Chao Phraya River Basin (Thailand)

[Based on information provided by the Office of Natural Water Resources Committee (ONWRC) of Thailand]

Population and socio-economic situation in the Chao Phraya basin

Population

The Chao Phraya basin is the most important basin in Thailand. The Basin covers 30% of Thailand's land area, is home to 40% of the country's population, employs 78% of its work force, and generates 66% of its Gross Domestic Product (GDP). The total population of the Chao Phraya basin was 23.0 million inhabitants in 1996. The Basin can be divided into eight sub-basins based on the natural distribution of its river system. About 50% of this population (11.5 million) resides in the Lower Chao Phraya basin, in which the highly populated areas of Bangkok Metropolitan Area (BMA) and its environs of Samut Prakan, Nonthaburi and Pathum Thani are located. Similarly there is a large concentration of population in the Upper Ping where Chiang Mai (the second largest city in Thailand) is located. Overall, about 68% of the total population of the Basin is rural, but there is considerable variation with over 90% of the population being rural in the Upper Chao Phraya basin compared to 45% in the Lower Chao Phraya basin, It is projected in the next decade that the rural population will decrease by an annual rate of about 1.31% and that the population growth rate will remain low at about 1.0% per annum. These trends should ultimately induce aggregation of farming land with consequential increase in household incomes. Population density averages 136 persons/km2, but varies greatly from 44/km2 in the Nan Sub-basin to 533/km2 in the Chao Phraya Sub-basin. Bangkok and its vicinity have the highest population density of 1,497 inhabitants/km2.

Map prepared for the World Water Assessment Programme by AFDEC.

Socio economic conditions

With Bangkok located in the Chao Phraya Sub-basin, this is economically the most important sub-basin, contributing 78.2% of the total GDP of the Basin. Sub-basins can be divided into three economic growth rate groupings:

- Tha Chin, Chao Phraya and Upper Ping with higher growth rates;
- Pasak and Wang at about the national growth rate;
- Lower Ping, Upper Yom, Lower Yom, Upper Nan, Lower Nan, and Sakae Krang with lower growth rates.

The division of the basin into prosperous north and south and poor middle is reflected in socio-economic conditions.

Bangkok panoramic

Source: World Water Assessment Programme, 2003, UN World Water Development Report 1: Water for People, Water for Life; Paris, UNESCO and New York, Berghahn Books, Chapter 16: Chao Phraya River Basin, Thailand, p. 387-400.

Formal employment and social services, such as health and education, are similarly concentrated, with a generally higher per capita provision, in the Bangkok Metropolitan Region (BMR) and the Upper Ping. Considerable variation exists in the Gross Provincial Product (GPP) and economic growth rates of provinces depending on the industrial and agricultural shares in provincial (sub-basin) economies; high growth sub-basins are industrial and low growth ones are agricultural. Considerable inequalities exists in per capita income between urban and rural populations. It must be stressed that although Thailand is considered to be economically relatively advanced among developing countries, rural people are still poor, with average per capita incomes of about US$1,000 per year. Typically, there is about a six-fold difference in average per capita income between the citizens of Bangkok and the rural areas.

Land resources and use in the Chao Phraya basin

Farmers at work in a field of tea

Over 90% of the area of the Basin is either used for agriculture or covered with forest, with the proportions of these land uses being roughly equal. Within the Basin, the largest sub-basins (in terms of area) are in descending order, the Ping, Nan, Chao Phraya and Tha Chin. The Yom and Pasak sub-basins are intermediate in size and the two smallest sub-basins are the Wang and the Sakae Krang. Agricultural land is concentrated in the southern sub-basins and ranges from 78% in Chao Phraya, 63% in Pasak and 55% in Tha Chin compared to 20 to 45% in the four northern sub-basins (Ping, Wang, Yom and Nan). The majority of forest cover occurs in the northern sub-basins where the percentage of forest ranges from 50-75% in Ping, Wang, Yom and Nan to 30% in Pasak and only 7% in Chao Phraya. In recent years there has been steady encroachment of people into forest areas for conversion to agricultural purposes while cultivated land near urban centres has been converted to residential or industrial use. The need to protect the upper catchment of the Chao Phraya basin from degradation and soil erosion has already been identified as a priority by government. Urban land use ranges from 1 to 3% in all sub-basins except the Chao Phraya where it is 10% of the total area.

Trees destroyed for hillside cultivation

Water availability is the key factor constraining future developments in agriculture in the Central Plain, being the core of diversification and of multi-cropping. Water resources are coming under pressure and their management is the challenge for the future, involving the following main aspects: Water quantity, which governs the possible extension of second rice cropping or other field crops in the dry season, and the pressure on underground water resources through increasing sinking of wells. Water management, which must aim at achieving greater equity and efficiency in water deliveries at the basin, project and on-farm level. Flood control and warning where improved flood management minimises damage to crops and to physical structures in urban areas particularly.

Source: World Water Assessment Programme, 2003, UN World Water Development Report 1: Water for People, Water for Life; Paris, UNESCO and New York, Berghahn Books, Chapter 16: Chao Phraya River Basin, Thailand, p. 387-400.

Water quality and sustainability, particularly pollution and salinisation which can have serious effects on agricultural production. Patterns of land use where the attainment of high water use efficiency through crop diversification is dependent on much greater local level control on water deliveries. Livestock and fresh water fisheries are also important elements of the agricultural scene in the Chao Phraya basin. They provide important additional sources of family income.

Fish vendor at Kanchanaburi market

Water resources in the Chao Phraya basin

Surface water resources

Riverine resources

The headwaters of the Chao Phraya river originate in mountainous terrain in the northern part of the country and consist of four large tributaries, the Ping, Wang, Yom and Nan rivers. The main river system passes through or close to many of the major population centres of the country including the capital, Bangkok, which is situated at its downstream end. The four upstream tributaries flow southwards to meet at Nakhon Sawan and form the Chao Phraya river. The river flows southwards through a large alluvial plain, called the delta area, splitting into four channels:

- the Tha Chin river(also called the Suphan and Nakhon Chaisi further downstream);
- the Noi river;
- the Lop Buri river;
- the Chao Phraya river.

Annual average runoff in Chao Phraya basin

Sub-basin	Catchment Area(km^2)	Total Volume(m^3)
Ping	35,535	9,073
Wang	11,084	1,624
Yom	19,516	3,684
Nan	32,854	11,936
Sakae Krang	5,020	1,096
Pasak	15,647	2,823
Tha Chin	18,105	2,449
Chao Phraya main stream	21,521	4,435
Chao Phraya basin	159,283	37,120

The flows in the Chao Phraya and its tributaries are dependent on the monsoon rains during May to October and are highly seasonal. Average annual precipitation in the Chao Phraya basin varies from a minimum of 1,000 mm in the western part to about 1,400 mm in the headwaters and up to 2,000 mm in the eastern Chao Phraya delta. Variations from year to year, which are responsible for floods and droughts, are key factors in determining the availability of the basin's water resources.

Source: World Water Assessment Programme, 2003, UN World Water Development Report 1: Water for People, Water for Life; Paris, UNESCO and New York, Berghahn Books, Chapter 16: Chao Phraya River Basin, Thailand, p. 387-400.

About 85% of the total runoff occurs in the months of July to December, and natural flows are small in the January to June period. Average annual runoff recorded in the upper Chao Phraya basin varies from about 250 mm in the sub-basin of the Ping above Bhumibol reservoir to some 450 mm in the sub-basin of the Nan above Sirikit reservoir. Average annual runoff for the Chao Phraya river at Nakhon Sawan is 226 mm.

Surface water storage

Since 1950 the Government has constructed some 3,000 dams to store the monsoon flows for release in the dry-season to exploit the Chao Phraya basin's vast agricultural potential and to meet the growing demands of industrial and urban users. The two largest dams constructed were the Bhumibol and Sirikit Dams to supply stored water for electricity generation, irrigation, and domestic and industrial water use. Together these two dams control the runoff from 22% of the area of the entire basin. Bhumibol Dam on the Ping River has a live storage capacity of 9.7 billion cubic meters (bm3), compared to the average annual inflow of 6.6 bm3 from a drainage basin of 26,400 km2. The installed hydroelectricity generation capacity is 713 MW. The dam was completed in 1963, and filled for the first time in 1970. Sirikit Dam on the Nan River was completed in 1972 and has a live storage capacity of 6.0 bm3 compared to the average annual inflow of 5.9 bm3. The installed hydroelectricity generation capacity is 500 MW. Several other large dams (Kiew Lom, Mae Ngat, Mae Kuang, Mae Chang, Thap Salao and Kra Sieo) have also been built during the last 20 years to increase the total surface water storage in the Basin, and recently another dam, the Pasak Dam, was commissioned in 2000.

Barrages

A number of barrages have been constructed in the lower Chao Phraya Basin to control and divert the water in the canal systems that provide irrigation water to some 1.0 million hectares in this area. The most important barrages in the delta area are the Rama VI barrage, which was completed in 1924, and the Chao Phraya (Chainat) Diversion Dam on the Chao Phraya river, which was construted in 1957. Although the Rama IV barrage was constructed about 75 years ago, it still maintains its structural shape and functions. These barrages divert water to a complex system of inter-connect canals serving the lower Chao Phraya basin irrigation system. Barrages have also been constructed above the Chao Phraya Diversion Dam. The Naresuan Dam across Nan River at Phitsanulok was completed in 1985 and diverts water to the whole area of the Phitsanulok Phase I Project. The water released from the Sirikit Dam meets the requirements of the Phitsanulok Irrigation Project as well as part of the demand for the Chao Phraya Delta area.

Groundwater resources

Hydrogeologically, the Chao Phraya river Basin comprises of seven groundwater sub-basin; namely; Chiangmai-Lampoon Basin, Lampang Basin, Payao Basin, Prae Basin, Nan Basin, Upper Chao Phraya basin, and Lower Chao Phraya basin. Within these groundwater sub-basins, water is held in either confined or unconfined aquifers. Eight separate confined aquifers are located in the Upper Tertiary to Quaternary strata of the Bangkok area. The natural groundwater condition within this succession of aquifers is a high degree of confinement, providing artesian conditions in each. The ease of exploitation, as well as the high chemical quality, are the main reasons for the original development of this source. Groundwater storage and safe yield has been estimated for each groundwater sub-basin, as shown below.

Source: World Water Assessment Programme, 2003, UN World Water Development Report 1: Water for People, Water for Life; Paris, UNESCO and New York, Berghahn Books, Chapter 16: Chao Phraya River Basin, Thailand, p. 387-400.

Groundwater storage and safe yield of the Chao Phraya river sub-basins *

Groundwater Basin	Groundwater Storage (million m^3)	Safe Yield per year (million m^3)	Safe Yield per day (m^3)
Chiangmai-Lampoon	485	97	265,000
Lampang	295	59	161,000
Chiangrai-Payao	212	42	115,000
Prae	160	32	87,000
Nan	200	40	110,000
Upper Chao Phraya	6,400	1,280	3,500,000
Lower Chao Phraya	6,470	1,294	3,500,000
Total	14,222	2,844	7,738,000

The calculation is based on the assumption that amount of groundwater storage is depend on the change of water level, area of aquifer, and storage which is varies to geology of each area, such as unconfined, confined, or semi-confined.

The basin faces a growing problem in the management of groundwater resources. Lack of investment in piped water systems has caused many municipalities and private users to install tubewells. Almost half of Bangkok's supply comes from groundwater exploitation that is not sustainable, and this problem is spreading to other parts of the Basin. Some of the more productive aquifers have low natural recharge and have become substantially depleted.

Water quality

Surface water quality

A study by Thailand Environmental Institute for the Pollution Control Department of the Ministry of Science, Technology and the Environment in 1997 reviewed the water quality data for the Central River Basin as routinely monitored by the National Enviromental Board (NEB) , the Pollution Control Department (PCD) and the Ministry of Public Health (MOPH). Results indicated that among the major rivers in the lower Basin there was evidence of heavy pollution in both the Chao Phraya and Tha Chin rivers, while overall water quality was acceptable in the Pasak and Sakae Krang rivers. The Chao Phraya river exhibited serious organic and bacterial pollution that was a threat to many species of aquatic life. Similarly, water quality in the Tha Chin River was heavily degraded, caused by the combined discharges of industrial, domestic and rural inflows.

Transplanting rice on new field which has been cleared by deforestation

Source: World Water Assessment Programme, 2003, UN World Water Development Report 1: Water for People, Water for Life; Paris, UNESCO and New York, Berghahn Books, Chapter 16: Chao Phraya River Basin, Thailand, p. 387-400.

The Pollution Control Department also carries out regular water quality monitoring for the Ping, Wang, Yom and Nan Rivers. Based on analytical data during the period 1994-1995, the overall water quality of the major rivers in the upper Basin were found to be polluted or degrading, particularly near urban centres.
Significant sources of pollution were identified in the upper reaches of the Ping River coinciding with urban development in Chiangmai Province. In the Wang River, degradation of water quality near centres of urban population in Lampang was attributed to domestic wastewater discharge coupled with effluent discharges from commercial establishments and factories located on the river banks. Overall water quality in the Yom River in 1995 had also deteriorated due to high bacterial contamination from municipal wastewater releases from households and business activities in urban areas in Pichit, Pitsanulok, Sukhothai and Phrae Provinces. Overall water quality in the Nan River had also deteriorated by 1995 from heavy bacterial contamination attributed primarily to the rapid increase of urban development in Pichit, Pitsanulok, Uttaradit and Nan Provinces.

The extensive network of interlinked waterways associated with the main delta irrigation system also constitutes a diffusion network for diverse kinds of pollution. Water pollution is caused by the discharge of agricultural wastes (pesticides, fertiliser, pork farm effluent, etc.), sewer outlets and industries. It has an adverse impact on domestic uses along waterways, on human health, aquatic fauna and flora and on several agricultural activities. Organic load, with subsequent low levels of dissolved oxygen in the water is mostly caused by domestic waste and by waste water discharged from prawn, duck and pig farms. High densities of water hyacinth often exacerbate the situation.

Groundwater quality

The main chemical constituents affecting groundwater quality are sodium and chloride. The average salinity of the groundwater in the unconfined aquifers shows a general increase in the downstream direction, except for the Ping catchment in which the salinity is comparatively high for its upper catchment situation. The groundwater of lowest salinity comes from the Wang catchment. Nitrate concentrations are almost invariably low in all catchments. The extent to which chemical quality is presently affected by contamination is not known, except in some specific areas. The effects of urbanisation and agriculture are the most likely sources of groundwater contamination to be locally problematic in the future. It is also known from recent studies that urban contamination is already an identifiable problem in city areas including Chiang Mai in the Upper Ping basin. Similar contamination might be expected in the vicinity of each of the major centres located above unconfined aquifers throughout the catchment, due to a combination of sewage infiltration and industrial waste pollution. Over-pumping, for example in Bangkok, can also lead to groundwater contamination through inadvertent disruption of existing groundwater continuums.

Woman cooking in a boat, Bangkok

Source: World Water Assessment Programme, 2003, UN World Water Development Report 1: Water for People, Water for Life; Paris, UNESCO and New York, Berghahn Books, Chapter 16: Chao Phraya River Basin, Thailand, p. 387-400.

Flooding

Floods are a natural phenomenon in the Chao Phraya river Basin and while residents have historically adapted their lifestyle to deal with annual flood events they cause significant economic losses. The major causes have been :

- the decline of flood retention areas and the confinement of flood plains due to increasing development;
- rapid urbanisation in the vicin;
- the intensification of agriculture.
- In recent years, the Government has had some success in reducing the magnitude of flooding through the construction of multi-purpose reservoirs and other flood control infrastructure. Although the extent of flooding has been reduced through construction of dikes, this has resulted in a higher overall flood risk.

Water resource use in Chao Phraya basin

Irrigation

Surface water irrigation systems

Irrigation development of the Chao Phraya basin began as early as the 1890's in the southern Chao Phraya Plain. The Royal Irrigation Department (RID) was formed as the agency responsible for water resource development in Thailand. The development projects include large scale, medium and small scale and pumping irrigation projects. Over 3,000 dams of all sizes have been constructed throughout the Basin.

Groundwater Irrigation Systems

The use of groundwater for agriculture is mainly to supplement surface water supplies. Groundwater consumption is more acute during the dry season and in drought years for land preparation, crop needs in the early part of the wet season and as a supplementary source of water for farms located at the tail-end of distribution canals. Pumped irrigation schemes are at present being implemented by the Department of Energy Development and Promotion to secure adequate irrigation water throughout the year in the middle Basin area.

Electricity Generation

Hydropower in the Chao Phraya basin in managed by the Electricity Generating Authority of Thailand (EGAT). At present there are only two major hydropower installations, at Bhumibol (713,000 KW) and Sirikit (500,000 KW) reservoirs respectively, with a smaller installation at Mae Ngat (9,000 KW) in the Upper Ping basin. EGAT is not presently actively pursuing new hydropower projects in the basin. The construction of further large reservoirs with hydropower potential would involve large-scale resettlement making such projects problematic. New reservoir construction in the upper basin has also encountered increasing opposition on environmental grounds.

Source: World Water Assessment Programme, 2003, UN World Water Development Report 1: Water for People, Water for Life; Paris, UNESCO and New York, Berghahn Books, Chapter 16: Chao Phraya River Basin, Thailand, p. 387-400.

Industrial Use

Past industrial growth has been greatest in Bangkok and pressure on existing infrastructure has led to new enterprises starting in the provinces surrounding Bangkok where land, labour and other resources are more readily available and infrastructure is less congested. The amount of water used for industrial purposes in the Chao Phraya basin is uncertain.

Domestic Water Use

Water supplies for domestic purposes are provided by water service facilities in urban areas and by wells in rural areas. At the provincial level, domestic water supply coverage is about 47% of all households. Water supply for domestic purposes for farm households is from piped schemes (56.8%) ,wells (37.2%) and rivers (6.4%). Overall, 62% of rural households consume water from unprotected sources, such as rainfall collection, rivers, canals and ponds. The majority of piped schemes for farm households are operated and managed by village communities. Nationwide, potable water supplies are generally provided by two agencies: the Metropolitan Waterworks Authority (MWA) and the Provincial Waterworks Authority (PWA). The MWA engages in production and distribution of potable water in the Bangkok metropolitan region while the PWA is responsible for all the provinces in Thailand. The PWA is responsible for water source development, conveyance, pumping, treatment, storage, and distribution facilities from all urban and rural communities in the provinces.

Woman transporting water

Navigation and river integrity

Navigation

Since early times, the Chao Phraya river has been a major navigation route far into the central part of the basin. Ships and barges have provided a very important means of transport of commercial goods. However, the increasing diversion of river flow for irrigation has had the effect of reducing minimum flows in critical reaches of the river such that navigation by vessels over a certain size is now restricted during the dry season.

Man in a boat in Bangkok

Source: World Water Assessment Programme, 2003, UN World Water Development Report 1: Water for People, Water for Life; Paris, UNESCO and New York, Berghahn Books, Chapter 16: Chao Phraya River Basin, Thailand, p. 387-400.

River integrity

The maintenance of river integrity is based on maintaining minimum stream discharges to repel salt-water intrusion at the lower reaches of rivers, minimise levels of pollutants and maintain minimum dissolved oxygen levels to ensure that the quality of the aquatic environment does not fall below acceptable levels. A minimum flow of 16m3/s is currently considered sufficient in the lower reaches of the Chao Phraya river to repel saline intrusion. Pollution control is more problematic. Most of the wastewater discharges of domestic and industrial origin have increasingly been controlled and mitigated through the enforcement of separate effluent standards by various regulating governmental agencies. In addition, the regulation of streamflow in the Chao Phraya river by releases from upstream reservoirs operated by EGAT and RID can to some extent improve the poor downstream water quality during the dry season.

Useful links and contacts

Read the complete case study, published in the first edition of the UN World Water Development Report (WWDR1)

To know more about the Chao Phraya river basin, here is a list of interesting projects and organizations:

- Thailand Environment Institute - [in english/in thai]
- Department of Agriculture of Thailand - [in thai]

The UN World Water Development Report, coordinated by the UN World Water Assessment Programme, is a joint effort of the 26 UN agencies and entities which make up UN-Water, working in partnership with governments, international organizations, non-governmental organizations and other stakeholders.
For more information, visit our website at www.unesco.org/water/wwap.

Source: World Water Assessment Programme, 2003, UN World Water Development Report 1: Water for People, Water for Life; Paris, UNESCO and New York, Berghahn Books, Chapter 16: Chao Phraya River Basin, Thailand, p. 387-400.