Making choices in the water allocation for the Lam Pao Reservoir Kalasin by Analysis Hierarchy Process

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Abstract: This study aimed to make a choice in the allocation water on shortage condition. An economic management, allocate reliability for all water uses, a compromise on water use activities of balance for supply and demand were considered in study process in order to reduce water shortage during insufficient condition. These choices were made for administrative authority using in decision support and decision making on the water allocation from the Lam Pao reservoir, Thailand. These three criterions of the economy, equity and reliability were created to analyze for determining the best choice from eight made choices. The analysis hierarchy process was used for analysis process. The priority criterion for water allocation was ranked as economy of 41.26%, equity of 33.79% and reliability of 24.95% respectively. The highest priority consist of the reduction of irrigation area 3% (1,277.60 hectares) reduction of aquatic farm area 3%, (35.68 hectares) and reduction the amount of water to maintain ecological balance of 3% (0.39x10^6 m^3/month).

Key words: Water allocation, Reservoir operation, Participation in water resource management, Analysis Hierarchy Process

INTRODUCTION

In the fact that water resources are necessary for creatures in the world and even humans need water in order to survive as a matter of factor. Water is almost a serious issue every year because of flooding. Certainly, the amount of water is excessiveness from various sources and hardly responds the demand of water supply including the issues of waste water or even contaminant problems. In particular, the flood disaster and water shortage issues are interesting issue of water quantity and time on causes and effect of flooding in public and environment. Thus, many conventional measures provide reservoir management regarding to floods and water shortages. It maximizes the benefits of reservoir management within technical and constraints and opportunities (Kangrang and Compliew, 2010).

According to recent research, it focuses on reservoir management because of climate, nature and human actions. It considers on frequency and magnitude of floods and drought each year that regulation in the reservoir would have to change (Panahi, et al., 2009; Daniel, et al., 2001). Therefore, it considers the issues involving in the reservoir system. The concept of integrated management focuses on water service equity in benefits of water supply which is reasonable in the term of time to achieve the most efficient and ecologically sustainable.

The management of the reservoir relies on variability of the data at all times. There is no certain solution because of the dynamic problems, so it should provide integrated management with efficient process e.g. human resources, reservoir system and equipment (Vaidya and Kumar, 2006). Complete system supports a balance between water supply and demand in the policy of water allocation regarding to the satisfaction of all parties.

Water allocation is divided into the appropriate quantity to the cultivated area by the time and agriculture needs in order to reduce water lost for more efficient irrigation. The important factor is that staffs must have sufficient knowledge, water management, monitoring and evaluation. Irrigation systems are designed in construction to comply with conditions in the field and adequate maintenance (Srdjevic, et al., 200).

Establishing criteria of water allocation is in many rules and conditions through calculation of water mass for many activities in the irrigation water for agriculture (crops, plants, vegetables, etc.) and water consumption for industry, the environment. Consequently, the prioritization of water supply set in the weighting of objectives which the function is related to the amount of costs at a time through analysis. Analysis Hierarchy Process (AHP) analyzes the sequence of tactic. This process applies in "Measurable Levels" of the decision on various matters. Effectively, it expresses the right decision in the objective as much as possible. The AHP technique of solving problem explicitly recognizes and incorporates the knowledge and expertise of the participants in the priority setting process making use of their subjective preferences. AHP model deals with prioritizing of decision making by reducing complex decisions to a series of pair wise comparisons and then synthesizing the results. AHP is one of multi-criteria decision making methods based on mathematics and psychology, originally developed by Prof. Thomas L. Saaty in the 1970s (Saaty, 1980; Saaty, 2000; Saaty, et al., 2003). AHP is a...
A complex decision-making structured technique provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions (Gandpa, et al., 2011). The hierarchical structure of the AHP model is presented in Figure 1.

**Fig.1:** Hierarchical structure of the AHP model.

It considers that the weighting of objectives provides with participants in the public sector, stakeholders in the area (water suppliers) which are presented in the policy of storage management through regulations in a demand for water activities. Highlights of the analytic hierarchy process (Qureshi, and Harrison, 2003; William, 2008) are as follows.

- The survey results are more reliable than other methods in a comparison with data in order to make decisions before practice.
- There is a hierarchical structure to mimic human processes which is easier for application and understanding.
- The certain result is as numbers to prioritize efficiently. It also uses to compare with the results (Benchmarking) and other agencies.
- It drives the elimination of prejudice or bias decisions away.
- It works with both the single and the group or groups.
- It leads to compromise and builds consensus.
- There is no need for specialists to take control.

A recent evaluation of the AHP method can apply in multi-criteria decision for the allocation of water in shortage condition in the several countries (Ibrahim, et al., 2011; Norouzi, et al., 2011). In addition, it grants the crisis of water holds in major benefits. Then, fairness and reliability are in the second concern. However, the allocation of water in the state of water shortage is not enough. It shows the participation of local people in the organization.

Therefore, this study purposes to the making choice in the allocation water on shortage condition. An economic management, allocated reliability for all water uses, a compromise on water use activities of balance supply and demand will be considered in study process in order to reduce water shortage during insufficient water. These choices were made for administrative authority using in decision support and decision making on the water allocation from the Lam Pao reservoir, Thailand. These three criterions of the economy, equity and reliability were created to analyze for determining the best choice from eight choices.

**MATERIALS AND METHODS**

**The Study Area:**

AHP is a more effective decision-making process. Start with the "importance" of the criteria used in decision for "Weighting" of each of the pre-post measurement as the "choice" to have all of the above criteria. The priority of each choice is in the research as follows (1).

1. Education statistics data for the monthly runoff which flows into the reservoir during the 40 years in 1968 – 2007. The demand for water is in many activities such as consumer, industrial, irrigation, livestock, and aquaculture. Assessment report in environmental impact, the projects enhance water storage reservoir in Lam Pao, Kalasin province, Thailand (Irrigation Department 2011).
2. Cooperating with authorities that are competent to manage the water in the reservoir which consists of the chief of general Lam Pao, the head of irrigation in the agricultural area in public and the area of organization. The location of the Lampao reservoir and irrigation project is shown in Figure 2.
3. It studies costs and financial return per acre of agricultural production and aquaculture.
4. A hierarchical analysis (the hierarchy structure) analysis to determine the best choice in allocation between different types of water activities.

![Figure 2: Location of the Lampao Reservoir and Irrigation Project](image)

**RESULTS AND DISCUSSION**

The purpose of this study aims to analyze the choice of the water reservoir in Lam Pao, Kalasin, Thailand. It uses the Analysis Hierarchy Process, AHP. Consequently, the analysis is divided into a hierarchy as shown in Figure 3.
1. Goal of this research is to study the runoff flowing into the reservoir with small quantities which it is efficient for the irrigation in each season, while, it could cause water shortages in drought conditions. This goal of the process, it is to analyze the allocation under shortage.
2. Criteria concern the factors that affect the success of management in irrigation.
   2.1 The development of the economy which is used to ensure accuracy and improve productivity. Especially, crops are suitable for climate and soil condition in order to reflect the view of cost and financial return.
   2.2 The equity is as social justice for the collaborative efforts of the organization's equity and fairness, but only among those with an interest in sustainability.
   2.3 Reliabilities are the performance of water supply and irrigation systems that plan for allocation including implementation, evaluation, operations, analysis and improvements.
3. Choices are to analyze and select the option for a decision based on environmental impacts. In the projects, it improves the storage of reservoir Lam Pao. The demand shows for water supply in 2008 as follows.

<table>
<thead>
<tr>
<th>Consumption</th>
<th>19.284 million cubic meters / year.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>17.340 billion cubic meters / year.</td>
</tr>
<tr>
<td>Livestock</td>
<td>1.088 million cubic meters / year.</td>
</tr>
<tr>
<td>The aquaculture</td>
<td>104.844 million cubic meters / year.</td>
</tr>
<tr>
<td>Irrigation</td>
<td>959.400 million cubic meters / year.</td>
</tr>
</tbody>
</table>

The study found that water shortage mainly occurs in the dry season and the demand for water supply affects the allocation of water in drought, especially in the aquaculture and irrigation.

There is an economic report in Kalasin Province during 2011 and 2012, no. 3/2011 and no. 4/2011 and demand of irrigation in 2012. Additionally, the expansion of the agricultural sector (API) in 2.8% and 4.8% respectively, resulting from space constraints and increasing costs.

The return is in irrigation area of aquaculture of 22,000 baht / acres, (1 US$ = 31 baht) irrigation (rice) of 3,100 baht / acres.

From the above information, choice takes into account of the total GDP in Kalasin as a major limitation in the area of aquaculture and irrigation (rice), the public accept a number of options including 8 choices, the hierarchical structure of the AHP model for Lampao Irrigation Project are presented in Figure 3.

1. Reduce the amount of water.
   - Agricultural area 3%
   - Aquaculture area 3%
   - Ecological balance 3%

2. Reduce the amount of water
   - Agricultural area 3%
   - Aquaculture area 3%
   - Maintain the ecological balance for reduction of water allocation 6%

3. Reduce the amount of water
   - Agricultural area 3%
   - Aquaculture area 6%
   - Ecological balance for reduction in water allocation 3%

4. Reduce the amount of water
   - Agricultural area 3%
   - Aquaculture area 6%
   - Maintain the ecological balance of reduction in water allocation 6%

5. Reduce the amount of water
   - Agricultural area 6%
   - Aquaculture area 3%
   - The ecological balance for reduction in water allocation 6%

6. Reduce the amount of water
   - Agricultural area 6%
   - Aquaculture area 3%
   - Maintain the ecological balance for reduction in water allocation 6%

7. Reduce the amount of water.
   - Agricultural area 6%
   - Aquaculture area 6%
   - The ecological balance for reduction in water allocation 3%

8. Reduce the amount of water.
   - Agricultural areas 6%
   - Aquaculture area 6%
   - Maintain the ecological balance for reduction in water allocation 6%.
Fig. 3: Hierarchical structure of the AHP model for Lampao Irrigation Project.

The weights assigned to the choices with respect to each of the criteria are shown in Table 1, the significant weight of each choice is revealed in figure 4. When arranged economy by weight, the results found that choice 1 ranked highest with a priority of 0.2736, followed by choice 5 (0.1824) and choice 7 (0.1797). It indicates that in case of reducing the amount of water, ecological balance is the first priority following by the reduction in water allocation and the ecological balance for reduction in water allocation respectively. With regards to equity arranged by weight, the results shown that choice 1 ranked highest with a priority of 0.4080, followed by choice 5 (0.2161) and choice 2 (0.1703). It shows that in case of reducing the amount of water, aquaculture area is the first priority following by the reduction in water allocation and the ecological balance respectively. In the case of reliability choice 1 is given the highest priority with a weight of 0.3580, and choice 2 with 0.2259 and choice 5 of 0.1800. It presents that in case of reducing the amount of water, aquaculture area is the first priority following by the ecological balance and the reduction in water allocation respectively.

<table>
<thead>
<tr>
<th>Choices</th>
<th>Economy</th>
<th>Equity</th>
<th>Reliability</th>
<th>Significant Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2736</td>
<td>0.0408</td>
<td>0.3580</td>
<td>0.3401</td>
</tr>
<tr>
<td>2</td>
<td>0.1569</td>
<td>0.1703</td>
<td>0.2259</td>
<td>0.1786</td>
</tr>
<tr>
<td>3</td>
<td>0.0961</td>
<td>0.0155</td>
<td>0.0155</td>
<td>0.0488</td>
</tr>
<tr>
<td>4</td>
<td>0.0438</td>
<td>0.0181</td>
<td>0.0000</td>
<td>0.0242</td>
</tr>
<tr>
<td>5</td>
<td>0.1824</td>
<td>0.2161</td>
<td>0.1800</td>
<td>0.1932</td>
</tr>
<tr>
<td>6</td>
<td>0.0634</td>
<td>0.0674</td>
<td>0.0728</td>
<td>0.0671</td>
</tr>
<tr>
<td>7</td>
<td>0.1797</td>
<td>0.0399</td>
<td>0.1228</td>
<td>0.1183</td>
</tr>
<tr>
<td>8</td>
<td>0.0000</td>
<td>0.0648</td>
<td>0.0251</td>
<td>0.0281</td>
</tr>
</tbody>
</table>
Fig. 4: Significant weight of each choice

**Conclusion:**

The research found that analysis provided the choice of the water reservoir in Lam Pao, Kalasin, Thailand. It has eight choices on the basis proportion of return and GDP in the area in Lam Pao Irrigation Project and the public participates into account the economic interests and return based on equity and confirmation. The result are appropriate for the water allocation in three parts in 26.5% in order to reduce the amount of water in the area of agriculture 3% about 7,985 acres (report of crop in dry season, 2011/2012 for 266,186 acres) with return of 24,755,298 baht (1 US$ = 31 baht), aquaculture 3% about 223 acres (report of crop in dry season of 2011/2012 of 7,438 acres), representing a return of approximately 4,909,080 baht and reduce the amount of water to maintain ecological balance by 3% about 0.39 million cubic meters. AHP analysis results show that water in the quantitative state of small reservoir. It focuses on economy of 41.26%, equity of 33.79% and reliability of 24.95% respectively that it shows the attitude of the staff and capacity of reservoir management.

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**REFERENCES**


