EVALUATION OF WATER RESOURCE SITUATION IN LAM TA KONG WATERSHED การประเมินสถานการณ์ทรัพยากรน้ำในลุ่มน้ำลำตะคอง

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Abstract

Lam Ta Kong Watershed, a sub-basin of Mun Basin, has had a high economical growing rate. Along with that comes a growing demand for water and there was only one source of water, the Lam Ta Kong Reservoir, to support all activities within the watershed. As a result, the Lam Ta Kong Watershed has had a long history of water shortage and it might cause another water conflict in the future. This research aimed to analyze the water scarcity among the different sectors in the Lam Ta Kong Watershed which was subject to the economic and spatial development plan of the government. This study was divided into 11 scenarios to evaluate the water use under the limitation of its water resource. The results of this study showed that the Lam Ta Kong Watershed was on the brink of a water shortage and that this problem was estimated peak in the year 2024.

In reference to the forecast of water demand in Lam Ta Kong Watershed, it was found that in 2024 the water demand was estimated to be 324.63 MCM. Therefore, the water demand in Lam Ta Kong Watershed was predicted to exceed its water budget by 153.61 MCM. Water use in Nakhonrachasima City was predicted to increase and this was expected to be a key factor in the upcoming water deficit. Moreover, a water conflict among the different sectors in the watershed could be expected. Also, Nakhonrachasima City has had a more authoritative reach to the water resource and the water allocation policy of the Lam Ta Kong Watershed prioritized the domestic water consumption of Nakhonrachasima City. For these reasons, the water conflict might eventually cause a social conflict between the urban and agricultural sectors or agriculturist and local government. Therefore, the government was

* corresponding author E-mail : i_am_saowanee@hotmail.com Phone : +66-2218-8137 21 suggested to plan a water resource management to allocate water resources to all involved sectors covering the supply and demand sides in the upstream and downstream areas. Also, an area-based analysis of the spatial and economic development plan was necessary to sustain the development in the Lam Ta Kong Watershed.

Key words: water shortage, water resource, Lam Ta Kong Watershed, Lam Ta Kong Reservoir, water resource management

บทคัดย่อ

ลุ่มน้ำลำตะคอง เป็นลุ่มน้ำย่อยของลุ่มน้ำมูล ซึ่ง มีอัตราการขยายตัวทางเศรษฐกิจสูง ทำให้มีความ ต้องการน้ำเพิ่มมากขึ้น โดยมีอ่างเก็บน้ำลำตะคองเป็น แหล่งน้ำหลักเพียงแหล่งเดียวของพื้นที่ที่ต้องสนับสนุน กิจกรรมต่างๆ ด้านท้ายน้ำ มีผลให้ลุ่มน้ำลำตะคองมี ประวัติยาวนานเกี่ยวกับการขาดแคลนน้ำ อาจมีผลให้ เกิดความขัดแย้งในการใช้น้ำได้ในอนาคต งานวิจัยนี้มี วัตถุประสงค์เพื่อวิเคราะห์การขาดแคลนน้ำในแต่ละ ภาคส่วนในลุ่มน้ำซึ่งขึ้นกับแผนพัฒนาเศรษฐกิจ ในการ ศึกษากำหนดสภาวการณ์การใช้น้ำออกเป็น 11 สถานการณ์ ภายใต้ปริมาณน้ำต้นทุนที่มีอยู่อย่างจำกัด ผลการศึกษาแสดงให้เห็นว่า ในปี พ.ศ. 2567 ลุ่มน้ำ ลำตะคองจะมีความต้องการใช้น้ำ 324.63x10⁶ ลบ.ม. และการขาดแคลนน้ำจะเกิดขึ้นสูงที่สุด โดยมีการ ขาดแคลนน้ำในปริมาณ 153.61x10⁶ ลบ.ม. พยากรณ์ว่า ความต้องการใช้น้ำของเมืองนครราชสี่มาจะเพิ่มขึ้นและ คาดว่าจะเป็นปัจจัยสำคัญที่ส่งผลให้เกิดการขาดแคลน น้ำเร็วๆ นี้ ยิ่งกว่านั้นคาดว่าจะเกิดความขัดแย้งในการ ใช้น้ำระหว่างภาคส่วนต่างๆ ในลุ่มน้ำได้ เมืองนครราชสีมา อีกเช่นกันมีความสามารถในการเข้าถึงทรัพยากรน้ำ มากกว่าและนโยบายการจัดสรรน้ำในล่มน้ำที่ให้ความ สำคัญในการใช้น้ำของชุมชนเมืองนครราชสีมาเป็น อันดับแรก ด้วยเหตุนี้ภาครัฐมีความจำเป็นต้องมี แผนการจัดการทรัพยากรน้ำในภาพรวมของทุกภาคส่วน ครอบคลุมด้านอุปลงค์และอุปทานในพื้นที่ต้นน้ำและ ท้ายน้ำ ดังนั้น การวางแผนการพัฒนาพื้นที่และเศรษฐกิจ ด้วยการวิเคราะห์เชิงพื้นที่จึงมีความจำเป็นไนการพัฒนา ลุ่มน้ำลำตะคองอย่างยั่งยืน

คำสำคัญ: การขาดแคลนน้ำ, ทรัพยากรน้ำ, ลุ่มน้ำลำตะคอง, อ่างเก็บน้ำลำตะคอง, การจัดการทรัพยากรน้ำ

Introduction

A popular myth often expressed today is "The next great war will be a water war". This is a response to the growing pressure and the increasing demand on natural resources worldwide. The water may someday become the casus belli between states as population grows and high rates of unsustainable water use drive more and more regions into conditions of water scarcity. In some areas, the demand for water already exceeds natural supply and a growing number of countries are expected to face water shortage in the near future⁽¹¹⁾. Most of the current conflict surrounding water occurs at the national levels and the basin levels.

Lam Ta Kong Watershed covers 6 districts of Nakhonrachasima Province. Since the Lam Ta Kong Watershed serves Nakhonrachasima City which is the growth center of the Northeast Region of Thailand. The center's service area is not only limited to the province but also some functions extend to the region. As a result, economic development of Nakhonrachasima has grown rapidly⁽²⁻⁷⁾. Therefore, each sector in the Lam Ta Kong Watershed has a growing demand for water. The Lam Ta Kong Reservoir

is the only water resource in the watershed and it has to support all activities within the five districts of Lam Ta Kong Watershed. At present, water is often stored which results in insufficient water to support present and future activities and this may eventually lead to a conflict of interest concerning water use⁽⁸⁾.

Lam Ta Kong Watershed is the important economic development area in Thailand which has the Nakhonrachasima City as the growth center of the Northeast region of Thailand. As a result the demand of water has expanded rapidly. Unplanned water use can cause several problems especially water shortage and the conflict of water use among sectors and water crisis in the watershed due to rapid growing demand of water. The water shortage in Lam Ta Kong Watershed will effect economic and urban development in the watershed. The study about water use and water shortage in the Lam Ta Kong Watershed is necessary for planning of economic and urban development and water resource management in Lam Ta Kong Watershed. Therefore, this research is focused on analyzing the growing demand for water throughout the Lam Ta Kong Watershed, its limited water budget, and the scarcity it may result in.

Objective

This research objective is to investigate and analyze the water use among sectors and the water shortage in Lam Ta Kong Watershed.

Scope of Study

1) The site study is downstream area of Lam Ta Kong Watershed which covers Si Kiew District, Sung Neon District, Kham Talae Sor District, Muang Nakhonrachasima District and Chalearm Prakeate District. The study size is 2,410 km².

2) The study is divided into 3 sectors;

- water for agricultural and industrial sectors
- water for consumption and

 water for the preservation of the environmental condition in the Lam Ta Kong River

3) Water use is divided into 3 periods: past situations, present situation and future situation in order to capture—the trend in watershed use demand. The past use and the present use are collected in 1993 and 2004, respectively, because in those years, there were water crisis problems. According to the economic and social development plan, the anticipated watershed use in 2024.

Methodology

1) Investigate the water use in 1993 involving collection, analysis and interpretation of literature.

2) Review and survey existing water consumption in the present situation.

 Evaluate the water use in each sector in the present situation.

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7)--Setting up the 11 scenarios to evaluate

11 scenarios were defined to cover the

water use: past situation (S1), present situation

(S2), future situation (S3) and analyzed the

increase of water use sector by sector to show

the effect that will occur on any other (S4-S11).

The amount of water for preservation of the

environmental condition in 2004 is approximated

to be the minimum benchmark due to the fact

that it's the lowest level to keep the balance of

ecological system of Lam Ta Kong River. The

definitions of water use in all scenarios are as

environmental condition

W : water for consumption

the water shortage.

W

 Calculate and investigate the water demand in each sector in the future situation by analysis of economic and spatial development plan of the watershed.

5) Analyze the water balance of Lam Ta Kong Watershed by using water balance model.

6) Analyze the water use in each sector with the water budget of downstream area in the watershed. The water use in each sector in Lam Ta Kong Watershed can be described by Equation 1.

$$W_{a} = W_{up} + W_{uc} + W_{un}$$
(1)
where

W_a : water budget (average water storage in Lam Ta Kong Reservoir)

W : water for agriculture and for industry

		Water use (year)							
Scenarios	Production			People	Preservation of the environmental				
	A I		С	Nakhonrachasima City	— condition of Lam Ta Kong River				
S1	1993	1993	1993	-	2004				
S2	2004	2004	2004	-	2004				
S3	2024	2024	2024	-	2004				
S4	2024	1993	1:993	-	2004				
S5	2024	2004	2004	-	2004				
S6	2024	2009	2009	-	2004				
S7	2024	2024	2014	-	2004				
S8	2024	2024	2019	-	2004				
S9	2024	2024	2024	2009	2004				
S10	2024	2024	2024	2014	2004				
S11	2024	2024	2024	2019	2004				

follows:

Table 1 The water scenarios in Lam Ta Kong Watershed

A-agricultural, 1-industrial, C- community

8) Different scenarios were used in determining the scarce water condition. The result of each scenario shows the inadequate water supply in the future.

The situation of Lam Ta Kong Watershed

Lam Ta Kong Watershed is sub-basin of Mun Basin which always faces the water shortage problem. The size of the watershed is 3,874 km² which cover 6 districts of Nakhonrachasima Province. The origin of the Lam Ta Kong River is in Khao-Yai mountain range, Khao-Yai National Park, the world heritage. The watershed can be divided into 2 areas, with the border being the Lam Ta Kong Dam: the upstream area, Pak Chong District and the downstream area, Sung Neon, Kham Talae Sor, Muang Nakhonrachasima and Chalearm Prakeate District (Figure 1). The reservoir is located 62 km before the town on the Friendship Highway. The capacity of the reservoir is 324.00 x10⁶ m³ (MCM) ⁽⁹⁾. Its primary purpose is to allocate water from the reservoir for irrigation. But since Nakhonrachasima Province has fast growing economy and is subject to urban expansion, the reservoir must also supply water for agriculture, industries and domestic consumption. Moreover, the reservoir is used to support the Lam Ta Kong hydro power electricity plant⁽¹⁰⁾.



Figure 1 Lam Ta Kong Watershed

The Lam Ta Kong Reservoir is the only source of water to support all activities within these 5 districts. The agricultural areas are 1,962.41 km² which can be divided into 1758.35 km² for non-irrigation area, 204.06 km² for the irrigation area. The registered population of the Lam Ta Kong Watershed is estimated to be approximately 948,968. The 11 urban communities and 69 rural communities are using the water resource from Lam Ta Kong Reservoir for water supply. Nakhonrachasima City is the biggest community in the watershed. Moreover, there are 22 big factories that directly pump water from the Lam Ta Kong River.

Results

Water situation in Lam Ta Kong Reservoir

According to the study of hydrological data (1970-2004) of Lam Ta Kong, it was found that the average water asset of the watershed is 274.10 MCM/yr, the average water asset of the downstream area 251.00 MCM/yr, the average water storage in reservoir 169.00 MCM/yr. and average water inflow to reservoir 251.00 MCM/yr while the average water outflow from the reservoir was 215.29 MCM/yr. A chart of the water inflow to the Lam Ta Kong Reservoir during 1970-2004 is shown in Figure 2.



Figure 2 Statistics of water inflow to the Lam Ta Kong Reservoir during 1970-2004

Water use in Lam Ta Kong Watershed

The study found that in 1993, 169.67 MCM was used which can be divided into 60.72 MCM/ yr for the agricultural sector, 7.40 MCM/yr for the industrial sector, 44.91 MCM/yr for domestic consumption and 56.64 MCM/yr to preserve nature.

In 2004, the total water use was 256.02 MCM/yr, 133.25 MCM/yr for the agricultural sector, 3.00 MCM/yr for the industrial sector, 63.13 MCM/yr for domestic consumption and 56.64 MCM/yr to preserve nature. This study shows that the total present water consumption is more than the amount of the average water flow into the reservoir and so it causes a water shortage in the Lam Ta Kong Watershed. At present, total water use exceeds the water budget by 33.78 MCM.

According to the calculation of the water balance of Lam Ta Kong Watershed, it found that in 2004 the amount water use which is exceeding water budget was 33.78 MCM. In the past decade, the Lam Ta Kong Watershed has had to coup with several water crisis's, especially in 2004, when the watershed was the most critical drought area in Thailand. Useable water in the reservoir had dropped to a 9% and as a result the government decided on sending in the military to regulate water consumption along the Lam Ta Kong River since adequate water must be available for domestic consumption, especially for Nakhonrachasima City. Moreover, the agricultural sector was not allowed to use water. This solution caused a conflict between the urban sector and the agricultural sector or, in other words, the government and the agricultural sector.

In reference to the forecast of water demand in Lam Ta Kong Watershed, it was found that in 2024 the water demand will be 324.63 MCM and can be divided as follows; 174.49 MCM for the agricultural sector, 9.77 MCM for the industrial sector, 83.73 MCM for domestic consumption of which 59.18 MCM is for consumption in Nakhonrachasima City, and 56.64 MCM to preserve nature. Therefore, by 2024, the water demand in Lam Ta Kong Watershed will exceed its water budget by 109.34 MCM. The water demand for each sector of Lam Ta Kong Watershed is shown in Table 2.

Year	Water demand (MCM)							
	A	1	С	Preservation of the environmental condition	Total			
1993	60.72	7.40	44.91	56.64	169.67			
2004	133.25	3.00	63.13	56.64	256.02			
2024	174.63	9.77	83.73	56.64	324.63			

Table 2 The water demand in each sector of Lam Ta Kong Watershed

A-agricultural, I-industrial, C-community

The water inflow and the water use in Lam Ta Kong Watershed

An analysis of the trend of water inflow shows that the water inflow to the Lam Ta Kong Reservoir may be decreasing while the water demand has expanded rapidly. The water in the reservoir frequently provides inadequate support for present and future activities. The study pointed out that if the economic development and the volume of water inflow to the reservoir follows the same trend as in the past. Lam Ta Kong Watershed will be short of water begin from 2001 (Figure 3). Moreover, a water shortage problem will occur in the watershed which can affect water use and economic development in the downstream area.

Because of this situation, the local government set up a priority of water allocation for all sectors in the watershed. In the rainy

season, water resources from the reservoir are impartially allocated for all activities. In this season water from the reservoir can be allocated for irrigation (204.06 km²) under an irrigation plan; this is a basic principle demand of the agricultural sector. For the dry season, government must be set the priority for water allocation because a limitation on water in the reservoir must be employed for all activities. The first priority is the domestic consumption of Nakhonrachasima City. The second priority is the industrial sector and the third priority is the preservation of nature and the agricultural sector. The water situation of the Lam Ta Kong Watershed has shown that in the dry season the amount of water in the Lam Ta Kong Reservoir is insufficient for supporting the first and second priority. The Lam Ta Kong Watershed has had water scarcity for a long time but now seems to more severe.



Figure 3 Water inflow and water demand of Lam Ta Kong Watershed

The water scenario and the water shortage in Lam Ta Kong Watershed

The study found that (S1) was the only year in which a water shortage did not occur in Lam Ta Kong Watershed. At present (S2), the amount of water used exceeded the water budget by 85.00 MCM. In the future (S3) there will be an increase in the demand for water by all sectors and it is calculated that this will exceed the water budget by 153.61 MCM. The water shortage for each scenario of the Lam Ta Kong Watershed is shown in Table 3.

Scenarios			Water demand (MCM)						
	Water Water		Production		Consumption		Preservation of the	Total	
	availability shortage						environmental condition		
	(MCM)	(MCM)	А	I	С	Nakhon-	of Lam Ta Kong River		
	rachasima City								
S1	171.02	1.35	60.72	7.40	44.91	-	56.64	169.67	
S2	171.02	-85.00	133.25	3.00	63.13	-	56.64	256.02	
S3	171.02	-153.61	174.49	9.77	83.73	- 1	56.64	324.63	
S4	171.02	-112.42	174.49	7.40	44.91	-	56.64	283.44	
S5	171.02	-126.24	174.49	3.00	63.13	-	56.64	297.26	
S6	171.02	-125.19	174.49	9.77	55.31	- 1	56.64	296.21	
S7	171.02	-132.39	174.49	9.77	62.51	-	56.64	303.41	
S8	171.02	-141.67	174.49	9.77	71.79	-	56.64	312.69	
S9	171.02	-124.02	174.49	9.77	17.39	36.75	56.64	295.04	
S10	171.02	-131.71	174.49	9.77	17.39	44.44	56.64	302.73	
S11	171.02	-141.40	174.49	9.77	17.39	54.13	56.64	312.42	

Table 3 The water shortage in each scenarios of Lam Ta Kong Watershed

A-agricultural, I-industrial, C-community

This study defines water demand for the agricultural and natural sectors (S4-S11) by minimizing its needs to maintain its level of development. Under these conditions there will still be a water shortfall if the following scenarios occur;

• S4 : water use in industrial sector plus water use for domestic consumption is the water use for 1993. The amount of water used exceeded its budget by 112.42 MCM.

• S5 : water use in industrial sector plus water use for domestic consumption is the total amount of water used in 2004. Water use is exceeded its budget by 126.24 MCM.

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• S6 : water use in industrial sector and water use for domestic consumption will increase till 2009. The demand for water in Lam Ta Kong watershed will exceed its budget by 125.19 MCM.

• S7 : the industrial sector is the most demanding water consumer. Water use for domestic consumption will increase further till 2014. Total water use will exceed its budget by 132.39 MCM.

• S8 : the industrial sector is the most demanding water consumer. Water use for domestic consumption will increase further till 2019. Total water use will exceed its budget by 141.67 MCM.

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• S9 : the industrial sector is the most demanding water consumer. Water use for domestic consumption in other communities will increase till 2024 and water use for domestic consumption for Nakhonrachasima City is similar to water use in 2009. Total water use will exceed its budget by 124.02 MCM.

• S10 : the industrial sector and water for domestic consumption in other communities will be the most demanding water consumers. Water for domestic consumption of Nakhonrachasima City is similar to water use in 2014. Total water use will exceed its budget by 131.71 MCM.

 S11 : the industrial sector and water for domestic consumption in other communities will be the most demanding water consumers.
Water for domestic consumption of Nakhonrachasima City is similar to water use in 2019. Total water use will exceed its budget by 141.40.

The water shortage in Lam Ta Kong Watershed

An analysis of water shortage in the Lam Ta Kong Watershed illustrates that in a normal situation of development (S1-S3), in which every sector grows, in the year 2024, when the demand for water will reach its peak and thus water shortage will climax, the conflict of water use will be more severe.

Since the water budget is limited but the need for water increasing, sectors will have to

share water resources to support their own sector. In this case, the sector that has a more authoritative reach to the waters will get more water. For example, Nakhonrachasima City has a direct pipe connection of raw water with the Lam Ta Kong Reservoir. Moreover, the water allocation policy of the Lam Ta Kong Watershed prioritizes the domestic water consumption of Nakhonrachasima City. When a water crisis occurs .at the Lam Ta Kong Reservoir, the agricultural sector is not allowed to use water from the Lam Ta Kong River. This solution caused a conflict between the urban sector and the agricultural sector or, in other words, the government and the agricultural sector.

Although water consumption for the agricultural sector is regulated to a minimum to maintain its development, increasing demand for water by the industrial sector and for domestic consumption will still cause a water shortage (S4-S7) and thus there will be a conflict of water use among the different sectors.

The conflict of water use will crest when there is an increasing demand for water for human needs (S3-S8). Though an increasing call for water for human needs in communities surrounding the watershed is a large part of the conflict, the conflict will reach its highest point when there is an increase in water use for human needs in Nakhonrachasima City. This is the conclusion drawn from S9-S11, when the annual increase of water use for human needs

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in Nakhonrachasima City is close to the volume of water deficit.

Conclusions and recommendations

From this study, it can be concluded that the economic and spatial development in Lam Ta Kong Watershed will have a water shortage problem and a conflict of interest concerning water use among the different sectors in the future. Water shortage will climax in 2024, when all sectors are fully developed. This situation may cause a critical scarcity concerning water in the Lam Ta Kong Watershed. The condition of this study is that agricultural and natural sectors get a minimum amount of water to maintain their level of development. If the agricultural sector needs more water, or if any sector increases its water use, the water shortfall will be more aggressive. However, the increasing demand for water for domestic consumption, especially in Nakhonrachasima City, is a key factor to take into account when analyzing the water deficit and its conflicts among the different sectors in Lam Ta Kong Watershed. This research shows that water deficiency will cause a conflict among the involved sectors and may become a social conflict later. The poverty of agriculturist will cause a migration to urban areas which, in its turn, will become an urban conflict. Nevertheless, if the water use pattern continues, the local government needs to make a realistic integrated plan to control the increasing demand for water demand and spatial and economic development in the holistic approach to avoid a water conflict in Lam Ta Kong Watershed.

However, when trying to slow down the increase in water use, defensive measures may help to control water use. For example, improvement of the production process, clean technology and recycle technology in the industrial sector. Also, the agricultural sector could use different technologies for cultivation like a water drop system, water save cultivation, cultivation system plans, and improvement of irrigated effectiveness. The water resource management and economic development plan in each sector can reduce the overall water shortage and the conflict of water use in Lam Ta Kong Watershed.

Integrated water resource management is an imperative tool to solve the water conflict in Lam Ta Kong Watershed. The concept of integrated water resource management is demonstrated in Figure 4. Moreover, a spatial and economic development plan is needed to analyze water availability (water budget) in the holistic approach for sustainable development.

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Figure 4 The concept of integrated water resource management in Lam Ta Kong Watershed

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