Comparative study of Infrastructure Asset Management (IAM) between Papah irrigation areas in Indonesia and Cu-Chi irrigation areas in Vietnam

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Abstract. Infrastructure Asset Management (IAM) is implemented to overcome problems in the management of the agricultural sector. For example, in this study, the 2 research areas had similar problems, namely the poor water supply system in which the amount of water supplied did not match the initial design. To overcome this problem, IAM implementation in these two areas focuses on Integrated Water Resource Management. The objective of this implementation is that the ratio between the amount of water distributed and the one designed is close to 1 or the same. Based on the research results shown after implementing this IAM this problem was resolved. However, Cu-Chi Irrigation Area is still experiencing problems in the financial sector because the income from the sale of water supply is still far from the initial supply price. Whereas in Papah Irrigation Area this financial problem can be resolved with the implementation of the Irrigation Service Fee (ISF) and better management of the management company. Seeing this result, this ISF system can be applied to DI Cu-Chi to overcome the imbalance problem between the costs incurred for water supply and the revenue from the sale of the water.

Keyword: Infrastructure Asset Management, Irrigation Service Fee, Integrated Water Resource Management, Water Supply

1. Introduction
Agriculture is one sector that is very important for the survival of a country. From this agriculture, various kinds of food commodities are produced which are used for the survival of the country's people. To support agricultural activities, good management is needed. Management needs to be done in various aspects of agricultural activities. If management is not carried out properly, there will be disturbances or obstacles that affect agricultural activities that occur. This is common in developing countries around the world including Indonesia and Vietnam. This study tries to compare the problems experienced by irrigation management in developing countries in Indonesia and Vietnam. The Papah Irrigation Area was used as a sample study for Indonesia and the Cu-Chi Irrigation Area for Vietnam. From the known problems, this study also tries to compare the form of Infrastructure Asset Management (IAM) implementation in the two study locations. The results of this comparative study try to develop the advantages of implementing IAM in each location to solve the problems and obstacles of existing agricultural activities.
2. Literature Study

In the previous section, it has been explained that agricultural activities require good management, both from the implementation system, the regulation of the number of tools and their use, the management of the financial system, and other things. The management system implemented is included in the Infrastructure Asset Management (IAM). IAM is a structured process for planning investments in infrastructure on a sustainable basis, to provide reliable services. The main purpose of having an IAM is intended to maximize the profit earned (i.e. return on investment) through trading, services, or expanding assets [1]. IAM in the irrigation sector has similarities and differences with the water industry in England. The similarities are:

- There are many systems and assets
- The asset operates as a hydraulically definable system
- Asset can be rated condition
- Individual assets perform their assigned functions
- A fee model can be prepared
- There are requirements for planning investments in the long term
- The system must provide services to customers
- The system is a geographic monopoly

while the differences include:

- System management plays a much more significant role in irrigation performance than is the case in the case of the water industry.
- Irrigation performance indicators are not easily well defined
- There are multiple performance levels defined for irrigation
- In customer service irrigation standards are often not defined

based on research that has been carried out the implementation of IAM in the field of irrigation can be carried out, it is just that there needs to be a modification of the IAM carried out for the water industry in the UK. The following is the implementation of IAM for the irrigation sector.

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**Figure 1. Overview of asset management planning for irrigation** [2]
3. **Main Problems**

In agricultural management, a good irrigation system is crucial. However, a good irrigation system alone does not guarantee proper agricultural management. There is a need for a support system to ensure proper agricultural management. In fact, in developing countries, agricultural management is still experiencing many problems. For example, the Papah Irrigation Area has problems in the form of poor water management wherein the tertiary plot ratio between the design flow and the available flow is below 0.5[2]. This shows that there is still a lot of water loss so that the tertiary plot of Papah Irrigation Area does not get an appropriate water supply. This can result in reduced agricultural yields. In addition, DI Cu-Chi in Vietnam also experienced the same problem [1]. This shows that the irrigation management problems experienced in developing countries are relatively the same. Therefore, it is necessary to conduct a study on the implementation of IAM in two irrigation areas in developing countries so that they can become examples of management, and hopefully, it can solve problems that exist in irrigation areas in other developing countries.

4. **Research Objectives**

In general, this study aims to study the problems experienced by Irrigation Areas in developing countries using Papah Irrigation Area in Indonesia and Cu-Chi Irrigation Area in Vietnam as examples. In addition, the study also aims to study the Infrastructure Asset Management (IAM) implemented in the two irrigation areas and compare them. The purpose of this comparison is to complement the implementation of IAM and become an example for other irrigation areas in developing countries.

5. **Infrastructure Asset Management (IAM)**

In the previous section, IAM was discussed. Infrastructure Asset Management (IAM) is a structured process for planning investments in infrastructure in a sustainable manner, to provide reliable services. Based on research conducted by the Institute of Irrigation Studies, University of Southampton, UK, there are several stages in implementing IAM in the irrigation sector, namely:

- Defining systems and functions;
- Stratified Random Sampling;
- Develop environmental, legal and development aspects;
- Assess system performance
- Studying Management and Operations
- Conduct an Asset Survey
- Conduct technical studies
- Create a cost model

5.1. **Defining systems and functions**

In making IAM, it is necessary to define the function of the existing irrigation system, for example, the main function of irrigation is to provide sufficient water both in quality and quantity when needed to meet crop needs. Meanwhile, the main function of the drainage system in irrigation is to drain excess water from the soil surface and the soil profile in a sufficient amount and time to match the plant water needs. These systems and functions need to be well defined so that the IAM can be implemented properly.

5.2. **Stratified Random Sampling**

Sampling is the process of selecting individuals from a larger population in a representative manner. A random sample was selected to avoid selection bias. In this case, the irrigation system is to be sampled. The steps required for SMP are these:

- the division of the study area into the appropriate system of units;
- classify systems (‘stratification’) according to their associated characteristics
• decide how many sample systems are needed and select them;
The main objective of conducting sampling is to simplify the research process where only one individual in each group/stratum can represent. So there is no need for all systems to be observed because it will take a lot of time and money.

5.3. Develop environmental, legal and development aspects
It is important to review the general context in which irrigation services operate to establish appropriate and comprehensive service standards, both current and future. Once established, this standard becomes a benchmark against which performance will be assessed. Therefore, this review must be carried out before a detailed investigation of the assets and systems can be carried out.

5.4. Assess system performance
In IAM it is very important to assess system performance, this is because the assessment of an IAM is successful or not based on the performance of the existing system. To assess performance, a parameter is needed, for example IAM implementation in Papah Irrigation Area uses the ratio between the design flow and the available flow to assess the success of IAM implementation in Papah Irrigation Area.

5.5. Studying Management and Operations
In IAM, the main component assessed is the performance of the infrastructure, assuming the management and operations are in good condition. However, it cannot be denied that the performance of an infrastructure depends directly on existing management and operations. Therefore, it is necessary to ensure that the performance of existing management and operations is good so as not to complicate existing infrastructure problems.

5.6. Conduct an Asset Survey
Part from the need to assess system performance, surveying existing assets is very important. This needs to be done to know the physical condition of the assets. Is there a need for replacement and others.

5.7. Conduct technical studies
Technical studies are at the core of IAM. From the input data carried out in the previous stage, it is collected and then reviewed. From the results of this study, we can determine what needs to be done to know what action needs to be taken.

5.8. Create a cost model
After completing all the steps above, a cost model for the actions taken can be created. So that it can be determined whether the action taken is economically / financially feasible or not.

6. Research Location
In the previous section, it was explained that this study used 2 study locations, namely Papah Irrigation Area and Cu-Chi Irrigation Area for a comparative study. This section will explain in general the location of each Irrigation Area.

6.1. Papah Irrigation Area (Source: Institute of Irrigation Studies, University of Southampton, UK 1995)
The Papah Irrigation Area is located in the Special Region of Yogyakarta [2]. It serves an area of 900 Ha west of Kali Progo. Water to irrigate Papah Irrigation Area taken from the Papah Weir which is located in Papah River. Kali Papah itself is a tributary of Kali Progo. The Papah Irrigation Area is one of the study locations for the results of capital investment to improve the performance of the irrigation system.
6.2. **Cu-Chi Irrigation Area**

The Cu-Chi Irrigation Area is one of the Irrigation Areas located in Vietnam [3]. In Vietnam, there are several irrigation systems for example the Cu Chi irrigation system in South Vietnam, Dan Hoai and La Khe in the Red River Delta in northern Vietnam. The location of each irrigation system is shown in Figure 3. Although within a country, each irrigation system has different systems, both water management systems, planting season, and financial management. This results in a unique irrigation management system and nothing is the same with one another.

In general, the Cu Chi irrigation system is located east of the canal branch of the Dau Tieng Reservoir in Tay Ninh Province. This system was built to supply irrigation to 12 extraction points covering 12,000 ha of rice fields in the northern part of Cu Chi Regency. To date, only 8,500 ha have been irrigated. The Main Canal has a length of 11 km, with a planned discharge of 14 m$^3$/s. The infrastructure of the irrigation system consists of more than 1500 concrete structures. In 1993 a canal was constructed to increase the irrigation area by 2500 ha. The soil in the Cu-Chi irrigation area has been partially affected by the effects of waterlogging and salination due to seepage. This resulted in damage to agricultural products on that part of the land. This area receives an average annual rainfall of 1861 mm of which 90% occurs in the rainy season. The rest of the season is dry, with only irregular rains. Low rainfall during the dry season makes irrigation indispensable for the cultivation of food crops.

7. **Problems in each Irrigation Area**

This section will explain in more detail the problems experienced by each irrigation area that is the study location. The problems discussed are not only concerning water supply but also concerning the management of the system and finance of the irrigation area.

7.1. **Papah Irrigation Area**

Based on a previous study by the Institute of Irrigation Studies, University of Southampton, UK, it was shown that the primary and secondary canals of the Papah Irrigation Area were doing quite well. This can be seen from the ratio of the actual flow to the design flow varies from 0.74 to 1. However, in the tertiary channel, there are several channels to the tertiary plot whose ratio is below 0.5. this
indicates a water loss of half occurred before irrigating the existing tertiary plot. Even so, the ratio between the irrigated area plan and the actual one is of good value. This is quite odd considering that the flow of water in the tertiary channel has lost, there should be some areas that do not receive water but the reality shows otherwise. This is due to the inconsistency of the management system of DI Papah.

7.2. Cu-Chi Irrigation Area

The problems that occur in DI Cu-Chi are almost the same as those in DI Papah, namely the inconsistency of water supply and poor management systems. This is shown in Table 1.

Table 1. Comparison of Supply Value and Water Demand for Cu-Chi Irrigation System

| Service Area | Winter-Summer 2001 | Summer-Autumn 2001 | Main-Monsoon 2001 | Winter-Summer 2002 |
|--------------|-------------------|-------------------|------------------|-------------------|
| 1            | 1.52              | 1.15              | 1.23             | 1.31              |
| 2            | 2.80              | 1.58              | 0.53             | 2.15              |
| 3            | 2.61              | 0.46              | 1.04             | 1.03              |
| 4            | 0.82              | 0.67              | 0.94             | 2.16              |
| 5            | 3.42              | 3.63              | 4.70             | 5.98              |
| 6            | 1.21              | 1.03              | 1.16             | 1.47              |
| 7            | 1.93              | 2.98              | 2.67             | 1.56              |
| 8            | 1.17              | 1.14              | 1.09             | 1.04              |
| 9            | 1.59              | 1.51              | 1.80             | 2.05              |
| 10           | 1.28              | 1.09              | 1.54             | 3.15              |
| 11           | 1.78              | 4.63              | 3.64             | 1.59              |
| 12           | 1.54              | 1.36              | 0.82             | 3.48              |
| 13           | 0.96              | 3.84              | 0.79             | 3.73              |
| 14           | 0.87              | 1.28              | 2.12             | -                 |
| 15           | -                 | -                 | -                | 4.43              |
| Average      | 1.68              | 1.89              | 1.72             | 2.51              |

It can be seen in Table 1 that, there is a tendency that almost all irrigated areas in various seasons supply water that is much greater than the amount of water required. This shows the wasteful use of water. Apart from the waste of existing water use, it is also necessary to look at the performance of the water structure in DI Cu-Chi as in Figure 3. Figure 4 shows the water balance in one of the Cu-Chi irrigation areas. It turns out that in one of the water channels to microsite 2 there is a considerable water loss. This can result in losses so it is necessary to maintain all water structures used. Apart from the problem of inconsistent water supply, there are also problems in irrigation area management.
Based on Figure 4, it can be seen that there is an imbalance between the costs incurred by the Irrigation Management Companies (IMC) as a Cu-Chi Irrigation Area management company and the income obtained from the water usage tariff. This shows the inability of IMC to manage the water supply from the Cu-Chi Irrigation Area. If the water supply can be balanced, the financial problems shown in Figure 5 can be resolved. Therefore it is necessary to apply IAM to Cu-Chi Irrigation Area.

8. IAM Implementation in the Study Area

8.1. Papah Irrigation Area
The implementation of IAM in the Papah Irrigation Area also experienced various problems as described in Table 2. However, from the implementation of IAM in the Papah Irrigation Area, it resulted in several instruments to manage Papah Irrigation Area so it is hoped that it can solve the problems in Papah Irrigation Area. The implementation of IAM in DI Papah is shown in Figure 5.
Table 2. Problems in Implementing IAM in Papah Irrigation Area

| Activities                  | Subject                                                                 | Explanation                                                                                                                                 |
|-----------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Stratification              | Specifies the system unit size for stratification/sampling              | The Irrigation Area classification method can be said to be unsatisfactory as an independent 'system'. The information available (e.g., maps) is insufficient. |
| Determine sampling criteria |                                                                         | The selection of criteria in the research process was made based on the information available and what characteristics were most visible in representing the differences between systems. |
| Irrigation System Performance Assessment | Performance indicator | Appropriate data for assessing 'service level' are lacking in both quality and quantity. Water Users' perceptions of what constitutes a 'good service' are hardly tested. |
| Engineering Studies         | Relating to the investment of each activity specifically with the performance benefits, how this adds up over time, and the costs of each activity | Previous research has tended to only consider the costs and benefits of the project as a whole without explaining each related element. |
| Cost Model                  | Net asset value (depreciation issue)                                     | A straight line (linear) relationship between the asset's 'condition' and its depreciable value is stated as an assumption for research.           |
| Estimating “Depreciation Life” for an asset consisting of several components with very different degrees of deterioration | In this study, the assumption of "Depreciation Life" is taken on the part that has the largest cost value. |
| Unit Cost specific to certain activities or assets |                                                                         | The cost data obtained is in its entirety so there is no information about the unit cost.                                               |
| OPEX / CAPEX relationship   |                                                                         | This type of interchange may be instinctively acknowledged by designers and operators, but quantification tends to be more difficult.           |
| Correlation of Asset values with existing quantity parameters |                                                                         | The correlation could not be determined because the information on costs was not detailed.                                                |
| The definition of the type of asset |                                                                         | An asset that has several functions is considered as one asset only                                                                       |
| Asset Condition Assessment  |                                                                         | Asset condition is assessed based on the condition of the individual components                                                          |
| Asset service capability assessment |                                                                         | The assessment is carried out not for each component but there is only one overall value                                               |
| Data collection form        |                                                                         | The forms that are made still have limitations and are not good enough                                                                 |
| IAM Implementation Strategic planning |                                                                         | The plans are carried out for 20 Years with a 5-year budget plan according to the water industry in the UK. This is not necessarily appropriate. |
| IAM Implementation Institutional Arrangements |                                                                         | This type of institution is not necessarily the most suitable for implementing this form of IAM so it needs a comparative study.          |
Figure 5 shows that to improve the performance of Papah Irrigation Area, four formulations are produced, namely:

- Irrigation Service Fee (ISF)
- Turnover / Privatization (PIK)
- Integrated Basin Water Resources Management
- Project Benefit Monitoring and Evaluation (PBME)

It is hoped that with the four formulations above, Papah Irrigation Area performance can be improved and the problems described in the previous section can be resolved, especially the existing management system management problems.

8.2. Cu-Chi Irrigation Area

Based on the problems discussed in the previous section, IAM is trying to be implemented in Cu-Chi Irrigation Area. One form of applying IAM to the Cu-Chi Irrigation Area to improve its performance is modeling the supply and demand for water in DI Cu-Chi using computer modeling. The following is a Cu-Chi Irrigation Area modeling scheme.
In addition to the DI Cu-Chi scheme data, this modeling requires data on the water entering and leaving the irrigation system. After the data is complete and processed, the result shows that there is an imbalance between the amount of supply and demand for water from Di Cu-Chi as shown in Table 3. From these results, a formulation is made to improve the performance of DI Cu-Chi. After modeling the alternative solutions, the results show that by using this solution, the ratio of water supply and demand will approach the value of 1, which means that the water supply equal the required needs. It is hoped that after implementing this alternative, financial problems can be resolved.

| Service Area | Supply:demand ratio |  |
|--------------|---------------------|-----|
|              | Continuous Flow     | Rotational Supply |
| 1            | 1.15                | -   |
| 2            | 1.18                | 1.21 |
| 3            | 1.12                | -   |
| 4            | 1.09                | 1.13 |
| 5            | 1.30                | 1.10 |
| 6            | 1.52                | 1.26 |
| 7            | 0.89                | -   |
| 10           | 1.33                | -   |
| 11           | 1.31                | -   |
| 12           | 1.13                | -   |
| 13           | 0.92                | -   |
| 14           | 1.30                | -   |
| 16           | 1.32                | -   |
| 17           | 1.27                | -   |
| 18           | 1.23                | -   |
| Average      | 1.20                | 1.18 |
| Coefficient of Variation | 0.13 | 0.05 |

9. **Comparison of IAM Implementation in Papah and Cu-Chi Irrigation Area**

In the discussion of the previous section, it was explained that the two irrigation areas have relatively the same problems but use different IAM applications. In Papah Irrigation Area to improve the performances, use IAM to produce 4 formulas, namely:

- Irrigation Service Fee (ISF)
- Turnover / Privatization (PIK)
- Integrated Basin Water Resources Management
- Project Benefit Monitoring and Evaluation (PBME)

Meanwhile, Cu-Chi Irrigation Area uses modeling to find solutions to improve the performance of its irrigation area. Both regions have their advantages and disadvantages. In Papah Irrigation Area, 4 this formula is good enough to solve management problems but still not enough to improve performance. Based on the discussion on the problems experienced, Papah Irrigation Area is experiencing problems in the lack of water supply compared to the need that is needed. Therefore, it is necessary to find a solution like what was done in Cu-Chi Irrigation Area by making modeling so that it can be seen if the loss in the tertiary channel is reduced, whether the existing water supply can meet the existing water needs. If not, what is a good water management strategy so that water supply can meet existing needs. All of these conditions need to be modeled carefully so that appropriate steps can be taken. Whereas in Cu-Chi Irrigation Area, IAM implementation is incomplete in the field of management, where IAM is only limited to improving existing water management so that the water supply does not experience excessive supply. However, it can be seen from the problems that occur, the imbalance between the costs incurred by the Irrigation Management Companies (IMC) as a Cu-Chi Irrigation Area
management company and the income generated from water usage rates not only due to excessive supply but also from the tariffs charged. in water users too low. This is due to the IMC being unable to charge water users higher tariffs. Therefore, it is necessary to apply IAM in Papah Irrigation Area to be applied to Cu-Chi Irrigation Area so that the imbalance can be resolved. So it can be concluded that the application of IAM for the two irrigation areas needs to be collaborated to solve existing problems.

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