



## FLOOD & DROUGHT MANAGEMENT TOOLS

### Chao Phraya Basin



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## 1. The Chao Phraya Basin

### 1.1 Physical characteristics and climate

The Chao Phraya Basin is considered the most important basin in Thailand for several reasons. The basin covers an area of 159,000 km<sup>2</sup>, corresponding to 30% of Thailand's land surface area. It stretches from the slightly elevated northern plains to the low alluvial plains where the river flows into the Gulf of Thailand. The basin hosts 40% of the country's population and generates 66% of the Gross Domestic Product (GDP); moreover, it includes the capital and largest city of Bangkok, which is Thailand's political, commercial, industrial, and cultural hub and is located at the delta of the Chao Phraya River.

The climate of Thailand is under the influence of the seasonal monsoon winds. Due to the Asian summer monsoon, rainfall distribution over the basin varies significantly between the rainy (May to October) and dry (November to April) seasons, ranging between 1,000 mm in the northeast region and up to 2,000 mm in the southeast region. Mean rainfall during the rainy season accounts for about 90% of mean annual rainfall in the Chao Phraya Basin. The upper part of the basin experiences a long period of warm weather because of its inland nature and tropical latitude, reaching temperatures near 40°C or more. In the southern part of the basin, temperatures are generally mild throughout the year due to the maritime characteristic of the region.

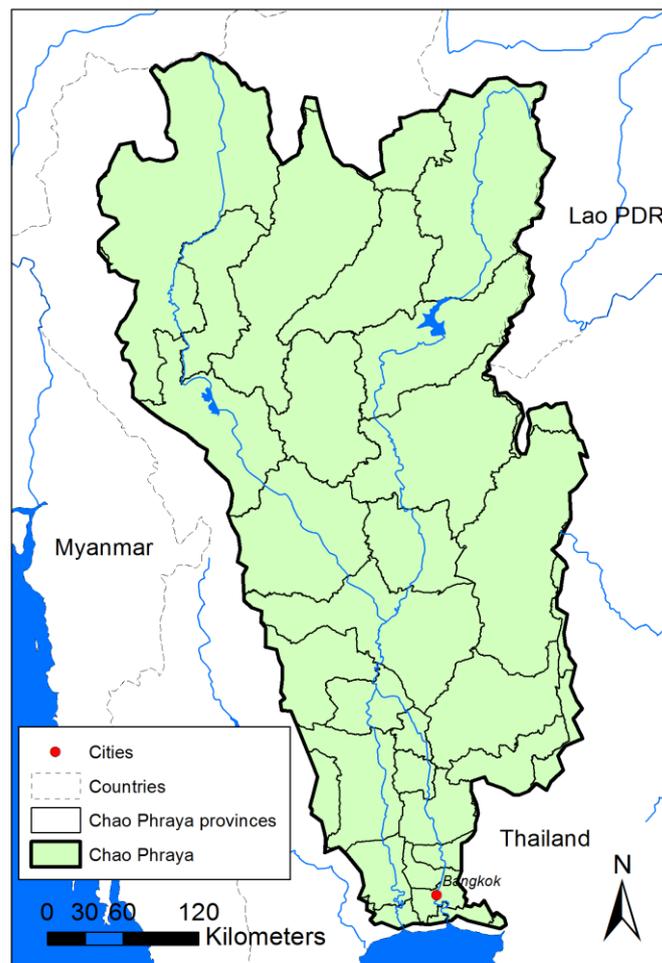


Figure 1. Map of the Chao Phraya Basin

## 1.2 Socio-economics

Approximately 50% of the roughly 30 million inhabitants of the Chao Phraya Basin live in the Bangkok Metropolitan Area (BMA), which generates 78.2% of the basin's share of GDP. The BMA and the Upper Ping sub-basin have the highest concentration of formal employment and social services, such as health and education. Agricultural lands, which cover over 90% of the basin, are concentrated in the southern part of the basin. About 68% of the basin population is rural.

Although Thailand has historically had a strong economy due in part to competitive industrial and agriculture exports, the rural population is relatively poor with an average income of close to 1000 USD/year. Typically there is about a six-fold difference in average per capita income between the citizens of the Bangkok and those in the rural areas.

## 1.3 Hydrology

The Chao Phraya Basin can be divided into 8 sub-basins: Ping, Wang, Yom, Nan, Sakae Krang, Pasak, Tha Chin, Chao Phraya main stream. The headwaters of the Chao Phraya River originate in the northern part of the country and consist of four tributaries: Ping, Wang, Yom and Nan rivers. In the downstream part, the Chao Phraya River splits into four channels of which Chao Phraya passes through Bangkok. Chao Phraya at Nakhon Sawan (the upper confluence) has an annual average flow of 718 m<sup>3</sup>/sec, reaching peaks of almost 6000 m<sup>3</sup>/sec.

Groundwater storage in the basin is estimated to be around 14,000 million m<sup>3</sup>/year. About half of Bangkok's water supply comes from unsustainable groundwater extraction, a problem that is dangerously spreading to other parts of the basin.

## 1.4 Impact of flood and drought

Floods are a regular feature of the Chao Phraya Basin causing significant economic losses. Floods have been aggravated by a number of factors: decline in flood retention areas and the confinement of flood plains due to increasing development, the rapid urbanisation in the vicinity of the river and the intensification of agricultural practices. The Thai government controls floods through the construction of multi-purpose reservoirs, dikes (diversions) and other flood control infrastructures, which are expensive for the country and can still fail. This containment strategy has managed to reduce the impact of flooding; however it has resulted in a higher overall flood risk as water reaches the flooding elevation much faster. The severe flooding that occurred during the 2011 monsoon season inundated large parts of the capital city of Bangkok, key land marks in Ayutthaya and over 20,000 km<sup>2</sup> of farmland, causing over 800 deaths.

Drought often occurs during the dry season, bringing serious problems such as salt water intrusion. Generally, rainwater and flows from dams keep saltwater from the Gulf of Thailand at bay, but during drought periods the saltwater creeps upstream, turning the Chao Phraya River brackish.

## 1.5 Hydraulic infrastructure

Since 1950, more than 3,000 dams have been constructed in order to store the monsoon flows to boost the agricultural potential during the dry season. The two largest dams are Bhumipol and Sirikit Dams; together they control 22% of the runoff from the entire basin land. The total installed hydropower capacity of these two dams is 1,200 MW. Numerous barrages have been installed on the main stream to divert water for irrigation schemes.

## 1.6 Institutional environment

The water institutional environment in Thailand is complex with a plethora of government agencies involved in managing water resource development, use and delivery. The principal boards and committees responsible for developing policies concerning water resource development, management and conservation are the National Economic and Social Development Board (NESDB),

the National Environment Board (NEB) and the National Water Resources Committee (NWRC). These institutions often have overlapping responsibilities.

At the provincial level, the Provincial Administration and District Administration offices (and similar agencies at the local government level) have an operational role in supplying local domestic and industrial water, but in reality have little role in water resource planning and management at the basin level.

Under the coordination of the Ministry of Natural Resource and Environment, Department of Water Resources (DWR), 25 River Basin Committees (RBC) were established with the hope of bringing about a more equitable sharing of resources and promotion of a participatory approach for wiser governance of water resources. However, the status of the committees, in particular their lack of judicial authority has limited their capacity function.

The Royal Irrigation Department (RID) is a key stakeholder in the Chao Phraya basin, and is responsible for the irrigation planning, and planning the dry season water allocation together with the Electricity Generating Authority of Thailand (EGAT). RID has recently completed a project with Japan International Cooperation Agency (JICA) on the development of a real time flood forecasting system for Chao Phraya.

EGAT is responsible for energy production in Thailand including hydropower generation. They undertake wet and dry season planning with respect to water allocation from the main reservoirs. This planning is carried out in consultation with five wet and dry season planning committees. EGAT has strong technical capabilities with respect to modelling (MIKE 11 and NAM).

The Hydro and Agro Informatics Institute (HAI) is the lead organisation for the Water Data Centre, and has extensive experience with Decisions Support Systems (DSS), modelling and real time systems. They also have a key role in data integration in Thailand.

Other relevant stakeholders in the basin include the Thai Meteorological Department (TMD) and the Geo-Informatics and Space Technology Development Agency (GISTDA). TMD runs regular projects of climate scenarios and undertakes seasonal forecasting. GISTDA has remote sensing data collected via satellites and aims at integrating hydrological information to provide better information for water management.

## **1.7 Key issues**

The Chao Phraya region, which has been for centuries the centre of rice production, is now in transition from water richness to water scarcity due to the increasing demands on this limited resource. In this critical phase, every small change in the hydrological situation can heavily impact the socio-economic conditions of the basin.

The fast population growth is causing the establishment of new settlements in areas where water management is already difficult. Forest areas are being destroyed at an alarming rate, reducing the capacity of the land to retain water and therefore increasing the risk of flash flood and landslides, soil erosion and sedimentation. The construction of dams and diversions often requires the resettlement of people in less productive lands. Highly populated areas as the Bangkok Metropolitan Area are producing solid waste and wastewater that pollute streams and water bodies, resulting in ecosystem degradation, loss of native species and increasing health risk for the population.

In the lower part of the basin, where intensive irrigation networks exist, the land is cultivated continuously and it has no time to be revitalised. The government now has even mobile land doctor units helping farmers diagnose and remedy land degradation problems.

## **1.8 Future changes**

Bangkok, Thailand's capital city and home to over 10 million people, has been sinking 10 cm annually due to the over-pumping of groundwater for industrial use. The land subsidence, coupled with rising

sea levels due to climate change, puts the city at risk of disappearing into the sea. Sea level rise will exacerbate freshwater constraints due to salinisation of estuaries and groundwater supplies.

Stronger and bigger waves triggered by climate change, as well as upstream dams that deposit less sediment at river-mouth areas, are causing coastal erosion and consuming precious land.

## **1.9 Projects and programs**

After the floods in 2011, the former government launched projects comprised under 9 construction modules to improve flood and drought management (including large floodways, flood barriers, reservoirs, and a data management system), however, little has been accomplished due to a combination of factors including protests by residents, political environment, lack of research into the projects, and the way the mega-projects were bundled together, making work on individual components hard to achieve.

Two key projects being implemented in the Chao Phraya Basin include the Integrated Study on Hydro-Meteorological Prediction and Adaptation to Climate Change in Thailand (IMPAC-T) project and the Development of Climate/Disaster Risk Assessment and Application of Risk Information in Development Planning in Thailand (THPRA) project.

The IMPAC-T project, supported by the Science and Technology Research Partnership for Sustainable Development (SATREPS) established by Japan, aims to provide a scientific basis for climate adaptation strategies. The IMPAC-T project embraces a transdisciplinary approach to research. It brings academia, operational agencies and funding agencies in Thailand together to enhance earth observations, understand climate change and develop integrated water resources models. The approach will help predict future hydrological changes associated with social and climate changes.

The THPRA project, spanning from June 2015 to February 2016, will assess and quantify disaster risk for 2 pilot provinces of Chiang Rai and Songkhla. The project will develop intensity maps of prevailing hazards in the selected provinces, collect data on the at-risk elements, study the vulnerability and derive the risk or possible impact of the hazards on those at-risk vulnerable elements. The project is supported by United Nations Development Programme (UNDP) and involves national agencies such as the National Economic and Social Development Board (NESDB) and Department of Disaster Prevention and Mitigation (DDPM).

## 2. Urban environments and utilities

### 2.1 Overview of urban areas in the basin

The Bangkok Metropolitan Area has the highest population density of almost 1,900 persons/km<sup>2</sup>. Chiang Mai, which is the second largest city in Thailand, is also part of the Chao Phraya Basin (see Table 1).

Table 1. Population distribution in the Chao Phraya Basin

City	Population
Bangkok Metropolitan Area	14,565,547
Chiang Mai Metropolitan Area	960,906
Nonthaburi	262,158
Nakhon Sawan	93,141
Phitsanulok	77,381
Lampang	58,915

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. Only 12% of domestic water supply in urban areas is from groundwater sources. Total domestic water requirements in 1993 were estimated at 3,194 mm<sup>3</sup>/year.

### 2.2 Major utilities in the basin

Across Thailand, potable water supplies are 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 Area, while the PWA is responsible for all the provinces of Thailand. The PWA is also responsible for water resource development, conveyance, pumping, treatment, and storage and distribution facilities of all urban and rural communities in the provinces. PWA has a total of 233 water utilities scattered throughout the country.

The MWA is a state enterprise under the Ministry of Interior and provides water supply to residences, businesses, and industries in Bangkok, Nonthaburi, and Samut Prakan. The Chao Phraya River and Mae Klong River are the main water abstraction sources. Despite the recent considerable expansion of the distribution system, the MWA is only able to supply 43% of the area and 66% of the population with piped water; the peri-urban areas of Bangkok are not fully serviced.

### 2.3 Water Safety Plan implementation status

In 2008, Environmental Cooperation-Asia (ECO-Asia) supported the PWA in attend a training on Water Safety Planning (WSP). From 2009 the PWA partnered with two peer operators under the Waterlink Network – Ranhill Utilities (Malaysia) and Korea Water Resources Corporation – which offered their experience in water quality monitoring and management operations to assist the PWA in developing and implementing the WSP approach in Nakorn Nayok and Khon Khaen. As a result of the partnerships, the Thai utility invested in water quality improvements to safeguard more than 100,000 residents in Khon Khaen against waterborne diseases. Moreover at least 100 staff members received training on the WSP approach.

Following its support in 2008-2010, ECO-Asia will assist PWA's plans to scale-up WSP development through targeted technical assistance.

The MWA started their WSP implementation in 2014.

## 2.4 Management of floods and droughts in urban areas

The Thai government controls floods and droughts through the construction of multi-purpose reservoirs, dikes (diversions) and other flood control infrastructures with the goal of storing water from peak rainfall events and use it during the dry season to mitigate drought risk. This containment strategy is no longer practical in Thailand, as well as in many other developed countries, since the best sites for flood control dams have already been exploited and the political tolerance for the environmental costs of such infrastructure is at its limit. The government needs to rethink its flood and drought management approach and start investing in alternative solutions, for example in natural infrastructure for sustainable water storage.

## 2.5 Interaction between Water Utilities and Basin Organisation

There is a great need for improved communication between various institutions, in particular with the sharing of data. The recent involvement of the PWA into the WSP approach is a promising starting point for a closer interaction between the utility and the local basin organisations and research institutes. The same applies to the MWA who started their WSP implementation in 2014.

## 2.6 Data and information availability

Basin data including data on surface water, groundwater, floods and droughts are primarily found with DWR, RID, TMD, Department of Groundwater Resources (DGR) and HAI. Data is available, even though access to information and identifying the best quality data is often challenging.

## 2.7 GEF past and present involvement in the basin

As a national basin, the Chao Phraya has not received dedicated project assistance from the Global Environment Facility (GEF), even though the Gulf of Thailand, where the Chao Phraya drains into, is linked to the South China Sea, which is the at the centre of various United Nations Environment Programme (UNEP), UNDP and World Bank (WB) interventions supported by the GEF.

## 2.8 Key contacts

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