International Review for Environmental Strategies
Vol. 6, No. 2, pp. 217 – 228, 2006

Special Feature on Groundwater Management and Policy

Water and Sanitation in Thailand

Monthip Sriratana Tabucanon[a]

Thailand completed its Eighth National Economic and Social Development Plan at the end of 2001. Important changes in natural resource management and environmental protection were made during the five-years of this National Plan. The Ninth National Economic and Social Development Plan carries forward many of these crucial efforts regarding natural resources and the environment. The promulgation of the National Environmental Quality Action Plan has proved that environmental concerns are now linked to economic and social issues in national development efforts. Sustainable development has been a part of Thailand's national development philosophy since 1980. Thailand's efforts towards sustainable development for water and sanitation have been intensified with greater emphasis on social development, sustainable natural resource management and use, and environmental protection and improvement. This article describes the national strategies regarding water and sanitation and how the various sectoral and cross-sectoral issues have been carried out over the past years. It highlights the following five sections; (i) Thailand water quality overview; (ii) Thailand water pollution; (iii) policy, plan, and legislation development; (iv) wastewater treatment; and (v) environmental expenditure and financing.

Keywords: Thailand, Water resources, Sanitation, Organic Discharge

1. Thailand water quality overview

Water resources are vital to the continued sustainable development of Thailand, as is the case worldwide. With a total area of 513,115 square kilometers (km^2) and an average annual rainfall of about 1,356 millimeters (mm), Thailand receives an estimated 737,000 million cubic meters (Mm^3) of rain annually. Table 1 shows the average annual amount of rainfall by region (1951–2003) and recent variations in volume. With the exception of the southern portion of the country, approximately 80 percent of the rain falls during the six-month rainy season from May to October.

Water shortages are common in the north and northeast regions, exacerbated by the fact that these are mostly mountainous areas (with only about 10 percent lowlands), there is a lack of well-drained soils, and rainfall is irregular. Flooding during the wet season and severe water shortages in the dry season are frequent occurrences. Added to this is the growing demand for water by industry and for increased crop production during the dry season.

Thailand's water resources have become increasingly under pressure over the years due to deterioration of watersheds, the disappearance of wetlands, and agricultural and industrial pollution. In addition, the demand for water has been growing rapidly along with Thailand's growing economy, while the amount of water available has remained constant. Water shortages, therefore, loom as a serious threat to future prosperity in virtually every region of the country.

a. Deputy Parmanent Secretary, Ministry of Natural Resources and Environment, Bangkok, Thailand.

Table 1. Average annual rainfall by region (1951–2003) and regional variations for 2002 and 2003

Region	Average annual rainfall (mm)	Area (km^2)	Rainfall volume (Mm^3)	Rainfall in 2002 (mm)	Rainfall in 2003 (mm)	Variation 2002–2003 (mm)
North	1,200.4	168,854	202,692	1,303.4	1,068.7	–234.70
Northeast	1,404.9	169,644	238,333	1,586.5	1,341.7	–244.80
East	1,846.6	36,503	67,406	1,670.3	1,803.4	133.10
Central	1,248.1	67,399	84,121	1,121.0	1,296.5	175.50
West Peninsular	2,507.3	46,760	117,241	2,034.2	2,534.2	500.00
East Peninsular	1,140.5	23,950	29,315	843.6	1,314.2	470.60
Total	—	513,115	737,109	1,364.4	1,322.7	–234.70

Source: Meteorological Department 2003.

The Thai government's Royal Irrigation Department (RID) divides water consumption into the following five categories: (1) domestic, (2) industry and tourism, (3) irrigated agriculture, (4) power generation, and (5) maintenance of downstream ecosystems. As agriculture is by far the largest consumer of water, the amount the sector uses is therefore a logical indicator of pressure on available water resources. Figure 1 shows total and regional water consumption between 1993 and 2002 and projections to 2006.

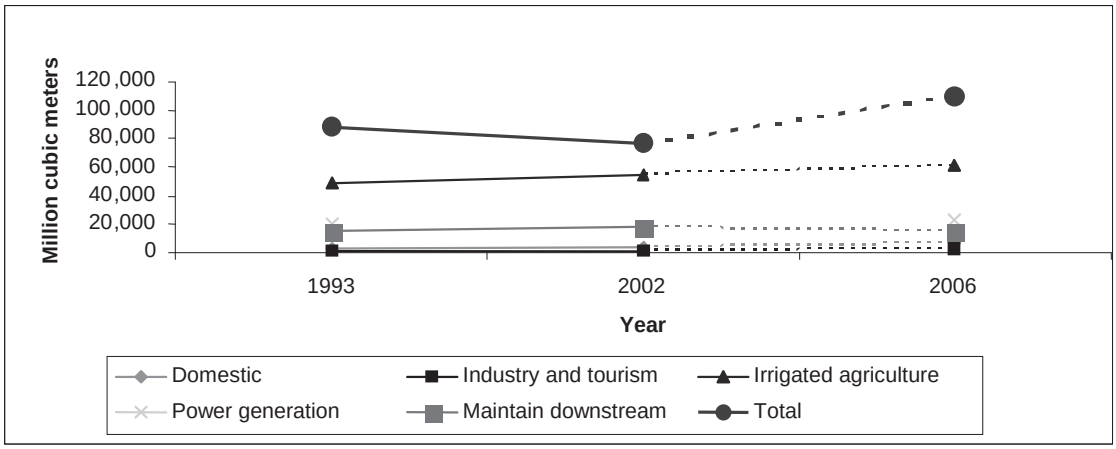

Figure 1. Water consumption in Thailand, 1993–2002, and projections to 2006

Note: The levels of power generation and domestic consumption are close to those of maintaining downstream ecosystems and industry and tourism, respectively.

As shown in the figure, agricultural water consumption rose from 48.2 billion cubic meters (Bm^3), or 54.3 percent of the total in 1993, to 61.7 Bm^3, or 56.5 percent, in 2006. According to the Water Resource Development Master Plan 1997–2016, overall water consumption by all sectors is projected to increase from 76.7 Bm^3 in 2002 to approximately 109.3 Bm^3 in 2006—an increase of nearly 23 percent. This

takes into account the huge consumption by agriculture, but it is projected that domestic water consumption will increase even faster. Most of these increases are expected to come at the expense of water supply that maintains downstream ecosystems.

Figure 2 provides some data about water shortages compiled by the Department of Agricultural Extension for the areas of under-irrigated lands during the dry seasons of 1990–2005. These water shortages affected more than 524,226 hectares (ha) of agricultural land and involved 930 sub-districts in 39 provinces (out of 76 provinces). Between 1995 and 1998, the water deficits were less serious, mainly because of a more favorable rainfall pattern during those years.

The extent of water shortages is clearly not static and depends on the quantity of rainfall as well as cropping patterns, in particular the availability and management of storage capacity and the higher demand for water during paddy cultivation.

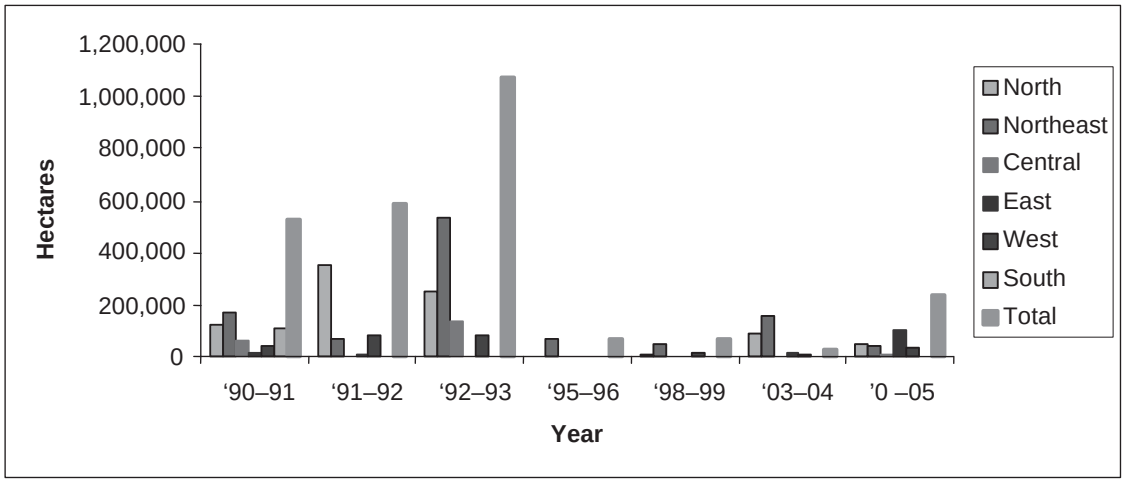

Figure 2. Area of under-irrigated land in Thailand, by region, 1990–2005

Source: Compiled by the Department of Agricultural Extension.

There are many initiatives that could counter the looming water shortage, ranging from greater irrigation efficiency, more efficient non-agricultural water use, improved water supply, economic incentives to conserve water, better management of water resources by the central government, improved planning (e.g., master plans for sustainable river basin development), groundwater development, and others.

Among the possible indicators to choose from, the amount of storage capacity can be used to evaluate the nation's efforts in lessening the impact of water shortages on irrigation. Time series data show that increasing storage can complement other measures such as establishing water user groups to manage small catchment areas. Table 2 shows the existing regional distribution of water storage capacity.

The figures point to a concentration of larger-sized water development projects in the central plain and the predominance of medium- and smaller-sized facilities in the north and northeast of Thailand. This is

due in part to the geomorphic characteristics of the north and the northeast, mentioned above, which are not conducive to the development of large water storage structures. Alleviating water shortages in this region therefore rests with medium- and small-scale reservoirs. The existing capacity for water storage under RID management in Thailand irrigates approximately 21 percent of all agricultural land, or about 9.7 percent of total land area. In 2002, 13,326 km^2 in the central plain were irrigated (almost 50 percent of agricultural land in the region), compared to 11,009 km^2 in the north (16.6 percent of agricultural land), 8,786 km^2 in the northeast (13.1 percent), 5,572 km^2 in the east (25.9 percent), and 6,616 km^2 in the south (15.5 percent). According to these figures, the northeast has the lowest proportion of irrigated land, but it still has a number of areas that could accommodate more development of water storage capacity, especially small- and medium-scale initiatives.

Table 2. Water storage facilities constructed by the RID and area irrigated, August 2002

Region	Water storage capacity (Mm^3)				Irrigation area (km^2)	% of agricultural area
	Large scale	Medium scale	Small scale	Total		
North	23,206	550	351	24,107	11,009	16.58
Northeast	3,037	1,646	841	5,524	8,786	13.09
Central	1,185	176	61	1,422	13,329	49.92
East	372	373	65	810	5,572	25.92
West	—	74	47	121	4,660	*
South	1,225	301	63	1,589	6,616	15.55
Total	29,025	3,120	1,428	33,573	49,973	21.39

Source: Royal Irrigation Department 2003.

*Percent of agricultural area merged with the central region.

In responding to the threat of drought, the government set a target of utilizing about 50 percent of the total rainwater available, as opposed to the only 20 percent presently used (40,000 Mm^3). Therefore, an additional 100,000 Mm^3 of rainwater could be used if storage capacity was increased (RID).

The Master Plan of Water Resources Development of the Royal Irrigation Department (1997–2016) set targets for increased water storage capacity and area of land irrigated in the next 3 National Economic Social Development Plan (3 NESDP). The targets are in line with the government's objective of increasing the percentage of land irrigated from approximately 27 percent of total cropland by the end of the Ninth NESDP (2002–2006). At the end of that period, according to the master plan, the irrigated area will have increased by 98,080 ha via construction of small-scale water storage projects, and by 970,000 ha via construction of medium- and large-scale water storage projects. The water to irrigate an additional 355,200 ha of land is expected to come from medium- and large-scale projects by the end of the 10th NESDP (2011).

The RID plans to develop additional water storage capacity of 4,286 Mm^3 by 2006 and 2,653 Mm^3 by 2011, as shown in table 3.

Table 3. Development of water storage capacity for irrigation, 1961–2011

National Economic Social Development Plan	Cropland area (%)[1]	Small-scale reservoirs[2]		Medium- and large-scale reservoirs[2]		% of cropland irrigated	Water storage capacity[2]	
		Irrigated area (km^2)	Increase (%)	Irrigated area (km^2)	Increase (%)		Mm^3	Increase (%)
1st, 1961–66				15,552			14,472.3	
2nd, 1967–71				17,536	12.8		15,078.6	4.2
3rd, 1972–76				23,008	31.2		24,346.6	61.5
4th, 1977–81	37.8	3,916.8	111.1	25,344	10.2	15.1	25,461.5	4.6
5th, 1982–86	40.5	8,267.2	33.3	29,936	18.1	18.4	28,668.9	12.6
6th, 1987–91	41.5	1,101.8	18.9	33,136	10.7	20.7	30,200.2	5.3
7th, 1992–96	41.3	13,094.4	5.1	34,688	4.7	22.5	31,662.1	4.8
8th, 1997–01	56.2	13,764.8	7.1	36,208	4.4	21.4	33,573.0	6.0
9th, 2002–06[3]		14,745.6		45,584	25.9	27.0	36,599.5	9.0
10th, 2007–11				49,136			39,252.7	7.3

[1] Numbers on area of cropland planted derived from data supplied by the Department of Agricultural Economics.

[2] Data from the RID.

In addition, the RID's Strategic Plan for Water Resource Development for 2003–2007 provides more specific targets for development of irrigation systems, as follows:

- Increase the area of irrigated land by 4,121,799 rai (660,000 ha)
- Develop 241 new medium- and large-scale water resource development projects in order to store 3,803 Mm^3
- Rehabilitate the deteriorated irrigation areas on 3,709,000 rai (593,000 ha)

2. Thailand water pollution

Rivers have always played an important role in Thai culture and have long been the main source of food, transportation, and water supply. With the growing economic activity of recent decades, the demand on inland water resources, both as sources of the nation's water supply and environmental "sinks" has increased. Water quality has been declining, especially in the densely populated sectors of Thailand's two main rivers (i.e., the Chao Phraya and the Tha Chin). To address water pollution, Thailand has put in place policies, plans, water quality standards, and budgets. A number of wastewater treatment plants have been constructed, mainly in municipalities, which are operated with varying degrees of efficiency.

2.1. Negative pressures

Organic discharges dominate as the main pressure on inland waters in Thailand. Unlike the trend of declining organic wastewater discharges in advanced economies, Thailand's organic discharges increased by more than 60 percent between 1980 and 1997, and it ranked ninth in the world in terms of biochemical oxygen demand (BOD) effluent generated per square kilometer of the country's surface area.

Agricultural runoff and domestic wastewater are the main causes of poor water quality in Thailand, although industrial discharges play a subsidiary and spatially well-defined role, mainly in the central and eastern regions. Agricultural pollution (in terms of BOD) is highest in the northeastern and central regions.

The dominant source of organic pollution is domestic wastewater, responsible for 54 percent of total national discharges. The total urban domestic wastewater discharges (from urban populations in municipalities only) increased only slightly between 1994 and 2000 to about 2 million cubic meters per day (Mm^3/d) prior to showing a significant increase from 2001 to 2003 (figure 2).

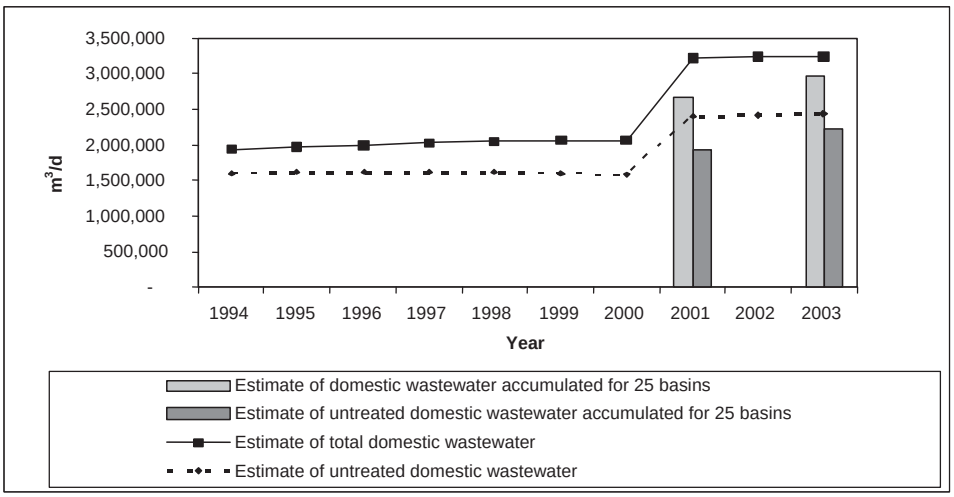

Figure 2. Discharge of untreated domestic wastewater (1994–2003)

A similar trend is also seen with the discharge of untreated domestic wastewater. When urban populations were considered separately (municipalities located in 25 major river basins), the total wastewater discharged increased from 2.6 Mm^3/d in 2001 to 2.9 Mm^3/d in 2003. Nevertheless, approximately 25 percent of total domestic wastewater was treated in 2001 and 2003. The estimated total discharge of untreated domestic wastewater from urban municipalities grew from 1.9 Mm^3/d in 2001 to 2.2 Mm^3/d in 2003. Bangkok itself discharged about 5 Mm^3/d, with 37 percent of its wastewater produced in areas where wastewater treatment plants exist.

In 1999, 79 percent of the total organic pollution load in Thailand's surface waters was generated in ten water catchment basins, namely, the Moon, Chao Phraya, Chi, Mekong, Tha Chin, Mae Klong, Pasak, East Coast-Gulf, Nan, and Bangpakong. These are characterized by large populations and intensive agricultural activities, along with industrial activities in the central region.

For the central region as a whole, domestic sources (39 percent) and agricultural sources (37 percent) were the largest contributors in terms of BOD, followed by industry (24 percent). In this region, the discharges are greatest in the Bangkok Metropolitan Region (BMR), which includes the city of Bangkok and the provinces of Pathum Thani, Nonthaburi, Samut Sakhon, and Samut Prakarn. The heaviest pollution was especially concentrated in the lower reaches of the Chao Phraya and Ta Chin rivers due to

the large populations residing there, heavy use of fertilizers for agriculture, and limited wastewater treatment capacity. For the BMR as a whole, BOD generated by households accounted for 81 percent of the total, industry for 19 percent, and agriculture for a negligible amount.

2.2. Status of water quality

The overall state of water quality is normally identified by the following three parameters: dissolved oxygen (DO), BOD, and fecal coliform bacteria (FCB). The baseline standards for these are shown in table 4.

Table 4. Thailand's DO, BOD, and FCB standards

Parameter	Rating				
	Class 1 Very good	Class 2 Good	Class 3 Moderate	Class 4 Poor	Class 5 Very poor
Dissolved oxygen (DO)	Natural	6	4	2	—
Biochemical oxygan demand (BOD)	Natural	1.5	2	4	—
Fecal coliform bacteria (FCB)	Natural	1,000	4,000	—	—

Source: Notification of the National Environmental Board, No. 8, issued under the Enhancement and Conservation of National Environment Quality Act (NEQA) 1992.

The Thai government's Pollution Control Department (PCD) has been monitoring the water quality of Thailand's major rivers since 1990. The general results of monitoring show that the overall quality of the country's rivers during the period 1993–2003 was average and stabilizing; however, poor water quality was reported in some receiving water bodies, such as the following four most heavily polluted ones: the lower Chao Phraya River, the lower Ta Chin River, the lower Lam Ta Kong River, and Songkhla Lake (figure 3).

The nationwide trends in water quality are a composite of uneven regional conditions. In the north, for instance, water quality generally remains good, reflecting agricultural underdevelopment and few industries. Agriculture and industry together account for 17 percent of the total BOD generation, while domestic wastewater accounts for 83 percent (World Bank 2001). Overall, DO levels of the northern rivers during 1993–2003 showed signs of increase, while BOD levels were quite low. On the other hand, FCB contamination was critical in some rivers such as the Wang and the Nan, which had values greater than 4,000 MPN/100 milliliters (mL), an indication of poor quality.

In the central region, the quality of its 12 main rivers during 1993–2003 was moderate in terms of DO and BOD levels except for the lower Chao Phraya River and the middle and lower Ta Chin River, where the quality of water was relatively poor and deteriorating. DO values decreased over that period, falling to less than 2 milligrams per liter (mg/L), BOD levels were at 2–4 mg/L, and the FCB count was greater than 4,000 MPN/100 mL.[1] Many remedial steps have since been taken to improve surface water quality.

1. MPN = most probable number.

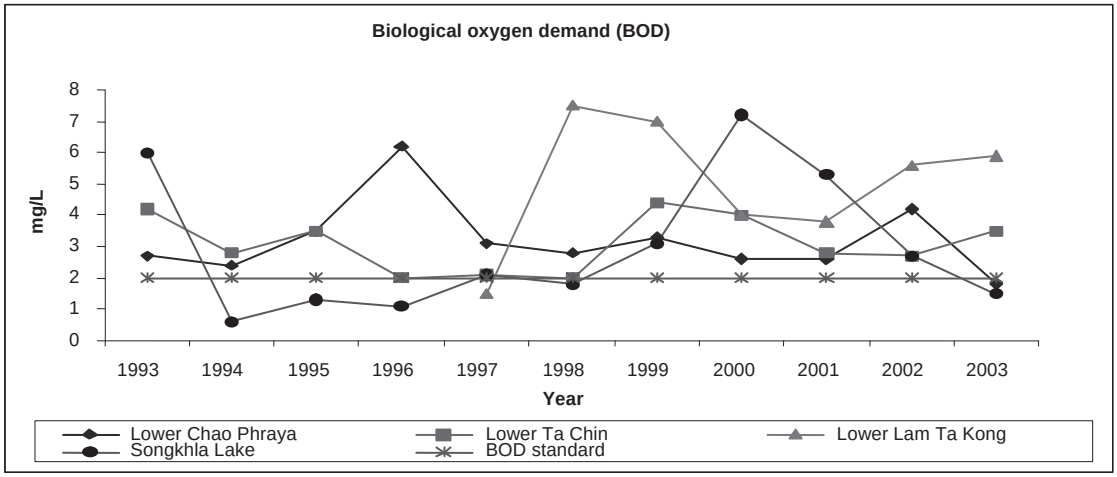

Figure 3. BOD levels in the lower Chao Phraya River, lower Ta Chin River, lower Lam Ta Kong River, and Songkhla Lake, 1993–2003

In the northeastern region, the overall quality of most rivers was relatively good and improving, with high DO and low BOD levels. The overall FCB count was also quite low for most rivers. On the other hand, poor water quality was observed in Lam Ta Kong Lake (low DO, high BOD, and high FCB).

In the southern region, river waters were of average and stable quality, with high DO levels and fair levels of BOD. A relatively poor and deteriorating water quality was observed in Songkhla Lake, however, where low DO, high BOD, and high FCB contamination was recorded. In this region, domestic wastewater discharges, primarily from the tourism industry, were responsible for nearly two-thirds of total BOD generation, whereas agriculture accounted for 26 percent and industry for the remaining 11 percent.

3. Policy, plan, and legislation development

The Thai government has put into place a number of policies, plans, and water quality standards in an effort to reduce water pollution. The Nineth National Economic and Social Development Plan (2002–2006) placed more emphasis on rehabilitation of the country's natural resources and made improved water quality an important component of that effort. The Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality (1997–2016) recognized the role of local governments and civil society in improving and protecting water quality with the following objectives:

- Accelerate the rehabilitation of water quality in important water bodies
- Reduce water pollution originating from communities, agriculture, and industry
- Apply the "polluter-pays" principle
- Promote private sector involvement in water pollution management

The PCD drafted the following three plans in 2003 for improving water quality:

1. Water Pollution Management Plan
2. Domestic Waste Water Management Plan
3. Rehabilitation and Improvement Plan for Collecting and Wastewater Treatment Systems for the Municipalities of Thailand

The *Water Pollution Management Plan* identified five strategies and 15 mitigation approaches to improve surface water quality. The plan's stated goal was to achieve DO values greater than 2 mg/L and BOD values less than 4 mg/L in all main rivers by 2007, and that the quality of water bodies in densely populated areas must also meet national standards by then.

The *Domestic Waste Water Management Plan* increased the responsibility of local administrations in mitigation, rehabilitation, protection, and day-to-day management of water pollution control facilities. The plan set forth the following objectives:

- Prepare local administrations to manage their own wastewater by 2011
- By 2001, give 344 urban communities the responsibility for at least 50 percent of the total wastewater generated and ensure that 1,130 urban communities have appropriate wastewater treatment systems by 2017

The plan recognized that urban and municipal areas exert more pressure on water bodies than peri-urban areas (areas outside municipalities) and identified the following two categories:

- Group 1: includes the river basins of Ta Chin, Chao Phraya, and Sonkhla Lake, which have serious water pollution problems
- Group 2: less water pollution with good to fair water quality

The *Rehabilitation and Improvement Plan for Collecting and Wastewater Treatment Systems for the Municipalities of Thailand* was aimed at improving the efficiency of wastewater treatment systems operated by local administrations.

The legislation on water pollution control is extensive, as shown in table 5. Enforcement is still weak, however, due to lack of political will (in some cases), inadequate coordination among various agencies, low technical capability for proving violations, and limited access to information. To initiate regulatory reforms and improve the compliance of firms with approved environmental quality standards, existing command-and-control measures are to be complemented by market-based instruments and public disclosure tools.

Table 5. Legislation related to water pollution

Legislation	Regulated activities
Enhancement and Conservation of National Environment Quality Act (NEQA) 1992	Regulates specific point sources for wastewater discharges into public water resources or the environment, based on effluent standards
Factory Act of 1992	Limits level of effluent discharged and restricts concentration levels of chemical and/or metal pollutants
Navigation in Thai Waterways Act (Volume 14) as amended in 1992	Prohibits dumping of any refuse including oil and chemicals into rivers, canals, swamps, reservoirs, lakes, or waterways that may pollute the environment or disrupt navigation in Thai waterways
Public Health Act 1992	Regulates nuisance activities related to water pollution such as odor, chemical fumes, wastewater discharge systems from buildings, factories, or animal feedlots that cause harmful health effects
Cleanliness and Tidiness of the Country Act of 1992	Prohibits dumping or discharging of wastewater into canals
Building Control Act of 1979	Regulates discharge of water pollution from buildings
Penal Code of 1956	Prohibits adding harmful substances in water resources reserved for consumption
Fisheries Act of 1947	Prohibits dumping or discharging of hazardous chemicals into water resources reserved for fishing
Royal Irrigation Act of 1942	Prohibits dumping of garbage or discharging polluted water or chemicals into irrigation canals

Source: World Bank 2001.

4. Wastewater treatment

There has been significant progress in constructing wastewater treatment plants in Thailand over the past 20 years. By 2002, the government had invested a total of 67,290 million baht in wastewater treatment systems. In 2003, 78 wastewater treatment plants were in operation, six were under construction, and the construction of three more was pending in the provinces of Saraburi, Nakorn Srithammarat, and Samut Prakarn). The total installed capacity of wastewater treatment plants is now approximately 2.2 Mm^3/d, but the actual amount of wastewater being treated is only 739,307 cubic meters per day (m^3/d). A large amount of untreated domestic wastewater continues to be discharged into water bodies (approximately 1.9 and 2.2 Mm^3/d in 2001 and 2003, respectively). This means that only about 25 percent of domestic wastewater is treated and the balance is discharged untreated into water bodies. According to evaluation reports of the Ministry of Natural Resources and Environment, 20 percent of wastewater treatment plants were operating well, 65 percent were fair, and 15 percent were operating poorly. The main causes of inefficiency include poor collection systems, limited budgets for operation and maintenance, lack of appropriately trained and experienced personnel, unclear legislation on wastewater treatment fees, lack of enforcement of standards, poor public relations, and insufficient public involvement.

A number of relatively simple and low-cost treatment technologies exist (i.e., oxidation ditches, aerated lagoons and stabilization ponds) that could generate significant improvements under competent

local management. On the other hand, even though employing an activated sludge treatment process is more complex and costly, it requires less land, thus making it more suitable for urban areas of the control region or the BMA.

5. Environmental expenditures and financing

The government's annual budget for pollution control increased from 500 million baht in 1990 to a high of 12,368 million baht in 1997, and then was reduced to 7,928 million baht in 2001 (table 6). These funds have been used mainly for controlling urban pollution, such as dealing with wastewater, air and noise pollution, and managing solid and hazardous wastes.

Another source of funding is the Environmental Fund, established in 1992 to support efforts intended to solve urgent environmental problems that would involve the participation of all stakeholders, in particular the provision of air pollution and wastewater treatment facilities along with waste disposal systems.

Table 6. Government environmental expenditures, 1990–2000 (in millions of baht)

Year	Water pollution	Air and noise pollution	Hazardous waste	Solid waste	Others	Total
1990	143.27	3.42	—	—	342.25	500.94
1991	295.44	36.79	—	1.63	503.02	836.88
1992	810.36	52.90	8.43	26.58	1,902.01	2800.28
1993	2,690.54	93.34	26.4	144.35	2,761.85	5761.48
1994	3,645	528.00	896	n.a.	1213.00	6,282.00
1995	4,037	347.00	1,435	—	1116.00	6,934.00
1996	5,948	472.00	1,193	—	2386.00	9,999.00
1997	7,258	439.00	1,192	—	2391.00	12,368.00
1998	6,562	183.00	369	79.50	446.00	8,355.00
1999	4,586	105.00	404	639.00	435.00	6,469.00
2000	6,630	158.00	915	587.00	675.00	8,965.00
2001	5,169	132.00	631	802.00	1,194.00	7,928.00

Source: PCD 1990–2001.

Significant investments in pollution control have also been made by the private sector both as a response to government pollution control policies as well as voluntarily through programs such as ISO 14001 (961 companies in Thailand are presently ISO 14001-certified).

In terms of funding improvements in water quality, Thailand has been an active party in the debate on how to balance the advantages and disadvantages of economic instruments as opposed to the more traditional "command-and-control" instruments of environmental policy, which include the following:

- Resource pricing
- User charges for water use, municipal solid waste disposal, hazardous waste disposal
- Wastewater charges for selected industrial clusters, the Industrial Estate Authority of Thailand, centralized municipal wastewater treatment plants, etc.

- Others (i.e., tax and price differentiation, green taxes, voluntary compliance mechanisms, and clean production initiatives)

The price of piped water in the BMA is set in the form of a two-tier tariff differentiated by customer categories (residential, government, industry, and commercial). Wastewater treatment by industrial estates is largely financed by charges levied on estate tenants. Several municipalities (i.e., Pattaya and Patong) have introduced differentiated wastewater treatment charges.

6. Conclusions

The quantity and quality of water resources in Thailand have been under increasing pressure over the years due to deterioration of watersheds, disappearance of wetlands, and inefficient allocation of water resources.

The demand for water has grown roughly in tandem with Thailand's GDP growth over the last two decades, but potential water shortages now loom as a serious threat to the future development of the country.

To address water pollution problems, Thailand needs to develop an integrated approach in the management of water resources. This will involve (1) fostering local community participation in water resources management; (2) harmonizing functions and laws by addressing overlaps in institutions and jurisdiction, and gradually decentralizing functions to local governments; and (3) increasing compliance with environmental standards by providing incentives for pollution control, improving the efficiency of budget allocation and rationalizing investments in the wastewater sector, promoting opportunities for private sector participation, and increasing public awareness.

References

National Economic and Social Development Board (NESDB). 2003. *The ninth national economic and social development plan (2002–2006)*. Bangkok: NESDB.

Office of Environmental Policy and Planning 1997. *Thailand policy and perspective plan for enhancement and conservation of national environmental quality, 1997–2016.* Bangkok: Ministry of Science, Technology and Environment.

Pollution Control Department (PCD). 2003. *State of water pollution Thailand 2003.* Bangkok: PCD.

Pollution Control Department (PCD) 2005. *Wastewater treatment for municipalities.* Bangkok: PCD.

World Bank. 2001. Assessing the status of water quality management in the country. In *Thailand environment monitor 2001*. Bangkok: World Bank.