EVALUATION OF WATER RESOURCE MANAGEMENT IN LAM TA KONG WATERSHED: THE WATER SCARCITY AREA OF THAILAND

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ABSTRACT

The spatial and economic development in Thailand emphasized on increase in Gross Domestic Product. This development pattern had not paid much attention to analyze water budget (water availability) of the developed area. Therefore, the development caused water shortage in all developed areas in Thailand. Lam Ta Kong Watershed has a high economic growth rate but is still facing water scarcity. This research was aimed to analyze the water situation in the Lam Ta Kong Watershed which was subject to the economic and spatial development plan of the government. This research was divided into 9 water scenarios to evaluate the water usage under the limitation of its water resource. The results of this study showed that Lam Ta Kong Watershed hasn’t water shortage situation while the total water usage is only the minimum use (165.28 MCM.) or the average use (300.81 MCM.). The Lam Ta Kong Watershed was on the brink of a water shortage and that this problem was at the peak during the maximum water usage and minimum water asset. Therefore, Lam Ta Kong Watershed couldn’t develop economically by government plan especially in agricultural sector. The government should have water resource management plan covering the supply and demand in the upstream and downstream areas. Also, an area-based analysis of the spatial and economic development plan was necessary for sustainable development of Lam Ta Kong Watershed.

Key Words: Economic development, Water resource management, Spatial development, Water shortage, Lam Ta Kong watershed

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INTRODUCTION
Water is an essential component of all life. Water plays various roles. Water is an indispensable resource for people to live and develop and at the same time it is an important element that constitutes the environment of the area. Moreover, water is an indispensable resource for human health, ecosystems and socio-economic activity. Water is becoming an increasingly scarce resource for most of the people. At the present, serious and complex problems concerning water are occurring worldwide, and in order to solve them, it is required to establish integrated water resource management that considers all the factors of water resources with a comprehensive point of view.

The pattern of economic development in Thailand emphasizes on increase of Gross Domestic Product (GDP). This economic development pattern is aimed to rapidly expand the agricultural, industrial, commercial and service sectors. These development run by the national economic and social development plan (NESD plan). The first NESD plan was established in year 1963 (1963-1968). Today, the economic development is run by the 10th NESD plan (2007-2011). The NESD plans used by energy region of Thailand for it’s development. The different of geographic, economic and social conditions in each region is not considered. Moreover, the natural resource especially the water resource that is the important capital for development. Therefore, the spatial and economic development in Thailand causes the water shortage in each region. The water crisis occurs in the growth center of the development such as Phuget Island, Ra-yong Province and Nakhonrachasima Province. The problem of water availability along with increasing water demand over the years makes water resource management and the pattern of spatial and economic development in Thailand an important issue. Lam Ta Kong Watershed is the important economic development area in Thailand which has the Nakhonrachasima Province the growth center of the Northeast region of Thailand. The Lam Ta Kong Watershed serve, Nakhonrachasima, the growth center of the Northeast Region of Thailand by the government policy (NESD plan 4 1997-1981) to solve the Bangkok’s primate city problem. The center's servicing area is not only limited to the province but also some functions extend to the region. As a result economic development of Nakhonrachasima has taken place rapidly. 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, the economic development is carried out without analysis of water budget in Lam Ta Kong watershed. The water is often stored, which results in insufficient water to support present and future activities and this may eventually lead to a conflict of interests concerning water usage.

The economic development in Lam Ta Kong Watershed without analyzing water availability of the watershed can cause several problems
especially water shortage, conflicts regarding water usage among sectors and water crisis in the watershed due to rapid growing demand of water. This development pattern is unsustainable which may cause the water conflict among sectors in the watershed. The study of water demand with the limited water assets under the economic development plan is significant for sustainable development. Therefore, the research is focused on the pattern of spatial development and water usages in each sector in Lam Ta Kong watershed for establishing the management of spatial development and water resource management in Lam Ta Kong Watershed.

**Objectives**

The research is aimed at evaluation of water demand in Lam Ta Kong Watershed under the economic development plan.

**Scope of study**

1) The site study is the 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 sq.km.

2) The study on water usage in Lam Ta Kong Watershed was divided into 3 sectors;
   - water for agricultural and industrial sector
   - water for consumption and
   - water for preserve the environmental condition in the Lam Ta Kong River

3) In this study, water usages were divided into 3 periods: past situation, present situation and the future situation in order to capture the trend in watershed usage demand. The past usage and the present usage were 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 usage in 2024

**METHODOLOGY**

In order to assess the economic and spatial development in Lam Ta Kong Watershed the following methodology was carried out:

1) Review of the secondary data for the water consumption in all sectors in the past situation from the organization in charge.

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

3) Evaluation of the water usage in each sector in present situation.

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

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

6) Analysis of the water situation by setting up the water scenario (WS) with 3 factors water inflow to Lam Ta Kong Reservoir, water outflow from the reservoir and water usage in the watershed (I-O-U Analysis).
7) Evaluation of the pattern of water situation of Lam Ta Kong Watershed by analyzing the water budget and water usage in Lam Ta Kong Watershed. The equation is applied from water balance equation. The water equation in Lam Ta Kong Watershed is showed as follow:

\[ W_{\text{out}} = W_{\text{in}} - W_{\text{ds}} \]  
(1)

\[ W_{\text{sit}} = W_{\text{out}} - W_{\text{usage}} \]  
(2)

\[ W_a = W_{\text{up}} + W_{\text{uc}} + W_{\text{un}} \]  
(3)

where

- \( W_{\text{out}} \): water outflow from Lam Ta Kong Reservoir
- \( W_{\text{in}} \): water inflow from Lam Ta Kong Reservoir
- \( W_{\text{ds}} \): water for dead storage
- \( W_{\text{usage}} \): total water usage in the watershed
- \( W_{\text{sit}} \): water situation of Lam Ta Kong

8) Evaluation of the pattern of water situation of Lam Ta Kong Watershed by setting up the water situation into 9 water scenarios (WS).

Water scenarios are defined to analyze the water usage by different situations with one source of water as Lam Ta Kong Reservoir. All water scenarios, are defined to cover all water factors in minimum volume (WS1), all water factors in maximum volume (WS4), all water factors in average volume (WS7) and analyze the water situation in various conditions (WS2, WS3, WS5, WS6, WS8 and WS9). The definitions of water usage in all scenarios are as follow:

Table 1: The water scenarios in the developed condition

<table>
<thead>
<tr>
<th>Water scenario</th>
<th>Inflow</th>
<th>Outflow</th>
<th>Water usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS1</td>
<td>inflow Min</td>
<td>outflow Min</td>
<td>use Min</td>
</tr>
<tr>
<td>WS2</td>
<td>inflow Min</td>
<td>outflow Min</td>
<td>use Max</td>
</tr>
<tr>
<td>WS3</td>
<td>inflow Min</td>
<td>outflow Min</td>
<td>use Avg.</td>
</tr>
<tr>
<td>WS4</td>
<td>inflow Max</td>
<td>outflow Max</td>
<td>use Max</td>
</tr>
<tr>
<td>WS5</td>
<td>inflow Max</td>
<td>outflow Max</td>
<td>use Min</td>
</tr>
<tr>
<td>WS6</td>
<td>inflow Max</td>
<td>outflow Max</td>
<td>use Avg.</td>
</tr>
<tr>
<td>WS7</td>
<td>inflow Avg.</td>
<td>outflow Avg.</td>
<td>use Avg.</td>
</tr>
<tr>
<td>WS8</td>
<td>inflow Avg.</td>
<td>outflow Avg.</td>
<td>use Max</td>
</tr>
<tr>
<td>WS9</td>
<td>inflow Avg.</td>
<td>outflow Avg.</td>
<td>use Min</td>
</tr>
</tbody>
</table>
Different water scenarios were used in determining the water situation. The result of each scenario shows the inadequate water supply by economic development plan.

RESULTS AND DISCUSSION

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 sq km which covers 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 Fig 1. The reservoir is located 62 kilometers from the town on the Friendship Highway. The capacity of the reservoir is 324.00 Million cubic meters (MCM). 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 in five districts. Moreover, the reservoir is used to support the Lam Ta Kong hydro power electricity plant.

Fig. 1: Lam Ta Kong Watershed (Thailand)
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 Fig 2.

![Fig. 2: Statistics of water inflow to the Lam Ta Kong (Thailand) Reservoir during 1970-2004](image)

The water usage in Lam Ta Kong Watershed

From the study, it was found that the total water usage in year 1993 was 169.67 MCM which could be separated into 60.72 MCM/yr for agricultural sector, 7.40 MCM/yr for industrial sector, 44.91 MCM/yr for domestic consumption and 56.64 MCM/yr for preserve the nature.

In year 2004, the total water usage for agriculture, industry and domestic use of five districts in downstream area was 256.02 MCM/yr which can be separated into 133.25 MCM/yr for agricultural sector, 3.00 MCM/yr for industrial sector, 63.13 MCM/yr for domestic consumption and 56.64 MCM/yr for preserve ecosystem. This study was showed that, the amount water
consumption demand in the present is more than the amount of the average water inflow to the reservoir, so it caused the water shortage in Lam Ta Kong Watershed. According to calculate the water balance of Lam Ta Kong Watershed, it was found that in the present situation, the amount water usage which was exceeding water budget was 33.78 MCM. Lam Ta Kong Watershed has faced the serious water crisis in this decade especially in 2004 Lam Ta Kong watershed was noticed as the most critical drought area in Thailand. Water in Lam Ta Kong Reservoir that can usable was only 16 percent of amount of water storage. For that reason, the government decided to send military army into the area in order to regulate the water consumption along Lam Ta Kong River since the adequate water must be supplied for the domestic consumption especially for Nakhonrachasima City. Moreover, the agricultural sector was not allowed to use water and these caused the conflict between urban sector and agricultural sector so government and agriculturist did.

Refer to the forecasting of water demand in Lam Ta Kong watershed, it was found that in 2024 the water demand will be 324.65 MCM and can be distinguished as follow; 174.49 MCM for agricultural sector, 9.77 MCM for industrial sector, 83.73 MCM for consumption which 59.18 MCM is for consumption of Nakhonrachasima City and 56.64 MCM for preserve the nature. Therefore, due to the water balance, by 2024 water demand in Lam Ta Kong watershed will have been 109.34 MCM exceeded the water budget. The water demand in each sector of Lam Ta Kong Watershed is shown in Fig 3.

Fig. 3 : The water demand in each sector of Lam Ta Kong Watershed (Thailand)
The water situation of Lam Ta Kong Watershed

Analysis of water balance in Lam Ta Kong Watershed found that the watershed still has the water shortage, as Lam Ta Kong Reservoir is the only one source of water budget. The result of water situation of Lam Ta Kong Watershed is demonstrated in Table 2.

Table 2: The situation of water resource in Lam Ta Kong Watershed in year 2024

<table>
<thead>
<tr>
<th>Water budget (MCM)</th>
<th>Water demand (MCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Water Inflow +251.00</td>
<td>- water for agriculture 174.49</td>
</tr>
<tr>
<td>- Evaporation of water from reservoir 22.11</td>
<td>- water for industry 9.77</td>
</tr>
<tr>
<td>- Reservoir discharge for volume displacement 8.55</td>
<td>- water for people 83.75</td>
</tr>
<tr>
<td>- Local flow, side flow 54.76</td>
<td>- water for nature 56.64</td>
</tr>
<tr>
<td></td>
<td>Total 275.10</td>
</tr>
<tr>
<td></td>
<td>Total 324.65</td>
</tr>
</tbody>
</table>

comparison water budget that can allocate for all activities with water demand of Lam Ta Kong Watershed, shows that the water demand in the future will exceed the water budget of the watershed. The exceeded water is 49.55 MCM, based on minimum volume of water to maintain the agricultural sector. If water for agricultural sector is the maximum usage follows the agricultural plan, the water demand for agricultural sector will reach to 313.58 MCM. Lam Ta Kong Watershed has exceeded the water budget of the watershed at 188.64 MCM. So it’s necessary to manage water demand and water budget in Lam Ta Kong watershed to avoid the water shortage problem from economic development which may lead to water conflict among sectors in the watershed.

The water situation in the developed condition

From the study, we found that the economic development pattern caused the water shortage in Lam Ta Kong Watershed. For spatial development without water shortage,
the pattern of developed area and water usage in Lam Ta Kong Watershed was analyzed by using water balance equation. The water situation was divided into 9 water scenarios. The water situations in all scenarios in Lam Ta Kong Watershed are shown in Table 3.

Table 3: The water situations in the developed condition

<table>
<thead>
<tr>
<th>Water Scenario</th>
<th>Inflow</th>
<th>Outflow</th>
<th>Water usage</th>
<th>Water situation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MCM</td>
<td>MCM</td>
<td>MCM</td>
<td>MCM</td>
</tr>
<tr>
<td>WS1</td>
<td>86.30</td>
<td>83.64</td>
<td>165.28</td>
<td>Shortage -81.64</td>
</tr>
<tr>
<td>WS2</td>
<td>86.30</td>
<td>83.64</td>
<td>443.04</td>
<td>Shortage -359.40</td>
</tr>
<tr>
<td>WS3</td>
<td>86.30</td>
<td>83.64</td>
<td>300.81</td>
<td>Shortage -217.17</td>
</tr>
<tr>
<td>WS4</td>
<td>477.28</td>
<td>355.59</td>
<td>443.04</td>
<td>Shortage -87.45</td>
</tr>
<tr>
<td>WS5</td>
<td>477.28</td>
<td>355.59</td>
<td>165.28</td>
<td>Normal 190.31</td>
</tr>
<tr>
<td>WS6</td>
<td>477.28</td>
<td>355.59</td>
<td>300.81</td>
<td>Normal 54.78</td>
</tr>
<tr>
<td>WS7</td>
<td>251.00</td>
<td>215.29</td>
<td>300.81</td>
<td>Shortage -85.52</td>
</tr>
<tr>
<td>WS8</td>
<td>251.00</td>
<td>215.29</td>
<td>443.04</td>
<td>Shortage -227.75</td>
</tr>
<tr>
<td>WS9</td>
<td>251.00</td>
<td>215.29</td>
<td>165.28</td>
<td>Normal 50.01</td>
</tr>
</tbody>
</table>

Table 3 the water situation from the economic and spatial development by government plan in Lam Ta Kong Watershed. Calculation of water scenarios found that Lam Ta Kong Watershed has almost of 6 situations water shortage. The critical water shortage has 1 situation (water demand exceed the water budget of the watershed). Lam Ta Kong Watershed doesn't have water shortage in 3 situations. The first situation is WS5, where the water inflow and water outflow are the maximum volumes and the water usage is the minimum. The second situation is WS6, where the water inflow and water outflow are the maximum volumes and the water usage is the average. The third situation is WS9 which the water inflow and water outflow are the average volume and the water usage is the minimum. The Lam Ta Kong Watershed doesn't have the water shortage condition when the total water usages are only the minimum use or the average use.

**CONCLUSION**

Although, Thailand is not classified as a water scarce country, water shortage is commonly reported in Thailand. Lam Ta Kong Watershed is sub-basin of Mun Basin, is the important economic development area in Thailand. The area is rapidly developed by the NESD plan covers the agricultural, industrial, and commercial and services sectors. This development results in increasing water demand in each sector, since Lam Ta Kong Reservoir is the only...
water resource in the watershed and it has to support all activities in five districts of Lam Ta Kong Watershed.

The study showed that, the amount of water consumption the present is more than the amount of the average water inflow, to the reservoir, so it caused the water shortage in Lam Ta Kong Watershed. Calculation the water balance of Lam Ta Kong Watershed found that, the amount water usage that exceeded water budget was 33.78 MCM.

From the study, it can be concluded that the Lam Ta Kong Watershed has faced the serious water crisis in the last decade and the water shortage will still occur in the future situation. The problem of water availability along with increasing water demand over the years makes water resource management in Thailand an important issue. Therefore, Lam Ta Kong Watershed doesn’t have shortage when the total water usage is the minimum use (165.28 MCM.) or the average use (300.81 MCM.). It means the Lam Ta Kong Watershed cannot develop economic only by government plan especially in agricultural sector. So it is necessary to manage the water demand and the spatial development in the watershed.

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