Gross Domestic Product and Economic Value of Water Resources of River Basins in Thailand

Pavisorn Chuenchum Pongsak Suttinon*
Chulalongkorn University, Pathumwan, Bangkok, 10330, Thailand
*Corresponding author Email: pongsak.su@chula.ac.th
(Received: July 21, 2018, 2018; Accepted: December 15, 2020)

ABSTRACT

Water resources are mainly natural resources for the economic development of each country in the world. In recent, the climate change has affected water resources in the productive process of every economic sector. It is imperative to have a consideration for water allocation in economic efficiency. This study aims to calculate the gross domestic product (GDP) and water demand in each sub-district (tambon) and assess the economic value of water (GDP/cu.m.) of 25 basins in Thailand. GDP and water demand were considered from the main economic sectors of Thailand such as agriculture, manufacturing, and service. They were estimated using the available secondary database from government's agencies. The results showed the GDP of basins, which found that the Chao Phraya River Basin is the maximum GDP, but it consumed only the moderate water. In addition, the economic value of water in the manufacturing sector is the highest values in generating the GDP. This study can recommend the policymakers for the design of economic and environmental policies in driving Thailand's economy.

Keyword: Gross Domestic Product (GDP), water demands, economic value of water resources and river basin of Thailand.

1. Introduction

Natural resources are the primary resources for inputs in the productive processes, especially the water resources. Economic development after the industrial revolution has resulted in heavy consumption of water resources. Thailand as a developing country relies greatly on its.

For instance, rice cultivation area in Thailand was 62 million rai (rai = 1600 sq. m.) in 2015 and its water demand was approximately 1,200 cu.m./rai [1], so rice production of Thailand consumed the amount of water around 75 billion cu.m., annually [2]. However, in the drought year,

• บทความนี้ได้ถูกนำเสนอบางส่วนในการประชุมวิชาการวิศวกรรมโยธาแห่งชาติ ครั้งที่ 23

water storage in the dams is inadequate to allocate for agriculture and caused water deficits in many irrigation projects. In the same way, the manufacturing and service sectors may be dehydrated occasionally. The GDP was effected from this incident, which can be explained by Fig. 1. It shows the relationship between the annual rainfall and the GDPs. If there is one year, the annual rainfall is less than average annual rainfall. The GDP of the three sectors were decreased or settled.

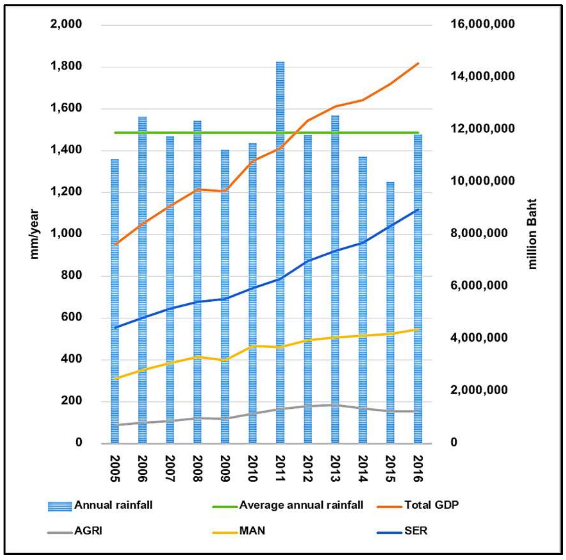


Fig. 1 The relationship between the annual rainfall and the GDPs

Therefore, the water resources is very important in driving the economy of Thailand. This is evident from the fact that the government established the Office of the National Water Resources when October 2016 [3]. It is responsible for integrated water management in all dimensions, especially socio-economic. The Information of GDP in regional and basin levels is essential for planning and national policy formulation in the future.

The purposes of this study are to build the databases and link the water resources to the economy in area-based information. Furthermore, this study estimates the economic value of water in 25 basins. These results can help provide information for policymaker in water resources management and allocation to achieve effective management and respond to the economic growth of Thailand.

2. Methodology

2.1. Study Area

This study focuses on the 25 basins in Thailand, where depending on the geographical characteristics. Thailand can be divided into four main geographical regions: The North, the Central Plains, the Northeast and the South [4]. The north region is covered by the most mountains, which serves as the origin of four major river basins, where include Ping, Wang, Yom, and Nan rivers. They converge to become the Chao Phraya river basin, the economic hub of this country. It is located in the central plains and it is the biggest agricultural area of Thailand.

The south region has the long mountains and the steep slope in many areas. It has the Tapi river and Andaman sea, where is a tourist attraction of this region. The northeast region is the most plateau and it has mainly three rivers, include Mae Klong, Chi, and Mun rivers, for farming and cultivation. This area is famous for jasmine rice, but it is also the poorest region in Thailand.

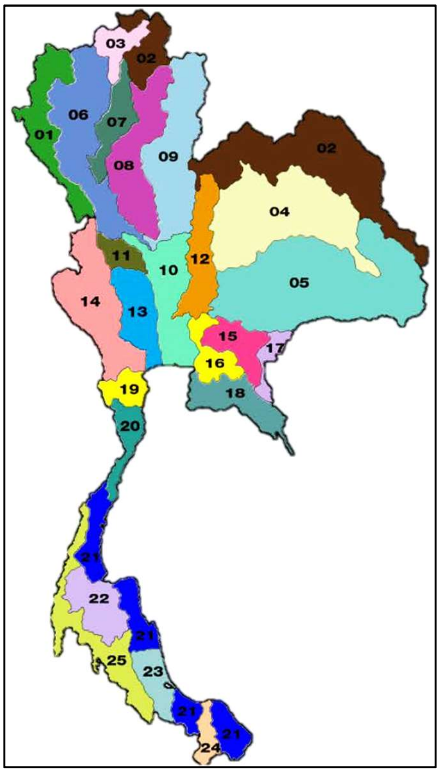


Fig. 2 The 25 river basins of Thailand [5]

Based on the geographical region, Thailand can be divided into 25 basins. It is shown in the Fig. 2 and the watershed area and annual runoff can be shown in the TABLE I. The average of annual rainfall and runoff are approximately 1,572.5 mm and 214,128 MCM [5]. The GDP of Thailand year 2010 is approximately 10,802,396 million Baht, which contributes from the agriculture, manufacturing and service sectors. Three economic sectors are about are 1,137,577, 3,725,272 and 5,939,547 million Baht [6], respectively. The maximum GDP of regions is the central region, the south, the northeast, and the north, respectively.

2.2. Methodological Framework

The methodological framework of this study consists of four parts. Firstly, we calculated the GDPs and water demand for the main economic sectors in the sub-district (Tambon) level (agriculture, manufacturing, and service). Each economic sector has a different way of calculation. The details are discussed in the next section. The products are prepared as a Geographical Information System (GIS) format. Second, the techniques of spatial analysis were

TABLE I

Watershed areas and annual runoff of the major river basins in Thailand [4].

Basin No.	River Basin Name	Watershed area (sq.km.)	Annual run off (MCM)
1	Part of Salawin	17,920.19	8,156
2	Part of Mekong	57,422.07	15,800
3	Kok	7,895.38	5,119
4	Chi	49,476.58	8,035
5	Mun	69,700.44	21,767
6	Ping	33,891.71	6,686
7	Wang	10,790.74	1,429
8	Yom	23,615.59	1,430
9	Nan	34,330.16	9,518
10	Lower Chao Phraya	20,125.25	4,925
11	Sakae Krang	5,191.43	519
12	Pasak	16,292.24	2,708
13	Tha Chin	13,681.24	2,815
14	Mae Klong	30,863.76	12,943
15	Prachinburi	10,481.32	4,502
16	Bang Pakong	7,978.15	4,900
17	Part of Tonle Sap	4,149.97	1,193
18	East Coast Gulf	13,829.72	25,960
19	Phetchaburi	5,602.91	1,140
20	West Coast-Gulf	6,745.33	1,013
21	Peninsular-East Coast	26,352.78	35,624
22	Tapi	12,224.53	17,380
23	Thale Sap Songkhla	8,494.97	7,301
24	Pattani	3,857.82	3,024
25	Peninsular-West Coast	21,172.25	9,918
Total		512,065.81	214,128

used to overlay GIS data by using ArcGIS. These results can be shown the GDPs and water demand in sub-district and basin level. Next, we estimated the economic value of water of 25 basins in unit: Baht/cubic meter and compared these values between basins for policy guidelines. The methodological framework can be shown in the Fig. 3.

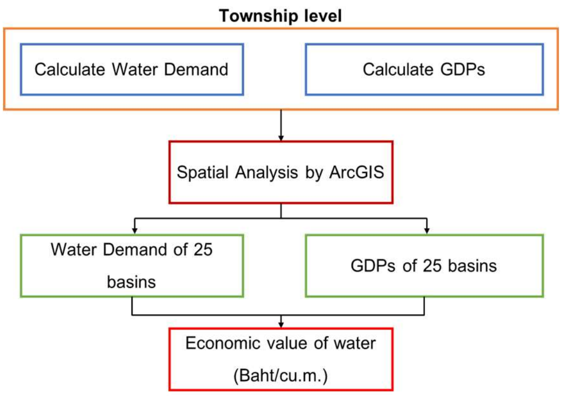


Fig. 3 The methodological framework

2.3. The GDP Calculation

The GDP is very important for the evaluation of economic status and the overall economic direction of the country. It is a monetary measure of the market value of all final goods and services produced in a period (quarterly or yearly) of time. This section is introduced the GDP calculation in each economic sector, namely the agriculture, manufacturing, and service. Based on the GDP data in 2010 from the Office of National Economic and Social Development Board (NESDB) was considered in this study.

2.3.1. The GDP of the Agricultural sector

Thailand has many cultivated crops. Thus, we consider especially five economic crops, namely rice (rainy season rice and dry season rice), sugarcane, cassava, maize, and para-rubber, because they are approximately 60 percent of GDP agriculture.

According to Chuenchum et al. [7], the calculation of GDP agriculture is considered from land use data in 2009-2011, which obtained from the Land Development Department (LDD). The information of yields and the price of products for each crop type are obtained from the Office of Agricultural Economics (OAE) and the Department of Internal Trade (DIT), respectively. The crop area, which is divided by each sub-district, is multiplied with the yield of crop and the price of each product. Results of the calculation are the selling price of each crop, which is the sum of cost and profit, but GDP is a profit only. We must calculate the costs from the Input-Output Table or the description of the economic structure of Thailand [8]. Hence, the selling price is deducted by the cost of each crop. Summation of the profit from every crop type is the GDP of the agricultural sector.

2.3.2. The GDP of the Manufacturing sector

The calculation of GDP manufacturing is estimated from an economic model in the field of macroeconomics and forecast production, which is called “Cobb-Douglas Production Function”. It can be shown in Equation (1). This equation is based on the relationship between productive inputs and the number of outputs.

$$Q = aK^{b}L^{C} \tag{1}$$

where *Q* is the GDP of manufacturing (Baht). *K* and *L* are the capital and labor inputs, respectively and constants *a*, *b*, and *c* are the total factor productivity, the output elasticity of capital and of labor respectively [7]. The constants *a*, *b*, and *c* are estimated by multiple linear regression of manufacturing data in provinces [9]. The GDP of the manufacturing sector is calculated from the number of industries, capital, and labor in the sub-districts and basins. The manufacturing data are obtained from the Department of Industrial Works (DIW) and the National Statistics Office (NSO).

2.3.3. The GDP of the Service sector

The GDP of the service sector is difficult in the calculation because many sectors cannot collect the details of the information. Thus, we assume that the density of the population represents the representation of GDP because the service sector includes the infrastructures (electricity, water supply, and gas), education and tourism etc. Therefore, the GDP of service is estimated based on Gross Province Product (GPP) from 77 provinces. The GPP is further distributed to sub-district level by weighting ratio of a number of population of the sub-district level to the number of population of provincial level. Then, the GIS is used for coverage to determine the river basin GDP.

2.4. Water Demand

The calculation of water demand in this study is considered from the secondary data of the government agencies, which are based on 2010. Water demand of three economic sectors is focused in this section.

2.4.1. Water demand of agricultural sector

In this section, we used the average water demand of the crops, which is based on the lysimeter test in the experiment from the Royal Irrigation Department (RID) [1]. Each province is different values because of the difference in temperature, rainfall, and humidity.

2.4.2. Water demand of manufacturing sector

The calculation of water demand for manufacturing can be calculated by using horsepower from industries in the sub-districts. The horsepower (*H*) is multiplied with a coefficient of water demand for each type of manufacturing plant [10] as shown in Equation (2).

$$WD\ Man. = H \times (Coeff. \times Correction\ factor) \quad (2)$$

The coefficient of water demand based on types of industries is based on the data in 2005. Thus, we must be adjusted to reflect water demand in 2010. The correction factor is used in the adjustment and is calculated from the total water demand of manufacturing in 2010 per total water demand of manufacturing in 2005, which is found to be 0.31. The correction factor is multiplied with water demand in 2005 of each manufacturing sector for adjustment data. The result will be the water demand in 2010 in each manufacturing sector.

2.4.3. Water demand of service sector

The calculation of water demand on service is complicated. A service sector consists of various sectors. Water demand of service sector can be categorized into two groups, namely household and service, and tourism as shown in Equation (3).

$$WD\ Ser. = Household + Service\ \&\ Tourism \quad (3)$$

Water demand of household can be calculated from household water usage (Lpcd, liters per capita per day) multiplied with a population in each sub-district. The population data are obtained from the Department of Provincial Administration, and the Lpcd is based on Suttinon et al. [11]. Similarly, water demand of the service and tourism is considered from the secondary data, which can be obtained from the National Statistics Office (NSO) of Thailand.

2.5. Economic Value of Water of 25 Basins

The definition of the economic value of water is one cubic meter of water can be generated how many monetary values (Baht/cubic meter). It is very important in water allocation for the best economic worthiness. The economic value of water can be estimated by the GDP basin per water demand. It is shown easily in Equation (4).

$$Economic\ value\ of\ water = \frac{GDP}{Water\ demand} \quad (4)$$

where the economic value of water is the value of water in generating monetary values, the GDP basin is the total of GDP in each sub-district, where is covered by basin boundary and water demand is the water used of the whole basin or each economic sector. Especially, water demand of service sector is divided as two kinds, namely the 60 percent (No generate GDP) and 40 percent (generate GDP) because water demand of service sector is combined between water consumption of people and water consumption of tourism, education and service businesses etc. Water consumption of people is water usage in the daily life of each person, which do not generate GDP, such as shower and cleaning. Conversely, water consumption of tourism, education and service businesses is water usage in service activities, which generates GDP. Thailand does not have the proportion of water usage in the service sector for generating GDP. The proportion (60/40) is based on Suttinon et al. [11], which is the assumption of water usage in the service sector of Japan.

3. Results and Discussion

This section can be divided into two parts, including the results from the GDP calculation and water demand and the results of the economic value of water.

3.1. The GDP Calculation and Water Demand

The GDP and the water demand results in sub-district and basin levels are shown in the Fig. 4, 5, 6 and 7, and the details of the GDP and water demand are shown in the Fig. 8.

The primary GDP of agriculture is rice and para rubber, which represents approximately 28 and 27 percent of this sector, respectively [8]. Rice cultivation can be divided into two times in a year, namely the in-season and off-season rice. The majority area of rice is the north, central, west and east regions. In the same way, the most area of the south region is the para rubber. The GDP of agriculture in sub-district and basin levels presents the dark green color, which is high GDP, in the north, west, central, east and south region. The main water resources are consumed from the Ping, Nan, Sakae Krang, Mae Klong, East coast gulf, Peninsula-East coast and Tapi river basins for generating the GDP.

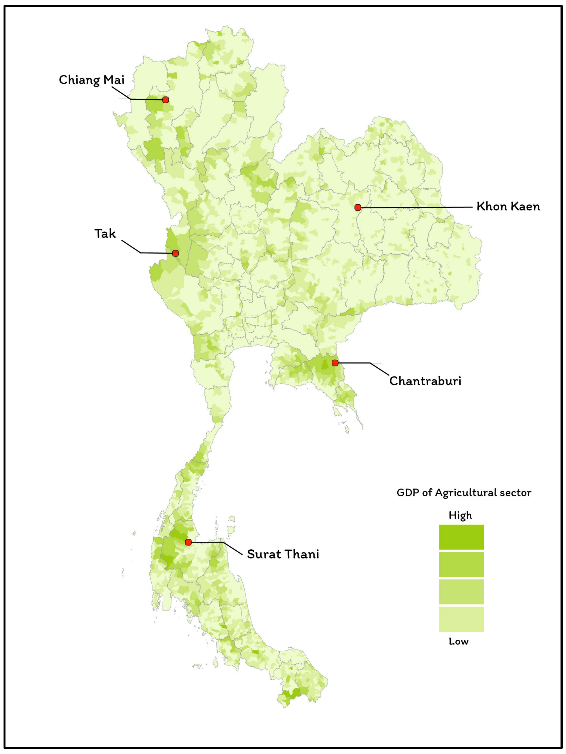


Fig. 4(a) The GDP of agricultural sector in sub-district

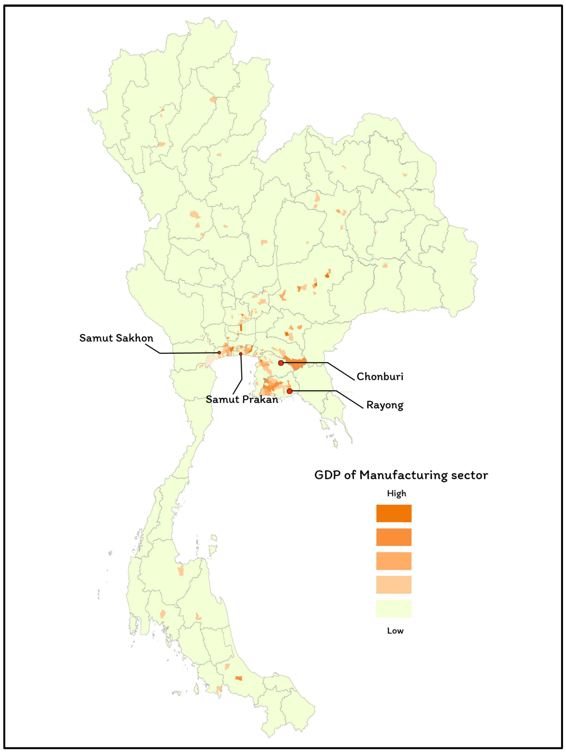


Fig. 5(a) The GDP of manufacturing sector in sub-district

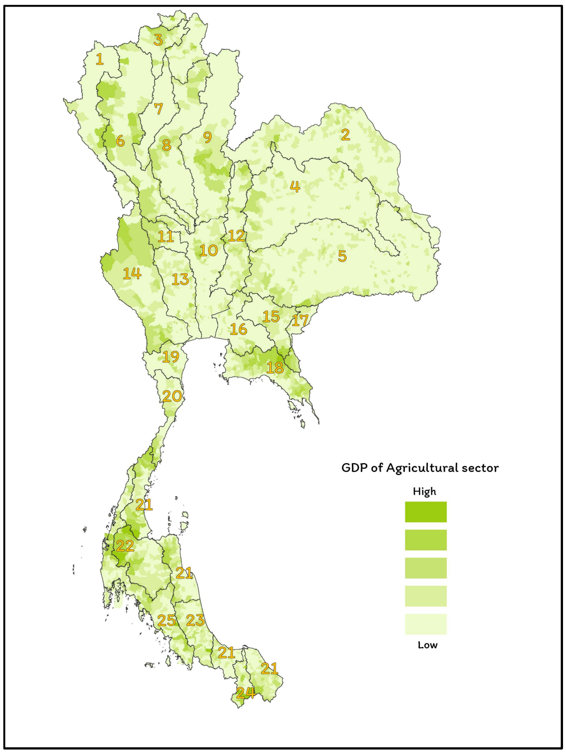


Fig. 4(b) The GDP of agricultural sector in basin level

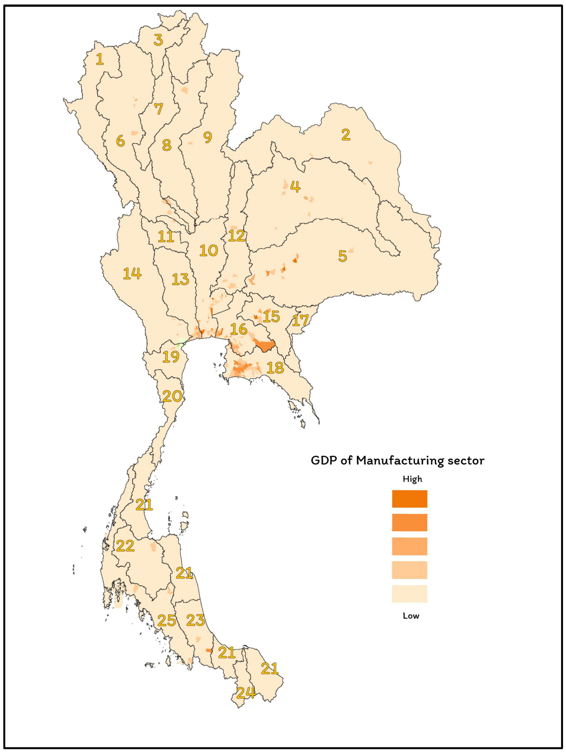


Fig. 5(b) The GDP of manufacturing sector in basin level

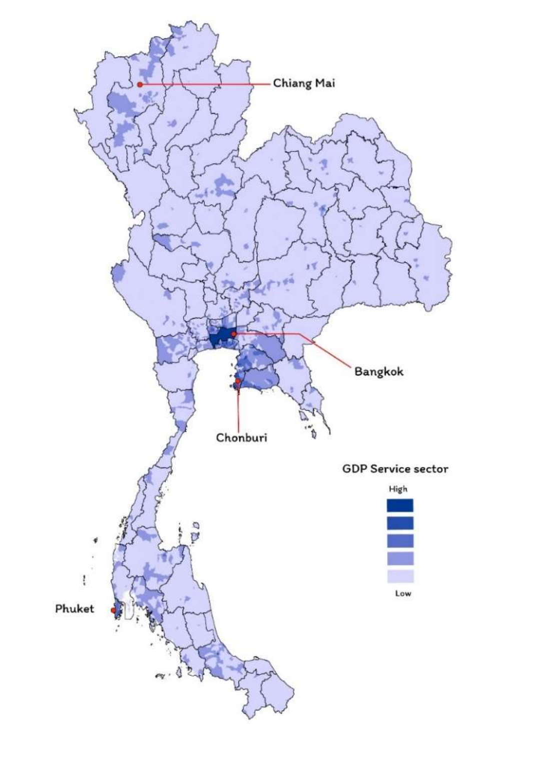


Fig. 6(a) The GDP of service sector in sub-district

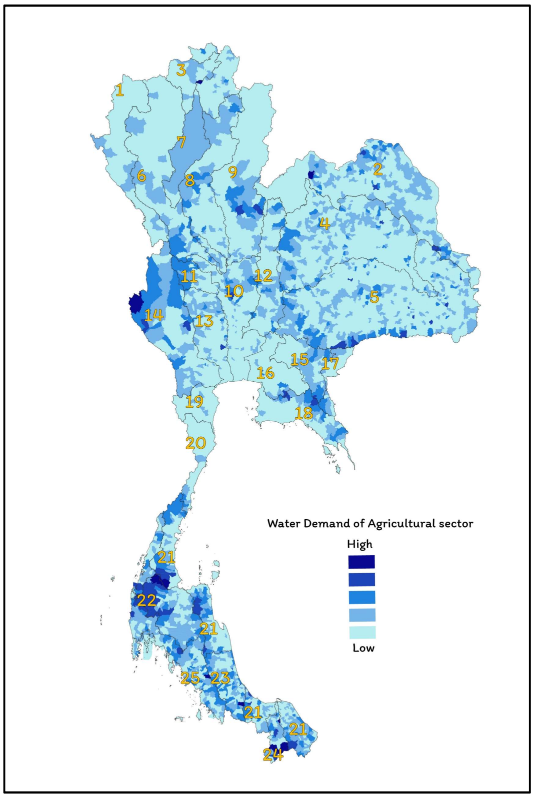


Fig. 7(a) Water demand of agricultural sector

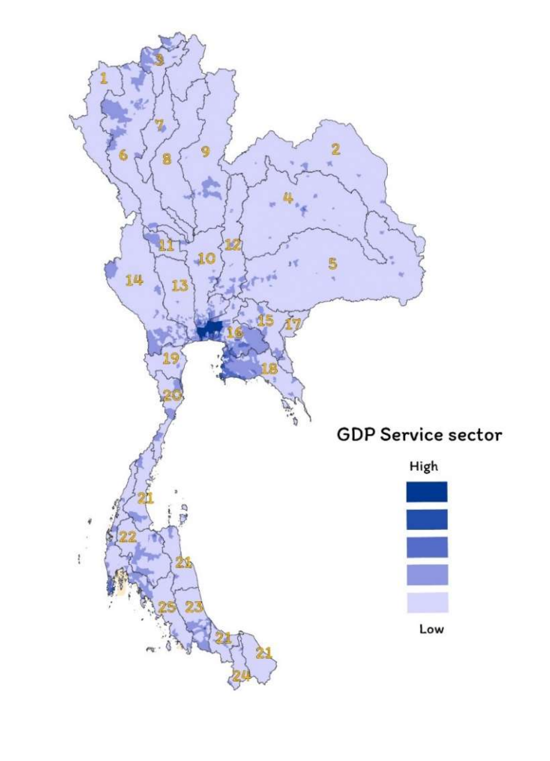


Fig. 6(b) The GDP of service sector in basin level

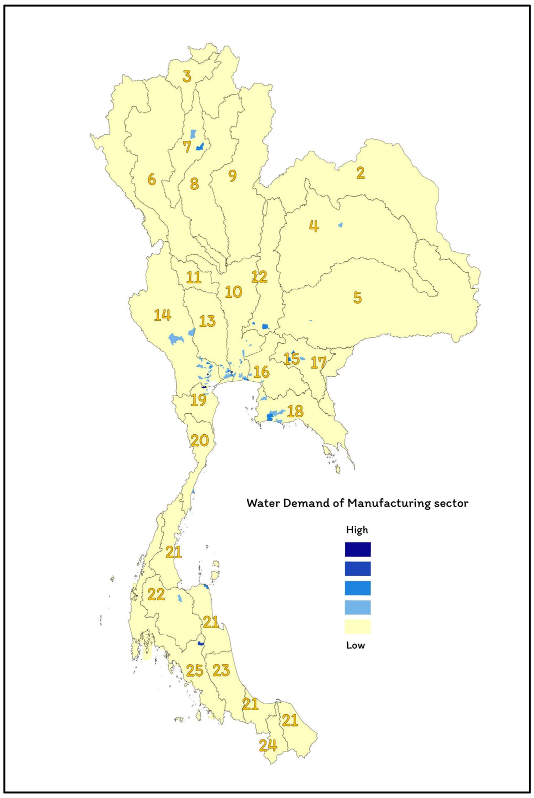


Fig. 7(b) Water demand of manufacturing sector

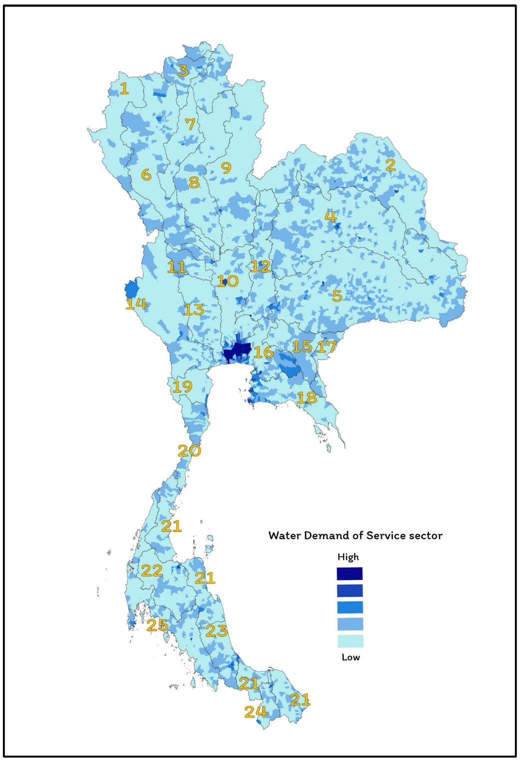
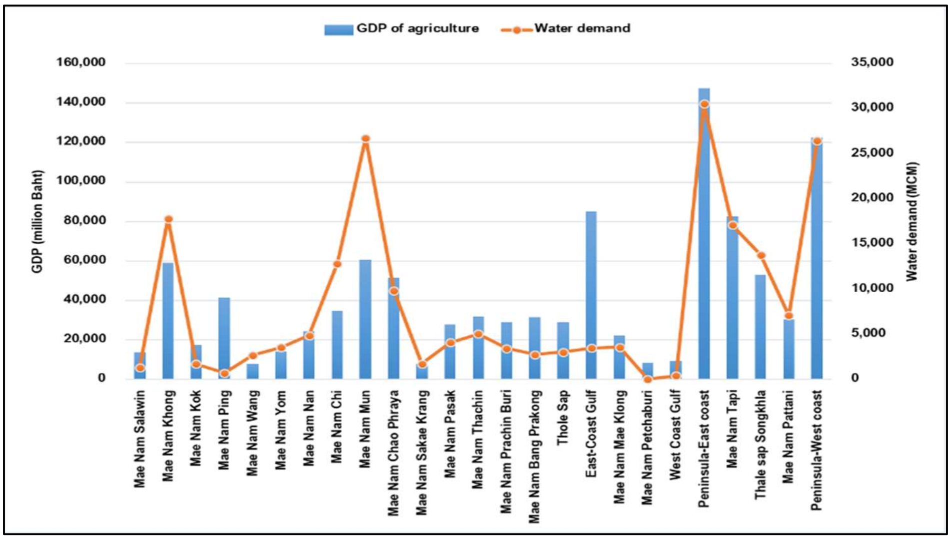


Fig. 7(c) Water demand of service sector

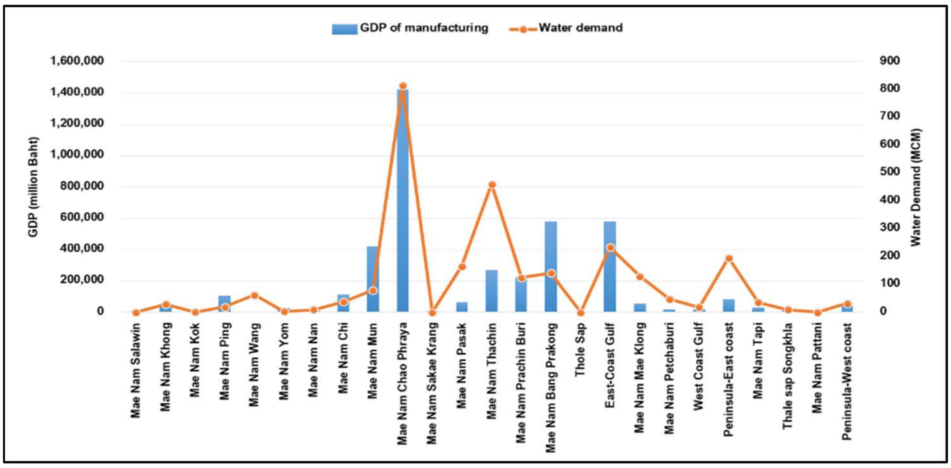
Fig. 8(a) shows the relationship between the GDP of agriculture and water demand. We can analyze and classify as three types of water demand for generating the GDP, including the low (Type I), moderate (Type II) and high-water demand (Type III). Type I, II and III can be explained that water used is low, moderate and high but it can produce high GDP. Hence, the results of Type I is the Ping, Petchaburi, and West coast gulf river basins. Type II is the Salawin, Kok, Pasak, Thachin, Prachinburi, Bang Prakong, Tole sap, and Mae Klong river basins. Type III is the remaining river basins. Moreover, we consider the GDP of five economic crops as GIS, which is shown in Fig. 9. The different GDP can be identified the behavior of farmers in each region. Thus, If Thailand wants to develop and reform the agricultural production, it will attempt to change as Type I and II. In addition, the government must support farmers from selling the raw agricultural product to processed agricultural products.

The GDP of the manufacturing sector is identified clearly in Fig. 5. The results show the dark orange color for high GDP, which matches with the main industrial area in some regions of Thailand, namely the central and east regions (Eastern Economic Corridor, EEC). They are one-third of the GDP in this sector. Other orange points display the major cities of the country, where the main roads cross. Fig. 8(b) shows the relationship between the GDP of manufacturing and water demand. The Chao Phraya river basin is the maximum GDP, and the Bang Prakong, East coast gulf, and Mun river basins are second values, respectively. They consume the low water demand for generating the GDP. Conversely, Thachin river basin consumes high water demand but it produces low GDP because this area has the food and food processing industries.

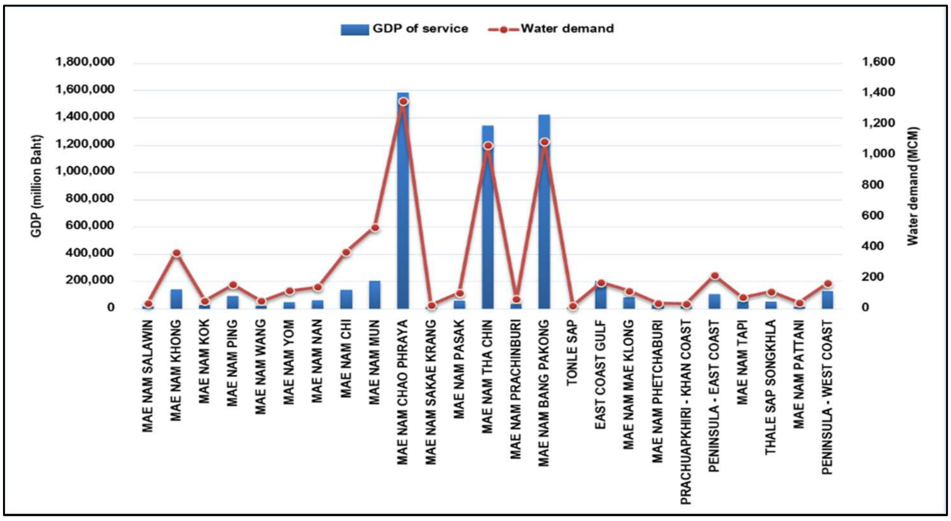
Finally, the GDP of the service sector is shown in Fig. 6. The service sector is very important because it is approximately 58 percent of the whole country. The results are similar to the manufacturing sector, but they are different in the south region. The most GDP of service is identified in the famous tourism and big cities of Thailand such as Bangkok, Chonburi, Chiang Mai, and Phuket. Fig. 8(c) presents the relationship between the GDP of service and water demand. The Chao Phraya, Bang Prakong and Thachin river basins are high GDP but they consume much water demand. On the other hand, the basins near the Gulf of Thailand and Andaman sea consume less water used but they can produce the moderate GDP.



(a)



(b)



(c)

Fig. 8(a), 8(b) and 8(c) The relationship between the GDP and water demand in each sector

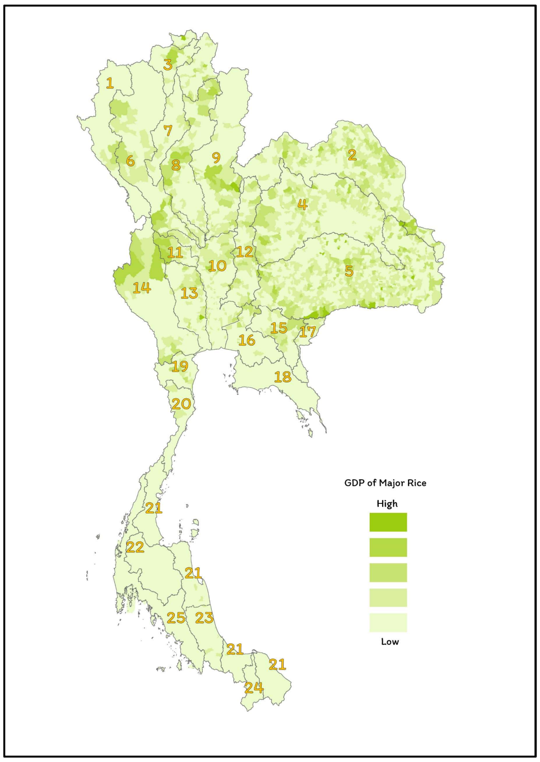


Fig. 9(a) The GDP of major rice in Thailand

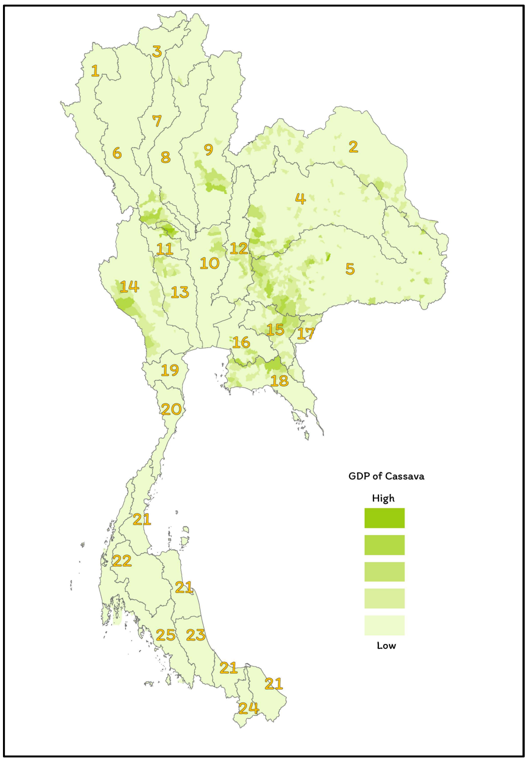


Fig. 9(c) The GDP of cassava in Thailand

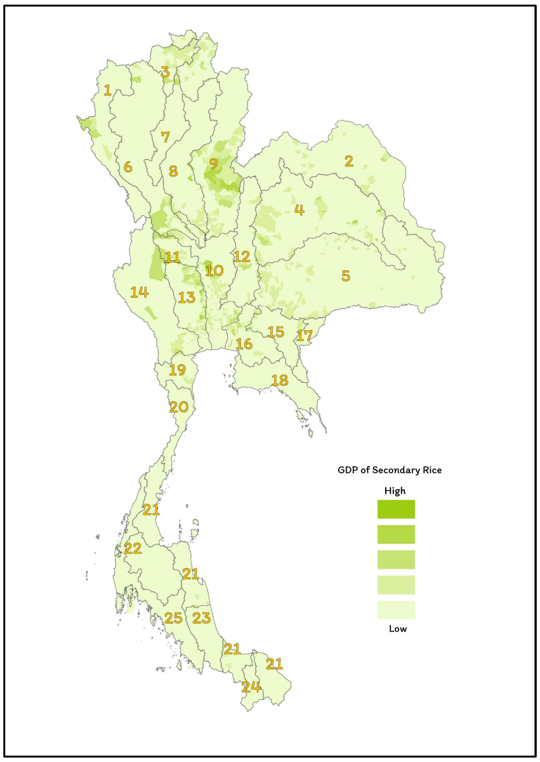


Fig. 9(b) The GDP of secondary rice in Thailand

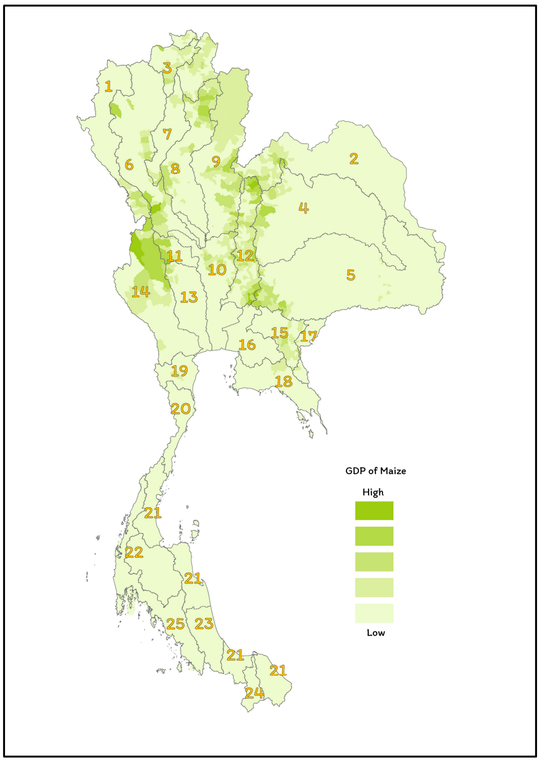


Fig. 9(d) The GDP of maize in Thailand

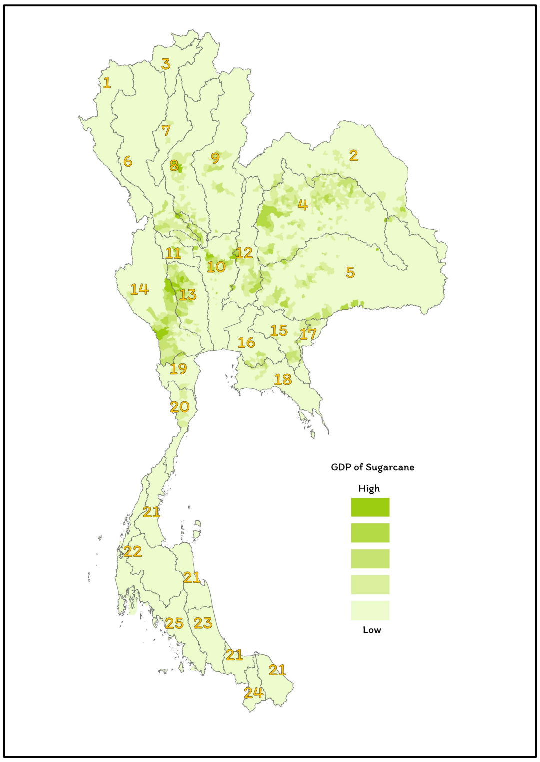


Fig. 9(e) The GDP of sugarcane in Thailand

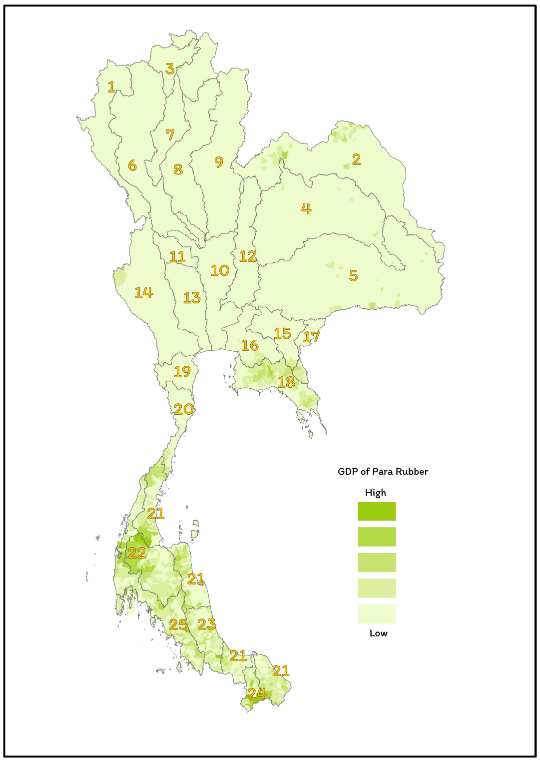


Fig. 9(f) The GDP of para rubber in Thailand

TABLE II

Economic value of water of 25 basins

(unit: Baht/cu.m.)

River Basins	Agri	Man	Ser
Mae Nam Salawin	10.6	1,700	1,174
Mae Nam Khong	3.3	1,413	972
Mae Nam Kok	10.1	1,606	1,226
Mae Nam Ping	58.2	5,589	1,503
Mae Nam Wang	3.0	56	1,203
Mae Nam Yom	3.9	8,224	1,062
Mae Nam Nan	5.0	1,168	1,107
Mae Nam Chi	2.7	3,033	932
Mae Nam Mun	2.3	5,295	967
Mae Nam Chao Phraya	5.2	1,744	2,924
Mae Nam Sakae Krang	4.5	2,088	1,107
Mae Nam Pasak	6.8	379	1,440
Mae Nam Thachin	6.3	586	3,151
Mae Nam Prachin Buri	8.5	1,790	1,407
Mae Nam Bang Prakong	11.4	4,119	3,264
Thole Sap	9.6	2,783	1,015
East-Coast Gulf	24.4	2,490	2,998
Mae Nam Mae Klong	6.3	45	1,820
Mae Nam Petchaburi	143.3	371	1,846
West Coast Gulf	22.2	929	1,718
Peninsula-East coast	4.8	434	1,209
Mae Nam Tapi	4.8	846	1,827
Thale sap Songkhla	3.8	1,369	1,163
Mae Nam Pattani	4.3	4,980	953
Peninsula-West coast	4.6	1,254	1,954

3.2. Economic Value of Water of 25 Basins

The results of the calculation of the economic value of water in 25 basins can be shown in TABLE II. The economic value of water in the agriculture is the least valuable of three sectors because it consumes a lot of water in production processes such as the rice cultivation (in-season and off-season rice), sugarcane, and rubber tree etc. but generating fewer profits.

The results present that the Petchaburi, Ping, and East coast gulf river basins are the most valuable of three sectors, respectively. The service sector has the middle economic value of water because one water unit of its can generate GDP, greatly. The Bang Prakong, Thachin, and Chao Phraya river basins are the maximum GDP of service. They are the center of tourism, government office, and service businesses. Finally, the economic value of water in the manufacturing sectors shows the maximum values in some basins, where are the huge industrial areas and the industry that produces high GDP such as the automotive industry and petrochemical etc. TABLE II shows that some basins are remarkable and inferior in the agriculture, manufacturing or service from the results of the economic value of water. It can be a way to plan and solve problems in accordance with current economic propulsion.

4. Conclusion

This study demonstrates the application of the relationship between GDP and water demand in the geographical information system (GIS) and the economic value of water in 25 basins. The methodology used in this study can be well-applied with the GDP and water demand calculation in sub-district and basin levels. The results of studies show that the GDP of the service sector is the maximum values, and the economic value of water in the manufacturing sector is the most valuable. There is the main economic driver of the country. The GDP of manufacturing sector mainly receives from the export, labor, and taxes, and the most industries are the assembly industry, which consumes our natural resources, and the products will be export to other countries. The GDP received from this sector is less than the service sector. Finally, the GDP of agriculture and the economic value of water is the least valuable because this sector consumes much water demand, but it produces less GDP. This study does not take into account social issues in consideration. Thus, it by no means implies water allocation policy to be based on the calculated economic value of water but the analysis demonstrated can be used as a tool for the policy formulation. Additionally, the procedures implemented in this study can be used as a guideline for increasing economic value of water and water planning and management in the spatial distribution.

5. Acknowledgment

This research was part of the research project “The Conceptual Framework for Water-Food-Energy Nexus Research towards Sustainable Development Planning”. The authors would like to express gratitude for the data sets used in this study from the relating government agencies such as the Royal Irrigation Department (RID), the Office of Agricultural Economics (OAE) and the Office of National Economic and Social Development

Board (NESDB). Finally, we would like to thank Mr. Tulyawat Mahawong for helping in the GIS data processing and the calculation in various parts.

6. References

[1] The Royal Irrigation Department (RID). (2018, April 11). Evapotranspiration (ET) of crops [Online]. Available: http://water.rid.go.th

[2] Centre for Agricultural Information, "Agricultural of statistics of Thailand 2010," Ministry of Agriculture and Cooperatives, 2010.

[3] Government Gazette. (2018, May 20). Establishment of the Office National Water Resources, Thailand [Online]. Available: http://www.ratchakitcha.soc.go.th

[4] Office of National Water Resources Committee. (2018, May 20). State of water environmental issues [Online]. Available: http://www.wepadb.net/policies/state/thailand/thailand.html

[5] C. Siripornpipul. (2018, May 20). Technological demand of water resources management in urban development in Thailand [Online]. Available: https://www.asef.org/images/docs/2%20Technological%20Demand%20of%20Water%20Management%20in%20Urban%20Development%20in%20Thailand.pdf

[6] The National Statistics Office (NSO). (2017, January 8). Gross Domestic Product (GDP) in Thailand economy [Online]. Available: http://service.nso.go.th/nso/nsopublish/BaseStat/basestat.html

[7] P. Chuenchum, P. Suttinon, and P. Ruangrassamee, "Input-output analysis of water deficits in nan river basin, Thailand," in *THA 2017 International Conference on Water Management and Climate Change Towards Asia's Water-Energy-Food Nexus*, Bangkok, 2017, pp. 265-271.

[8] The Office of National Economic and Social Development Board. (2017, January 8). The Input-output table of Thailand 2010 [Online]. Available: http://www.nesdb.go.th

[9] N. Chuenchum, *Theory of Economics and Analysis*. Bangkok: Thammasat University Press, 2005.

[10] S. Koontanakulvong, C. Suksri, T. Kitpaisalsakul, P. Santithamnon, A. Putthividhya, P. Hoisungwan, A.D. Gupta, and S. Nasu, "Effectiveness Aspect of Surface Water Management and Impact on Groundwater," Chulalongkorn University, Bangkok, Thailand, Final Rep., 2005.

[11] P. Suttinon, S. Nasu, N. Bongochgetsakul. K. Uemoto, and T. Ihara, "Hybrid water input- output model for regional management," *J. SSMS.*, vol. 9(1), pp. 1-9, Dec. 2013.