4. Situation of Water Resources Demand and Allocation for Human Survival and Food Production of Thailand

Bancha KWANYUEN[1]

Introduction

Thailand is the center of communication and agricultural production for Southeast Asia. The government has a policy to develop a strong agricultural sector and food industry. There are many factors that influence the achievement of the goal and water resources is an important factor for the development of agro-industry. Surface water has been used as the main source for irrigation, water supply, industry, service, and other purposes. However, in the last two decades surface water exploitation in many regions has been developed to its full, and therefore groundwater is considered as an alternative source for domestic and industrial supply and irrigation. According to the latest government policy on water resources, the priority of water use is as follows: domestic water supply, agriculture and other sectors. In addition an analysis of total water demand and its allocation will give a great benefit in understanding the current situation of the country.

General Description and Climatic Conditions

Thailand is situated in the middle of Southeast Asia and has an area about 512,000 square kilometers. The agriculture area is more than 60 percent of the total area. The country falls within the tropical monsoon zone and is subject to the southwest monsoon during the period of May to October and tropical cyclonic storms from the South China Sea during the end of the rainy season between September and October. There are three seasons: summer from March to June, rainy season from July to October and cold season from November to February. The annual rainfall ranges from 900 to more than 2000 mm per year. The rainfall distribution is classified as bi-modal: the first peak occurs from June to July and the second from September to October. Irrigation is needed for both wet and dry seasons, such that supplementary irrigation is undertaken during dry spells in the wet season, and fall irrigation undertaken in the dry season. Due to the tropical latitude Thailand's temperature is uniform (28 °C) throughout the year with little seasonal variation. The average temperature in the hottest month (April) is 32 °C while the average temperature at the coldest month (December) is 25 °C. The total population of Thailand is approximately 62 million. The majority of the population is in the agriculture sector but the majority of country income is generated from the industrial sector.

River Basin and Water Availability

There are 25 major watersheds in Thailand as shown in Figure 1. However, eight watersheds in the north and central plain (number 6 to 13) may be considered as Greater Chao Phraya river basin, two watersheds in the east (number15 and 16) may be considered as Bangpakong river, and two watersheds in the northeast may be considered as Mun river. In addition all basins may be grouped according to the geographic location into 6 regions as north, northeast, central, west, east, and south and the discussion in the paper will be based on this information.

The annual water supply for Thailand is about 205,467 mcm which contributes from the mean annual rainfall of 1,421 mm. The southern region shows the highest annual specific yield

[1] Assistant Professor, Dept. of Irrigation Engineering, Faculty of Engineering, Kasetsart University, Thailand

about 30 liter/sec/km² due to the influence from the Andaman Sea and Gulf of Thailand; the eastern region shows a slightly high annual specific yield about 20 liter/sec/km²; and the other regions have a lower and similar yield ranging from 5 to 10 liter/sec/km². The water supply and demand of major watersheds may be summarized as Table 1. The southern region has abundant amount of water about 8,591 m³ per capita. The eastern, western, northern, and northeastern regions also have relatively large amount of water ranging from 2,200 to 6,200 m³ per capita. The most critical part of the country in term of water supply is the central plain since there is insufficient amount of water. According to the analysis by IWMI on relative water scarcity, Thailand has no water shortage and may require even less water by 2006 due to water conservation. The situation is better than most of neighboring countries such as Myanmar, Cambodia and Malaysia since they may need to increase the water withdrawal (IWMI, 1998). The available water per capita can be shown regionally as Table 2.

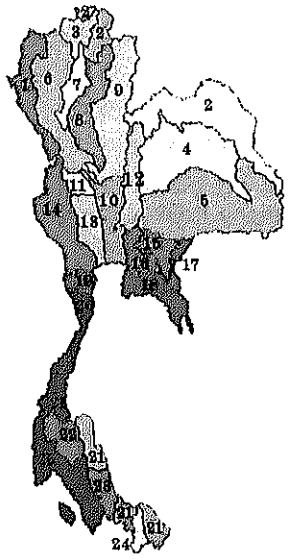

Figure 1 Major River Basins in Thailand

Another important source for water supply is groundwater and the amount of groundwater recharge is dependent on the holding capacity of

Table 1 Surface Water Availability and Demand for Major Watersheds in Thailand

Region	No.	Watershed	Area (Km²)	Annual Supply (mcm)	Annual Yield (l/s/km²)	Annual Demand (mcm)
North	1	Salawin	17,920	8,570	15.16	1,220
	3	Kok	7,895	5,275	21.19	5,884
	6	Ping	33,898	7,308	6.84	574
	7	Wang	10,791	1,483	4.36	4,590
	8	Yom	23,616	3,324	4.46	2,923
	9	Nan	34,330	9,158	8.46	2,503
Northeast	2	Mae Khong	57,422	19,362	10.69	657
	4	Chi	49,477	10,269	6.58	1,254
	5	Mun	69,700	17,146	7.80	3,649
Central	10	Chao Phraya	20,125	4,629	7.29	12,977
	11	Sakaekrang	5,192	1,297	7.92	750
	12	Pasak	16,292	2,820	5.49	1,262
	13	Thachin	13,682	1,900	4.40	960
West	14	Mae Klong	30,837	12,373	12.72	6,244
	19	Phetchaburi	5,600	1,826	10.34	854
	20	West Coast-Gulf	7,100	1,420	6.34	3,449
East	15	Prachinburi	9,821	5,268	17.01	402
	16	Bangpakong	8,679	3,712	13.56	1,092
	17	Tonle Sap	4,150	6,266	47.88	1,087
	18	East Coast-Gulf	13,830	11,115	25.48	1,482
South	21	Peninsula-East Coast	26,352	25,347	30.50	7,593
	22	Tapi	12,225	12,978	33.66	2,777
	23	Thalesap Songkhla	8,495	4,896	18.28	3,169
	24	Pattani	3,858	2,738	22.50	1,851
	25	Peninsula-West Coast	21,172	24,887	37.27	1,585
	Total		512,459	205,367	-	70,788

Table 2 Regional Available Water Per Capita of Thailand

Region	Population (%)	Water Supply (mcm)	Water Supply (%)	Available Water Per Capita (m^3/year)
North	18.8	35,118	17.1	3012
Northeast	34.2	46,777	22.8	2206
Central	21.8	10,646	5.2	787
East	6.8	26,361	7.6	6252
West	5.1	15,619	12.8	4940
South	13.3	70,846	34.5	8591
Total	100	205,367	100	-

porous mediums. The amount of recharge in Thailand can be classified into three levels: 10, 3 and 2 percent of average annual rainfall respectively. The total area with high recharge is estimated to be 40 percent, and the areas with moderate and low recharge rate are 35 and 25 percent, respectively. The central region is the area with the highest groundwater potential, the north and the south regions are the area with moderate groundwater potential and the east, west, and northeast regions are the area with the lowest groundwater potential. From the estimation, the total amount of recharge for the whole country is approximately 38,000 mcm per year or about 4.75 percent of the annual rainfall and equals to 18 percent of the total runoff of the country (KU, 2000).

Water Demand

The water usage can be classified as irrigation, domestic water supply, industry, hydropower, environment, and other objectives. Since hydropower is a non-consumptive use, the location of the dam is generally at the upstream area of the watershed and the hydropower release during water shortage (dry season) will normally agree with the other uses then the amount of water usage for hydropower will not reduce the availability of water to other uses and will not be analyzed in this study. In addition the total amount of water use for the other objectives such as fishery and navigation is relatively small in comparison to the total water demand and it will not be considered either. The distribution of annual water demand can be presented as Figure 2. About 78% of the water is used for irrigation but environmental control, domestic supply and

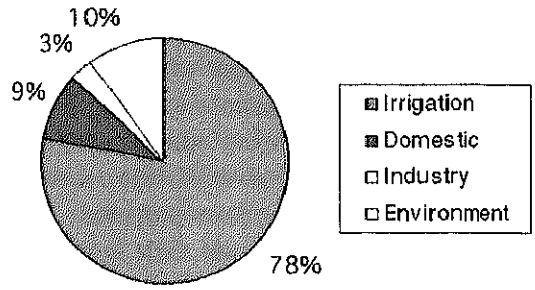

Figure 2 Percentage of Water Demand for Each Activity

industry consume only about 10%, 9% and 3%, respective. In this study, the low flow of the upstream watershed will not be evaluated since the release water can be used for the other objective downstream. Therefore environmental demand will consider only the release water for the control of saline water at the mouth of the river.

The average annual water demand for the country is about 1142 m^3 per capita. Although the amount of water supply for the country is about three times higher than the water demand but there is still water shortage through out the country because of insufficient water storage. The construction of new reservoir is difficult since dam has already been constructed at most of the suitable location. In addition the environmental issue is also a major constraint for the construction of any large storage reservoir. The water shortage has occurred in every region of the country especially northeastern, central and eastern. The reasons for water shortage are different regionally as follows. In the north, there is water shortage because of huge water release for greater Chao Phraya basin downstream, the recession of inflow at the upstream area, and the increase in

water requirement for the larger community and new small-scale irrigation project. In the northeast, water shortage is rather serious because there are limited suitable locations for the construction of large reservoir and groundwater quality is generally too salty for irrigation or domestic supply. In the central plain, water shortage occurs because of excessive water consumption for irrigation, domestic supply and industry. Therefore extra water is released from the reservoir at the upstream basin in the north. In addition groundwater is extensively used for both irrigation and water supply and some water is also transferred from the west (Mae Klong basin). In the east, a rapid development of industry under the eastern seaboard program increases the water demand for domestic supply and industry enormously such that many new storage reservoirs have been constructed for these purposes. In the south, rainfall is very high but there is still little water shortage due to lack of water storage for the dry season. Finally, the western is the only region that has sufficient amount of water and can be transferred to the neighboring basins.

Surface water is the main source of irrigation water but groundwater is an important source for domestic supply. Actually there is only one groundwater irrigation project for the whole country covering an area of 11400 hectares. Groundwater development for irrigation by government is less than one percent of total irrigation area but small wells developed by individual farmer for irrigation have greater number especially in the central plain. Groundwater is mainly used as a supplementary irrigation for the dry spell during the wet season and the primary source during water shortage in the dry season. Farmers rely heavily on the irrigation water from the canal but they will shift to pond, river, drain, and well if there is insufficient amount of water.

In addition the analysis of rainfall tendency shows that there is a decline in annual rainfall for many river basins in the central, eastern and northeastern regions of Thailand (Kwanyuen, 2000; Kwanyuen et al., 1998). The recession of runoff in many basins has also confirmed this event. This may further reduce water supply and increase water shortage therefore water use in the future should be more efficient in order to cope with the recession.

Irrigation Area And Irrigation Water Use

Since irrigation is the major water use for the country then its detail should also be discussed. The total agriculture area of the country is about 21 million hectares or about 41 percent of the country area. The total irrigation area is about 4.7 million hectares or about 22 percent of total agricultural area. The majority of irrigation area is in the central plain including the east and west regions as shown in Table 3. The central plain is also the most productive area in term of yield per unit area for most of the crops. Total irrigation area has been gradually increased from less than two million hectares in 1960 to the current level with two major irrigation projects: Greater Chao Phraya and Greater Mae Klong projects. For the north and northeast regions pumping scheme from the river is a favorable choice due to a large difference in elevation between headwork and irrigation area and the undulate or steep terrain of the area. At present, the increase rate of irrigation area is reduced due to water shortage and rare suitable site for large-scale irrigation project.

The irrigation efficiency in Thailand ranges from 15 to 67 percent with the average value of 40 percent depending on the project location, condition of the project, amount of water supply, growing season, and annual rainfall. Irrigation efficiency can be summarized regionally as shown in Figure 3.

The irrigation season has a great influence on irrigation efficiency such that efficiency of the wet season is lower than the dry season because of the error in the estimation of effective rainfall

Table 3 Current Irrigation Area in Thailand

	North	Northeast	Central	South	Total
Irrigation Area (10^6 ha)	1.24	0.78	2.17	0.50	4.70
Percentage (%)	26.3	17.0	46.1	10.6	100
Pumping Area (10^6 ha)	0.21	0.31	0.07	0.05	0.64

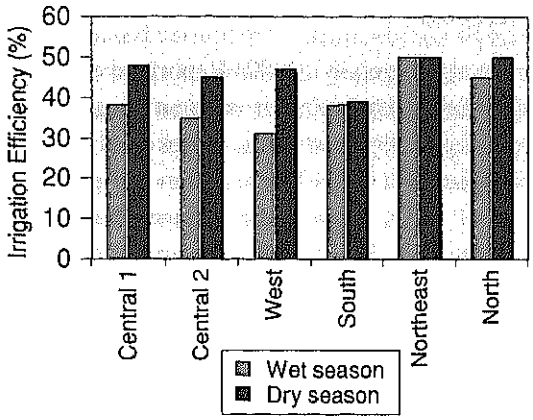

Figure 3 Irrigation Efficiency for Thailand

in the wet season. On the other hand the irrigation efficiency in the dry season depends on the available water for the dry season and the size of irrigated area. Varawoot (2002) has found that irrigation efficiency in the wet season has a linear relationship with the annual rainfall while the dry season irrigation efficiency is linearly related to the available water at the beginning of the dry season and the irrigated area. In order to reduce water use, irrigation efficient should be improved. Actually the government has a policy to improve irrigation efficiency such that irrigation water requirement in 2006 will be less than its requirement in 2003.

Productivity of Water

Thailand has a lot of food surplus and is a major exporter of many agricultural products such as rice, maize, cassava, sugar, palm, fruits, rubber, etc. However the crop yield for many crops are still relatively low e.g. rice, sugarcane, soybean, maize, cotton, and vegetable and they must be increased in order to compete in the world market. For irrigated crops, crop productivity is an important index to measure the effectiveness of the production system which may be considered as crop yield or crop return per unit of water. The crop productivity in term of crop yield and income per unit of water for the main irrigation crops are summarized in Table 4. Rice is the crop with the lowest productivity because paddy rice loses a lot of water through percolation and evaporation. Sugarcane has the highest productivity in term of yield per unit of water. However considering income per unit of water, vegetable gives the highest crop productivity. The most profitable crop per unit of land is orchard and its income is about 3 to 4 times higher than rice. In addition, vegetable may be grown 2 to 5 times per year depending on the age of each vegetable and it may give the highest income per unit of land per year. In practice, sugarcane is a popular crop since it is the only crop with strong organization and profit sharing system between factory and farmer. Although rice has the lowest productivity but it is still the most popular crop because of its potential for internal consumption and export. In addition rice also has an important role economically and socially.

Agro-Environmental Education

The government strategy on agro-environment education is implemented in three approaches. First is the people's participatory in large development project particularly water resources development in order to preserve the watershed for the benefit of the next generation. Second is the curriculum about land, water and environment in the primary, secondary and high school education for people understanding in earth resource, water resource and other natural resources. Third is the workshop and seminar for

Table 4 Productivity of Major Irrigated Crops in Thailand

Crop	Irrigation Water (m^3/ha)	Crop Yield (kg/ha)	Income (US$/ha)	Crop Productivity (kg/m^3)	Crop Productivity (US$/$m^3$)
Rice	14025	3750	469	0.312	0.0334
Vegetable	4937	7187	683	1.456	0.1383
Soybean	8125	1562	371	0.731	0.0457
Maize	7450	3750	375	2.198	0.0503
Sugarcane	15475	87500	1094	5.654	0.0707
Orchard	14281	6312	1578	0.442	0.1105

Remark: Irrigation water requirement is estimated based on the dry season or annual demand.

the youth and stakeholder on water resources and water pollution arranged by the river basin sub-committee and other related agencies. As the outcome, the new generation will be well aware of land, water and forest resources and be the partner in protecting their own resources.

Conclusion

Generally the annual specific yield of water for Thailand is relatively high due to high rainfall in every region of the country. The water availability per capita is also relatively high except the central plain due to high density of population. The surface water will be abundant only in the rainy season but the amount of flow may reduce greatly in the dry season. In this situation the alternatives are to construct water storage reservoir and to use groundwater as the second source of water.

The major water uses are irrigation, domestic water supply and industry, respectively. According to the government policy domestic supply must always get the highest priority follows by agriculture. Although the country has large amount of water supply but there is still water shortage through out the country due to insufficient water storage, recession of inflow and excessive growth of water demand. In addition the main source of water for irrigation and domestic water supply for the municipality is surface water but the main source of domestic water supply for the rural area is groundwater.

Rice is the crop with the lowest productivity in term of yield and income and vegetable is considered to be the most productive for water and land. Nevertheless rice is still the most popular crop since it has a high potential for both internal consumption and export.

In order to cope with the situation of higher risk of water shortage for agriculture, the water industry must improve water allocation and water management especially for irrigation. Irrigation efficiency must also be improved so that more crops can be produced with less amount of water. Finally agro-environmental education may promote better understanding of water resource system and may help in reduction of water use in all sectors.

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THAILAND: DISCUSSION

Question: What is the real target of agro-environmental education, farmer or government officers?

Answer: The main target is the water user or stakeholder from various groups such as farmer, industry, and other. This will also expand to include some officer of local administrative unit.

Question: What will be the gain expected by the education? Should some water in the rivers be released for ecology?

Answer: The major benefit from the agro-environmental education is the understanding and awareness of the water resource so they may help

to preserve them. Recently the ecology issue has been discussed seriously by the government especially the water requirement for ecology at the influence zone near the mouth of the river. There is insufficient information about it so research will be carried out for the ecology water requirement for each major river basin.

Question: Please give the structure of the river basin committee especially about water allocation and conflict resolution?

Answer: There are two levels of river basin committee: national river basin committee and river basin subcommittee for each river basin. The subcommittee comprises of government officer, water user for various groups (stakeholder) and the expert. The duty of subcommittee is to make decision about water management, allocation, development, and conservation within each river basin including conflict resolution among water user under the framework of national river basin committee.

Question: What is the operational policy on Mekhong River regarding irrigation and flood control for Thailand and downstream country?

Answer: There is very little control of flood protection on the Mekhong River since Thailand has a few number of storage reservoir in the region contributing to a few percent of watershed area in the country. Thailand has tried to develop irrigation in this region by construction of weir in the Mun and Chi rivers, which are the tributary of Mekhong River. The plan to pump the water from Mekhong is under consideration but it must be discussed within the Mekhong secretarial committee since it is an international river.