alternatives for Long Xuyen Quadrant include 4 groups of main structures as follows:

- Controlling floods flowing across the border to the Long Xuyen Quadrant to drain out to the West Sea.
- Constructing structures to drain flood out to the West Sea.
- Constructing structures to prevent salinity intrusion and to keep fresh water for the coastal area in the West Sea.
- Constructing a structure system to control floods from the Bassac River to the Long Xuyen Quadrant.

Group No.1 - Structures system in the coastal area in the West Sea.

- Dredging, newly excavating, and constructing 23 canals to drain floods from Rach Gia - Ha Tien to the West Sea.
- Improving bridges along National Road 80.
- Constructing 74 km sea dike system in the West Sea with dimensions as follows: adapting the tidal level 1.2m at Rach Gia, top level of the dike +2,00m, top width B=3m as well as constructing 23 sluices to prevent salinity.

Group No.2 - Structures system to control floods flowing across the border.

Constructing a dike system to prevent the floods flowing across the border and constructing flood control structures to control the floods flowing across the border to the Long Xuyen Quadrant include:

- Flood prevention dike from Chau Doc to Tinh Bien and from Ba Chuc to the beginning of Ha Giang Canal. This dike is built in the south bank of the Vinh Te Canal.
- Flood control structures including Tra Su sluice with B=28 m, bed level –3.0 m with a drain capacity of 700 m3/s; structures at the beginning of Moi Canal, T5, T4, T3, T2, Nong Truong canals and 7 bridges at the beginning of canals in the Ha Tien Quadrant.

There are two different ideas on the flood control site from Chau Doc to Tinh Bien including i/ located along the south bank of the Vinh Te canal and ii/ beside the National Road 91. In addition, there are a number of different ideas on the dimension of the Tra Su sluice. These ideas will be clearly resolved in the feasibility study phase.

- Dredging and enlarging Vinh Te Canal with bed width of B=30m, bed elevation -3,0m to ensure the discharge Q=37 m3/s in the dry season, enlarging flood plain along the Vinh Te canal from K23+600 toK36+500 to drain the flood discharge of 1,940m3/s (used flood in 1961).
- Construction of spillway in combination with construction of a “dry” bridge in the north of Xuan To (no name bridge), with a width B=300m, bed elevation +1.0m to drain a maximum discharge of 1,220 m3/s.

Group No. 3 - Canals to drain inland flood to the West Sea.

- Construction of a canal system for irrigation, drainage of water and acid water, and to bring sedimentation including 18 main and first canals with a total length of 721km. These canals almost exist but improvement is needed except for some new canals.

There are some issues needed to pay attention, when construction of flood control system in the Long Xuyen Quadrant is implemented. The implementation of this system should be started from the seaside first in order to create capacity of flood drainage and combination with transportation system and ring dike to protect towns and resident areas.

Group No. 4 - Structures system to control floods from the Bassac River to Long Xuyen Quadrant

- Construction of 8 sluices at the beginning of canal along the Bassac River including: canal No.2, Can Thao, Tri Ton, Muoi Chau Phu, Ba The, Chac Nang Gu, Mac Can Dung and Chac Ca Dao canals.

2. The Western area of the Bassac River

The western area of the Bassac River is limited by the Cai San Canal in the north, the Bassac River in the East, the Cai Lon River in the west and Cai Con, Quan Lo - Phung Hiep in the south, and located in the land of Can Tho and Kien Giang provinces. Total area of the western area of the Bassac River is 365,060ha, of which, the agriculture land is about 288,143 ha.

The objectives of flood control in the western area of the Bassac River are to

- Ensure the safety for resident areas, towns, urban areas and transportation routes as National Road No., National Road 80, provincial road Can Tho - Long My, National road Can Tho - Vi Thanh - Go Quao- Rach Gia.
- Control floods year-round for over 42,000 ha of fruit;
- Control floods year-round for cultivation triple crops for most of the paddy fields;
- Bring sedimentation from the Bassac River to farm fields for fertilization of the soil;
- Combine with other water resources constructions to form a complete system for agriculture development at high level and also combine with transportation construction, resident area to build rural areas in trend of civilization and modernization.

Flood control alternatives for the western area of the Bassac River

- It is prevented the flow of the floods from Long Xuyen Quadrant to the western area of the Bassac River due to its poor quality and due to the fact that this flow causes

inundation of the western area of the Bassac River. It is controlled the flow of the flood from the Bassac River in order to take the initiative of bringing sedimentation for soil fertilization. To drain flows inland to the Cai Lon River by saline prevention construction and taking advantage of the neap tide duration to drain out.

- Construction of flood control structures along the national road 80, as well as construction of flood control structures for farm fields year-round as follows:

  - ❖ In the Cai San-Xa No sub-area, the eastern area of the National Road 91 the flood control construction is built by setting up small areas and the western area of the National Road 91 to build embankement to protect according to the 3 subprojects as Cai San - Thot Not, Thot Not - O Mon, O Mon - Xa No.
  - ❖ In the Can Tho - Long My sub-area, small, medium scale projects will be implemented in accordance with particular conditions.

3. The Plain of Reeds area

The Plain of Reeds is limited by the Vietnam-Cambodia border, the East Vam Co, the Cho Gao Canal and the Mekong River with a total area of about 703,338 ha, sharing 18% of the Cuu Long Delta.

The objectives of the flood control for the Plain of Reeds are to:

- Ensure the safety for resident areas, towns, urban areas and main transportation routes as National Roads No. 1, 30, N1, 62, 50, 864 and provincial roads Bac Nguyen Van Tiep, Cai Lay - Kien Binh, Dong Phuoc Xuyen and Tram Chim - Tan Hong,
- Take the initiative of control early floods and ending floods to ensure the production of double crops in winter-spring and summer-autumn seasons for the northern area of the Nguyen Van Tiep Canal;
- Control flood year-round for the southern area of the Nguyen Van Tiep canal, fruit areas and industrial areas in the eastern area of the Bo Bo Canal, Tan Lap state-managed farm (Cu Chi) and the Bac Dong - Cho Bung area;
- Combine with other hydraulic works to form a complete water resources system for agriculture development as well as combination the water resources development with development of road network, resident area in trend of building the civilization and modernization rural areas.

Flood control alternatives for the Plain of Reeds area

Group No. 1

- Construction of flood prevention and flood control routes along the south bank of the Tan Thanh Lo Gach canal, with top elevation of + 6.5 m at Hong Ngu and + 5.5 m at Vinh Hung. Dredging and enlarging Tan Thanh Lo Gach canal phase 2 with bed width of 32 - 24m, and bed elevation of –3.0m.
- Building of 10 sluices along the flood these routes, of which, there are five sluices for flood control such as Construction 2/9, Khang Chien, with bed width B=30m, construction Binh Thanh B=20m, Construction Thong Nhat B=20m, Cai Cai B=25m and the remaining five sluices for irrigation.
- Enlarging 3 floodgates including Electricity Pillar No. 10, Tra Du - Cay Da and Cai Sach -Nam Hang along the road Nam So Thuong enough for drainage of flood to the Mekong River from Hong Ngu to Tan Chau. These floodgates can drain about 3,700 m3/s.

- Dredging 4 flood drainage canals adjacent to the Mekong River including Canal 2/9, Khang Chien, Binh Thanh, Thong Nhat which link with Doc Vang Ha, Doc Vang Thuonng and Ba Rang river mouth to drain 3000 m3/s, enlarging the Song Trang canal linked with Ca Rung ditch and Ca Gua canal with a width of 20m, bed elevation of -3m; enlarging canal 28 with a width B=20m, bed elevation of -3m.

Group No. 2

- Dredging and upgrading block 2 of the Hong Ngu canal with bed width of 40m, bed elevation of - 4m to drain flood water to the West Vam Co River.
- Dredging and upgrading the Dong Tien - Lagrange canal to ensure the requirement of sources of freshwater, drainage as well as navigation requirement of the Plain of Reeds with bed width of B=30m, bed elevation of -3.50m.
- Dredging and upgrading An Phong-My Hoa-Nam Ngan - Bac Dong canal with bed width of B=14m, bed elevation of -3,00m, with a total length of L= 90km.
- Enlarging and dredging Canal 79 to drain floodwater in August and ending flood to the West Vam Co River, supplement freshwater for this area. Total length of about 45 km, bed width of 15m, and bed elevation of -3.0m.
- Constructing the Lagrange sluice for saline prevention, drainage of tidal water, floodwater and constructing other sluices adjacent to the Vam Co River.

Group No. 3 (southern area of the Nguyen Van Tiep canal)

- Dredging and enlarging 21 canals linked the Nguyen Van Tiep canal with the Mekong River such as canals 307, Cai Beo, Duong Thet, Canals 6,7,8... Both banks of these canals will be used as flood control dikes
- Construction of sluices for prevention of tide and drainage: These constructions uses for prevent the spring tide level and drain during the neap tide duration along the Mekong River from Cao Lanh to My Tho to take initiative of preventing inundation, quickly drain inland water to the Mekong River.

Group No. 4: (The area between the two Vam Co rivers)

- Dredging and enlarging the Bo Bo Canal to drain out the flood waters, dredging and enlarging canal linked two Vam Co rivers, bank embankment to create ring dikes to prevent inundation caused by floods for industrial tree cultivation as: sugarcane, pineapple, banana...

Group No. 5

- Protection of 12 towns located in deeply inundated area such as Tan Hong, Tan Hung, Vinh Hung, Thanh Binh, Tam Nong, Thap Muoi, Moc Hoa, Tan Thanh, Thanh Hoa, Hong Ngu, Tan Phuoc and Dong Thanh.
- Protection of commune centers and important resident areas against inundation.
- Building 3 ecological reservoirs such as Lo Moi (Tan Phuoc), Lang Sen (Moc Hoa) and Tram Chim (Tam Nong) to preserve the natural and ecology of the Plain of Reeds, to improve the climate, to keep moiture and supply water partly in the dry season.

4. Flood control for the area between the Mekong River and the Bassac River

The area between the Mekong River and Bassac River is limited by the Mekong River in the north, the Bassac River in the south, the border of Vietnam and Cambodia in the west and the East Sea in the East with an area of about 357,277 ha.

The flood control areas between the Mekong River and Bassac River can be classified into 7 sub-areas as the northern area of the Vinh An canal, the area of the Than Nong canal, the Cho Moi area, the northern area of Lap Vo, the southern area of Lap Vo, the Northern Mang Thit area, the Cho Lach - Chau Thanh (Ben Tre) area and islands. Particularly, the northern area of the the Vinh An canal has a relation with the drainage of flood flow from the Mekong River to the Bassac River, therefore, this is a non-control flood area. The remains are the year-round flood control areas.

III.6 Environment

III.6.1 Soil environment

The sub-area 10V is blessed with the most fertile soils of Vietnam favorable for agriculture development and fishery particularly fruits with high value for export. However, the soils in the area are degraded due to impacts by the nature as well as human activities.

- The exploitation of preservation forest areas is seriously resulting in rapid vegetation cover reduction, reduction of the biological diversification, many precious animals is extinct due to unbalance ecology system. Therefore, an efficient measure to protect special used forest areas is needed as well as forming more preservation areas to preserve precious genes.
- Due to forming year-round flood control areas, the sedimentation in farm fields is reduced, and also to limit the advantage of flood to clean the toxic matters, farm field sanitation, therefore the soil is degraded.
- The Cuu Long Delta has a large area of acid sulfate soils where the cultivation by embankment for cultivating pineapple, sugarcane, cassava have affected to adjacent areas.
- Due to triple rice cultivation, the fertile of the soil is reduced remarkably.
- Due to brackish and saline fishery cultures, the areas, where conjunction between the freshwater and saline water are formed, have affected to socio-economic development.
- Often forest fires have changed the ecological environment, particularly in the Ca Mau, Bac Lieu, and Kien Giang provinces.

III.6.2 Water environment

- At present, waste waters without treatment from towns, cities, industrial zones, hospitals are directly poured into canals resulting in water pollution with the indexes such as COD, BOD, etc. higher than the acceptable values.
- Due to un-well managed infrastructure development, that changes the flow regime, causing bank erosions like in Tan Chau, Chau Doc, Long Xuyen, Sa Dec, Vinh Long town, My Tho city...seriously affected to living condition of the local people, increasing the sedimentation in canals, reducing the life of canals.
- Drought: Annually, there are six months in the dry season when the total rainfall shares only 10-15% of the average annual rainfall, particularly almost no rainfall in February, March, and April. Parallel with the drought, the salinity intrusion also increases further inland; in year 1998 the salinity intrusion increased further inland about 20-30km, resulting in difficulty for water supply for irrigation and domestic uses.

- Floods and inundation: Due to the characteristics of the hydrological regime, floods occur in the area annually causing inundation over a large area of 1.9 million ha, with inundated depth of about 0.5-4.0m, and the inundation duration of about 2-5 months. After flooding, the matter of resolving post-flooded problems in terms of environment is costly, annually an amount of about 1000-2000 billion VND has to spend for this matter.
- Due to construction of infrastructure in the inundation area, that limit the movement, reside, growing and development of the water flora and fauna. This results in reduction of natural sources of fishery in farm fields, and in canals. The larger flood control area much higher the reduction of natural sources of fishery.

IV. ANALYSIS OF THE SUB-AREA

IV.1 Development opportunity, demands and constraints

IV.1.1 Development opportunity

The sub-area 10V covers 12 provinces of the Cuu Long Delta of Vietnam. Despite of many difficulties and limitations, the sub-area has many opportunities for socio-economic development as following:

- ***Priority development policies of the Government of Vietnam***

Based on the conditions of the sub-area, in particular, and the conditions of the nation, in general, the Government of Vietnam has launched the priority development polices for regional development, specially the Decision Nos. 01/1998/QD-TTg, 99/QD-TTg and 173/QD-TTg for development activities and programs for the sub-area by 2010, as well as policies on changes in movement of economic structures, economic development of all sectors in order to improve the loving condition of the local people, particularly the minority communities of the sub-area 10V. These policies include:

- Encouraging non-state enterprises and local people to invest into agriculture, fishery development, agriculture, fishery production processing industries with a priority on development of dominant production in the sub-area such as rice, fishery production, and fruit.
- Forming, extending agro-commodity production areas and industrial trees, which have potential for export.
- Prioritizing to licensing land use right and to give the land use license for farming owners, which give them the ways to loan from the banks.
- Prioritizing the settlement, sustainable cultivation, construction of transportation, power supply, and culture activities in the remote areas (program 135 – hunger clearance and poverty reduction).
- Prioritizing reasonable state budgets in combination with ODA loans for investment on transportation and water resources development in the sub-area.
- Exempting from or reduce or income tax, VAT for projects, which invest on processing industry; and industries, which servers for agriculture development. Exempting agriculture land use tax for extremely difficult households.
- Implementing priority policies for national and international investment, reducing renting land prices, and reducing income tax in the beginning period.

On the other hand, the Government of Vietnam will implement priority policies as follows:

- Encouraging all socio-economic sectors to create jobs and training, state budgets will prioritize to invest into main infrastructures development.
- Reserving land and encouraging investors carrying out aquaculture projects in new reclamation areas, where investors develop infrastructure and they can sell, hire, or rent in order to get back their investment in the vein that apply to industrial zones.
- Establishing linked organizations such as: farmer -cooperative – enterprise with reasonable policies aiming at the farmers who should produce their product by advanced contracts. By year 2005, there must be over 50% farmer households who produce their product by contracts with economic organizations, processing enterprises, and trade organizations. Firstly, implementation of contracts on sugarcane, cotton, milk cow, and

fishery production, then step by step implementing other production contractions will be carried out. The contract on the production consumptions is one of responsibilities of the processing enterprises and consumptions belong to all economic sectors. Formation of associations on assistance in production and consumption, protection of production and business rights foe each sector.

- Budgets including state budget and local budget, mobilization local sources and other donors in order to increase investment on the infrastructure such as transportation, water resources, education, health, resident areas, public works in resident areas.
- Launching a policy to encourage economic sectors to invest in producing suitable materials for house construction, infrastructure in the sub-area areas.
- Launching a state investment credit to ensure budgets for socio-economic development projects, projects on production processing for export, agriculture, forestry and fishery development projects.
- Developing a public encouragement policy as supporting in training programs; exempting or reducing land use taxes for investors; a prioritized credit for all kinds of investment in industry, handcrafts in the sub-area 10V. Establishing a stimulate industry fund (by the state fund, from donors, privates and from investment capital restore) in order to develop industry and handicraft.
- Solving basic problems such as no land or shortage of land use of farmers: create more land by reclamation. Reviewing land uses of all organizations, state enterprises in order to revoke land use licenses in year 2001 and in early 2002 all land where it is used inefficiently or not yet used, will be given to local authorities to license to farmers for their production. Creating conditions for part of farmers, who have no land or are shortage of land, to reside in new economic areas; improvement of land management capacity, completions of land administration report, licensing land use right, and close management of changes in land use. Illegal land use transfer is strictly forbidden. Complain and dispute in land use must be completely resolved; It is continued to implement the policy of reducing tax of agriculture land use in the inundation areas and local areas where there are difficulties in terms of consumption market; exempting poor households (according to the new criteria) and households under program 135 from the tax of agriculture land use must be implemented.
- Regarding minority community, it is continued to implement the aid policy on price for Khmer people, whose living conditions are really difficult. Resolving the loan for minority people from the bank of the poor and other sources are prioritized; activities on encouraging agriculture and increasing of guiding minority people for practice and production must be well implemented. From 2002 forward, exempting the poor minority people and policy households from (a) the contribution to school construction, school fees, book fees for students; and priority resolving of the problem of job of graduated students (b) the fees of medical examination at all medical stations, hospitals must be implemented.

- ***Development cooperation between 10V Sub-area with Cambodia***

The sub-area 10V borders with Cambodia over a length of 330km, where has high potential for bordering cooperation and exchange of culture. The governments of Vietnam and Cambodia have agreed to study a common development plan (flood control planning,...) and on that basic the trade agreement, clearance of tariff will be signed, and will progress in common agreement for trade and tourism.

It is implemented the trade centers in the border as Ha Tien, Tinh Bien, Tan Chau, Moc Hoa, Duc Hue, Moc Bai as well development of transportation routes linked with the border as National road 30, 91, N1, Asia Road...).

Regarding the ASEAN cooperation framework, beside of transportation, the cooperation must be implemented in information technology.

- ***International cooperation in the sub-area development***

The sub-area 10V is a focal area of the nation, therefore many studies and investments from international agencies and governments have implemented. The following are some typical international cooperation:

- The study on salinity intrusion (supported by the Australia Government)
- The master study on socio-economic development of the Cuu Long Delta (VIE 87-031) (supported be the World Bank)
- The program on clean water and rural environment sanitation (supported by UNICEF)
- Program on investment in water resources projects in the Cuu Long Delta (supported be the World Bank)
- Flood Control Planning (supported by South Korean Government)
- The project on investment in National Road No.1, Highway Ho Chi Minh - Can Tho, (supported be the World Bank)
- Natural Disaster Mitigation Program, (supported be the World Bank)
- Support to Capacity Building of Water Resources Institutes, (supported by DANIDA)
- The Mekong River Commission (MRC) has also supported some studies/programs as BDP, WUP, Tam Phuong project, flooding control plan...

- ***Investment for studying water resources development plan in the sub-area***

The water resources development in the Cuu Long Delta has been studied by Sub-Institute for Water Resources Planning (SIWRP) and related institutes and agencies. Some major studies include:

- The orientation of water resources development in the Cuu Long Delta, (implemented by SIWRP in 1990)
- SIWRP has implemented 40 projects on water resources development for sub areas
- Flood control planning in the Cuu Long Delta, (implemented by SIWRP in 1999)
- Water resources planning for Ca Mau peninsula, Long Xuyen quadrant, Plain of Reeds (implemented by SIWRP in 1997-2002).
- Master Plan for the Cuu Long Delta, (implemented by SIWRP)
- Water resources plans for 12 provinces of the Mekong Delta
- Pre-feasibility and feasibility projects for areas and hydraulic works...

- ***The potential of the sub-area***

- The Cuu Long Delta is a large plain and fertile area of the Southeast Asia and of the World, and is an important area for food production, fishery, and fruit of the nation. It is determined as an area for the national food security of the nation.
- The Cuu Long Delta has the coach over 700 km, about 360,000 km2 of privilege economic zone, bordering with the East Sea and Gulf of Thailand, very favorable for marine economic development.

- The Cuu Long Delta is located in very important area in terms of international exchanging relation, located in the most dynamic economic one of Vietnam at present, bordered with the dynamic and developed economic zones and important partners such as Thailand, Singapore, Malaysia, Philippine, Indonesia.... Moreover, the Cuu Long Delta is an area, which has international navigation routes as well international airlines linked South Asia and East Asia as well as other continentals and islands of the Pacific Ocean...
- The Cuu Long Delta is bordered with Cambodia, adjacent to Laos, Central Highland, and Southern Area, where have minerals resources, rich forest, and high potential hydropower.
- The Cuu Long Delta is located in the flat area with a densely river network favorable for navigation.
- The Cuu Long Delta is located in the tropical monsoon area favorable for a diversified agriculture development. Moreover, mild climate, and no typhoon are also advances of the Cuu Long Delta.
- The Cuu Long Delta has abundant fresh water resources, a diversification hydrological regime, creating different ecological zones. These support the sub-area to develop many sectors such as agriculture, fresh and salty fishery, and ecological tourism...
- The Cuu Long Delta with 16.7 million people, of which about 8.1million people in labor age, about 22.3% that of the nation, are the important human resources for socioeconomic development.
- The farmers of the Cuu Long Delta easily cope with the commodity production structure, which are suitable for agro commodity export.

IV.1.2 Development requirements

During the last few years, due to growing population rate, low agro-commodity price is, the local people income is low in comparison with that of the nation and the rate of poverty and hunger is high pressure on the economic development requirement

The Vietnamese government wish to promote the industrialization, modernization, rural development, trade and changes in economic structure are also increasing the water demand which in turn cause the degradation of the water resources, salinity intrusion, pollution, forest fire, frequently floods occurred...therefore it is necessary to have a water resources development in the Sub-area 10V in order to develop the sub-area in terms of sustainable, socio-economic development, and society equity and civilization.

The Government of Vietnam has identified that the Cuu Long Delta is the area, which serves as the national food security area of the nation; therefore the Government will have the priority policy for the next year. Particularly, the delta has a relationship with neighboring countries in general, and Cambodia in particular, based on the principle of improvement of living condition in terms of basic needs, culture, mental of the local people.

Based on the fundamental of development opportunities, development requirements, the orientation of the development of the Sub-area 10V are as follows:

- Control foods, salinity intrusion, and develop water resources system in order to support for the needs of changes in economic structure;
- Develop services, processing and post harvesting technologies;
- Sustain and improve the local people knowledge;
- Cooperate with Cambodia and other countries in the border area

- ***Trade, tourism and services development***
  - It is necessary to do well the forecast activities, market information, trade promotion in order to expand the international and national markets by fund of state enterprises, the donors and private supports with the support from the government; Construction and development of frontier pass economic zone in the provinces, which have favorable conditions.
  - Exploitation of the potential and advantage of the sub-area to develop the tourism, ecological tourist and try to keep the growing rate of the tourist sector in the period of from 2001-2005 reaches over 20%/year, and by 2005 the value of the tourist sector must reach over 800 billion VND.
  - Diversification and improvement of the efficiency of service activities, of that rapid speeding up the services which serve for goods production, export and serving for people like: transportation, export, labor export, technological services, input and output material supply services for agriculture and fishery. The growing rate of these service sectors in the period of 2001-2005, must reach 8-10%/year.

- ***Science, technology and environment***
  - Improvement of scientific, and technology capacity in the area and mobilization of sources of scientist and technologist from outside to create the incentives for new studies with high efficiency aiming at improving the contribution of the science and the value of the product and creating the incentives for socio-economic development in the Mekong Delta of Vietnam.
  - Investment for upgrade of the infrastructure for agriculture, forestry and fishery development studies in order to apply these new technology to support for changes in production structure, particularly changes in seeds for cropping, varieties for breeding and fishery culture, agriculture, forestry and fishery product processing and maintaining industries aiming at satisfying the requirement of the national and international markets and export.
  - Application of new science and technology in construction, and new materials for construction structures that are suitable for areas where are soft foundation, and annual flooding; study on the dredging the route from Ding An river mouth to Can Tho port for 10000-ton ship accessed.
  - Study on establishment of software technology at Can Tho and development and exploitation of internet of the sub-area.

- ***Health, education and training***
  - Reinforcement and development of hospital system which support for preliminary health services, controlling diseases, diagnosis and heal for local people, immediately investment for construction of regional hospital at Can Tho in order to satisfy the need of health services of the local people in the sub-area with a high quality.
  - Continuation of consolidation and upgrading local heath services station particularly in commune, hamlets; it is needed to have a policy to persuade doctors to work at local health service centers in communes, by year 2005 there will be about 80% communes which have doctors.
  - Rapidly creating changes in education and training, satisfying the need of education of local people and socio-economic development of the sub-area; paid attention to attract young children of the Khmer people and other minority groups to go to schools.
  - Consolidation and completion of the school network plan including the kindergarten schools and primary and secondary schools (including the resident schools for the minority groups) in combination with resident planning suitable for frequent

inundated areas; try to clear school rooms which serves for three shifts per day in the year 2001-2002, by year 2005 construction of solid and semi-solid schools try to reach 80%, ensuring the study and can avoid the flood problems.

- ***Labor and job***
  - Parallel with changes in economic structure; strongly develop traditional works, investing in development of rural infrastructure which is suitable with plans, changes in production structure, creating jobs for local labors.
  - Provinces in the Mekong Delta of Vietnam have to coordinate with central ministries, sectors and enterprises in studying, supplementing education and training program in order to satisfy the need of labor sources; striving to move about 240000 labors from rural areas to serve for industry and services; reducing the rate of unemployed in the urban areas to below 4%; trying to keep the labor structure by year 2005 as 53% in agriculture sector, 17% in industry and 30% in service.

- ***Infrastructure development***
  - Continuing to promote the construction of the infrastructure to create the condition for rapid socio-economic development in the sub-area; plans of transportation, construction, resident, power, water supply are needed to supplement, adjust correspondingly with water resources development and flood control plans in order to satisfy the flood drainage requirement; at the same time ensuring the safety for infrastructure when annually flood occurs.

- ***Water resources:***
  - Investment in construction of hydraulic works in combination with transportation and fishery developments, build of resident areas according to the Decision No 99/TTg dated 09 February 1996, in order to support for changes in production structure and people.
  - Starting supplementation and completion of master plan on water resources development in term of irrigation, drainage of acid water, salinity intrusion prevention and keeping fresh water... satisfying the need of programs of changes in economic structure of the sub-area; supplementing and adjusting the flood control planning based on the calibration of the floods of 2000 in combination with the whole Mekong River basin context in order to make the suitable for flood variation and the new issues occurs in the basin as well as ensuring the requirement of rapid and sustainable socio-economic development of the sub-area.
  - The objectives by year 2010 are to complete water resources development and flood control system of the sub-area in order to satisfy better the need of the production and reducing the damage which causes by floods, ensuring the safety for local people, and economic infrastructure.
  - Continuation of implementation and completion of water resources development constructions in terms of irrigation and drainage, flood control, salinity intrusion prevention in Long Xuyen Quadrant; Promoting the study in which give the basic fundamental for investment for construction water resources construction and flood control for the Plain of Reeds and the area in the Vam Co River basin.
  - Completion of construction units in the project funded by the World Bank as in Quan Lo Phung Hiep, South Mang Thit, and O Mon Xa No; Ba Lai water resources project in Ben Tre province..; construction and completion of in-farm hydraulic works in order to support for abut 800 thousand ha of shrimp and other fishery production.
  - Implementation water resources system in the West Area of the Bassac River, in the south of Ca Mau peninsula … in the U Minh Thuong, U Minh Ha that satisfy the

need of diversification of production. Review, completion of the seas dike system, river mouth embankment in the coastal provinces in order to support for changes in production structure, resident protection, and drainage of the sub-area.

- ***Transportation:***
  - In the next five years, it is necessary to solve the problems on the transportation particularly road system and take advantage of navigation in to account of the sub-area; routes of national and provincial roads which need to be improved and solidified with an aim at 90%; new construction of Routes N1, N2 parallel with national Road No1, new construction of route QuanLo- Phung Hiep, route in the south of Bassac River (91c).
  - Upgrading harbors in the main navigation routes such as Vinh Long Port, Cao Lanh port on the Mekong River; My Thoi port in the Bassac River, ports in the Ca Mau River, My Tho port (in Tien Giang province), Dai Ngai port; improve the dimension of bridge Mot Thang Gieng (Bridge 1st January), Soc Trang, Vinh Thuan bridge, improvement of Sa Dec bridge, construction of Thoi Binh bridge.
  - Completion of two navigation routes in the south and Can Tho port; continuation of improvement of Can Tho port phase 2 comprising of 76 m of harbor bridge, construction of road system in the harbor station, loading facilities; investment in construction of Cai Cui (Can Tho), Can Giuoc port (Long An), Dinh An port (Tra Vinh).
  - Determination of dimension, location of bridges in the road system in conjunction with the canal system in order to find out the suitable measures (over flood level, dry bridges, ways of flood drainage…) aiming at not only ensuring the safety of transportation but also not affecting the flood flows and caused rise of flood levels.

- ***Construction of resident areas, routes and houses of local people in the frequently inundated areas:***
  - Construction of resident areas, routes over flood level (floods in 1996 and 2000 used as designed criteria). Construction of resident areas, routes and public constructions such as schools, medical stations, etc..., must ensure over the flood levels of 1961 and flood level of 2000, local people in the inundation areas having safety, sustainable lives and not having to remove to other places when foods occurs; at the same time create favorable conditions for production development suitable to the condition, traditions of the local people, shifting the local people to civilization, modernization direction and satisfying the need of industrialization, rural modernization and development.
  - Resident routes, areas, and local people's houses have to be built according to the plans in terms of raising house foundations, construction of ring dikes or construction of pillar houses ensuring the safety for houses in the flood season suitable for the plans ratified by People Committees when commented by the Ministry of Construction.
  - Creation of public infrastructures for education, health, and cultures, which can be operated in the flood season.
  - Have to implement, complete the construction plans, resident areas in combination with infrastructures supporting for local people's living conditions. In the short term, the priority is paid to the deeply inundated areas.
    - ❖ In the towns, high density population combination raising house foundation in local area with building ring dikes to protect the resident areas, as well as finding out measures to drain water and sanitation activities, necessary public infrastructures, suitable with particular condition of each area.

- ❖ In case of commune centers, where commune offices, schools, medical stations, markets, houses located have to build with a scale of about 3-5 ha for about 100-120 households in combination with farmland suitable with living condition, production of local people and construction of public infrastructures.
- ❖ Resident routes are built based on the main canal banks and along the main roads; on these routes locating the resident areas. Resident areas can be located on only one side or both of a canal, a road and can be continuously or in some parts of the routes suitable for flood control planning and particular conditions.
- ❖ In case of building dikes for protection of production and living condition of the local people with a scale of commune, district it must have a concrete plans, and must not build scattered that could be protected local areas but caused problems for large areas.

- The five-years plans from 2001-2005, it needs to concentrate on the completion of construction of route and areas of resident and essential infrastructure in the inundation areas and in the coastal areas ensuring normal operation of school system, hospitals, medical centers, cultural areas in the flood seasons against floods and ensuring no inundation for these areas.
- In the next coming years, completion of detail construction plan of the resident areas in the inundation areas, concentration on the completion of five resident areas in the pivot areas where the implementation of resident areas are not yet completed, summarizing for experience for enlargement, and by year 2005, it must have completed the resident routes, areas protect against flooding.

IV.1.3 Difficulty and constraints

- ***Natural condition***

- About 30% area in a total of 3.97 million ha of natural area have favorable condition for agriculture development, the remaining consists of 1.6 million ha of acid sulfate soil, 750,000 ha saline land and gray soil and 134,000ha are not favorable for agriculture development.
- There are two distinct seasons in the Cuu Long Delta that is affected by the tidal regimes from the East Sea and the West Sea; the dry season is affect by salinity intrusion in the coastal areas (about 750,000ha); in the rainy season the problem is the flooding which causes inundation of about 1.9 million ha, with a duration of about 4-5 months with a depth of about 0.5-4.0m. About 4-5 years the high flood occurs causing many damages in terms of people deaths, loss of properties these are the main constraints on the socio-economic development in the Mekong Delta of Vietnam.
- Poor infrastructure, particularly the transportation system, power supply network and water supply system. Temporary houses like cottage, bamboo share about 73%, in comparison with that of the nation this rate is about 42.3%; Households, which accessed the power supply system, are about 24.4% in comparison with that of the nation this rate is about 54.8%. The road system with a length of about 6,600km (excluding the rural roads), of which there are 12 national roads with a length of 1,600km, provincial roads of about 2,499km. National Road No. 1 is main road with a good condition (just improvement), the remain is serious degraded causing difficulty in transportation, on the other hand commune roads are very few (about 400 remote communes, small cars cannot access), “monkey” bridges are many and annually destroyed by floods.

- ***Social situation***
  - By year 2020, the population of the sub-area is estimated at about 27 million people of that the migration to the urban areas is previously is understood due to the fact that the urbanization increases annually 3-5%. This will press to the environment, natural resources, infrastructure, and services, which will not satisfy the urban development.
  - Although the economy of the sub-area are progressing forward in trend of increasing industry and service and decreasing the agriculture but the agriculture is still a dominant sector. The agriculture labors are still high sharing about 73%, and the income in the rural areas is rather difficult, the rate of poverty and hunger is lower than that of the nation. The living condition of the local people are still very difficult, the rate of the poverty and hunger is about 17.2%, in comparison with the nation the sub-area is ranked third after the northern mountainous zone and zone 4 in terms of the poor.
  - Low industrial development, poor facilities, technique and technology particularly the non-state industry. Industrial labors are in general not well trained, mainly craftsman, low mechanism, only about 4-5% of labors are graduated university, and focus on the management activities. Rural industry does not have their direction in the planning, mainly unprompted, in addition rudimentary and simple production does not have the investment of the Government.
  - The rate of government fund mobilization is about 10% GDP of the sub-area, sharing about 9.2-12.2% of the nation. About 20% of the local expenditure is focus on the basic construction, on under-developed urban areas, the rate of urbanization is low (about 15-16%), and is unbalanced (some provinces this rate reached only 7-8%)
  - Socio-economic disparity between the Mekong Delta of Vietnam and the southern focal economic zone is very large, GDP per person of the sub-area is about one third that of the focal economic zone. If the Mekong Delta is still continue in low development the emigration current will be move to HCMC and other provinces in the southern focal economic zones.
  - At present, the price of agro-commodity is extremely falling down reducing the income of the local people in the rural area particularly in the remote area, and minority groups.

- ***Management of planning activities***
  - Planning management activities are not synchronous, flexible, and are not linked with the consumption markets. These have experienced in 2000, 2001, 2002 such as local people have changed rice cultivation to shrimp culture causing problems to the ecology of the sub-area. At the same time, the local people are not guided technically; have not the consumption markets resulting in out of business of the local people and when they want to grow rice back, the land is affected by the salinity intrusion.
  - On the other hand, sector-planning studies are not in integrated manner. Sectors develop their planning but not combine with other sector plans resulting in contradiction and low efficiency in implementation. When plans had studied, the contents of these studies are not understood by the local people therefore investment activities are unprompted and some time contradiction. The attitudes and execution of the local households are not high which mainly follow the markets causing loss in investment.
  - Parallel with planning management the investment structure is not reasonable, or investment is not synchronous and is not concentration therefore the efficiency if not high. This is the fact of the un-developed countries therefore in order to avoid the

above-mentioned problems it is necessary to have supported from the government in the planning and water resources development activities.

IV.2 Impacts on the environment by the water resources development activities

IV.2.1 Impacts on socio-economic environment

Water resources development activities, which support for socio-economic development, aim at:

- Supporting industrialization of the sub-area, improving the growing rate of economy, and creating internal economic accumulation;
- Serving the progress of economic changes, labor structure according to orientation of industrialization;
- Serving the changes of cropping and breeding structure, taking advantage of the sub-area in combination with the markets. This sub-area is a large area of agriculture development, fruits and fishery therefore hydraulic measures supported for agriculture development is very important in order to sustain the improvement of the efficiency of production as well as creation of condition for agro-product processing industry.

Specially, water resources development scenarios in the sub-area will, in principal, solve the problems of annual inundation, the shortage of fresh water in the dry season. In addition, these will contribute to sustainable living condition of the local people, incomes and their living condition. However, parallel with the economic benefit, there are some disadvantages when implementation of water resource development projects is carried out.

- ***Emigration***
  - On the population side, the Cuu Long Delta had about 16.740.000 people in year 2002. This is main human resources for economic development. The population density was estimated at about 412 people/km2 higher than the national average (235 people/km2), and ranked third in terms of population among 8 national economic zones of Vietnam after the Red River Delta and Southeast Area. The population of the Cuu Long Delta is rather densely and almost there has not been immigration since the last few years. At present, natural growth rate is about 2.4% and urban population shares a rate of about 17.5%, rural population of about 82,5%. Rate of using agricultural labor time is only about 73.1%. Subsequently, there appears a trend that the immigration from the rural areas to urban areas and in industrial areas, however no study on this matter so far.
  - The Cuu Long Delta has a densely river network and one has resided in this areas few hundreds year ago. In order to reside and maintain their lives, people have lived in high elevation land strips along rivers and canals. Therefore, people housed along the canal popularly. This main characteristic creates many favorable conditions in their lives but its impacts on the socio-economic development such as houses, means of transportation, and means for fishery capture which cause many limitations to navigation, roads, and construction of hydraulic works due to compensation in implementation and enlargement of existing construction. For instance, there are some constructions in which the compensation rate cost about 40 - 50% the total investment cost. In addition, the pollution caused by untreated wastewater from resident areas has been increased.

- ***Public analysis***
  - There are about 10 million labors in all economic sectors in the Mekong Delta of Vietnam but the rate of skilled labors is as low as about 3.4% wile this rate of the nation is about 15%. This is a basic constraint to development of all sectors. At present, it appears that newly-opened industrial areas are shortage of skilled labors. In fishery sector, skilled labors in terms of capture and pilots are shortage or serious shortage of technical aspect when fishery aquaculture has progressed strongly since recent three years.
  - The situation of un-evenly distribution of land use is popular in the Mekong Delta due to un-evenly population density. The average land use in the riparian areas along the Mekong River and the Bassac River is about 0.1-0.2ha/person, about 0.2-0.3 ha/person in other areas. The uneven distribution of land use results in difference in income and living standard between the highest and the lowest about 7.9 times. This is also a reason causing the encroachment of forest for cultivation, hunting, etc. which cause land loss and forest fires.
  - Due to low income existence, unequal economy most of local people could not get loans for investment in agriculture production, fishery aquaculture and means for fishery captures, means of navigation in order to response to the high requirement of production demand. In addition, the application of science technology such as crop varieties, processing industry, post-harvesting industry, young tree culture and slowly use of phytopathology have caused many impacts on product quality and economic efficiency in agriculture.

IV.2.2 Ecosystem impacts

Water resources development causes positive impacts and activities as follows:

- Protection and reforestation of protection forests, special used forest;
- Construction of flood control, salinity control, resident protection, water supply and drainage works;
- Agriculture development;
- Navigation development;
- Fishery development;
- Reforestation, increasing of forest coverage, harmonization of ecosystem in the area

However, the development of water resources system also cause negative impacts with respects to:

- Loss of fish emigration current and spawning;
- Lost of land and coverage;
- Increase of eutrophication at year-around flood control areas;
- Changes in ecosystem in the Mekong Delta of Vietnam;
- Impacts on natural preservation forest
- Pollution on large area due to agriculture, fishery development which use chemical fertilizers resulting in changes of and extinction of flora and fauna in the water as well as existing sources of fishery.
- Navigation safety: navigation accidents like shipwrecks, ship crash causing damages and water pollution (e.g. oil spreading).

IV.2.3 Impacts of the physical environment

- ***Geomorphology***

  - When implementation of water resources system, if there are no careful plans, would cause changing flow regime resulting in riverbank, bank erosion and sedimentation of the river-canal systems.

- ***Surface water***

  - Salinity intrusion is one of natural phenomena in the coastal area of the Mekong Delta. On the main river, salinity with an index of 4g/l from the East Sea intrudes strongly into inland from 40 to 50km and from 20 to 30km on the West Sea. Total salinity-affected area was estimated at about 1.4 – 1.6 million ha. Of that, there were about half of that the duration prolongs from 1- 3months. During the last 25 years, strong salinity intrusion occurred in 1977, 1992, 1993 and 1998 that seriously affected to production and people's lives in the coastal area. Increasing water uses in dry season upstream causes further salinity intrusion inland in the Cuu Long Delta of Vietnam.
  - Acid sulfate soils and acid water movement are the major constraints in the Mekong Delta. Total acid sulfate soils area is about 800 - 900 thousands ha. Most of that are located in the Plain of Reeds, Long Xuyen Quadrant, and Ca Mau Peninsula. Annually, acid water (pH<5) occurs two times, from May to August and from December to January, with total period of time of about 3- 6 months. The existing strong acid water affected include Bac Dong, Bo Bo (Long An), Ha Tien Quadrant (Kien Giang) and the center of Ca Mau Peninsula. During the implementation of water resources systems in these areas acid sulfate index increases during the first three to five years causing difficulty for agriculture development and fishery of the surrounding areas.
  - In the year-around flood control areas, acid water effects also occur due to agriculture development and drainage system.

- ***Groundwater***
  - Water abstraction for cultivation and domestic uses that if there are not good management, the pollution will be more serious due to infiltration from waste water after uses into existing not so good groundwater.

IV.3 Trans-boundary Impacts

The water resources development in the Sub-area 10V would cause potential impacts through international border as follows:

IV.3.1 Impacts due to construction of flood control, irrigation and drainage systems

- The construction of flood control system along the Vietnam and Cambodia border, along the Vinh Te - Vinh An - Tan Thanh - Lo Gach canals as well as the "closed" areas with the year-round flood control embankment could cause increasing inundation depth and duration in the Cambodia side. At the same time, it could change partly flow regime in the Cambodia side. These problems would be reduced if there were a good international cooperation.

- The construction of resident protection areas along the Vietnamese and Cambodia border would affect to the flow regime and fish migration current from Cambodia to Vietnam.
- The construction of irrigation and drainage along the border would reduce water levels on the Cambodia's side that is one of implicit contradiction in using of water resources.
- The construction of hydraulic works in main tributaries would change the ecosystem along the Mekong River as well as fresh water fishery immigration currents that would reduce sources of fishery for Cambodia.
- The increase of water abstraction of the upstream countries would affect to the low flow regime of the Cuu Long Delta in Vietnam that would cause more serious salinity intrusion and acid water problems than that of the present.

IV.3.2 Infrastructure development

The Mekong River is the main navigation route of the countries located in the basin therefore the construction of bridges, dredging the river and its branches, harbors will impact on the countries which use the water resources both in the dry season and the flood season and the ecosystem.

IV.3.3 Cooperation on the development in the border areas

Water resources development in the sub-area 10V based on basin development plan will result in such positive impacts as:

- Promoting cooperation on sharing water resources, reducing implicit contradictions in uses of water among countries and sectors in the basin;
- Developing the economy, encouraging the cooperation in exchange of commodity, relation among the upstream countries;
- Finding ways to reduce investment to flood control structures, land reclamation, irrigation and drainage involved in agriculture development;
- Improving living standards in the area, contributing to preserve traditional cultures of all communities, ensuring the national security; improving public awareness in sharing and using water resources; and
- Cooperating nations in protection of the ecology and environment, reducing poverty and hunger through out economy development.

V. CONCLUSION

- The Cuu Long Delta is a fertile area having favorable conditions for agriculture, fishery, forestry development and development of agro-product and goods processing industries. The Cuu Long Delta is a rice bowl of the nation sharing about 50% of the total national rice product, and the main rice exporter of the nation. Therefore, the Cuu Long Delta of Vietnam plays very important role in the economy of the nation.
- Over the last two decades, the Cuu Long Delta has progressed remarkably, particularly the agriculture and fishery development. Rice planted area has increased from 2.12 million ha in 1976 to 3.81 million ha in 2002, rice product from 4.7 million tons in 1976 to 17.5 million tons in 2002 (estimated at all over the Mekong Delta in Vietnam). However, the agricultural production in Vietnam Mekong Delta has faced to a lot of difficulties in term of water shortage in dry season in areas far from main river; salinity intrusion so far inland, acid-sulfate. The most difficulty in socio-economic development is caused by flooding and inundation. Regarding to fishery sector, the areas for aquaculture has been considered but the supply water for fishery is still not taken into account so far. The degradation of forest ecosystem has largely affected to the environment particularly the coastal environment. The main reason caused the forest degradation is due to deforestation for shrimp culture, agriculture cultivation, and illegally deforestation for fire woods.
- Although the Cuu Long Delta has remarkably progressed, its development is, in general, still at low level, the living conditions of the local people is low, undeveloped infrastructure, poor environmental sanitation condition; the living condition of the local people in the inundation areas is unstable due to deeply and prolonged flooding annually; its economy is mainly based on agriculture, the industry and services is not developed yet. Regarding to the agricultural economy, it is mainly based on rice production, do not created a comprehensive, diversified agriculture; the product quality is not high, does not solve the problem in terms of product consumptions which resulted in not creating incentives for production development.
- Water resources: The water resources of the Cuu Long Delta of Vietnam is unevenly distributed over the area in terms of space and time, the dry water volume is about 20-30% the total water resources while the water requirement, in general, and water requirement for irrigation, in particular, is concentrated on the dry season, therefore the shortage of water for supply in dry season is out of control of Vietnam. In order to develop the Cuu Long Delta of Vietnam, Vietnam needs a close cooperation on sharing water resources of the Mekong River for common benefit.
- Major impacts on the development of the Cuu Long Delta include: (i) undeveloped infrastructure, particularly road systems; (ii) difficulties in product consumption; (iii) farmers' fund shortage for agricultural production; and (iv) Slow development of agro-product processing industry. Resolving these problems well will create good condition for rapid development in the Cuu Long Delta of Vietnam. On the other hand, it is needed to supplement socio-economic development plan in the Cuu Long Delta of Vietnam to create basic conditions for sustainable, right orientation, development which is suitable with the real national situation and the Cuu Long Delta in the new stage of development.
- The water resources development plays significant role in the development of the Cuu Long Delta. In the past, water resources systems have been developed that positively contributed to land reclamation, improvement of the environment, drainage of acid water, saline protection, fresh water maintain, flood control in early season, enlargement of irrigation area for agriculture development. However, there remain a number of issues such as flood control which annually cause much damage, shortage of freshwater

in the coastal areas, un-synchronous water resources systems which result in low efficiency, poor water resources management activities.

- In water resources development aspect, it is needed to construct a flood control system immediately to reduce flood damages, to create a safe and sustainable lives, to created a suitable condition for development of local people in the inundated areas, as well as to coordinate with the neighboring countries to find out efficient solutions to control floods for the whole Mekong Delta. On the other hand, it is needed to implement salinity prevention structures, to protect against the natural disasters in the coastal areas, to enlarge the fresh water areas, step by step to implement synchronous water resources constructions; to use the Mekong water resources reasonably, to strengthen/consolidate hydraulic works and water resources management systems
- Trans-boundary impacts and problem settling: The water resources of the Mekong River plays very important role in the development of the Cuu Long Delta. It is the main sources of fresh water and the important sediment sources, which creates the fertility for the soil of the Cuu Long Delta of Vietnam. On the other hand, the Mekong River also causes annual floods resulting in much damage in the Mekong Delta.
- The Mekong River runs through six countries. The Cuu Long Delta of Vietnam is located in the end of the basin therefore it is largely impacted by upstream activities. Major upstream activities, which impact to the Cuu Long Delta in Vietnam, include: (i) increase of irrigation areas in dry season causing low flow reduction, (ii) industrial development resulting in water pollution, (iii) over deforestation causing high floods for downstream, (iv) capture, exploitation, and other activities that reduces the sources of fishery of the Mekong River; (v) dredging such as exploding waterfalls for navigation affecting to the water environment and water living condition. Among the above-mentioned activities, the low flow reduction is the most serious one. In the near future, upstream countries will increase the cultivation areas, therefore the flows of the Mekong River in the Delta reduces largely resulting in more difficulty for irrigation, and resulting in much more salinity intrusion further inland. In case of large reservoirs implemented the regulated low flows in the dry season would increase that would resolve the above-mentioned problems.

Activities of the upstream countries will strongly affect the Cuu Long Delta of Vietnam. In order to reduce negative impacts due to the upstream activities the following issues needs to be implemented:

- Strengthening the cooperation among the countries in the basin aiming at using the Mekong water resources reasonably in terms of ensuring each national benefit and in terms of sustainable development and reducing the interaction impacts.
- Strengthening the cooperation among the countries and the Mekong River Commission in order to immediately resolve problems related to each national benefit/right in terms of using the Mekong water resources, in terms of studying efficient and sustainable uses of the water resources of the Mekong River.
- Strengthening international cooperation in order to collect information from the upstream countries to deal with negative impacts originating from upstream, and in order to study to forecast long-term impacts to find out suitable measures for the Mekong Delta of Vietnam.

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