PERFORMANCE ASSESSMENT OF IRRIGATION SYSTEM USING INDICATORS FOR DECISION MAKING

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ABSTRACT

This study involves the assessment of the performance of technical irrigation system in Aceh, Indonesia, namely the Pante Lhong technical irrigation system. The Pante Lhong technical irrigation system performances were evaluated using measured internal and external indicators that covered different aspect of evaluation. The Rapid Appraisal Process (RAP) is a visual assessment tool was used to evaluate the internal indicators performance. The selected indicators were grouped in terms of actual water delivery service performance and infrastructure maintenance. The external indicators were crop yield and production cost. The data are collected from the farmers in the three regions which were upstream, middle stream and downstream. Data were collected through field observation and face to face interviews with the irrigation staff and the farmers. The results for the infrastructure maintenance indicators showed that the current canal network received 74.25 % of the expected infrastructure maintenance. The results also found that the continuous supply method is quite enough to excellent performance of flexibility, reliability and equity of water distribution. However, the control flow to farmers in the next level at third canal/tertiary level and measurement of volumes delivered sub components had performed at worse than expected. In the crop yield indicator, the average maximum productivity was 3.91 ton/ha and the income generated was Rp.11.730 million rupiahs/ha. The total production cost of the Pante Lhong technical irrigation system was Rp. 4.126 million rupiahs/ha and hence in term of return of investment (ROI), it is still profitable and feasible to be developed for the farmers.

Keywords: rapid appraisal process, internal indicators, external indicators.

Introduction

Agriculture remains the largest employment sector in most developing countries and international agriculture agreements are crucial to a country's food security. Indonesia is an agricultural country where most of the population consumes rice as a major part of their diet. The population of Indonesia has reached 240 million people with a population growth of 1.49 %. The agriculture sector still play strategic, central and dominant role for national economic growth, because agriculture also provide a significant means of livelihood of Indonesia's population. Agriculture products contribute about 95.36 million US$ or 15.3% of Gross Domestic Product (GDP) and 39% the country's employment work in agriculture (BPS-Indonesia, 2010).

The irrigation performance in Indonesia has been reported 70 % as poor (BPS-Indonesia, 2010). The cause of the poor irrigation performance has been blamed on technical, financial, managerial, social and institutional causes. The rapid expansion of the population and unstable production of the basic foodstuff is now beginning to expose a potentially dangerous imbalance between national supply and demand for food. To obtain continuous national supply, the government's Department of Water Resources Development constructs many irrigation canals to supply water to the fields to meet the demands of the nationally irrigated rice-crop system. Most irrigation projects in Indonesia use surface irrigation in which water is conveyed on to the land by gravity flow. To divert and raise the water level, a diversion weir is constructed across the river so that water can be diverted to a canal when it is required. Practically all the irrigation works are designed to supply water to the paddy fields.

Three types of irrigation schemes are constructed in Indonesia. There are technical, semi-technical, and people's irrigation. Technical irrigation schemes are large works of a permanent nature, constructed and operated by a government agency. Semi-technical irrigation schemes are minor works, either permanent or temporary, constructed by government and operated by the farmer themselves. People's irrigation schemes are minor works with temporary or no weirs, constructed by the farmers. Technical irrigation projects in Indonesia have been developed in all the three categories of service areas of less than 1000 ha, 1000 ha to 3000 ha and above 3000 ha, with management responsibilities distributed from district, province and national levels respectively. Irrigation areas of less than 1000 ha are considered small irrigation areas and are the responsibility of the district authorities. Irrigation areas in the range 1000 to 3000 ha and transdistrict irrigation areas are the responsibility of the provincial authorities. Irrigation areas of greater than 3000 ha and transprovince irrigation areas are the responsibility of the national government (Kristianto and Sitompul, 2005). One of the greater irrigation system (more than 3000 ha) in Aceh Province is the Pante Lhong technical irrigation system. The Pante Lhong technical irrigation system is located in Bireuen City, Bireuen Regency in Aceh Province of Indonesia (5°12'18" North - 96°42'06" East). is about 5,578 ha and includes six districts. The water resources for the Pante Lhong technical irrigation system from the Krueng Peusangan River and the catchment area is 1,879 km^2.

For the Indonesian irrigation cases, although many technical irrigation schemes had been constructed, most of the irrigation schemes have not been nationally evaluated and current performance figures are limited (Kristianto and Sitompul, 2005). The primary objectives of this study are to evaluate the actual performance based on tertiary and final delivery area using selected indicators from the RAP (Rapid Appraisal Process) method for the Pante Lhong technical irrigation system by the continuous irrigation supply method and to identify the actual crop yield based on external indicator and to study the production cost for determining feasibility and return of investment (ROI) of farming and farmer income based on the crop yield in the Pante Lhong technical irrigation system.

Literature Review

The aim of an irrigation management practice is to supply and apply the right amount of water at the right place and the right time (Asawa, 2005) as well as removal of the excess water (Bos et al., 2005). The operational objective of an irrigation system is to provide the equitable distribution of available irrigation supplies to all stakeholders, as efficiently and as effectively as possible (Latif and Tariq, 2009). In practice, the irrigation scheme has extensive canal network branches, numerous water control structures along their length and water distribute over large areas. These situations cause a major complication for irrigation water management (Gorantiwar and Smout, 2005). To provide good serviceability of water distribution to the sfarmers, operation of irrigation canal networks requires a separate service level (Bos, 1997). This involves responsibilities of the stakeholders from the irrigation office authority, field main system operators, water user associations and farmer in operating and maintaining all elements of the system (Burt, 1996).

According to Malano and Hofwegen (1999), the primary concern of farmers on irrigation supply is to produce maximum crop yields. This requires flexibility in water supply in terms of frequency (how often), rate (how much) and duration (how long). Besides, the farmers needed the reliability and predictability of the water supply. Therefore, they added that the irrigation authority has responsibility to provide adequate water delivery service and water distribution service to the various users. To achieve optimal productivity at scheme level, they stated that the rules are required on how water is to be distributed, especially in time of shortage. They defined the concept of level of service as a set of operational standards set by the irrigation and drainage organization in consultation with irrigators and the governments and other affected parties to manage an irrigation and drainage system. Moreover, Malano and Hofwagen stated that performance indicators, standards and targets are identified to enable assessment of compliance and level of delivery in the delivery of service.

Furthermore, Styles and Marino (2002) evaluated water delivery performance of 16 irrigation systems worldwide in developing country, which were selected on the basis that they had some element of modernization either in institutional development or physical infrastructure based on the FAO Water Report 19 data. Internal indicator were obtained through a Rapid Appraisal Procedure (RAP) to quantify how the systems were operated and maintained in the field through a systematic use of a rating scale for the purpose of consistency. The services described in RAP are related to three indices: (1) flexibility, composed of frequency, flow rate, duration, (2) reliability and (3) equity. The external indicators are expressions of various forms of efficiency, whether the efficiency are related to crop yields. The important indicators such as adequacy, reliability, equity, flexibility (frequency, rate and duration) and measurement of volumes can be used to assess water delivery service at each level of irrigation network (Daniel *et al.*, 2007).

Moreover, Sudrajat (2000) studied about analysis of the cost of rice production with the activity base costing (ABC) approach and the factors that affect rice production in Central Java, Indonesia. This study used the ABC system to calculate the overhead of all activities related to rice production costs, with the concept of production costs as revenue, then to test the feasibility of rice production, of uses the approach of cost-volume-profit analysis or also called break-even analysis. This analysis studied the factors that interact in influencing the production. One of the significant aspects in this analysis was called the analysis Break Even Point (BEP), where total revenues equal total costs. He found that business of rice production profitable and feasible to be developed. Similarly, Deptan (1999) stated that the analysis of rice production business can be calculated by using the coefficient ratio of Revenues and Costs (C/R), and then analyzed by using the Break Even Point (BEP). To see the potential of farming/growing rice especially in its ability to provide incentives to farmers, is to use Return of Investment (ROI) analysis approach. ROI is equal to income after-tax, before interest divided by the total investment.

In the case of Indonesian irrigation schemes, although many irrigation systems have been constructed, most of the irrigation canal networks have not been nationally evaluated and current performance figure are limited (Kristianto and Sitompul, 2005). Therefore, to obtain real situation on currently government managed irrigation canal networks, field assessment on the physical infrastructure, operation and maintenance performance as well as their impact on water delivery service is needed.

Methodology

Rapid Appraisal Process (RAP) is a visual assessment tool that provides a systematic evaluation of the irrigation systems and internally water distribution process at various levels (Burt and Styles, often), rate (how much) and duration (how long). Besides, the farmers needed the reliability and predictability of the water supply. Therefore, they added that the irrigation authority has responsibility to provide adequate water delivery service and water distribution service to the various users. To achieve optimal productivity at scheme level, they stated that the rules are required on how water is to be distributed, especially in time of shortage. They defined the concept of level of service as a set of operational standards set by the irrigation and drainage organization in consultation with irrigators and the governments and other affected parties to manage an irrigation and drainage system. Moreover, Malano and Hofwagen stated that performance indicators, standards and targets are identified to enable assessment of compliance and level of delivery in the delivery of service.

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Methodology

Rapid Appraisal Process (RAP) is a visual assessment tool that provides a systematic evaluation of the irrigation systems and internally water distribution process at various levels (Burt and Styles, 2004). In this method, the performance is evaluated using primary indicators that covered many aspects of evaluation. In general, these aspects consist of maintenance and water delivery service. Each of the main indicators has sub indicators which contain a number of criteria or statement descriptions and related score value. These score have a potential maximum value of 4 (best of the most desirable condition) and a minimum possible value of 0.0 (worst or indicating least desirable). The rating score value was classified as worst (0.0), worse (0.5), very poor (1.0), poor (1.5), enough (2.0), quite enough (2.5), good (3.0), very good (3.5) and excellent/best (4.0) were proposed by Burt and Fecon, [14]. In this study, a series of indicators and sub indicators were selected from the RAP performance standard, which is considered to be related to the objective of the current evaluation. The selected indicators were grouped in term of maintenance and actual water delivery service aspects. The list of selected internal indicators is presented in Table 1. From the calculated performance indicators values, the judgment was classified according to the RAP performance criteria.

The external indicator assessed were crop yield and production cost. Crop yield data was collected from the farmers in the three regions which were upstream, middle stream and downstream. The crop yield data (productivity) was compared to the productivity data at local, provincial and national level. Data on the production cost were calculated based on land preparation cost, growth stage cost (maintenance, fertilizer and insect) and harvesting cost. Each of production cost is shown in Table 2.

In this research, data were collected based on qualitative and quantitative methods. The primary data were obtained on field surveys or observation on the irrigation canal networks. Data on daily irrigation operation were collected through in depth interviews with irrigation staff as well as discussion with farmer and heads of water user associations. The interviews were aims at obtaining the details on the internal process of current canal networks, focusing on water management and operation as well as identifying the problems related to the technical and non technical aspects. The data was focused in continuous irrigation supply with the canal tertiary level selected at Light Canal System (LCS), Right Canal System-1 (RCS-1) and Right Canal System-2 (RCS-2). The farmers as respondents were selected in same tertiary block at final delivery. The amounts of the respondents were 81 farmers and the location selected at three tertiary blocks where each block had 27 farmers. In each tertiary block area, the farmers were divided into three sub area with the same location in the area of tertiary blocks. All of samples were located in continuous supply method. The secondary data were obtained from district irrigation office and sources.

Table 1 Selected the RAP internal performance indicators

No.	Indicators	Sub Indicators
1	Maintenance	Floor and canal bank
		Seepage
		Level of gate maintenance
		Available of proper equipment
2	Water Delivery Service	Flexibility
		Reliability
		Equity
		Control of flow to costumers

Table 2 Production Cost

No.	Description	Elements cost
1	Land Preparation Cost	Seed Seed nursery Ground processing Tractor Implementation of planting seed
2	Growth Stage Cost	Handling and Maintenance Fertilizer Insecticide
3	Harvesting Cost	Cutting Threshing rice Transporting crop Water fee to Water Usher Association (WUA)

Result and Discussion

Infrastructure maintenance performance

The average value for the infrastructure performance indicator was 2.97 out of 4 which is about 74.25 % of expected serviceability (see Table 3), and the rate is judged as being quite enough by the performance criteria. For the floor and canal bank sub indicator, the value of the ranking criteria is considered based on the sedimentation in the hydraulic canal cross sectional area in which the effect on the reduction of normal cross sectional area is recorded in percentages (i.e., a reduction of 5 to 20 % is valued as 2 and a reduction 20 % - 30 % or even more is valued at 1), in which the amount of sedimentation in the canal cannot be removed manually but must be done by heavy equipment. A reduction in cross sectional area of less than 5 % sedimentation can be cleaned manually by in routine maintenance. During interviews and field survey, it was found that the reason for the low performance of floor and canal bank is the bed load problem. These poor conditions could be the main cause for the floor and canal bank having a low average ranking score value of 1.89 (poor performance). The high sedimentation content in the water supply was basically transported from surface run-off into the system, especially when the water passes through and causes erosion of hill area during the rainy season.

However, the current canal system has a rating score value of 4 (excellent performance) for seepage. The reason is most of the concrete lined canals exhibited good condition. Another ways to assess seepage is based on visual observations of the concrete lined canal surface, to observe whether surface cracking has an effect on the level of water reduction is correlated to the RAP ranking criteria. The maintenance level is assessed based on routine maintenance that is conducted by the gate operator. The decision was made based on the visual observation on the gate condition and discussion with the gate operators. The gate was damaged due to vandalism (gate component lost such as gate plate and staff gauge) and is outside the consideration for performance assessment.

Table 3 Average infrastructure maintenance performances for Pante Lhong technical irrigation system

No.	Performance Indicators	Irrigation Infrastructure Maintenance		
		Average (LCS)	**Average (RCS-1)**	**Average (RCS-2)**
1	Floor and canal bank	2.00	2.33	1.33
2	Seepage	4.00	4.00	4.00
3	Level of gate maintenance	3.00	3.00	3.00
4	Available of proper equipment and staff	3.00	3.00	3.00
	Average	**3.00**	**3.08**	**2.83**

Following Asawa (2005) for maintenance criteria, the current canal network conditions might be classified as a deferred type of maintenance. In this situation, the deterioration of the canal adversely affects the hydraulic performance. Moreover, he added that for accumulated deferred maintenance, the canal system might deteriorate so much that could lead to rehabilitation and maintenance. For maintenance, the Bireuen irrigation authority has been contracted to excavate the bed load from canals amounting to a total of 11,707 m^3 (Office, 2005) and 5,953 m^3 (Office, 2006) of sediment removed, which cost Rp. 643 million rupiahs and Rp. 729 million rupiahs in 2005 and 2006, respectively. During these years, the authority spent a total of Rp. 1.3 billion rupiahs or equivalent to Rp. 246 thousand rupiahs/ha. This value is 1.64 times higher than the national maintenance standard cost of Rp. 150 thousand rupiahs/ha. On the other hand, the current evaluation in May 2009 found that the significant canal bed load was estimated to be about 1,722 m^3 from a total 19 sediment locations from a total of 69 km canal length.

Current findings are considered important to the irrigation districts office. As reported by some researcher (Malano *et al.*, 1999; Merret, 2002; Vandersypen *et al.*, 2006), maintenance of the canal system depends on the farmers and resources expended, which directly relates to the water delivery service performance. For example, there are three possible types of performance reduction which are caused by physical and structural deterioration. Firstly, poor structural maintenance of canal and control structure has a negative impact on their life and the ability to perform their intended function (Malano *et al.*, 1999). Secondly, for canal networks that faced high deposition rates, their water supply across the network becomes inequitable and unreliable (Merret, 2002). Lastly, adequacy would deteriorate as the irrigation networks degrade gradually over time (Vandersypen *et al.*, 2006).

According to Brewer and Sakthivadivel (1999), most of canal deterioration occurring in government managed irrigation system, especially in developing countries were due to lack of sufficient resources for maintenance. However this limitation can be overcomed by properly conducting cost-effective analysis on irrigation maintenance (Bos *et al.*, 2005). It can be achieved through good practice of tracing the root cause of the problems. The importance of maintenance and operational monitoring aspects on the water supply can be found in Dayton Johnson (2003). He explained that performance of good infrastructure maintenance and frequent water supply monitoring will indirectly affect the effectiveness of the irrigation supply and contributes directly to the irrigation service delivery performance.

Water delivery system (WDS) performance

Table 4 shows the current water delivery service performance of continuous flow provided by tertiary canals as well as how the authorities had managed the system. This average result obtained from analysis average performance of LCS, RCS-1 and RCS-2. The average value of the delivery service indicator was 2.5 out of 4 which is about 62,5 % of target service delivery. This rate is judged as being quite enough by the performance criteria. As shown in Table 4 the flexibility, reliability and equity sub indicators achieve the rating score values between 2.5 to 4, which is judged as quite good to excellent according to the performance standard. For the control of flow to the customers, its rating score value was less than 1 which is very poor, performing less than 12.5 % of the expected value. The reason for the sufficient performance of the three sub indicators earlier mentioned was that the sub indicators were determined from the ability of the canal system to achieve the intended flow rate (i.e., event up to 100 % of designed capacity) based on the arranged schedules at downstream system without any water shortages during the operational process.

Table 4 Water delivery service performance irrigation at the tertiary level

No.	Performance Indicators	Water Delivery Service at Tertiary Canal		
		Average (LCS)	Average (RCS-1)	Average (RCS-2)
1	Flexibility	2.50	2.50	2.50
2	Reliability	4.00	4.00	4.00
3	Equity	4.00	2.00	3.00
4	Control of flow to customers	0.50	0.50	0.50
	Average	**2.75**	**2.25**	**2.50**

However, a localized water control at the tail-end section of the Paya Geudebang/LCS was found during the field survey. As explained in the previous section, poor maintenance of the floor and canal banks (sub indicator) was considered as the main contributing factor to the canal reduction in capacity. Nevertheless, the field survey showed that different crop plan schedule practiced by farmers between the tertiary blocks gave an improvement on the peak flow reduction. Field observation and interviews with gate operators found that most of the continuous supply areas were performing in excess of the requirement. It explains the effect of poor water measurement performance to the costumers as well as the crop planned schedules at the tertiary block not being properly followed by the farmers. In this situation, the excess water caused by over supply was diverted to the tertiary drainage system.

These findings indicate that satisfactory service of reliability and equity (sub performance indicators) were achieved through over supply. This condition might lead to poor efficiency performance of the canal network (Unal et al., 2004). Renault and Vehmeyer (1999) stated that good service cannot be provided with unreliable infrastructure. They added that high level of reliability and flexibility are ideal situation. The condition to achieve obviously, if can be concluded that reliability should be the first priority in enhancing the performance of the irrigation system. As such, the system with high reliability performance or high predictability is easier to manage. Moreover, they added that equity is reflected in the way the irrigation service is spatially distributed. Because of the physical dependability of the downstream sectors on the upstream sectors, the quality of downstream service is highly dependent on what happens in the upstream part of the system.

Crop Yield of the Farmer

Table 5 illustrates the comparison of average crop yield between the Pante Lhong technical irrigation systems and other average crop yield. The other average crop yield (secondary data) was obtained from BPS (Central Agency on Statistic in Indonesia) of district, province and national office. The productivity in Pante Lhong is the lowest of all. The Pante Lhong technical irrigation system targeted production of 4.5 ton/ha (Office, 2005). This result indicates that the Pante Lhong crop yields are still below average compared to production at the local, regional and national. This result indicates that there are problems both in terms of engineering (technical) and non engineering (non technical) factors that resulted in the irrigation performance being below the intended target and give the contribution to crop yield. In technical aspect, the performance of infrastructure maintenance performance (i.e., canal, gate and structure off-farm) and water delivery service performance (i.e., flexibility, reliability, equity and measurement of volume deliveries) still below from 75 % of the expected target. This caused by sedimentation in canal, loss of water gate to control the volume, the quality of maintenance and rehabilitation of irrigation structure make the average crop yield below than others.

Furthermore, non engineering (non technical) factors such as diversity and variety of seed, fertilizer, soil, pest and disease, field size, farmer behavior, water user association, culture and tradition, give the crop yield impact too. Because the diversity and variety non technical factor, make crop yield decreasing caused paddy plant easy attacked by pets and disease. Therefore, required uniformity and collaboration with non technical knowledge like agriculture and sociology to solve the problem and achieve the target. This problem can be seen from the data in Table 5, from 2008 to 2010, the productivity of the Pante Lhong technical irrigation system is always at the lowest level when compared with other productivity in Indonesia.

However, the result is directly related to the performance of the internal indicators in the technical aspect. According to Style and Marino (2002), this condition indicates a strong correlation between the internal performance indicators and one external indicator i.e. the relative yields. Based on the above evaluation, the lower performance of the sub internal indicators on infrastructure maintenance and water delivery service performance influenced the crop yields. The sub indicators are the control of flow to costumers to the next level and canal, and the general condition of floor and canal banks. The control of flow to customers to the next level of performance indicator is a sub indicator which get score values less than 1 and categorized as worst performance. Although the average in yield in Pante Lhong technical irrigation systems is still low compared to others, therefore efforts and increased technical improvements should be done in order to increase production.

Table 5 Comparison of the average crop yield of rice during 2008 – 2010 between the Pante Lhong technical irrigation system, local (BPS-Aceh, 2010), regional and national crop yield (BPS-Indonesia, 2010)

No.	Year	Crop Yield (Ton/Ha)			
		Pante Lhong	Bireuen	Aceh	Indonesia
1	2008	3,66	4,31	4,25	4,71
2	2009	3,59	4,33	4,26	4,89
3	2010	3,91	4,43	4,33	5,00

Furthermore, Clemmens and Molden (2007) stated that substantial improvements are not possible by making big improvements at only one level within the system. Physical or management improvements are needed at all levels before substantial improvements in performance can be taken. Deng *et al.* (2005) added that mechanization and technology application are keys to increase production. In addition, non-technical factors other than being described above such as pests and plant diseases, rodents and fertilizer also affected the yield of the crop farmers.

Cost of Production for the Farmer

The average production cost of the Pante Lhong technical irrigation system is Rp. 412.67/m2 (Table 6) or Rp. 4,126,700/ha. This average value is derived from the sum of land preparation cost, growth stage and harvesting cost, based on location (upstream, middle and downstream). Following Sudrajat (2000), total revenues costs equal total revenues, thus the average cost of Rp. 4,126,700 in the total cost production and price of rice used is the market price at that time. The revenues could be used to obtain the ratio of R/C and the result of R/C should for feasible and profitable farming (Deptan, 1999).

Table 6 Production cost of the Pante Lhong technical irrigation system

Description	Production Cost (Rp/m^2)		
	Upstream	Middle	Downstream
Land Preparation	71	75	68
Growth Stage	231	222	223
Harvesting	130	113	105
Total	**432**	**410**	**396**

Therefore, the crop yield (productivity) that was produced by farmers in 2009 which covered one hectare of land in one cycle of production in 105 days of the growing season the average yield of rice is 3,910 kg or 3.91 ton (Table 5). The range price of rice in 2009 is between Rp. 2,600/kg - Rp. 3,400/kg depending on market condition and the middle value taken is Rp. 3,000/kg. Accordingly, the income gained is Rp. 11,730,000 where only a few farmers 8.64 % that did not sell their crops due to their own consumption and the remaining 91.36 % sold for profit and also used their crops for own consumption.

Moreover, the advantages of the rice farming are derived from the calculation of base price multiplied by the average rice yield then divided by the total production cost. The results of the analysis showed that the amount of the average profit earned by farmers is Rp. 7,603,300/ha for each harvest or Rp. 72,412/ha/day. In the Pante Lhong technical irrigation system, the ownership of fields are divided into two groups, private ownership was 70.37 % and those renting ownership was 29.63 %. As for the farmer with rent ownership, their profit is shared with the land owner where the workers took 2/3 part (70%) and 1/3 part (30%) for owner, where all production costs are covered by workers.

The Pante Lhong technical irrigation system targeted crop yield was 4.5 ton/ha which was not meet. This result shows that there are problems both in terms of engineering (technical) and non-engineering (non technical). From the technical aspect, the external/crop yield result is directly related to the performance of the internal indicators. The average production cost of the Pante Lhong technical irrigation system is Rp. 412.67/m^2 or Rp. 4,126,700/ha. Based on this comparison it is found that the R/C ratio is 2.84. This means, paddy farming is still a profitable venture to be developed and feasible for farmers to perform farming with an average profit of Rp. 231,165/month.

Conclusions

Based on the evaluation of various performance indicators, the following conclusions can be drawn:

1. The results of infrastructure maintenance indicators using the RAP method showed that the infrastructure performances indicator was 2.97 out of 4, meaning the system performed about at 74.25 % of the expected infrastructure maintenance. This rate was judged as being quite enough by the performance criteria.
2. The results found that the average value of the water delivery service indicator at the tertiary canal was 2.5 out of 4 or the system performed at about 62.5 % of the target service delivery. This rate was judged as being quite enough by the performance criteria. The results also found that the sub indicator of flexibility, reliability and equity of water distribution achieved was judged as quite enough to excellent according to the performance standard.
3. For the crop yield indicator, the average maximum productivity for yield was 3.913 ton/ha. The results revealed that the productivity level was low relative to the irrigation objective and this result indicate that the Pante Lhong technical irrigation system crop yield was still below average when compared to the production standard at the local, regional and national levels. However, this result is directly related to the performance of the internal indicators in the technical aspect.
4. According to the production level the total income was Rp.11,730,000/ha and the production cost at the Pante Lhong technical irrigation system was Rp. 4,126,700/ha. The amount of the average profit earned by farmers was Rp. 7,603,300/ha for each harvest. Therefore, it can be concluded that paddy farming is still profitable and feasible. This conclusion results from the analysis of the coefficient ratio of Revenues and Costs (R/C) of more than 1, the majority of farmers were able to obtain profit monthly with the minimum field size of 3,158 m^2 was required to achieve the Break Even Point (BEP) and Return on Investment (ROI) was obtained 156.61 %. Farming is therefore still profitable and feasible to be developed.
5. The Internal Indicators comprising of infrastructure maintenance performance and water delivery service performance influence and correlate with external indicators related to crop yield and production cost. The performance of irrigation is determined by the canal conditions and crop yield. These findings indicate that irrespective of the water supply method, the performance of irrigation was determined by the main system performance (i.e., canal, structure and gate) and crop yield.

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