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Evaluating the Irrigation Efficiency using Rapid Appraisal Process Technique (RAP) in a Large Scale Irrigation, Case Study: Mae Lao Operation and Maintenance Project and Chiang Rai Irrigation Project, Thailand

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The purpose of this research was to evaluate the irrigation efficiency using Rapid Appraisal Process technique (RAP) in a large scale irrigation in order to propose the improvements on water distribution system for the Mae Lao operation and maintenance project and the Chiang Rai irrigation project as a case study.The irrigation projects in Thailand play the important role in agriculture which can be harvested twice a year. However, in order to irrigate water to the targeted areas as planned, there are many problems such as water deficit, staff shortage in irrigation operation, broken irrigation structures, water distribution management and conflict between upstream and downstream water users. As mentioned, the irrigation project cannot achieve the objective of water distribution. Therefore, the evaluation for the rrrigation efficiency is required and the RAP technique is used to evaluate the irrigation efficiency of the Mae Lao operation and maintenance project and the Chiang Rai irrigation project.
It was found that the Chiang Rai irrigation project (74%) had more efficient in irrigation than the Mae Lao operation and maintenance project for 183%. The main cause of the irrigiation inefficiency of the Mae Lao operation and maintenance project is the irrigated water did not meet the water users' requirement while the problems of the Chiang Rai irrigation project were the fairness of irrigated water between upstream and downstream irrigation areas and broken irrigation structures.

Keywords: Evaluation for Irrigation Efficiency, Rapid Appraisal Process, Evaluating for Large Scale Irrigation

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Introduction

The irrigation projects in Thailand play the important role in agriculture which can be harvested twice a year if the available water for irrigation is sufficient. However, in order to irrigate water to the targeted areas as planned, there were many problems (see in Figure 1) such as water deficit, staff shortage in irrigation operation, broken irrigation structures, water distribution management and conflict between upstream and downstream water users (Burt, 1998). As mentioned, the irrigation project cannot achieve the objective of water distribution.

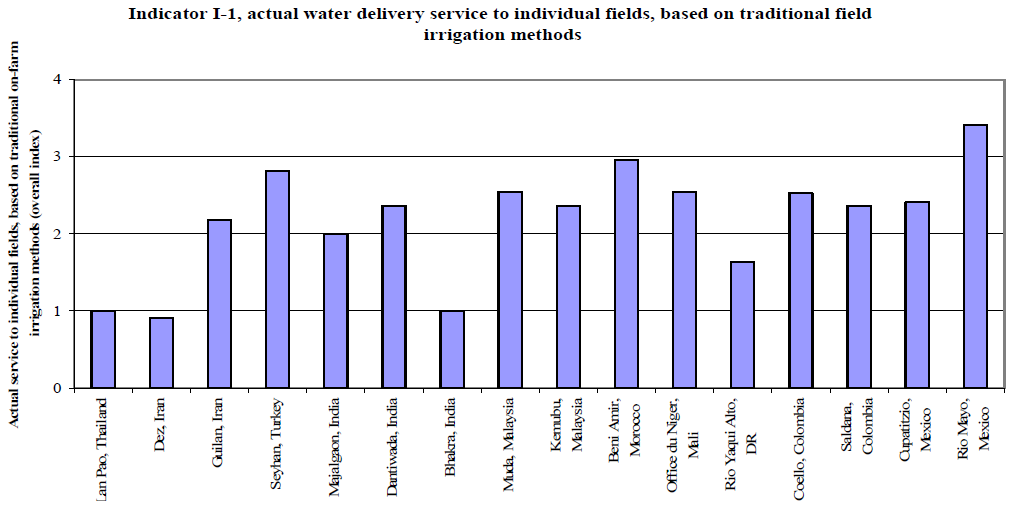

Figure 1. Actual water distribution to individual fields of sixteen irrigation prjects

In order to evaluate the irrigation efficiency by manual technique in the large scale irrigation, its evalutation provides the high accuracy but this technique requires a lot of labors and high budget because of the expensive instruments for evalution and measuring discharge at all important points in the large scale irrigation (Burt, 2001). Therefore, the Rapid Appraisal Process (RAP) technique is the better option for evaluating the rrrigation efficiency and this study will apply the RAP technique to evaluate the irrigation efficiency of the Mae Lao operation and maintenance project and the Chiang Rai irrigation project as the case study.

The RAP is a technique for evaluating the achievement of water distribution in the water supply system (Burt, 2001). This technique has been used to evaluate the irrigation projects in Thailand to identify the current irrigation efficiency and the problems on water distribution in order to manage and improve the irrigation system.

Objectives: to evaluate the irrigation efficiency using Rapid Appraisal Process (RAP) technique in a large scale irrigation in order to propose the improvements on water distribution system for the Mae Lao operation and maintenance project and the Chiang Rai irrigation project as a case study.

Materials and methods

Study area

Most irrigation projects in Thailand were designed to provide full command areas during wet season as supplemental irrigation water. Most water distribution problems were found and occurred during dry season and it becomes worse in large scale irrigation projects. Therefore, in this study, the irrigation efficiency in a large scale irrigation project is focused in dry season and the Mae Lao operation and maintenance project and the Chiang Rai irrigation project are the study area as the sample of the large scale irrigation projects.

The Mae Lao operation and maintenance project and the Chiang Rai irrigation project locate in Chiang Rai province, the northern part of Thailand. These irrigation projects are the study area of this research, where is one of the large irrigation projects of the Royal Irrigation Department (RID) of Thailand.
The headwork of the Mae Lao operation and maintenance project is the Mae Lao weir, which constructed across the Mae Lao river since 1950. The type of the Mae Lao weir is an ogee weir with 2.50 m height and 30.50 m length. The maximum flow rate of the Right Main Canal (RMC) is 26.70 m^3/s and its distance is 49.48 km. On the other hand, the maximum flow rate of the Left Main Canal (LMC) is 8.532 m^3/s and its distance is 24.39 km. The irrigated area of this irrigation project is 29,440 ha. In 2011, the land use for agriculture was 23,734.88 ha. (see Figure 2). Most land uses were paddy fields and there were 18 groups of water users (Royal Irrigation Department, 2016) and (Wongtragoon and *et al.*, 2010).

The weir of the Chiang Rai irrigation project (see Figure 3) has 11 m width and 4 m. height. Its weir was constructed across over the Kok river. The distance of the RMC of the Chiang Rai irrigation project is 59.97 km covering the irrigable area for 6,880 ha with 16 groups of water users. The distance of the LMC is 37.69 km covering the irrigable area for 5,600 ha with 11 groups of water users (RID Royal Irrigation Department, 2016).

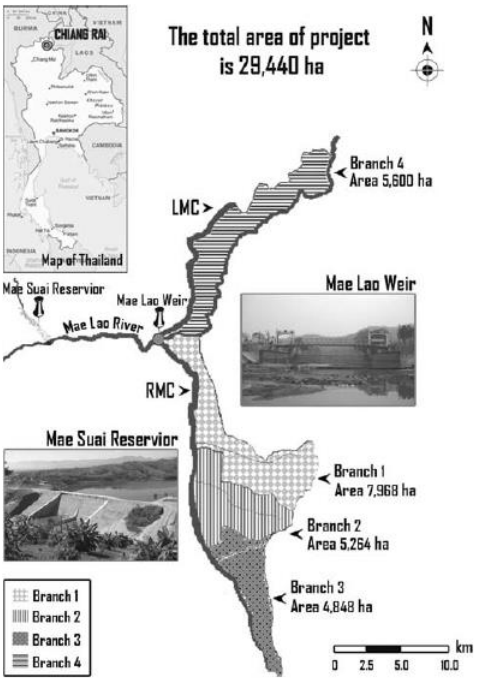

Figure 2. Map of Mae Lao operation and maintenance project

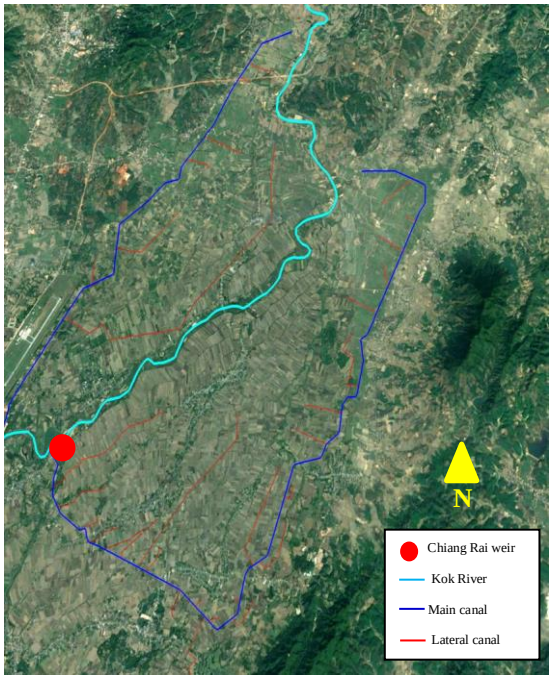

Figure 3. Map of Chiang Rai irrigation project

Methodology

Based on the Rapid Appraisal Process (RAP) technique, there are 5 steps; (1) collecting the relevant information from the RID officers such as irrigable area, irrigated area, discharge, landscape, budget and human resource, (2) interviewing during the field observation for more information, (3) evaluating the collected information, (4) analysing the information and providing the solutions and (5) validating and summerizing the information.

According to the RAP technique, Microsoft excel 2016 is applied (Irrigation Training and Research Center, 2001) for evalution including field observation and interview. In order to evaluate the irrigation efficiency by the RAP technique, there are 2 indicators; (1) the external indicators and (2) the internal indicators.The external indicator is to examine the inputs and outputs of the irrigation project system in order to clarify the outcomes of the irrigation projects. The outcomes of external evaluation are shown in terms of (1) maximum irrigation water requirement, (2) irrigation efficiency of irrigation project, (3) irrigation efficiency in the paddy field, (4) relative canal capacity, (5) actual discharge and (6) annual value of agricultural production. To improve the better result of the external evaluation, the internal indicators are used because the internal indicators monitor the water management process.The internal indicator is an indicator that can identify the internal problem of the irrigation project and the priority of the problem. The result of internal evaluation will lead to the improvement of the irrigation project. Mostly, the internal indicators consist of a sub-indicator, which has a weighting factor for each indicator (Irrigation Training and Research Center, 2001). There are 39 internal indicators and 122 sub-internal indicators.It is expected that the evaluation of the irrigation projects using the RAP technique is capable of identifying the irrigation efficiency while the internal performance of the irrigation projects can be clarified. Therefore, the sources of the problems on water distribution management in the irrigation project can be noticeable and the solutions for improving the irrigation efficiency of the irrigation project can also provide the service as Service Oriented Management (SOM) in order to meet the requirement of water users.

Results

According to the evaluation of the efficiency of the Mae Lao operation and maintenance project and the Chiang Rai irrigation project by using the RAP technique, the results of external and internal evaluation of both irrigation projects are described as below;

External evaluation

The use of water resources for water distribution of the Mae Lao operation and maintenance project in dry season (December 2016 – April 2017) was 50 MCM for 10,880 ha of irrigation area. On the other hand, the Chiang Rai irrigation project delivered 90 MCM of water during dry season (December 2016 – April 2017) for 10,671 ha of command area.

Table 1. Result of external evaluation of the Mae Lao operation and maintenance project and the Chiang Rai irrigation project during dry season (December 2016 - April 2017)

No.	External indicator	Mae Lao operation and maintenance project	Chiang Rai irrigation project	Unit
1	Maximum irrigation water requirement	0.008	0.008	**Litre/sec/rai**
2	Irrigation efficiency of irrigation project	106	55	**%**
3	Field irrigation efficiency	183	74	**%**
4	Relative gross canal capacity	0.31	0.33	-
5	Relative actual canal flow	0.56	0.37	-
6	**Total annual value of agricultural production**	**15.41**	**18.13**	**Million USD**

*Note: The percentage of irrigation efficiency should be between 1-100. If the percentage of the irrigation efficiency is over 100%, it indicates that water is shortage.

The results of external evaluation (as shown in Table 1) indicated that the irrigation efficiency of the Mae Lao operation and maintenance project was 106%, which was worse than the irrigation efficiency of the Chiang Rai irrigation project (55%). Moreover, the field irrigation efficiency of the Mae Lao operation and maintenance project was poor (183%), which was doubled over the Chiang Rai irrigation project (74%). The main cause of poor irrigation system in the Mae Lao operation and maintenance project was water deficit and lost water during irrigating water as broken irrigation structures (as shown in Figure 4). However, the total annual value of agricultural production from both irrigation projects were not much different.

Figure 4. Broken right main canal of the Mae Lao operation and maintenance project

Internal evaluation

The internal evaluation of the irrigation projects using the RAP technique consisted of two categories; (1) service and social order and (2) irrigation system capability.

The internal evaluation of service and social order

According to the results in Table 2, there were all 7 internal indicators indicating the capability of service and social order of both irrigation projects. These internal indicators mainly focused on irrigated water and water distribution plan at each paddy field, the downstream area and the main canal. In overall, for the Mae Lao operation and maintenance project, its service and capability was worse than the Chiang Rai irrigation project. Particularly, the service and social order in terms of the irrigated water at the downstream area of the Mae Lao operation and maintenance project was very poor. On the other hand, the service and social order in terms of the water distribution plan at the main canal of the Chiang Rai irrigation project was the highest score.

The results showed that the service for irrigating water at the main canal of both irrigation projects were similar while the irrigation capability of the Mae Lao operation and maintenance project in terms of irrigated water in each paddy field and wateter distribution plan at the downstream area was worse than the service of the Chiang Rai irrigation project.

Table 2. Result of internal evaluation of the service and social order at the Mae Lao operation and maintenance project and the Chiang Rai irrigation project during dry season

No.	Internal indicator	Mae Lao operation and maintenance project	Chiang Rai irrigation project
1	Irrigated water at each paddy field	1.1	2.0
2	Water distribution plan of irrigation project targeting for each paddy field	2.0	2.2
3	Irrigated water at the downstream area of irrigation project	0.8	1.5
4	Water distribution plan at downstream area of irrigation project	1.6	2.7
5	Irrigated water at the main canal	1.8	2.0
6	Water distribution plan at the main canal	2.0	3.6
7	Operating of irrigation project under the regulations or rules	2.0	2.3

The detail of internal evaluation of service and social order was as for each paddy field shown in Figure 5. It can be seen that both irrigation projects did not measure the amount of water in each paddy field due to the deficit of measuring tools and human resource. For the flexibility, the reliability and the equity of water distribution, the Chiang Rai irrigation project had better scores than the Mae Lao operation and maintenance project.

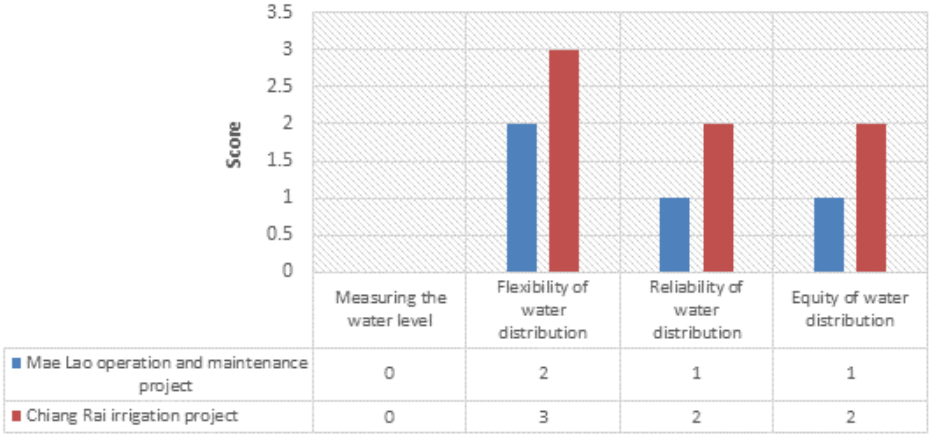

Figure 5. Scored level of the service and social order in the paddy field (range 0 – 4 score)

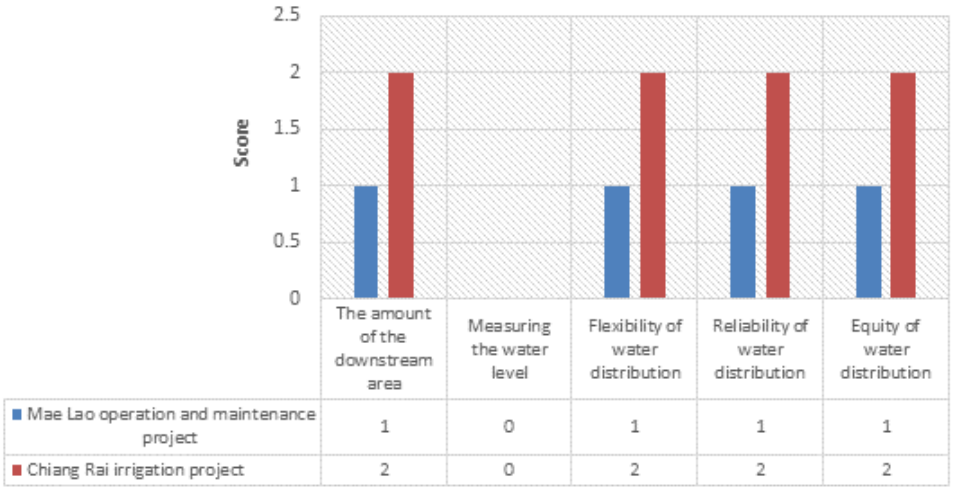

Figure 6. Scored level of the service and social order at the downstream area

In Figure 6, the water distribution at the downstream area of the Chiang Rai irrigation project was able to irrigate more than the Mae Lao operation and maintenance project. This was because the downstream areas of the Mae Lao operation and maintenance project had a problem of water shortage and the water distribution was unpredictable.

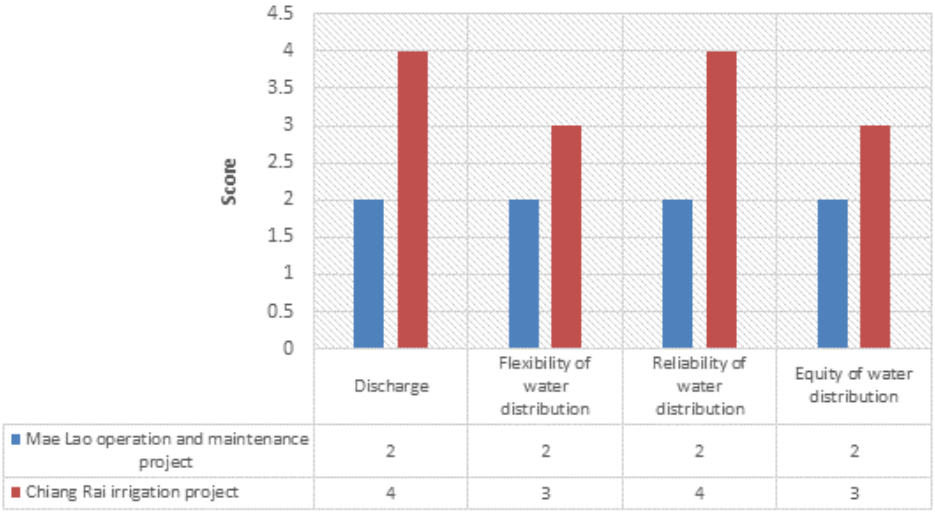

Figure 7. Scored level of the service and social order at the main canal

In Figure 7, the water distribution in a main canal of the Chiang Rai irrigation project had higher capacity than the Mae Lao operation and maintenance project because the Mae Lao operation and maintenance project

found the problems such as unsteady of discharge, conflict of water use, sediment in a main canal.

The internal evaluation of irrigation system capability

According to the internal evaluation of irrigation system capability, it was found that the system capability of the Mae Lao operation and maintenance project (1.96 scores) should be improved while the system capability of the Chian Rai irrigation project was good (2.30 scores). However, in both irrigation projects, the irrigation system capability in budget, officers and water users may cause the problems because of lowest scores.

Table 3. Result of internal evaluation of the irrigation system capability at the Mae Lao operation and maintenance project and the Chiang Rai irrigation project during dry season

No.	Internal indicator	Mae Lao operation and maintenance project	Chiang Rai irrigation project
1	Irrigation system capability at the main canal	1.85	2.20
2	Irrigation system capability at the lateral canal	1.88	2.16
3	Irrigation system capability in budget, officers and water users	1.36	1.56
Overall irrigation system capability		1.96	2.30

In detail, it can be seen that the irrigation system capability at the main canal (Figure 8) in both irrigation project had no the regulating reservoirs in the main canal. There were the diffences in the water distribution at lateral canal, communication, general condition and water controlling between the Mae Lao operation and maintenance project and the Chiang Rai irrigation project. The Chiang Rai irrigation project had the better scores than another. It was because the Chiang Rai irrigation project can irrigate water into most lateral canals with communiting to the water users on the water distribution and its irrigation structures were maintained. Moreover, the situation of the irrigation system capability at the lateral canal had the similar results of the irrigation system capability at the main canal.

For the irrigation system capability on maintenance and workability of headwork and irrigation structure in both irrigation projects, Figure 9 showed that the maintenance and workability of headword and irrigation structure of the Chiang Rai irrigation project was better than the Mae Lao operation and maintenance project. According to the observation, the irrigation structures of

the Mae Lao operation and maintenance project were damage and filled with sediment.

Figure 10 showed that the budget and water user of both irrigation projects were similar while the Mae Lao operation and maintenance project lacked the officers to operate the irrigation system. It became worse because the Mae Lao operation and maintenance project has the irrigation areas more than double of the irrigation area of the Chiang Rai irrigation project.

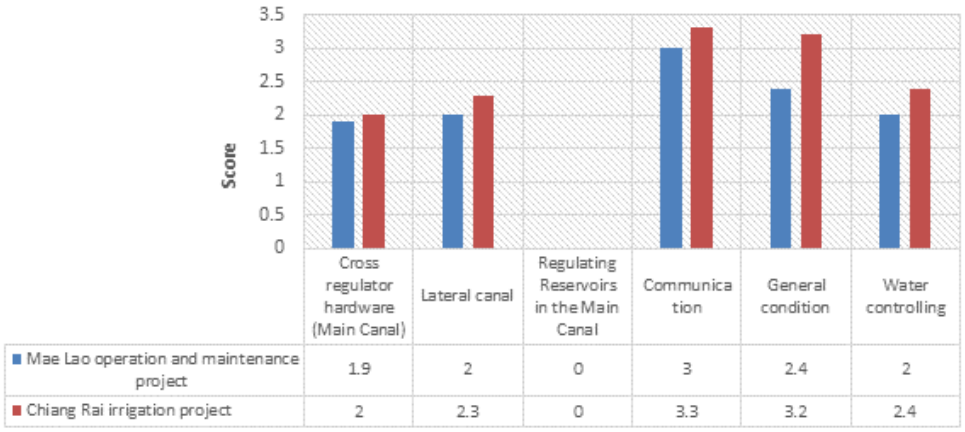

Figure 8. Scored level of the irrigation system capability at the main canal (range 0 – 4 score)

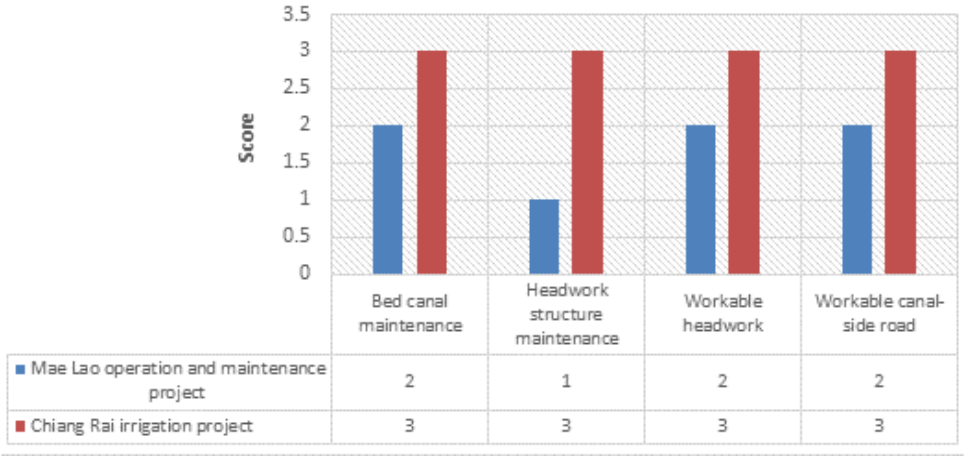

Figure 9. Scored level of the irrigation system capability on maintenance and workability of headwork and irrigation structure (range 0 – 4 score)

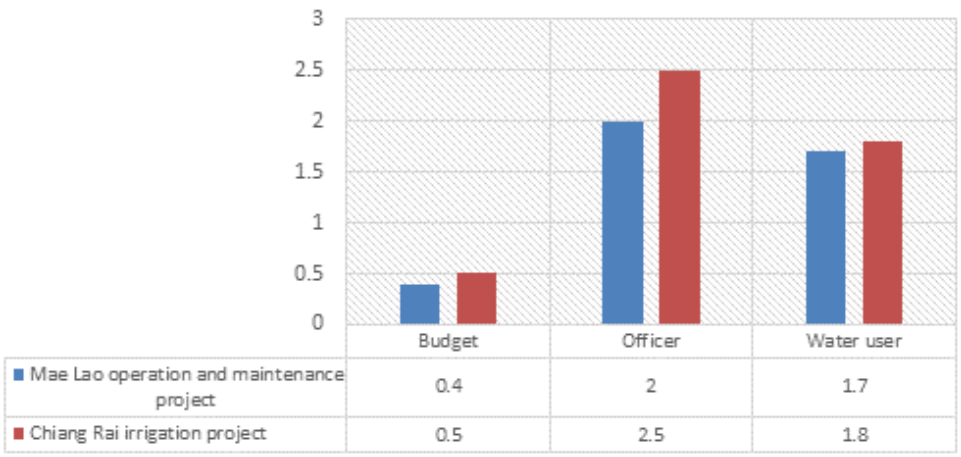

Figure 10. Scored level of the irrigation system capability on budget, officer and water user (range 0 – 4 score)

Discussion

As the literatures about the evaluation of the irrigation efficiency has been reviewed, the Rapid Appraisal Process (RAP) technique is the better option for evaluating because the evaluation by manual technique consumes much resources such as the special tools for measuring discharge, labors and budget (Burt, 2001). The RAP technique is capable of the external and internal evaluation for the irrigation project. The RAP technique was used to evaluate the operation management of the irrigation system and the capability of the automatic control structures of water distribution (Soteyome and Wudhiwanich, 2008), (Soteyome and *et al.*, 2009) and (Soteyome and *et al.*, 2010). The evaluation by using the RAP technique was also used to provide the solution for improving the water distribution management for some part of its irrigation system of the irrigation project and for the small irrigation project (Yenjai, 1997), (Ongcharoensuk and Kwanyuen, 2003) and (Lorite, Mateos and Fereres, 2004). However, the irrigation efficiency of the large scale irrigation project by using the RAP technique to evaluate a whole irrigation system was not tangible. Therefore, in this study, there is the opportunity to study the capability of the RAP technique in the whole irrigation system evaluation for the irrigation project and the irrigation system comparision between two irrigation projects is conducted to verify the accuracry of the RAP technique.

The irrigation system of the Mae Lao operation and maintenance project and the Chiang Rai irrigation project were evaluated by the RAP technique. In the whole irrigation system of these two irrigation projects, there are two main canals (the right main canal and the left main canal).

The Mae Lao operation and maintenance project provides water for irrigation about 29,440 ha. for 18 groups of water users while the Chiang Rai irrigation project provides water for irrigation about 12,480 ha. with 27 groups of water users.

According to the results of the external evaluation, the Mae Lao operation and maintenance project had overall irrigation efficiency (106%) less than the Chiang Rai irrigation project (55%) as well as the irrigation efficiency in the paddy field. Moreover, the capability in the service and social order, and irrigation, which indicated the internal efficiency, clarified the poor capability of the Mae Lao operation and maintenance project in detail.

The main causes of the poor irrigation efficiency of the Mae Lao operation and maintenance project were (1) non-maintenance and damage irrigation structures such as headwork, gates, control structures, main canals and lateral canals, (2) less communication with the water users, (3) lack officers and (4) the large amount of irrigation area. These causes lead to flexible of water distribution, water deficit and inequity of water distribution.

As a result, the irrigate efficiency of both large irrigation projects was identified by the RAP technique. To improve the irrigation efficiency of the Mae Lao operation and maintenance project, the chief of water distribution or the director of the irrigation project should consider the mentioned main causes as the first priority for making the decision and solutions and the service oriented management (SOM) may be the guideline of improvement.

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