Performance Assessment Of Irrigation System Using External Indicators For Decision Support System

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Abstract. This research is aimed 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. These system performances were evaluated using measured/rewarded/collected 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 external indicators performance. The external indicators were crop yield and production cost. The data of crop yield and production cost were 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 production cost data were calculated based on the land preparation cost, growth stage cost and harvesting cost. 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 (US$ 1289/ha). The total production cost of the Pante Lhong technical irrigation system was Rp. 4.126 million rupiahs/ha (US$ 453.50/ha) and hence in term of return of investment (ROI), it is still profitable and feasible to be developed for the farmers.

Keywords: External Indicator, RAP, Crop Yield, Production Cost, ROI

1 INTRODUCTION

However, a total of 925 million people are still estimated to be undernourished in 2010 and 578 million in Asia and Pacific, representing almost 16 percent of the population of developing countries. The fact that nearly a billion people remain hungry even after the recent food and financial crises, indicates a deeper structural problem that gravely threatens the ability to achieve internationally agreed goals on hunger reduction: the first Millennium Development Goal (MDG) and the 1996 World Food Summit goal. It is also evident that economic growth, while essential, will not be sufficient in itself to eliminate hunger within an acceptable period of time [1].

Around a billion people globally do not have adequate food to meet their basic nutritional needs. The world faces a potentially even greater crisis in food security as the global population is expected to grow from about 6.9 billion in 2010 to more than 9 billion by the mid-century. The FAO has predicted that demand for food will grow by 50% by 2030 and

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70% by 2050. However, global supply of food calories per person rose from 2254 kilocalories per day in 1961 to 2809 kcal in 2003. Therefore the challenge, in essence, is to meet the rising demand for food in ways that are environmentally, socially and economically sustainable, and in the face of evolving world-wide markets and distribution mechanisms, and global climate and demographic changes. In future, food supply (including production, processing and distribution) must – as far as possible – use the same or less land and fewer inputs, produce less waste and have a lower environmental impact [2].

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 the country’s employment work in agriculture than 39 % [3].

The irrigation performance in Indonesia has been reported 70 % as poor [3]. 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 rice fields.

Three types of irrigation works 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 [4].

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 located in Bireuen City, Bireuen Regency in Aceh Province of Indonesia (5^o12’18” North - 96^o42’06” East) area of this modern network is about 5,578 ha and includes six districts. The water source of the water is from the Krueng Peusangan River and the catchment area is 1,879 km^2. The development of Pante Lhong technical irrigation system begun in 1979 and completed in 1991. It consumed amount of Rp. 12.5 billions (rupiah) funds that was financed by the central government and loan from government of Japan. The Pante Lhong irrigation since 2005 –

2008 had used substantial amount of money Rp. 15.59 billions (rupiah). The break down are for rehabilitation Rp. 14.02 billions (rupiah) (89.89 %), maintenance Rp. 1.37 billions (rupiah) (8.81 %) and operation 202.2 millions (rupiah) (1.30 %). The main water source is obtained from the Krueng Peusangan River which has a catchment area of 1,879 km^2. The Ogee type of headwork was constructed using concrete material, which has a 96 m in width and a 7.3 m in height.

The topography of the paddy field is almost flat which covered the four administrative sub districts. The operation and maintenance of the main system is controlled by the Bireuen District Irrigation Office authority. The current capacity area of the Pante Lhong technical irrigation system is 5,578 ha, which divided in to two irrigation system supplies there were continuous supply method and rotation supply method are used. The continuous supply method ensures farmer can access water every day from off-take structure and the service area is about 3,658 ha (66 %). The rotation supply method is where the farmer may access water only at certain time or about 24 hours per week and the service area used for the rotation supply method is about 1,920 ha (34 %).

In order to achieve irrigation objectives such as increasing the crop yield and achieving a low cost for operation and maintenance budget, the government proposed an irrigation reform agenda by means of increasing performance of irrigation system management. However, as the program is still under way, the performance of Indonesian irrigation system have not been nationally evaluated and current performance figures are not yet available [4].

Rapid Appraisal Process (RAP) is a visual assessment tool that can provide a systematic evaluation of the irrigation system and internally water distribution process at the various levels. The internal indicators were selected from the RAP method that was considered relevant to the current assessment of irrigation management practice performance in the canal levels. In this method, the performance made use of the primary indicators that covered many aspects of the evaluation. The data of infrastructure maintenance performance was collected at third canal/tertiary canal and the data of water delivery service was collected at the third canal and final deliveries. The water delivery service aspects were flexibility, reliability, equity and measurement of volume deliveries using the RAP method. According to the RAP method, the sub component indicator of infrastructure maintenance performance were floor and canal bank, seepage, level of gate maintenance and available proper equipment and staff.

In general, these aspects consist of water structure condition, maintenance and water delivery service. Each of the main indicators has sub indicators which contain a number of criteria or statement description and related score value. These score have potential maximum values of 4.0 (best or the most desirable condition) and a minimum possible value of 0.0 (worst or indicating least desirable) was given based on the visual condition/observation and direct communication with the respondents by the surveyor. 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), quite good (3.5) and excellent/best (4.0).

2 METHODS

2.1 Participant and Design

In this research, the external indicators used were crop yield and production cost of the farmers. The data for the external indicators such as crop yield and production cost were collected based on the field survey from selected respondents and locations. The numbers of respondents for the survey are 81 farmers. The data on the current average crop yield was compared to the national average crop yield in ton/hectare (t/ha). The secondary data from BPS (Central Agency on Statistic in Indonesia) from the District, Province and the National office were used for the standard purpose. Production cost was calculated in Rupiah/hectare or Rupiah/m^2 (Rp/ha or Rp/m^2). The data on current production calculated were based on the land preparation cost, growth stage cost and the harvesting cost. The land preparation costs consist of the purchase cost of seed, seed nursery fees, ground processing costs (cleaning, plowing and piracy), the cost of tractors and the cost for the implementation of planting seeds. The growth stage of the cost includes the cost of handling and maintenance of plants, fertilizer costs and the cost of spraying insecticide. Cost of cutting when harvesting rice, threshing rice, the cost of transporting crops and water fees to water usher association (WUA) were included in the harvesting cost. The cost production was used on the analysis of the rice crop farming.

2.2 Data Collection Procedure

In this research, data were collected based on the qualitative and quantitative methods. The primary data were obtained based on the field surveys or observations done on the irrigation system. Data were collected through detail interview as well as discussions with farmers and/or heads of water user association (WUAs). The interviews were aimed at obtaining the details on the internal processes as well as identifying the problems related to the technical and non technical aspects. The secondary data were obtained from the district irrigation office and other sources.

Primary data were observed from the main intake point, main diversion structure and the 65 off-takes structures scattered along the 77.2 km concrete lining canals. Interviews were carried out with 25 field irrigation staffs, 81 farmers and a number of WUAs. Due to most of the primary data not being available both at the sub irrigation offices and district irrigation office, the related data were prepared based on the field observations and interviews with both irrigation staff, farmers and WUAs. Field data were interpreted in accordance to the RAP judgment criteria for the indicators. In this research, data of water delivery service performance and infrastructure maintenance performance were obtained based on tertiary canal/third canal and final delivery. The data for the crop yield and production cost were collected based on the field survey, questionnaire and interviews with 81 farmers.

The farmers were selected from the three regions based on the irrigation structure in the Pante Lhong technical irrigation system, there were block BPg.1 with plot Pg.1.Kn represent to at upstream, block BJb.2 with plot Jb.1.Kr represent to at middle stream and block BT.7 with plot T.7.Kr at represent to downstream in the irrigation system. Farmers as respondents/samples were identified based on the outlet location for each region and 27 farmers were selected as samples at each location (nine farmers at every location with their plot (paddy field) position are at upstream, middle stream and downstream of the canal. The farmers were selected randomly in each area and location. The irrigation conditions in all areas of the research were continuously carried out. Statistical formula ratio was used to analysis the data for the external indicators for characteristic of the sample. Break Even Point (BEP) and ratio of Revenue Cost (R/C) were used analysis was focused on the analysis profitable and feasible of the farming rice crop for farmer.

2.3 The Sample Characteristics

In this research, data were collected based on field surveys or observations on the Pante Lhoong technical irrigation system. Data were collected through detailed interview and discussion with irrigation staff, farmer and head of water usher association. The data was focused in continuous irrigation supply, with the canal tertiary level selected at LCS, RCS-1 and RCS-2. In the final delivery, the data selected for tertiary block, BPG.1 at July sub district representing upstream location, BJb. 2 at Kuala Raja sub district representing middle stream and BT.7 at Kuala sub district representing downstream. 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. Each block is representative of location with block BPg.1 with plot Pg.1.Kn representing upstream area, block BJb.2 with plot Jb.2.Kr representing middle stream area and block BT.7 with plot T.7.Kn representing at downstream area. 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 compositions of the respondent were based on gender where 88.89 % (72 farmers) were male, while 11.11 % (9 farmers) were female. They had the same position, duty and authority related field and responsibility. The majority of the farmer was older person, where most of them were more than 45 years old (67.90 %). Most of them have had experience in farming more than 15 years (69.14 %). Furthermore, majority of them just got the education at the junior high school level (71.60 %). All of them are able to read and write well. In this location research, the ownership of the field are divided into two categories, there were private field and rent field. Most of them had private field (70.37 %) compared to the rent field of (29.63 %). The average field size of the farmer are in the range of 2000 – 4000 m^2, although some of them had the field size less than 2000 m^2 (34.57 %) and few of them had the field size more 8000 m^2 (4.93 %).

3 RESULTS AND DISCUSSION

3.1 The Crop Yield of the Farmer

The data of crop yield (productivity) was collected based on the field survey from the selected respondents and location. The unit of measurement used for crop yield is ton/hectare (t/ha). The number of the respondents was 81 farmers and the location was selected at three tertiary blocks and each block consist of 27 farmers. Each block was representative of location with block BPg.1, plot Pg.1.Kn representing the upstream area, block BJb.2 with plot Jb.2.Kr representing the middle stream area and block BT.7 with plot T.7.Kn representing the downstream area. In each tertiary block area, the farmers were divided into three sub areas with the same location in the area of tertiary blocks.

During the study, the data was collected through field observation, face to face interview and questionnaires. The data obtained was based on the productivity/crop yield in ton/ha during the period of three years. The data from each farm was collected and average for each tertiary block and is divided into three groups, namely upstream, midstream and downstream.

Based on the interviews, the farmers conceded that water distribution is normally better (quicker and easier) in the upstream region. On the other hand, the upstream region also required a lot of other costs for production because most distributions of water are being done from field to field, although a lot of them can be obtained water directly from irrigation channels/tertiary channels. Distribution from field to field has to be done because the channel is unconnected directly to in each field. This problem is caused by the diverse size and shape of each field. The fields downstream received water depending on the circumstances upstream. The good role of water user association (WUA) and understanding of the farmers are required. The control of flow influences the productivity/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. 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. 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 Styles and Marino [5], 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.

Furthermore, Clemmens and Molden [6] 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. [7] 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.

3.2 The Cost of Production for the Farmer

The cost of production for the farmer is one of external indicator in this research. The unit of measurement used for crop yield is Rupiah/hectare (Rp/ha or Rp/m^2). The total cost of production is all the costs contained and related in the production process that will relate to the income of farmers. Rice prices applicable at the farm level are determined by the market price at the time of harvested.

Data on current production was calculated based on the land preparation cost, growth stage cost and harvesting cost. The land preparation cost consisted of seed cost and preparatory cultivation cost. The growth stage cost involve maintenance cost, fertilizer cost and insecticide cost. Cutting cost, threshing, transport (including transporting rice from the fields to the road or home and factory) and water fees are part of the harvesting cost.

The average cost of land preparation is Rp.71/m^2 or Rp. 710,000/ha. Based on interviews from the farmers and analysis of the data received, the cost of paddy seeds is the main contributor to the of land preparation. Some farmers had bought seed crops and some had used their own seeds obtained from their crops. More than half (60.71 %) the farmers at plot T.7.Kn used the seeds from their harvest compared to other plots. The main reason why farmers buy seeds are that the seeds bought are of better quality and can increase yield. The cost of land preparation by using tractors does not only depend on land area, but the price is based on the lacation of fields and is negotiable. Further cultivating is done by human labor, which is usually done by the farmers themselves or by other farmers paid to cultivate the land.

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 (US$ 835.50/ha) for each harvest or Rp. 72,412/ha/day (US$ 8/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 % (refer to Table 3.12). 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.

3.3 The Assessment of Return Of Investment (ROI)

The Return Of Investment (ROI) is a performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. To calculate the ROI, the income after-tax of an investment, before interest is divided by the cost of the investment and the result is expressed as a percentage or a ratio. In this study, the ROI analysis approach is to evaluate the potential of farming (growing rice) especially in its ability to provide income and incentive to farmer. The Break Even Point (BEP) and ratio of Revenues and Cost are used to evaluate the feasibility of the farming.

According to BPS data for Aceh in 2009, rice consumption levels per capita in Aceh is 130 kg per year with average number of people per household 4.58 people per family. The average total rice consumed by a family is 596 kg per year. Minimum income that must be obtained by the farmers to be able to buy rice demand is Rp. 1,788,000/year (US$ 196.48/year) or Rp. 149,000/month (US$16.37/month). Land area used as the basic assumptions to calculate the income eligibility level is 3000 m^2 or 0.3 ha, because more than 50% farmers have the fields 3000 m^2 (Table 3.13). Based on Table 4.21, the average income of farmers per year in is Rp. 23,460,000/ha (US$ 2,578/ha), assuming they planted rice twice in a year in one hectare. Based on land area assumption of 0.3 ha, the income earned by farmers is Rp. 4,561,980/year (US$ 501.31/year) or Rp. 380,165/month (US$ 41.78/month). Thus the majority of farmers are only able to earn a profit of Rp. 231,165/month (US$ 25.40/month). Therefore, farming is still profitable.

The way to increase the farmer’s income is to increase the production level. As mentioned earlier, production is closely related to the technical factors and non-technical factors. In relation to the technical aspect, production is directly related to the performance of the internal indicators. According to Styles and Marino [5] this condition indicated a strongly correlation between the internal performance indicators and one external indicator, i.e. the relative yields, where the internal or process indicators measuring one aspect, and external or output indicators measuring the others [6]. Therefore improvements of various aspects and indicators are needed for the well being of the farmer and his family.

4 CONCLUSION

This research is very closely related to the improved performance of irrigation and crop yield. The increasing performance of irrigation, will lead to the increase of the crop yield. The increasing of crop yield will give impact and benefit to improving the living standard of the farmers and Indonesia's economy because agriculture's, activity and output constitute a major contribution to Indonesia's GDP and eventually being able to fulfill food supply to the world community. This research has also added some knowledge and methods in terms of assessment and improvement performance of an irrigation system.

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.

According to the production level the total income was Rp.11,730,000/ha (US$ 1289/ha) and the production cost at the Pante Lhong technical irrigation system was Rp. 4,126,700/ha (US$ 453.48/ha). The amount of the average profit earned by farmers was Rp. 7,603,300/ha (US$ 835.53) for each harvest. Therefore, the can concluded that farming paddy 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, minimum field size of 3,158 m^2 was required to break event point (BEP) and return on investment (ROI) was obtained 156.61 %.

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