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Research Article

Water usage management, Thailand

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Abstract: Water use in Thailand is probable to increase rapidly due to economic and social changes, change in water usage activities, changes in government investment policies increase in the number of tourists, and climate change. The increase in water use results in water shortage which leads to insufficient water to meet the demand. Therefore, short-term and long-term water resource managements need the water demand information from the physical factors of the area. The water allocation in accordance with the needs of each water user is provided. Although the government agencies have already published water usage information via the website, the water usage data in form that truly reflects the water image and quantitative use at all levels are not fully presented nor up to date. This study presents the previous water shortage problem, assessment of water demand for primary activities, information related to government water use assessment and, proposes guidelines for water use assessment that are consistent with the changing context of Thailand. The assessment of water demand should be adjusted in accordance with the rapidly changing situation and show the concentration of spatial water usage activities at all levels for a comprehensive assessment and the slightest mistake.

Keywords: Water demand, Water shortage, Water usage, Water conservation, Thailand.

1. Introduction

At present, Thailand has classified public water use according to the Water Act of 2018 as follows: (1) public water use resources for livelihood, household consumption, agriculture or raising animals for subsistence, household industry, maintaining ecosystems, customs relief, transportation and other small water usage activities. (2) public water use resources for industry, tourism industry, electric power production, water supply and other businesses, and (3) public water use resources for large businesses that use large amounts of water or may cause cross-basin impacts or extensive coverage (Water Resources Act., 2018). The water use of each type vary according to the physical characteristics of the area. For example, an area with a large population will have a lot of water consumption, in such areas, the number of people who use water in the actual area must consider the number of latent populations in that area. The industrial water demand can be estimated by the horsepower and capacity (Koonthanakulwong, 2005). The water demand for agriculture depends on the weather, plant type, cultivation calendar and plantations. As mentioned above, the current water demand is directly influenced by population migration, land use change, economic and social growth (Water situation in EGAT, 2015). Therefore, calculations for estimating water usage are needed to consider the influence and impact in all aspects.

The term "water use" refers to the amount of water generated from the actual water use of each activity, such as water consumption or water use for the industrial in the area are estimated from amount of water that sold to the particular water user. However, numbers of the water demand and water consumption differ, which more or less depend on the nature of the area, whether it is a city or rural area (Koonthanakulwong, 2005). The data limitation in the water storage consumption or information on water usage for industrial purposes do not cover water use from the concession tap water. There is still lack of an actual water usage, the tap water from local administrative organizations, water information for agriculture and, even in irrigated areas. Currently the method of storing farmland data used is calculated when the weather data is calculated and then converted to water. Additional information for understanding the actual amount of water usage is water accounting, which is the principle of analysis between amount of water cost and water demand. Consequently, the results of the amount of water consumption is close to the actual state.

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Thailand water demand management must use information that is consistent and related to the amount of water the government agencies provide in order to sufficiently meet the needs of all sectors. However, the technology and information that many agencies support and use and can be discussed further.

2. Purpose

The research objective is to assess water use in the main activity of water shortage problems in the past. The water use is assessed by the public sector as well as suggesting guidelines for assessing water use, which is consistent with the context of change for Thailand.

3. Thailand water use crisis

In the past, Thailand has experienced a water shortage for cultivation (Figure 1), causing many economic crops to be damaged. Farmers have no agricultural products to pass to the factories, thus some factories have ceased production and some have closed stagnating the economy of Thailand. Thailand's water crisis is a conflict between industrial and agricultural users and water shortage problems (Off-season is reducing impacts on the public money of 50 billion baht., 5], as in the cases of drought events in 2005 and 2015.

The reservoir of Ubolratana and Lam Ta Khong Dams had fallen below the dead storage because of drought which caused the municipality a failure to produce tap water for the people. The city economies are heavily damaged by drought. Water shortage problems result in lack of water in irrigated areas because the amount of water or allocation cost for irrigation in the dry season is not enough for agriculture in irrigated and rainwater areas (Drought events record, 2015 ; Drought 2005 and government operations) . Therefore, Thai's government announced the farmers will not do off-season farming [4]. Another group of farmers who have been affected by drought are fisheries and some industrial plants which require raw water for production or in the production process. Water shortage for a long time causes many factories to suspend or stop their businesses which results in the damage of future national economy causing suspend or stop the business of many factories, which resulting in the lack of continuity of production and national economic are damaged future. In addition, the tourism sector is very sensitive to water shortages.

Figure 1 Example of drought events (Drought events, 2018) ; Drought events, 2019)

4. Theory

Most researchers use the consistency of sufficient water supply to meet the water demand, as equation (1), in water balance considerations.

Water supply = Water demand (1)

In the case under consideration, the amount of water supplied is not equal to the amount of water used, an analysis should be done to balance the water evenly. The water account consideration must consider the amount of water, the cost or the amount of water supplied in the system, the amount of water allocated to the stream and the water demand. The amount of water is calculated from human water use activities and the amount of water for ecological preservation.

Agriculture water demand is related to agricultural areas, which is economic data on cultivated areas in irrigated areas of Thailand such as rice, second crop of rice, sugarcane. The irrigation projects in each province, region cultivation calendar, climate data such as rainfall in each province and the rate of transpiration of plants and water use coefficient of reference plants are considered for water demand.

Researchers determine the amount of water to maintain the ecosystem from the results of ecological and environmental analysis. The ecosystem system balance is determined by the downstream water usage such as some processes that use water to expel salty water or waste water, water level maintenance for navigation and the water demand for consumption or industry. Therefore, the minimum amount of downstream water needed to maintain the watershed ecosystem is different. Calculation of the amount of water needed to maintain the ecosystem is considered the amount of water from the flow duration curve of the monthly runoff. The runoff demand needed to maintain the ecosystem depends on different watershed areas, that will consider the monthly runoff at 10% of the lowest runoff ever occurred in the past (Ximing, 2003).
Although many Thai agencies involved in the water management collected and analyzed water usage and water demand, some practitioners still have the confusing idea that both data and numbers are the same (Blokker, 2010). In fact, water requirement numbers are just numbers that are based on basic data in the area. The number of water use is actually water used by users. Additionally, there is the view of using water through the allocation and production processes such as water use to generate electricity or water use to produce tap water. Water used to generate electricity may be considered water lost and remains in the water source system. Therefore, this water is not taken into account in the water balance of the basin. The water budget information is used to analyze the amount of water lost from the system in the water budget equation.

Thailand researchers have a concept of assessing the water demand in form of physical water demand and economical water demand (Koonthanakulwong, 2005), which has a different assessment methods. The physical

water demand parameters depend on the physical characteristics of the area, such as the urban and rural population, number of horsepower or capacity of various industries, number of pets for consumption, number of tourists, number of entrepreneurs, number of students and teachers and, number of hospital beds etc. Normally researchers use the amount of variables to multiply with the water consumption rate of each water use type and number of days of water use in each type that is the number of work days of the factory (about 210 days) or the number of working days of the school (about 200 days). The economical water demand depends on the physical quantity that is the input variables with the dimensions of economic numbers. The example of the variables are GDP and marginal price products, which are adjusted with the elasticity. However, the amount of water that can be estimated with the economics yield through the non-linear or stochastic equations are used to predict the water demand (Drought events record , 2015).

5. Organizations and technology to manage water demand

Thailand faced a water shortage crisis in 2005. The government reused a water diversion to the sea project (Drought 2005 and government operations). The eastern seaboard watershed is located on a rocky layer which provides water with low to medium potential. In addition, the water quality in the area is brackish to salty, which causes the water to not be utilized. Therefore the project is not as successful as it should be. In addition, the government has mobilized the tool to drill groundwater in more than 100 wells in the eastern region, which still appear in the area near many factories. They are hoping it will be reused again one day if the drought reoccurs (Summary of the drought situation during the year, 2005). The industrial sector are surveying, finding and digging their own water sources and solving the water shortage problem, not only waiting for the allocation of government water. In addition, some industrial factories have purchased land that has been excavated for sale or abandoned earthen ponds to use the area as a reserve for their own water. The water shortage crisis can raise awareness in the government, water management and private sectors in the provision of their own water resources.

Obstacles and problems of the past water usage data sources have restrictions on publishing at the individual level, thus agencies cannot publish information. Agencies were concerned with water consumption at the operational level, they tried to survey household water usage data, industrial and agricultural plants in order to obtain information, analyze and apply the results to benefit. An example is a survey data of water usage for developing the database of the National Statistical Office (Ximing, 2003), which is still in operation. Goal of the water use database is an important tool for further planning of water resources management in Thailand. However, the water use database development surveying is a process that uses a relatively high budget and rapid economic and social growth are causing many weaknesses. However, the current survey work does not cover the number of latent populations, water efficiency and factory production. The evaluating survey data may be used for 2-3 years only because of the information that is a static or slow data change. In reality population data, land use, including economic and social growth can be called dynamic data. Therefore, exploring the use of water is also a challenge and we need to brainstorm to obtain accurate and current information.

The water usage information is published on website by government agencies. This depends on the roles, duties and responsibilities of each department, such as the National Water Resources Agency, MWA Provincial Waterworks Authority, Royal Irrigation Department and Department of Industrial Works. They have published water usage data in the overview of the service unit, but it did not clearly separate water use activities for example the Royal Irrigation Department has published water for agriculture information in the form of plantations in each week. Some researchers analyze the industrial water usage data by calculating the number of horsepower or capacity of each type of industrial plant multiplied by the water consumption rate of each industry type. The information of industrial factories has been published on the website by the Department of Industrial Works.

Water demand management for Thailand has agencies to support information. The information of each agency is derived from the application of various technologies as follows:

5.1 Office of the National Water Resource (ONWR)

ONWR formerly known as the National Water Resources Management Office is in direct control to the Prime Minister under the Prime Minister's Office. The office was established by the directive of the leader of the National Peacekeeping Council Acting to integrate information Project Planning Department, Budget Management Department and the Department of Water Resources Monitoring and Evaluation, which is the benefit of setting up a water resource management policy for the whole system of Thailand with the Secretary of the National Water Resources Office as the highest commander.

The National Water Resources Office has the following roles: (1) establish water usage plans for water supply agencies and allocate water by setting the water allocation target according to the amount of water cost, so that the water users can receive water equally (2) follow up the results of the water allocation of the relevant agencies which can be carried out by allowing the relevant authorities to report the number of water usage according to activities to the national water data warehouse (3) update the information at all times by linking water usage data from water allocators such as the Royal Irrigation Department, Provincial Waterworks Authority and Metropolitan Waterworks Authority (4) surveying water use at the local level. The Department of Water Resources has collected data on water usage which is information on waterworks, concessions or municipal waterworks local tap and village waterworks such information represents the location, number of households using the service and

production capacity. Personal water consumption numbers according to various activities is not clear enough to support and disseminate information (5) prepare water accounts that reflect the amount of water, water allocation costs and water usage. Water accounting data will make the relevant departments aware of water allocation efficiency. The amount of water loss that occurred for the relevant agencies to bring the evaluation results to improve the production process and allocate water to be more efficient and (6) establish the standards for water consumption rates of various industries.

5.2 Metropolitan Waterworks Authority (MWA)

MWA achieve the survey by providing raw water sources and providing raw water for use in water supply, production, delivery and distribution of tap water in the local area Bangkok, Nonthaburi and Samut Prakan Province. MWA controls standards regarding private water supply systems and conducts other businesses that are related or beneficial to the water supply taking into account the interests of the state and the people. MWA provides information on the amount of water produced, amount of water sold and the number of users of water fiscal year on their website https://www.mwa.co.th (figure 2).

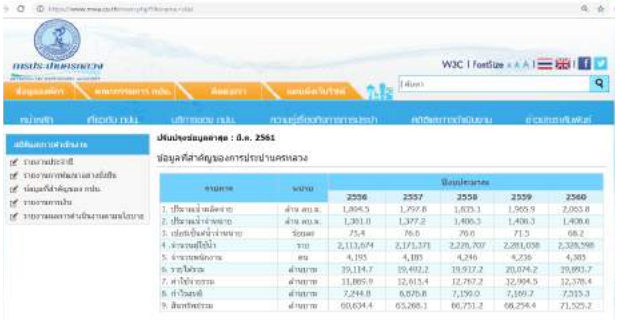

Figure 2 Water consumption data report of the Metropolitan Waterworks Authority (Water consumption data report of the Metropolitan Waterworks Authority)

5.3 Provincial Waterworks Authority (PWA)

PWA has the obligation to produce, deliver and sell tap water throughout the country including other businesses related to or continuing with the plumbing business. The benefit in utility of PWA is providing services by taking into account the benefits of the state and the public health of the people. Waterworks affiliated throughout the country except in Bangkok, Nonthaburi and Samut Prakan. PWA has information service via the website https://www.pwa.co.th (Figure 3). PWA supports information, types of water users and eservices. The eservices consists of water user requirement system, water monitoring system PWA1662, PWA Wallet, PWA Payment and complaint notification system, which is an application to facilitate the water users of the PWA (Figure 4).

Figure 3 Classification of water users of the Provincial Waterworks Authority (Classification of water users of the Provincial Waterworks Authority)

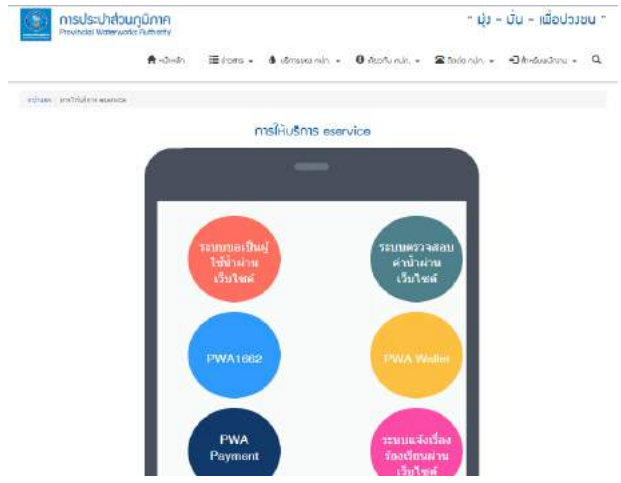

Figure 4 Service of eservice of the Provincial Waterworks Authority [15]

5.4 Royal Irrigation Department (RID)

RID is an agency that Uses Irrigation Water (UIW) (Figure 5). UIW performs the following responsibilities (1) It is a planning center for education, experimenting, researching, testing, demonstrating and analyzing information to obtain appropriate data for irrigation at the farm level, which includes water delivery methods (2) study, research, determine and control water quality that affects plants correctly in accordance with water standards for agriculture (3) study guidelines for development and improvement in order to increase water delivery efficiency in irrigation systems, study and analysis of water usage data in irrigated areas to develop and improve the use of irrigation water correctly and (4) cooperate with relevant agencies in the cultivation of crops, fisheries and raising animals to be suitable for the quality and quantity of irrigation water and academic use of irrigation water. UIA consists of the statistical department of irrigation water use, Department of Irrigation Water Distribution and an experiment station for irrigation water use through the website: http://wate RID is an agency that Uses Irrigation Water (UIW) (Figure 5). UIW performs the following responsibilities (1) It is a planning center for education, experimenting, researching, testing, demonstrating and analyzing information to obtain appropriate data for irrigation at the farm level, which includes water delivery methods (2) study, research, determine and control water

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Figure 5 The website of the Irrigation Department (The website of the Irrigation Department)

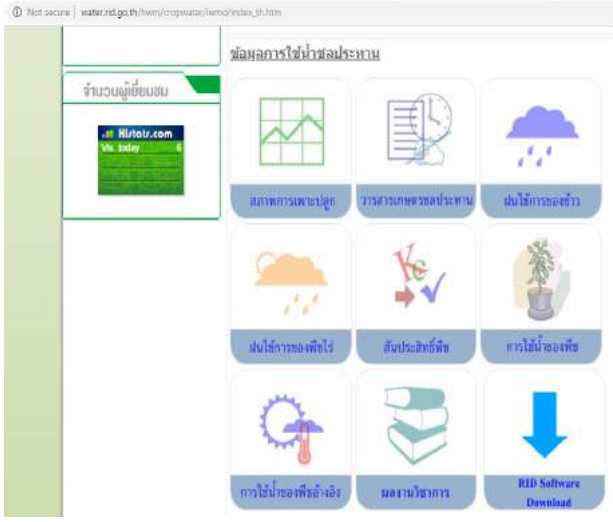

Figure 6 Irrigation water usage data (Irrigation water usage data)

5.5 Department of Livestock (DL)

DL, a central government agency, is an information and communication technology center. It has the following powers and duties (1) establish an information and communication technology master plan (2) covey the management of information and communication technology (3) study and develop information systems and networks to providing advice, training, and information technology transfer (4) study statistical analysis and establish a report on livestock (5) act as a center for providing news and information on livestock and (6) working or supporting the operations of other related or assigned agencies. Information and communication technology center, Department of Livestock Service and Support Report and weekly livestock data statistics as shown in Figure 7.

Figure 7 Weekly performance summary report by Department of Livestock Development (Weekly performance summary report by Department of Livestock Development)

5.6 Office of Agricultural Economics (OAE)

OAE has the responsibility to (1) propose and create the policy strategy, development plan, agricultural measures, creating attitude and participating in trade negotiations, agricultural products and cooperation in the international agricultural economy (2) study and analyze research on agricultural economics, prepare reports on the situation of agricultural economies, both domestic and international.

OAE supports and disseminates information with information on agricultural product production as shown in the Figure 8. Agricultural product prices weekly production and marketing situation price and productivity index import and export agricultural economy production factors, land use, economic conditions, society, household and agricultural labor cost calculation and spatial data shown in the website http://www.oae.go.th/

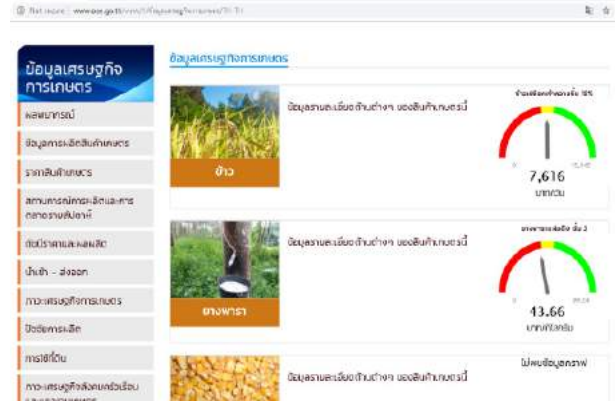

Figure 8 Agricultural economic data by the Office of Agricultural Economics (Agricultural economic data by the Office of Agricultural Economics.)

5.7 Department of Industrial Works (DIW)

DIW manages the industrial business supervision including hazardous materials production, environment and safety. DIW management is in accordance with international laws and agreements. They promote information and knowledge on machinery, production, environment, safety, hazardous materials, energy and responsibility social for the benefit of industrial business development. DIW supports and disseminates information on factory, factory type accounts, factory information, list of factories that are licensed for monthly business operations, list of factories, list of factories for sale, monthly registration and, summary of factories for license operation. Industrial area and knowledge warehouse including factory statistics (Figure 9).

Figure 9 Factory information by the Department of Industrial Works [20]

5.8 Ministry of Tourism & Sports (MT&S)

MT&S duties are as follows (1) develop policies and strategies for the development of tourism and sports that are relative with the development guidelines of the country (2) set guidelines for allocating resources to support the operations of all sectors effectively and implement policies and strategies into effective practice (3) develop the necessary factors for tourism and sports in personnel basic structure and supporting factors (4) develop technology and information technology systems for administration and services as well as the knowledge and innovation that can increase the economic value of the tourism and sports industry and (5) create collaboration between agencies in the tourism and sports industry in an integrated manner with all relevant sectors. MT&S publish tourism statistics as shown in Figure 10.

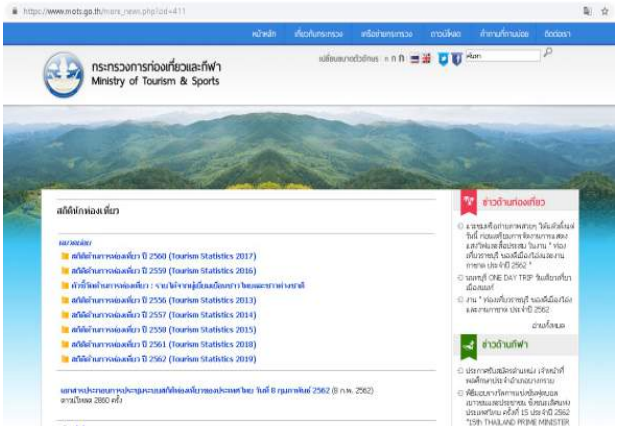

Figure 10 Tourism statistics by the Ministry of Tourism and Sports [21]

7. Conclusion and suggestions

Water scarcity is a problem that requires water resource management planning in accordance with the amount of water cost and climate forecast technology and the water consumption forecast for all sectors. The results from the predictions can be used as information for drought warning in advance. Moreover, the government agencies, the private sector and the general public can set up measures to accommodate drought that may occur in a timely manner. In addition, the database of potential water resources of both surface water and groundwater sources are another component, which should be carried out simultaneously. Determining the reserve water source for use in times of crisis should a proactive work instead of solving the problem of water shortage at the end of the crisis. Water demand management should be used for serious water use control measures, for example determining the target area for cultivation in accordance with the amount of water cost and the demand for agricultural products of the market. This will also promote an efficiency in the use, reuse and circulation of water in industrial plants.

Technologies are needed to cope with the rising water demand, this could be a mobile application that can demonstrate the concentration of water use activities in spatial areas at the municipal or district level that can be used in the water management planning and monitoring of water shortage problems. An additional approach should create a water use estimation system based on the physical characteristics of the area to fill in the missing parts including the preparation of a water budget accounting system which should be linked to the information of agencies that allocate water use such as the Metropolitan Waterworks Authority, Provincial Waterworks Authority and Royal Irrigation Department. In addition, the measurement of agriculture water use data should develop a tool to measure the amount of water that is drawn into a field or farmland, which will assess the use of agricultural water more accurately.

The method of assessing water demand for various activities should be as closely adjusted in accordance with the current water situation for example the water consumption demand should consider the latent population

living in that area. A latent population is another variable that may cause the water consumption per capita to be higher than the anticipated demand. Industrial purposes water demand should be considered as the actual production capacity. The number of working days of the factory efficiency and the ability to save water using these factors will affect the evaluation of water use for the industry. Water demand management for agricultural water can be assessed from current weather data. An assessment with survey of plantations with satellite image technology and survey of the registration of cultivation of farmers should be considered. The variables will make the planning of water allocation efficient, reduce water loss and estimate the amount of water allocated. Finally, the businesses and services that have been overlooked or rarely used for water use planning can feature in the government's water management plan. This water requirement is called use of daytime water or the use of water by operators. The use of water to do business, hospital water use or the use of water in educational institutions are important and a necessary part, which should be included in the calculation of current and future water usage planning.

8. Acknowledgement

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