CHAPTER 8

GEOGRAPHICAL AND ECONOMICAL SETTING OF THE PEARL RIVER ESTUARY

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1. INTRODUCTION

A shown in Figures 1 and 2, the Pearl River discharges into the South China Sea (SCS) through eight distributaries, locally called "the eight Gates" (or distributaries). The four western Gates (distributaries), the Modaomen Gate, Jitimen Gate, Hutiaomen Gate and Yamen Gate, discharge directly into the SCS. The four eastern gates, Humen Gate, Jiaomen Gate, Hongqimen Gate, and Hengmen Gate, discharge their waters into the "Lingdingyan", which will be called the "Pearl River Estuary" (PRE) in subsequent discussions.

The PRE has an area of over 2,000 km^2, varying in width between 15 km at the northern end and about 35 km at the southern end, with a length of about 70 km. There are two deep channels, which are used for shipping. The western channel connects the SCS via the Lantau Channel (Figure 2) through the southeast side of the estuary mouth. The eastern channel leads to the SCS through Hong Kong waters. The water depth increases from north to south and, in the southern part of the estuary, the water depth decreases from east to west. Except for the deep channels and the areas around the two outer islands, Wansham Islands and Dangan Islands (Figure 2), where the water depth ranges from 20 to 30 m, most of the PRE is quite shallow with a water depth between 2 and 10 m.

The annual average discharge of the Pearl River is around 10,000 $m^3 s^{-1}$, 53% of which flows through the four eastern gates. Eighty percent of the total discharge occurs in wet season between April and September, the ratio of maximum to minimum discharges in a year varying between 3 and 6 times (Chen and Heinke, 2002).

E. Wolanski (ed.), The Environment in Asia Pacific Harbours, 113–125.

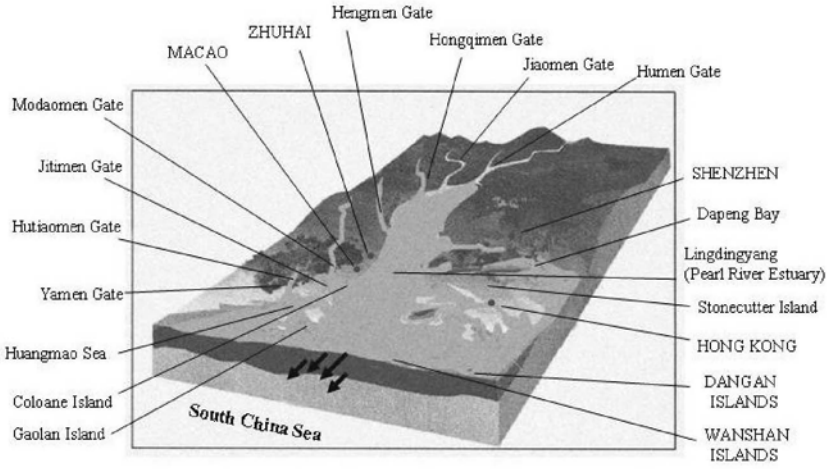

Figure 1. *Schematic diagram of the Pearl River estuary (adapted from Chen and Heinke, 2002).*

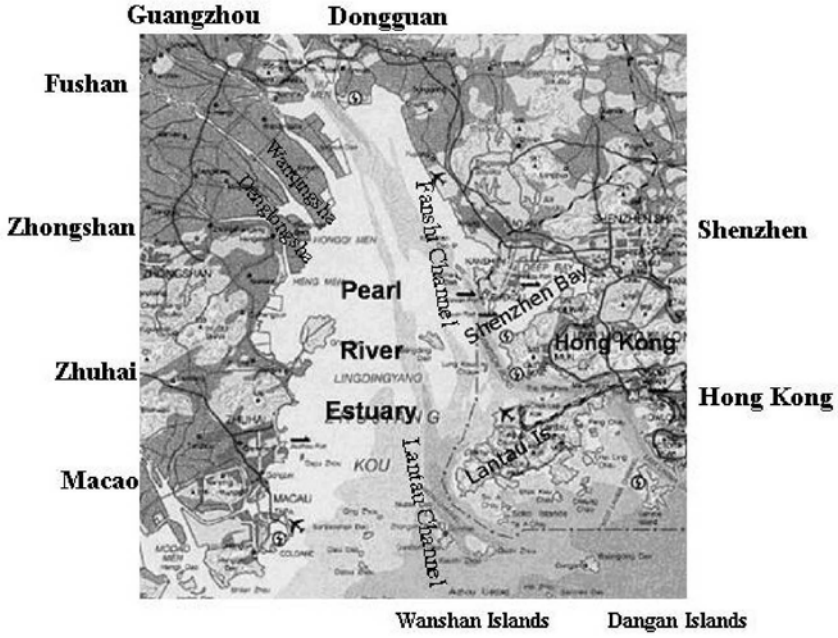

Figure 2. *The Pearl River estuary (PRE).*

2. RIVER DISCHARGE AND SEDIMENT LOAD

The Pearl River has three major branches (Xijiang, Beijiang and Dongjiang) and a network of small rivers in the river delta (Figure 1). Table 1 summarizes the discharge and the suspended sediment load of the rivers. The Xijiang River has by far the largest amount of discharge and suspended sediment transport, accounting for 77% of the water discharge and 86% of the suspended sediment discharge.

Table 1. *Water and sediment transportation from the Pearl River (adapted from Luo and Zhen, 2000; PRWERC 1993).*

	Water Discharge		Suspended Sediment Load	
	Annual discharge (10^9 m^3)	% of the total	Annual transport (10^6 ton)	% of the total
Xijiang River (Gaoyao)	225.0	67.5	76.60	86.5
Beijiang River (Shijiao)	49.0	14.7	8.17	9.2
Dongjiang River (Boluo)	28.0	8.4	2.94	3.3
Rivers in the Pearl River Delta	31.3	9.4	1.01	1.0
Total	333.3	100.0	88.72	100.0

Table 2 lists the average annual discharge of water through the eight Gates (distributaries). The total discharge through the eight Gates is slightly less than that of the Pearl River (Table 1), because some of the discharge from the Pearl River enters the sea through small rivers in the delta. Table 3 lists the average yearly volume deposition inside the PRE and near the four western Gates (distributaries). High deposition rates (> 2 cm y^{-1}) occur outside the delta slope and over the shoals west of the PRE. The deposition rates reach peak at 5-8 cm y^{-1} in some local areas in Modaomen Gate, PRE, and Denglongsha and Wanqingsha shoals (Figures 1 and 2). Very high rates of 10-15 cm y^{-1} have been recorded in parts of the channels.

3. HUMAN POPULATION

The total population in the Pearl River basin rose rapidly from 43.1 million in 1956 to 89.42 million in 1993 (Figure 3). The yearly population growth rates were 2.14%, 1.72% and 1.85% for the periods 1956-1980, 1980-1985, and 1985-1993, respectively. The population density in the region reached 211 people km^{-2} in 2000, much higher than that of the whole country (PRWRC, 2004).

Table 2. *Tidal range at the water discharge through the eight Gates of the Pearl River (adapted from Luo and Zhen, 2000; PRWERC 1993). 1=Humen Gate; 2=Jiaomen Gate; 3=Hongqimen Gate; 4=Hengmen Gate; 5=Modaomen Gate; 6=Jitimen Gate; 7=Hutiaomen Gate; 8=Yamen Gate.*

		1	2	3	4	5	6	7	8	Total
Tidal range (m)	Average	1.63	1.36	1.21	1.11	0.86	1.01	1.20	1.24	
	Maximum	3.39	2.81	2.79	2.48	2.29	2.71	2.66	2.95	
Annual river discharge ($10^8 m^3$)		603	565	209	365	923	179	202	196	3260

Table 3. *Sedimentation in the Pearl River estuary and neighboring waters (adapted from Luo and Zhen, 2000; Dong 1986).*

		Area of deposition (km^2)	Yearly deposition ($10^4 m^3$)	Average deposition rate (cm y^{-1})
River channels		700	1450	2.1
Eastern 4 Gates	Lower PRE	1000	2000	2.0
	Upper PRE	1000	800	0.8
Western 4 Gates	Modaomen Gate	180	450	2.5
	Jitimen Gate	107	160	1.5
	Yamen Gate and Huangmao Sea	535	730	1.4

The Pearl River Delta is one of the most populated areas in the Chinese mainland with a population over 28 million and a density of 674 people km^{-2}, excluding Hong Kong and Macau (1999 data). In total, 28 cities and 420 towns are found in this delta with a "town density" of 10 towns per 1,000 km^2. The population in the 12 largest cities of the delta is shown in Table 4; it grew from 27.02 million people in 1996 to 28.27 million people in 1999.

Table 4. *Population of the 12 largest cities in the Pearl River delta (millions of people) (adapted from Statistics Bureau of Guangdong Province 2000; Statistics Bureau of Guangxi Province 2000).*

Cities	1996	1997	1998	1999
Guangzhou	6.561	6.665	6.742	6.850
Shenzhen	1.034	1.095	1.146	1.199
Zhuhai	0.654	0.673	0.695	0.714
Foshan	3.161	3.210	3.250	3.292
Huizhou	2.601	2.665	2.700	2.718
Zhaoqing	3.615	3.683	3.725	3.813
Jiangmen	3.744	3.771	3.789	3.798
Dongguan	1.453	1.471	1.488	1.508
Zhongshan	1.268	1.284	1.301	1.320
Shunde	1.025	1.040	1.053	1.068
Nanhai	1.043	1.058	1.071	1.085
Panyu	0.867	0.880	0.896	0.911
Total	27.026	27.495	27.856	28.276

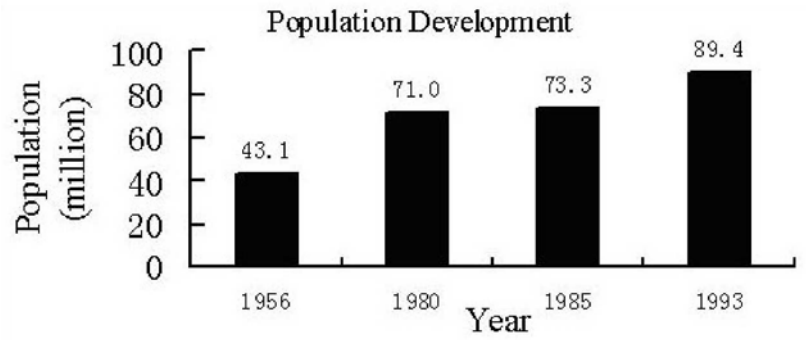

Figure 3. *Population growth in the Pearl River Region (adapted from PRWRC, 1993).*

4. ECONOMIC DEVELOPMENT

The total gross domestic product (GDP) in the basin was RMB 1330.0 billion in 2000, with a per capita GDP of RMB 7,917 or approximately US$960. Although significant economic growth has occurred across the whole region, the delta's economy has grown much faster than other areas in the basin, with a per capita GDP exceeding US$3600 in 2000, the highest in the country. From 1980 to 1994, the GDP in the Pearl River Delta increased by 17.8% annually, while that of Guangdong province and the whole country increased by 14.5% and 9.7%, respectively (Figure 4). The economy has continued to boom with GDP growth of more than 10% from 1995 till present.

In the Pearl River delta, Guangzhou, Shenzhen (Figure 2) and ten other cities are the most important economic units in terms of their economic scale, degree of economic innovation, ability to attract skilled workforce, knowledge and investment.

Table 5 lists the GDP values in these 12 cities. Four cities, Guangzhou, Shenzhen, Fushan and Dongguan (Figure 2), play a remarkable role in the delta's economic development. Nearly three-fourths of the 2003 GDP of the delta came from these four cities.

Not only did the GDP increase but the structure of the economy has also improved during this period. Figure 5 shows the rapid increase of the proportion of the "Tertiary Industry" from 29% to 44% between 1980 and 1999 and the concurrent decrease of the "Primary Industry" from 26% to 6%. The Pearl River Delta has become an important supplier of a variety of products to the world. In 1999, the exported goods from the Pearl River delta were valued at US$ 67 billion.

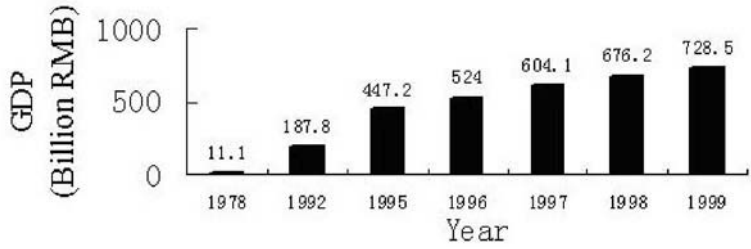

Figure 4. *GDP growth in the Pearl River Delta (adapted from Statistics Bureau of Guangdong Province 2000; Statistics Bureau of Guangxi Province,2000).*

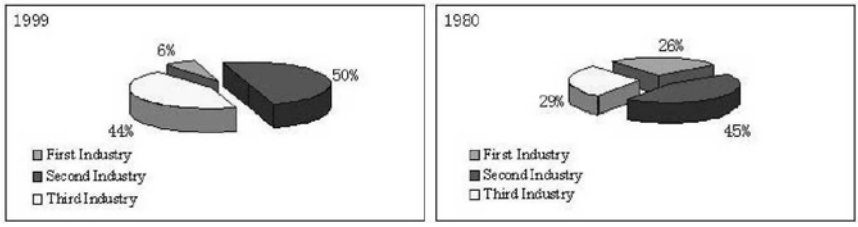

Figure 5. *Change in the economic structure in the Pearl River Delta (adapted from Statistics Bureau of Guangdong Province 2000; Statistics Bureau of Guangxi Province 2000).*

5. HARBORS AND TRANSPORTATION

The Pearl River Estuary is densely distributed with ports (Figure 6). Guangzhou, Shenzhen and Hong Kong are the principal ports in the region, while the others are lateral ports or feeding ports of the main ports.

Figure 6. *Location of ports in the Pearl River estuary and surroundings.*

Table 5. *GDP (billions of RMB) of nine major cities in the Pearl River delta (adapted from Statistics Bureau of Guangdong Province 2004; Statistics Bureau of Guangxi Province 2004).*

City	1999	2000	2001	2002	2003
Guangzhou	205.674	237.591	268.576	300.169	346.663
Shenzhen	143.603	166.574	195.417	223.941	286.051
Foshan	83.379	95.720	106.836	116.866	137.993
Dongguan	41.284	49.271	57.893	67.227	94.753
Jiangmen	51.469	56.751	61.516	65.829	73.109
Huizhou	39.237	43.724	48.039	52.546	59.020
Zhaoqing	35.549	38.340	41.102	44.388	50.115
Zhongshan	27.268	31.282	36.250	41.553	49.710
Zhuhai	28.661	33.026	36.659	40.627	47.327

5.1. Guangzhou Port

Guangzhou Port is located in the center of the Pearl River delta. It is the main port of South China and has 140 berths with different functions, 9 of which have a capacity of 10,000 t, 8 with a capacity of 20,000-25,000 t and 15 with a capacity of 35,000 t. It also has 22 mooring areas, each with a berthing capacity of over 10,000 t; the maximum capacity is 300,000 t. The total length of the navigable channel of the Port is about 173 km, including the seagoing channel of 115 km. General cargo ship of 13.5 m draught and container ship of 4th and 5th generations ships are able to pass through during the flood tides. (source: Information and Communication Center of Guangzhou Harbor Bureau)

The first stage of the Guangzhou Port watercourse dredging project was completed in 2000. This resulted in deepening the navigation channel depth from 9 m to 11.5 m. Further dredging is planned to deepen the channel to 13 m by the end of 2005 (Zhou, 2004).

5.2. Shenzhen Port

Shenzhen Port comprises a total of nine port areas, namely, the Shenzhen Inner Port area, Shekou, Chiwan, Mawan, Dongjiaotou, Fuyong, Yantian, Xiadong, and Shatianchong (Figure 6). The western ports are situated along the Fanshi Channel (Figure 2) by the upper reaches of the PRE, about 35 km north of Hong Kong. The eastern port is located in northern Dapeng Bay (Figure 1) with water depth of 12 to 14 m (Zhou, 2004). Altogether Shenzhen Port has 102 berths with capacity over 500 tons, in which 23 are above 10,000 t and 65 for production berth. In 2003, Shenzhen's container handling capacity reached 10.6×10^6 TEU and the total cargo handling capacity was 87.67×10^6 t in 2002 (Statistic Yearbook of Guangzhou, 2004), making it the fourth largest container transportation base in the world.

5.3. Hong Kong Port

This is described in other chapters in this book.

5.4. Macao Port

Macao Port is situated on the west side of the PRE, 150 km south of Guangzhou and 70 km west of Hong Kong. The Port covers three sub areas: the inner part of the Port is on the west coast of the Macao Peninsula and the outer part on the southeast side of the Peninsula, while the Jiuao Port is at the southeast side of the Coloane Island (Figure 1) (Port Bureau of Macau, 2004).

Macao Port silts readily and thus not suitable for a deep water port. The major function of the port is the transportation of both passenger and cargo between Macao, Hong Kong, and the mainland.

5.5. Zhuhai Port

Zhuhai Port consists of a number of sub-ports located both on the west coast of the PRE and around the Gaolan islands (Figure 1) in the Huangmao Sea. The sub-ports are, namely, Jiuzhou, Xiangzhou, Gaolan, Hongwan, Qianshan, Jing'an, Tangjia, Doumen, Wanzai, and Guishan (Figure 6). The sub-ports can be grouped into three parts in accordance with their location and function. The Gaolan area of the Zhuhai Port is a transitory base for international freights. The middle part of the port is mainly for passenger and the west part is mainly for transportation of petrochemical products and various other goods. In total, the Zhuhai port has 8 berths of over 10,000 t capacity, with an annual total handling capacity of 28×10^6 t (Statistics Bureau of Guangdong Province 2004).

6. WASTEWATER DISCHARGES

Wastewater discharge in the Pearl River Delta originates mainly from the rapidly developing cities such as Guangzhou, Shenzhen, Zhuhai, Dongguan, and Zhongshan, on the Chinese mainland (Figure 7), as well as Macao and Hong Kong, together with from shipping and transportation activities over the estuary.

Table 6 provides data on the Pearl River delta, as well as on the percentage of the industrial wastewater treated. Much of the industrial wastewater is treated. However, there is no information available on the extent of the treatment of household wastewater.

Table 6. *Discharge of household and industrial wastewater in 10 major cities in 1997 (adapted from Statistics Bureau of Guangdong Province 1998).*

	Total discharge of wastewater (household and industrial) (10,000 m^3)	Total discharge of industrial wastewater (10,000 m^3)	Percentage of industrial wastewater treated (%)
Guangzhou	105,327	26,764	87.3
Shenzhen	44,781	2,666	98.3
Zhuhai	11,238	3,741	73.2
Shantou	16,596	4,003	81.4
Shaoguan	22,581	13,130	93.6
Dongguan	29,370	8,930	86.2
Zhongshan	10,400	5,905	88.7
Jiangmen	20,878	10,689	65.7
Foshan	32,488	12,391	93.4
Zhanjiang	22,547	8,947	60.7
Total	316,206	97,166	83.6

7. ADMINISTRATIVE MEASURES TOWARDS SOLVING ENVIRONMENTAL PROBLEMS

The PRE is facing a continued rise in pollution load and the increasing occurrence of red tides. This degrades water quality and endangers aquaculture and fishery resources. To solve these environmental problems, different strategies and measures as follows have been proposed.

7.1. Industrial pollution control

Industrial pollution control measures taken in the area are many, namely: to ensure that the effluent criteria for industrial wastewater discharge are met; to speed up the restructuring process in industrial sector; to actively promote "clean production" and to increasing the efficiency of energy use; to reinforce the implementation of environmental impact assessment system; to build central wastewater treatment plants in industrial parks and to decrease the level of disposed pollutants; to increase the recycling and re-use of water in the manufacturing industry; to prohibit the building of new thermal power plants (using coal) and to timely resolve the desulfurizing problem for the existing thermal power plants. At present the effort in pollution regulation and control is focused on the following industries that have serious pollution problems: electric power generation, construction material, chemical, pulp and paper making, metal refining, sugar, fermenting, plating, spinning, printings and dyeing.

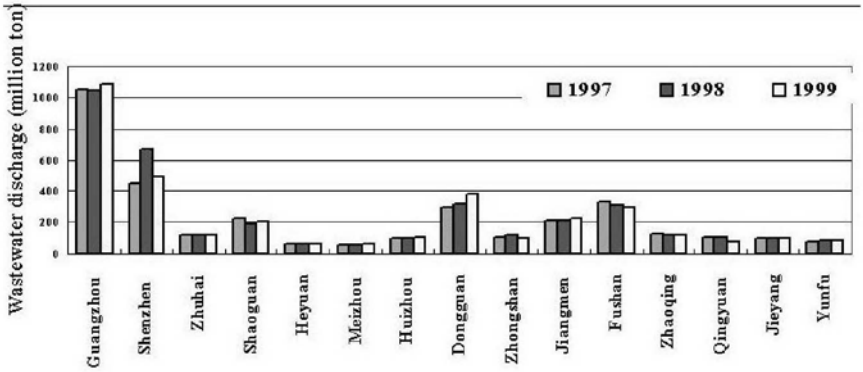

Figure 7. *Yearly wastewater discharge from 15 major cities along the Pearl River from 1997 to 1999 (adapted from Statistics Bureau of Guangdong Province 2000; Statistics Bureau of Guangxi Province 2000).*

7.2. Domestic sewage treatment

Domestic pollution control measures taken in the area are many and include: to coordinate the building of wastewater treatment plants in urban and rural areas; to promote building new and expanding existing wastewater treatment plants in a

comprehensive way, and improving the operation efficiency of these plants; to reduce the discharge of nitrogen and phosphorus by raising the efficiency of the denitrification and dephosphorization treatments in sewage systems; to prevent and control the non-point pollution sources and to remove the black and odor materials in urban small rivers and creeks.

There are 67 wastewater treatment plants in urban areas of the Guangdong province with daily treating capacity of 5.083×10^6 t, out of which eight new plants were built in 2004. Among these 67 plants, 55 are located in the Pearl River delta region with the daily treating capacity of 4.738×10^6 t.

By the end of 2001 the Stonecutters Island (Figure 1) wastewater plant in Hong Kong was put into operation with the daily treating capacity of 1.70×10^6 m^3. There are 16 catchments in Hong Kong collecting and treating more than 98% of the wastewater. The whole system consists of wastewater collection network with the total length of about 1,320 km and 200 wastewater treatment plants. The treated wastewater is discharged into the deep sea for further dilution and diffusion. 75% of the wastewater around Victoria Port (Figure 6) was well-treated (by secondary treatment) before being discharged. (The Drainage Services Department, Government of Hong Kong). Macao has three wastewater plants with daily capacities of 144,000 m^3, 70,000 m^3 and 20,000 m^3, respectively. About 90% of the wastewater networks are connected to the wastewater plants in Macao except for small areas like the docks in the Inner port of Macao and small islands nearby. All of the wastewater from the public works and household in Macao is treated completely before being discharged (Environmental Statistic Information Network).

7.3. Prevention and treatment of petro-waste in the sea

Oil tankers with carrying capacity over 150 ton and other cargo ships over 400 ton are required to be equipped with wastewater treatment facilities. Wastewater treatment facilities capable of treating petro-wastes have been built for each commercial port, and first and second class fishing ports. The discharge of poisonous liquid materials, engine rooms waste, sewage, and ballast water is prohibited; the principle of zero discharge of petro-pollutants is enforced. Emergent response plans/schemes have been drafted to deal with oil spills and other serious pollution incidents.

7.4. Pollution control regulations for river mouth areas

The following measures are included in the pollution control regulation for all the eight Gates (distributaries) in the Pearl River delta: to implement a system to control the discharge from aquaculture and to strengthen the diffuse (non-point source) pollution control; to dredge channels with serious polluted sediment; to prohibit the dumping of rubbish; and to regulate the exploitation of estuary sand for construction material.

7.5. Total pollutant load control

The following measures have been taken: to control the gross pollutants discharging into the sea and to control the quality of the water environment for each district on the basis of water environment capacity; to strengthen efforts in areas where the water quality is below acceptable standards, to closely monitor the water environment, and to take strong measures to enhance the water quality management for the intensive development areas; to strive for a harmonization between advanced and base water utilization.

The problem of wastewater disposal for Hong Kong is solved through 16 wastewater disposal systems covering the whole Hong Kong and through the "plan for harbours cleaning" implemented to collect all the wastewater. A sewer system and wastewater treatment plants are planned based on the pollution source areas, and an "Integrated Plan for Waste Water Collection" has been formulated. The Joint Working Panel of Environmental Protection for Guangdong and Hong Kong has developed a 15 year plan to improve the estuary's environment. The plan covers three phases with a duration of 5 years each and will be implemented from 2005.

In addition, the following measures are also taken: to establish eco-agriculture systems along the riparian areas; to emphasize awareness of protection of ecosystem/environment in the tourism industry; to reinforce management for delineated protection areas and protection of a tree belt along the shore; to ensure the proper treatment of solid wastes; to build a sophisticated system of environmental monitoring and information gathering; to reinforce the enforcement of the laws and regulations; to increase the investment for environmental protection; and to promote international cooperation in these activities.

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