PERFORMANCE ASSESSMENT OF IRRIGATION SYSTEM USING INDICATORS FOR DECISION MAKING

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FACULTY OF ENGINEERING
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2012

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DISSERTATION SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING SCIENCE

FACULTY OF ENGINEERING
UNIVERSITY OF MALAYA
KUALA LUMPUR
2012

UNIVERSITI MALAYA

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ABSTRACT

Food security is a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. However a billion people globally do not have adequate food to meet their basic nutritional needs and the world faces a potentially even greater crisis as the global population is expected to grow from about 6.9 billion (in 2010) to more than 9 billion by the mid-century. 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.

To ensure the efficient performance of agricultural and for sustainability in output systems, a proper technical irrigation system has to be in place. 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. The Pante Lhong technical irrigation system has system area of above 3000 ha. 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/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 internal indicators performance. The selected indicators were

grouped in terms of actual water delivery service performance and infrastructure maintenance. The four sub indicators under the performance of water delivery service indicators consists of flexibility, reliability, equity and control of flow to the customers/farmers. Likewise, four sub indicators under the performance of infrastructure maintenance indicator consists of floor and canal bank, seepage, level of gate maintenance and available of proper equipment and staff. The external indicators were crop yield and production cost. The data of crop yield and production cost arecollected 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 (maintenance, fertilizer and insecticide) and harvesting cost.

The results for the infrastructure maintenance indicators showed that the current canal network received 74.25 % of the expected infrastructure maintenance. This value demonstrated a sufficient routine maintenance for canal network by the irrigation authority. 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 at final 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 (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.

ABSTRAK

Keselamatan makanan merupakan satu keadaan yang wujud apabila semua orang, pada setiap masa, mempunyai akses fizikal, social, ekonomi dan makanan yang mencukupi, selamat dan berkhasiat yang memenuhi keperluan makanan mereka dan pilihan makanan untuk kehidupan yang aktif dan sihat. Walau bagaimanapun satu billion orang di seluruh dunia tidak mempunyai makanan yang mencukupi untuk memenuhi keperluan asas pemakanan mereka dan dunia berhadapan dengan krisis yang berpotensi lebih besar dalam keselamatan makanan sebagai penduduk global dijangka meningkat daripada kira-kira 6.9 bilion (pada tahun 2010) kepada lebih daripada 9 bilion pada pertengahan abad. Pertanian kekal sebagai sektor pekerjaan yang terbesar di negara-negara membangun dan perjanjian pertanian antarabangsa penting bagi keselamatan makanan negara. Indonesia merupakan sebuah negara pertanian yang mana juga kebanyakan penduduk menggunakan beras sebagai sebahagian besar makanan mereka.

Untuk memastikan prestasi pertanian yang cekap dan untuk kemampanan dalam sistem output, sistem pengairan teknikal sepatutnya telah berada di tempat. Projek-projek pengairan teknikal di Indonesia telah dibangunkan dalam tiga kategori kawasan perkhidmatan kurang, iaitu, daripada 1000 ha, 1000 ha hingga 3000ha dan melebihi 3000 ha, dengan tanggungjawab pengurusan yang diedarkan dari daerah, wilayah dan peringkat kebangsaan mengikut turutan. Sistem pengairan teknikal Pante Lhong mempunyai kawasan perkhimatan melebihi 3000 ha. Kajian ini adalah berkenaan dengan prestasi pengairan sistem teknikal di Aceh, Indonesia yaitu irigasi Pante Lhong sistem teknikal.

Kinerja pengairan Pante Lhong sistem teknikal, dievaluasi dengan diukur/dinilai/ dikumpulkan dari indikator internal dan indikator eksternal yang meliputi aspek-aspek yang berbeda dari evaluasi. Rapid Appraisal Process (RAP) adalah alat penilaian visual digunakan untuk menilai petunjuk prestasi indikator internal. Indikator yang terpilih telah dikumpulkan dari segi prestasi penyampaian perkhidmatan air sebenar dan penyelenggaraan infrastruktur. Empat sub indikator di bawah prestasi penunjuk penyampaian perkhidmatan air yang terdiri daripada fleksibiliti, ekuiti, kebolehpercayaan dan kawalan aliran kepada pelanggan/petani. Begitu juga, empat sub indikator di bawah prestasi penunjuk penyelenggaraan infrastruktur terdiri dari pada lantai dan kanal, rembesan, tingkat penyelenggaraan pintu dan peralatan serta staf yang tersedia. Indikator-indikator luaran adalah hasil tanaman dan kos pengeluaran. Data hasil tanaman dan kos pengeluaran telah dikumpulkan daripada para petani di tiga kawasan, iaitu huluan, aliran tengah dan hilir. Data telah dikumpulkan melalui pengamatan lapangan dan wawancara berhadapan kakitangan pengairan dan petani. Data kos pengeluaran dikira berdasarkan kos penyediaan tanah, peringkat pertumbuhan kos (penyenggaraan, pupuk dan racun serangga) dan kos penuaian.

Hasil untuk indikator penyenggaraan infrastruktur menunjukkan bahawa rangkaian kanal semasa menerima 74.25% penyenggaraan infrastruktur yang dijangka. Nilai ini menunjukkan penyenggaraan rutin yang mencukupi untuk rangkaian kanal oleh pihak berkuasa pengairan. Hasil juga mendapati bahawa untuk kaedah bekalan yang berterusan, prestasi didapati pada tahap cukup hingga sangat baik untuk fleksibiliti, keandalan dan ekuiti pengagihan air. Walau bagaimanapun untuk kaedah aliran terkawal ke pelangan di peringkat seterusnya di kanal ketiga/di tahap tertiari dan pengukuran jumlah yang disampaikan pada komponen sub akhir yang dihantar telah didapati lebih buruk daripada yang dijangkakan. Dalam penunjuk hasil tanaman, purata produktiviti maksimum 3.91 ton/ha dan pendapatan dijanakan adalah Rp.11.730 juta rupiah/ha. Kos pengeluaran adalah Rp. 4,126 juta rupiah/ha dan oleh itu dari segi return of investment (ROI) masih menguntungkan dan layak untuk dimajukan bagi petani.

ACKNOWLEDGEMENT

My sincere appreciation goes to my supervisor, Associate Professor Dr. Zakaria Harun, for his assistance, enthusiasm, encourage, guidance especially the preparation of this dissertation, invaluable help, good teaching and patience for all aspect from this dissertation progress. I am grateful for Associate Professor Dr. Sumiani Yusoff, co supervisor, for her motivation, and valuable advice offering, enthusiastic guidance, lots of good ideas, her inspiration and advice. Her numerous comments, criticisms and suggestion during the preparation of this project are gratefully praised. Mostly for their patience on any problem that occurred during the dissertation is invaluable and appreciated.

Recognition is directed to Faculty of Engineering and Department of Civil Engineering, University Malaya. I am also deeply grateful to State Polytechnic of Lhokseumawe for the leave of absence that I can pursue my study.

I am indebted to my colleagues especially Mr. Edi Majuar, Mr. Samsul Bahri, Mr. Irwan Nurdin, and Mr. Md Salam. I also wish to express my appreciation to all other individuals who provide earnest assistance for this research work.

Lastly, and most importantly, I wish to thank my parents, Ibrahim Basyah and Djuairiah Umar. They born me, raised me, supported me, taught me, and loved me. I show deep gratitude to my parents in law, M. Nur Husin and Nur Jamaliah, for their precious and encourage. Finally, I dedicate this dissertation to my wife Nadia Sartika and my beloved daughter, Arina Arifatunnisa for their continuous spirit, love and patience. It is an undeniable fact that my family gave me the inspiration to complete this study.

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LIST OF SYMBOLS AND ABBREVIATIONS

BEP	Break Even Point
BJb.2	Bangunan Juli Barat 2 (Name of Tertiary Block Structure)
BPg.1	Bangunan Paya Geudebang 1 (Name of Tertiary Block Structure)
BPS	Badan Pusat Statistic (Central Agency on Statistic in Indonesia)
BT.7	Bangunan Teube 7 (Name of Tertiary Block Structure)
CDG	Crump de Gruyter
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
ha	hectare (SI unit)
ITRC	Irrigation Training and Research Center
kg	kilo gram (SI Unit)
km	kilometer (SI unit)
km^2	kilometer square (SI unit)
L	Liter
LCS	Left Canal System
m	meter (SI unit)
m^2	meter square (SI unit)
n	number (unit)
Pg.1 Kn	Paya Geudebang 1 Kanan (Name of Tertiary Field)
RAP	Rapid Appraisal Process
RCS	Right Canal System
Rp	Rupiah (Indonesia Currency)
R/C	Revenue and Cost Ratio
Rp/ha	Rupiah/hectare

Rp/m^2	Rupiah/meter square
SOP	Standard of Procedure
s	second
t	ton (SI Unit)
T.7 Kn	Teube Kanan 7 (Name of Tertiary Field)
t/ha	ton/hectare
US$	US Dollar (American Currency)
WDS	Water Delivery Service
WUA	Water User Association

Conversion SI Unit:

1 km = 1,000 m

$1\ km^2$ = 100 ha = $1{,}000{,}000\ m^2$

1 ha = $10{,}000\ m^2$

1 ton = 1,000 kg

1 L = $\frac{1}{1{,}000}\ m^3$ = $1\ dm^3$ = $1{,}000\ cm^3$

1 s = $\frac{1}{60}$ minute = $\frac{1}{3{,}600}$ hour

Conversion Currency:

1 US $ = Rp 9,100

CHAPTER I

INTRODUCTION

1.1 Background

With the escalating number of population growth, the importance of food supply or food security is a pertinent issue. The Food and Agriculture Organization (FAO) defines food security as a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2002). 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 (FAO, 2010).

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 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 (BBSRC, 2011).

According to the Biotechnology and Biological Sciences Research Council (BBSRC, 2011) the world food crisis has been caused by:

- Global population growth, coupled with demographic chance, increasing affluence and urbanization.
- Global climate and other environmental changes that will have direct or indirect impacts on food production.
- Environmental impacts of farming and food: negative impacts can include increasing water and land use, soil erosion and degradation.
- Key resources for agriculture are limited, notably land, fresh water and energy. Shortages of resources may be exacerbated by increasing competition, for example from urban and industrial development.
- Social drivers include urbanization, demographic change, issues of land tenure, governance and international security, changing patterns of consumer needs.
- Policies of international financial institutions and developed countries.

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).

Water management on irrigation systems had been divided into two responsibility levels. The first level water management is done by the government through the Irrigation Department with the level of responsibility from main structure to division structure or tapping structure. At the second level, the responsibility of management is given to the water user association with water place building from box tertiary or quarter. The problem that often appear is the weakness of the water management at the level of the user so that the distributions of water to the plot of rice field did not fulfill the needs and the timing did not follow to the schedule that have been planned.

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^{o}12’18” North - 96^{o}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}.

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 (Kristianto and Sitompul, 2005).

Field investigations on management of water at on-farm level and also irrigation performance have been studied by different researchers in which different methodologies and strategies have been proposed. Nevertheless, it can be concluded that the application of best management practice could improve the irrigation management performance.

1.2 Problem Statements

The aim of an irrigation management practice is to supply and apply the right amount of water at the right place and at the right time (Asawa, 2005) as well as removal of excess water (Bos *et al*., 2005). In practice, the irrigation scheme has an extensive system of branched canals, numerous outlets along their length where water is distributed over large areas causing a major challange for irrigation water management (Gorantiwar and Smout, 2005). Thus, for this reason it requires a separate service level (Bos, 1997). To ensure its effectiveness, all stakeholders must play their role from the irrigation office authority, field main system operators, water user associations and farmers in operating to maintain all elements of the system (Burt, 1996).

The hydraulic structures in an irrigation system function as a control in which the water can reach the field at the proper time and in the quantities needed. Control is good when the gate intake structures are available. To ensure equitable and efficient distribution, measurement is required at the flow regulating point (Bosch *et al.*, 1993). However, the infrastructure facility is not only the single variable that affects the water delivery service. This is because irrigation is not only about canals, peoples, or crops. It is an interactive process among hydraulic, institution, and biological mechanisms, and the whole result cannot be explained by any single discipline (Djibril and Diemer, 2004). For that reason, the optimal irrigation performance cannot be achieved through technical aspects only; such as the measurement of frequency, rate and duration of water supply. The institutional aspects of service delivery such as the legal framework, management decision making or social attitudes, can fundamentally undermine the proper functioning of service provision form and are often unseen but nevertheless, a crucial part in their relationships (Bos *et al.*, 2005). As a result, the quality of water delivery service is determined by several elements such as adequacy (a measure of water supply ability to meet the water demand for optimal plant growth), reliability (a measure of the confidence in the irrigation system to deliver water as specified by the level of service), equity (a measure of the access to a fair share of the water resource according to the amount specified by the water rights) and flexibility (a measure of the ability of users to choose the frequency, rate and duration with which the irrigation water is supplied) (Malano *et al.*, 1999).

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). Therefore, a research study on the Pante Lhong technical irrigation scheme as one of large-based irrigation area under the central government authority (> 3,000 hectares) is needed to evaluate its efficacy after 18 years of operation. The research needs to be carried out to define a methodological appraisal development for the scheme using the primary and the secondary data available, to identify current contributing factors on the performance reduction and could determine the required priority setting in the improvement plans by the irrigation authority.

1.3 Research Objectives

The primary objectives of this study are presented as follows:

1. 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.
2. To identify the actual crop yield based on external indicator and relevant controlled supply internal indicator with external indicator that will result in improving the infrastructure maintenance and water delivery service in crop yield.
3. 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.

1.4 Scope of Research

An irrigation system is a combination of diverse, yet related, part that form a unified whole. To conduct this study, the canals and the farmers are selected in three region areas, upstream, middle stream and downstream of the Pante Lhong technical irrigation system. Each region study area is divided into three sub regions (head, middle, and tail) and number sample for each area is nine samples. The amount sample each region is 27 samples and the total samples are 81 samples. The study is based on the continuous irrigation supply method. A total of 81 farmers were selected in three regions in the Pante Lhong technical irrigation system with a continuous irrigation supply. Besides utilizing existing secondary datasets, data were collected through on site and field study based on existing irrigation systems. To ensure that the data was recorded properly, a questionnaire survey was also conducted for the farmer’s production at selected site. The identification of infrastructure conditions in the tertiary area of the Pante Lhong technical irrigation system was collected through field observations.

In this study, a series of indicators and sub indicators were selected from the Rapid Appraisal Process (RAP) performance standard, which was considered to be related to the objective of the current evaluation. The selected indicators were grouped in terms of infrastructure maintenance and actual water delivery service. The infrastructure maintenance performance indicators consisted of floor and canal bank, seepage, level of gate maintenance and availability of proper equipment and staff. For the water delivery service aspects, indicators used were flexibility, reliability, equity and control of flow to costumers. These indicators were selected from the RAP performance standard. Although the results of this study are limited to the location and condition of the infrastructure, the methodology developed can be used for further study to compare existing performance level in different systems, locations and conditions.

The scope of irrigation canals and irrigation structures in this research are located in the tertiary and final delivery area with continuous irrigation supply method. Because the problems in tertiary area very complex and in this area the farmers or water user associations have responsibility to operate, adjust, manage and organize the schedule of water and activity on-farm of the irrigation system. In other hand, the Pante Lhong technical irrigation system is wide and large area to be studied. Moreover unavailability of the secondary data about the Pante Lhong technical irrigation system cause this study just focus on tertiary and final delivery. To collect all the parameters at each irrigation parts (primary, secondary, tertiary and final delivery) take a long time and huge costs. In continuous irrigation supply method, no water shortage is find during both paddy planting seasons and the farmers may withdraw water every day from off-take structures.

1.5 Research Methodology

The Rapid Appraisal Process (RAP) method is a visual assessment tool that provides a systematic evaluation of the irrigation systems and internal water distribution process at various levels. In this method, the performance is evaluated using a number of internal indicators and external indicators that covers different aspects of evaluation (Burt and Styles, 2004).

The internal indicators were selected from the RAP method that is considered relevant to the current assessment of irrigation management practice performance at the canal level. The RAP method is a performance appraisal tool to facilitate decision making, strategic planning and management process. The present study was focused on the four sub indicator performance of water delivery service indicator which consisted of flexibility, reliability, equity and control of flow to the customers/farmers. Additionally, this research also incorporated with four sub indicators performances of infrastructure maintenance indicator, which are the floor and canal bank, seepage, level of gate maintenance and availability of proper equipment and staff. Each of the sub component indicators contained a number of criteria or statement description and related score values. 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, (2001).

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. The land preparation cost consists of seed cost, preparatory and cultivation cost. The growth stage cost involves maintenance cost, fertilizer cost and insecticide cost. Cost for cutting, threshing and transportation (including transporting rice from the fields to the road or home and factory) are part of the harvesting cost. The average of cost production was used to calculate the feasibility level analysis of rice production. Figure 1.1 shows the flowchart model depicting the overall process of the research methodology.

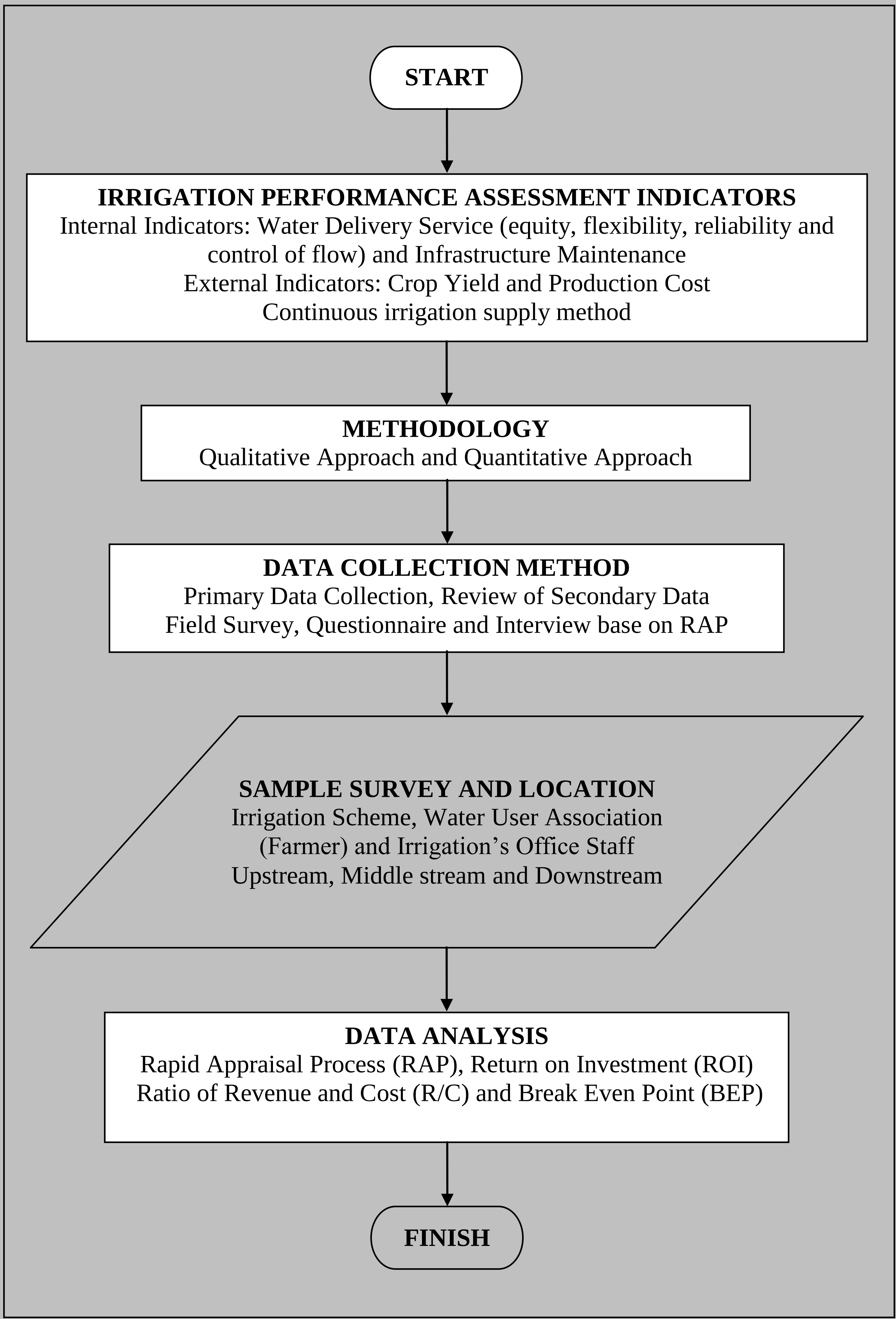

Figure 1.1 A flow chart of the overall process of the research methodology

1.6 Significance of Research

The problems and challenges of food in the world are increasingly complex. The growth of global population are related with growth in demand for food which in turn is related to agriculture**.** On the other hand, key resources for agriculture are limited, notably land and water. Decreasing quantity and quality of land and water resources will put a strain on improving food productions. Thus, assessment and improvements on existing resources related to food security is crucial, one of them being irrigation performance. This study is an assessment of performance and productivity of irrigation system. This is done to fulfill the research objectives which are review and identify the actual irrigation and the actual crop yield based on internal indicators and external indicators. Hopefully this will result in improving the infrastructure maintenance and water delivery service in crop yield. This research is expected to improve the management and strategic planning formulation in implementing and developing irrigation system performance which should result in increasing crop yield (production) of food and improve the farmer’s life. Enhancing irrigation performance should result in more efficient water usage and increase food production which are important dimensions of food security.

1.7 Thesis Structure

This dissertation consists of five chapters excluding the appendices, the references and bibliography.

Chapter one briefly gives the introduction to the research, provides the background and motivation behind the study. It covers the background, problem statement, research objectives, scope of work, research methodology, significance of the research and thesis structure.

Chapter two reviews the general literature relevant to the irrigation water management. This chapter also focuses on the performance evaluation of irrigation projects as a process of collecting and analyzing data obtained from both office and field surveys. In terms of data collection, methods have been proposed both quantitative field data measurement and qualitative data survey are utilized. It presents the on-farm performance evaluation and on-farm measurement and survey.

Chapter three presents the methodology and data collecting procedure of this research. The case study and site location of the Pante Lhong technical irrigation system is discussed and included in this chapter. The chapter describes an approach to collecting data based on field observation and face to face interview. This chapter also explains the canals, infrastructure of the irrigation system and the history of the Pante Lhong technical irrigation system. This chapter also details out the characteristics and farmer sample chosen based on gender, education, field size and others related to the research.

Chapter four presents the result and discussion. This chapter will presently discuss the internal performance indicators assessment such as floor and canal bank, seepage, level of gate maintenance and availability of proper equipment and staff for infrastructure maintenance indicator and flexibility, reliability, equity and control of flow to costumers for water delivery service indicator. The external performance indicator assessments result include are farmer production (yields) and cost of production. At this stage an analysis was carried out to obtain the impact of the canal network to the water delivery service performance and impact of internal indicator to external indicators. The analysis was focused on the business analysis of the rice crop in Pante Lhong technical irrigation system with continuous irrigation supply method.

Chapter five gives the conclusions derived from this research and recommendations for future improvement. Some recommendations and suggestions are deliberated further for clarity and discussion.

The dissertation ends with the references and bibliography used in the research. The references are books or papers read by the author and ones directly quoted in the dissertation. The bibliography included material which were consulted during of this research work but not quoted directly.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The literature review conducted in this chapter includes general information related to rice and irrigation water management. This chapter highlights studies research publications such as a quantitative field data measurement and qualitative data survey. This chapter also review the success of irrigation management depending on planning, operation, evaluation and farmer participation. While quality of service irrigation can be assessed through some indicators.

2.2 Rice

According to Chandrasekaran *et al.* (2008) rice is hydrophytic plant and often cultivated as a semi-aquatic crop. Rice (*Oryza sativa*) is a general consensus that was domesticated somewhere in Southeast Asia. However, there are varieties and strains, which are ground under, dry or rain fed and semi-dry conditions. For the efficient physiological functions of the plants, a saturated condition of the soil is sufficient. It is not correct to assume that rice crop requires standing water. The practice of maintaining a standing sheet of water is for checking the growth of weds. Rice is essentially a crop of sub-tropics and on higher elevations up to 6000 feet above sea level, it is also cultivated. Besides the abundant supply of fresh water needed for irrigation, the rice growing areas are characterized by high temperatures during the growing seasons and high atmospheric humidity. High altitudes and low temperatures delay flowering and maturity.

The conducive temperature range is from 21^{o}C to 31^{o}C, although extremes over these are also tolerated by the crop. Rice can be grown successfully on a variety of soils. The most important requirement of the soil is its ability to hold moisture for a considerable period. Rice alluvial soils with impervious sub-soils are ideal for the crop. Rice thrives over a wide range of soil reaction ranging from 4.5 to 8.5 pH. The most favorable range is 5.5 to 7 pH. Only few rice varieties possess tolerance for saline and alkaline conditions (Chandrasekaran *et al*., 2008).

2.3 Irrigation Management System

Irrigation is an artificial application of the water so that crops can utilize it for maximizing production. Based on this, the function of management is to supply the right quantity of water at the right time and place, with the objectives of water control and resource conservation. With these objectives, deliveries made from a tertiary conveyance system are expected to be made in an adequate, equitable and reliable manner such that losses at the end of lateral outlet are minimized.

The objective of irrigation system is to provide the amount of the water as needed by crop in order to achieve its target production and economic returns. However, Dedrick *et al.* (2000) explained that to meet production objectives, various resources besides water only such as irrigation practices, weather factor, farm internal factors (e.g., technology, labor and financing) and farm external factors (e.g., water delivery rule, local regulations and crop prices) are needed. Therefore, due to the complexity of production system, a systematic understanding of the system performance, application of water management to improve and assure the sustainability of irrigated agriculture, a regional perspective to improve agriculture water management were needed.

In addition, Jahromi and Fayen (2001) argued the fundamental objective of any irrigation system is to provide the amount of the water as needed by crop in order to achieve its target production and economic returns. Farm irrigation systems must supply water at adequate rates, quantities and correct times to meet farm irrigation requirements and schedules. They divert water from a water source, convey it to cropped areas of the farm, and distribute it over the target area (Kanber et al., 2004). The farm irrigation systems facilitate management by providing a means of measuring and controlling flow.

Although the primary function of irrigation is to provide water delivery service for agriculture use, there have been a few significant effort made to measure the characteristic and success of this function, quality of irrigation service or conveyance manage ability while low efficiencies have been documented in various projects (Burt, 1996). Accordingly, Pereira (1997) noted that irrigation scheduling refers to when and how much water to apply, i.e. the irrigation depths and timings. These depend not only on the crops demand but also on the soil water reserve, climatic patterns, crop management, and irrigation method and water availability. The farm water supply systems play a major role when selecting the water application and the irrigation scheduling systems.

Within irrigation schemes, Gorantiwar and Smout (2005) explained that the success of irrigation water management depends on appropriateness of planning, operation and evaluation process. In planning phase, the targets focus on distribution of land, water allocation and water delivery schedule to different crop up to tertiary level. In operation phase, the target focus on implementation or modified and implementation. In the evaluation phase, data are collected and analyses to determine the performance. Nevertheless, they added that, there is a perception that many irrigation schemes in developing countries with huge investment in infrastructures of irrigation system do not achieve its objectives.

Dedrick *et al.* (2000) explained that competition for water by users and on-farm water mismanagement are some of key problems faced by irrigated agriculture. The complexity of the agriculture activity and the diversity of interest affected by water management decisions make the development of strategies to accomplish the goals a difficult task. Therefore, there is a need for a holistic process to guide change in irrigated agriculture that takes into account multiple stakeholder goals and priorities.

The irrigation management at tertiary level can be improved towards the better use of available water through the existing irrigation networks using the technical (e.g., infrastructures) or/and non-technical aspect (e.g., establishment of water user association organization). Some of research publications on relevant topics are summarized as follows. For example, the Thailand government in 1999 developed a program for the modernization of water management system (MWMS) using Participatory Irrigation Management (PIM) concept. The main success of the projects are as follows: (1) improvement of irrigation facilities with the farmers' participation; (2) providing an opportunity for discussions with farmers to enable the adjustment of water allocation through the establishment of an Integrated Water Users' Group (IWUG) in the early stages of the project; (3) holding monthly meeting of the IWUG;

(4) developing, operating, and monitoring the water allocation plan in cooperation with both farmers and government officials (Shioda and Onimaru, 2006).

To overcome budgetary problem, poor irrigation performance, increase level of productivity, and cutting public expenditure, the Mexican government introduced the Irrigation Management Transfer (IMT) program at the end of 1980s. In this program, the government adopted the policy of transferring of the management authority from irrigation district to water user association. The water user will be participated in the effort to increase the productivity, improve the viability of irrigation district and decreasing costs for both the farmers and the government. That enabled the WUAs to function as autonomous and special purpose organizations for irrigation management (RAP, 2006).

Similar conditions are also faced by Turkish government to overcome budget constraint for operation purposes. After 1994, they started to transfer irrigation management from government authority to water user association (Unal et al., 2004). Responsibilities of WUAs include: (a) scheduling and delivering water within the WUA unit; (b) monitoring deliveries to farms; (c) collecting operational monitoring data; (d) resolving disputes; (e) paying irrigation pumping cost and also the farmers can widely participate in irrigation management at a local level. This is considered as the basic element to enhance the performance of farmer manager irrigation system for sustainability rice production as well as the farmer may solve conflict at field level cause by water shortage and dissatisfaction about the timeliness of water distribution (Pasaribu and Routray, 2005).

Mark and Ruth (1997) explained those farmer programs are needed induce farmer participation in irrigation systems to make important contributions to management. Farmer participation in planning and management is a key element of most future-oriented strategies for irrigation management improvement. Suprodjo and Sahid (1993) stated that less farmer participation in irrigation development can cause the effect in operation and maintenance of irrigation network, due to (1) lack of farmer understanding on ability of irrigation network service; (2) farmer not understanding how to operate irrigation network; and (3) lack of responsibility from farmer about the maintenance of the sustainability of irrigation network.

The obvious dimensions of irrigation are tangible such as how much water are used, what acreages of land were irrigated, what types of crops are grown, what forces of change and responses are seen. However, to understand irrigation and how evolve in the future, we must consider the more intangible (the culture of irrigation) such as the social meaning and attitudes toward of irrigation. Furthermore, they added that understanding local irrigation culture is often as a key to resolving conflicts and to identifying and implementing creative practical solution to irrigation problems. Irrigation management research, particularly in Asia, has identified important linkages between cultural, institutional, and technological dimensions of irrigation practice (Staff, 1996). Nevertheless, irrigation is about not only canals, people, or crops. It is an interactive process among hydraulic, institutional, and biological mechanisms, and the resultant whole cannot be explained by any single discipline (Djibril and Diemer, 2004).

In the past, there have been two major approaches to evaluating the overall performance of irrigation schemes: (1) its production or return on investment and (2) its efficiency of water use. In recent years, the International Irrigation and Drainage Community have attempted to provide more useful performance parameters. Two major approaches to performance evaluation have been to consider (1) how well service is delivered and (2) the outcomes of irrigation in term of efficiency and productivity of resources use. These have been referred to as internal and external performances, with internal or process indicators measuring one and external or output indicators measuring the others. Recent works on performance assessments have used both of these for assessing (Bos *et al.*, 2005).

2.4 Performance Evaluation of Irrigation System

Performance evaluation of irrigation projects is a process of collecting and analyzing data both secondary data (official data) and field survey. In term of data collection, there are two comman methods that have been proposed in many research publications such as a quantitative field data measurement and qualitative data survey.

2.4.1 Quantitative Field Data

Bos *et al*. (2005) explained that performance measured with indicator, for which data have been collected and recorded. The analysis of the indicators then informs us on the level of performance. The purpose of performance assessment is to achieve efficient, productive and effective irrigation and drainage systems by providing relevant feedback to management at all level.

Gorantiwar and Smout (2005) described that the performance of irrigation system could stated as the extent to which the land and water resources in the irrigation schemes planned for allocation to different users according their spatial and temporal distribution in planning and operation stages follow the objectives of the irrigation scheme. They proposed four types of performance measurement, such as (1) economic (productivity); (2) social (equity); (3) environmental (sustainability); and (4) management (reliability, adequacy, efficiency and flexibility).

Renault and Vehmeyer (1999) stated that a good service cannot be provided with unreliable infrastructure. They added that high level of reliability and flexibility are ideal situation. However, tentative conclusion can be stated 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 spatially distributes. 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.

Various criteria have been developed and used for evaluating irrigation system performance. They include mainly social, economical and technical (hydraulic) indicators of performance of irrigation systems. These are known as the performance criteria of a system. They are, for instance, productivity, social stability, financial and economic criteria, effectiveness, efficiency, equity, reliability, and general welfare criteria (Essafi, 1995).

Daniel *et al*. (2007) proposed 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. The quality of service to agricultural users can be specified through indicator similar to those used for performance assessment, e.g. adequacy, flexibility, reliability and timeliness. The service to farmers is usually defined with reference to three time related aspects that are important for farming organizations: (1) allocation of water for the season or year; (2) irrigation delivery scheduling; and (3) actual water delivery.

Vandersypen *et al.* (2006) analyzed hydraulic performance of the Office du Niger irrigation system of paddy rice at tertiary level in 1995 and 2004. Major physical rehabilitation, economic and institution reforms carried out from the 1980s to success the project. The internal performance indicators of adequacy, efficiency, dependability and equity were used. The indicator compared the volume of water required with the water delivered of a certain sub region during a certain period. The instant flow rates at the intake of canals from the samples ware measured daily during the growing season and considered constant for that day. Adequacy assessed whether the requirement has been met the amount of water delivered. Efficiency is a measure for the excess of water delivered in comparison with the requirements. Dependability expresses the degree of temporal variability of irrigation delivery compared to requirement. Equity is a measure for the spatial uniformity of water deliveries and shows the fairness of water delivery across delivery points. They found that the interventions and current management practice on in the irrigation project succeeded in establishing a good adequacy of water supply of 0.96 in 1995 and 0.92 in 2004. Efficiency is 0.51 in 1995 and 0.56 in 2004 which indicated low and no improvement. Dependability and equity is poor in accordance to Molden and Gates' criteria. Furthermore, they concluded that to improve efficiency at tertiary level while maintaining the good adequacy, dependability and equity of water delivery, investment in water management is required.

Jahromi and Feyen (2001) stated that the fundamental objective of any irrigation system is to control water in such a way that it increases agricultural production. The adequate, reliable and equitable delivery of water in irrigation canals plays an important role in the achievement of this objective. In order to achieve effectiveness of performance analysis and due to the nature of irrigation, the performance should assessed in a spatial and in a time context by means of a dividing them into several sub-systems and assessing the delivery performance at these lower levels. A hydraulic performance indicator (the ratio of actual discharge to required discharge) at primary, secondary, and tertiary levels provide information on spatial distribution at the higher level as well as the performance of the structural and management components of the systems. They explained that the values of temporal and spatial of delivery performance ratios (adequacy, equity, reliability, and uniformity) could be determined using matrix. To indicate the degree of variability and its uniformity at various evaluation levels, the statistical indicator such as the coefficient of variation (standard deviation divided by the average) was used.

The measurement data of actual discharges were made in nine outlets from each selected canal at the head (T25), middle (T27), and tail end (T29) using current meter method. The results showed that no great difference in adequacy performance with regard to intended amount during the different irrigation periods, but canal that located in the tail end of the district, did not receive such an adequate amount of water as others during the three last irrigation periods. The temporal delivery of water to the three irrigation canals shows a difference between head and tail, and most of the outlets located at the head (T25) and middle (T27) of canals received more than their intended share of water. For the output values of the performance evaluation indicators show that minimum variability could be found for the temporal average of the delivery performance ratio at the mail level, the degree of spatial variability at the main evaluation level is more than the degree of temporal variability. This means that performance relative to reliability is better than that relative to equity. Both spatial and temporal variability have the same uniformity, which could be due to their uniform management. They concluded that performance variability and uniformity indicators are both necessary for assessing and analyzing water delivery systems. Without considering the uniformity of the spatial and temporal variability of water delivery at different levels, proper assessment of variability performance is not possible. Application of this approach to the Doroodzan Irrigation System revealed that it was able to deliver adequate water according to the intended supply, and that the water was delivered relatively more reliably than equitably in the irrigation canals of the Hamonn District.

Okada (2005) stated that except for crop yields, however, cause-effect relationships between external factor and internal performance are not quantitatively validated. Therefore, further research is necessary to make clear what internal factors have significant effects on particular performance measure. Irrigation project performance improvement planners need to properly understand the effect of farmer participation on particular performance measures, as well as considering other internal factors that may be relevant.

2.4.2 Qualitative Field Data

McKay and Keremane (2006) studied the institutional arrangements government water use and distribution and also try to elicit the farmers' perception of the Mula irrigation scheme, India, after the transfer of management responsibilities to the WUA by Irrigation Department. Data for the present study was obtained through face-to-face interviews with the irrigator, member of the WUA and key-informants that included official from the Irrigation Department (ID) and office bearers of the WUA. The questionnaire used for the study was designed after considerable literature survey, consultation with ID officials, local key researchers, and also to fulfill the project brief from the Australian Centre for International Agricultural Research (ACIAR) project that aimed at studying the water management institution in India. It used a number of 10 point Likert Scale translated into local language of Marathi allowing the respondents to mark the document when asked for their perception whether they agreed or disagreed with the propositions. Respondents were selected randomly from the list of members provided by the secretary of the WUA, and 70 respondents were selected so as to include at least 20 per cent of the total number of members. The data collected was statistically analyzed using SPSS statistical software to produce frequency tabulations and graphical representations. The results show that the chi square estimate is not significant suggesting that the sample is the same as the population. Around 71 % of the farmers indicated water shortage was the main reason for forming a WUA, 7 % indicated inefficiency of ID as the most important reason. Around 8 % perceived that government policies related to water was the diver for forming a WUA. In terms of rule for water distribution, the farmer perception was only about 13 per cent agreed that the rule. Recording of flows is done jointly by the canal inspectors from the ID as well as the WUA and the distribution of water to individual farmers is done by the WUA on crop-area after comparing the quantity of water demanded (by WUA) and the amount sanctioned (by ID) was good. Furthermore, they found that the water distribution on volumetric basis would be better idea. Chi square estimated indicated that all farmers; irrespective of their age group or land holdings had a similar perception about this rule. However, the WUA official had their reason not delivering water based on volumetric basis. Their consider that measuring the flows, computing the quantity of water and maintaining individual farmers’ accounts were difficult.

Burton *et al.* (2003) evaluated the function of 19 User's Associations in the Tunuyan irrigation systems, Argentina. They studied the performance of the knowledge and know-how of the UA's on the basis of an 85-question questionnaire and related interviews on distribution of water, management and control, irrigation water and social factor. They found that to be able to maintain and modernize the irrigation system, sufficient funds must be available. It is necessary to modernize the management capabilities of canal inspectors and to provide support for the technical staff advising and planning the inspectors' decisions. This assistance should be given in such a way that the natural leadership of the inspector and users' participation in the UA are supported.

Bhatta *et al.* (2005) studied the affect of irrigation management transfer from government agencies to the farmer based on the field investigation during the year 1996 and 2001 of Chitwan irrigation system, Nepal. Thirty respondent farmers were selected, three each from all ten branch canals in which three farmers each canal that portioned from head, middle and tail region. Semi-structured questionnaire were used for data collection on two aspects. First details on cost of production and income from agriculture enterprise along with the yield level of rice, which is a major water consumer, is collected from 1996 and 2001. Second, farmers are asked about their satisfaction level to the present management by farmer-managed irrigation system (FMIS) compared to the agency-managed irrigation systems (AMIS). Two approaches were for data analysis: direct using Logic Model and indirect method by t-test. They concluded that most farmers are satisfied with the management transfer and perceive FMIS to be superior to AMIS. Over 66% of the sampled farmers believe that equity had improve, around 60% believe that leakage had reduced, the rice productivity increased by more than 30% and profits from agriculture has nearly doubled due to IMT.

Maton *et al.* (2005) investigated the relationship between maize irrigation strategies and three farming sub-systems: the production system, the water resources system and the irrigation equipment system of irrigation system in south-western France. Some 70 variables of the farming system were available for the 56 farmers. Data were analyzed based on typologies from the three farming sub-systems and from irrigation strategies and the link between the different typologies. Irrigation strategies were developed based on four decision rules: when to start the main irrigation season, when to start subsequent cycles of irrigation, a rule to delay irrigation due to precipitation and when to stop the irrigation season. Multivariate analyses, cluster analyses, linear regressions and regression trees were used for that purpose. The results showed that the hydraulic an institutional context explained the difference in spatial and the variability of the irrigation strategies mainly depends on the characteristic of the regions. Strategic management of irrigation is similar amongst in a given area while more operational actions differ from farmer to farmer.

Deng *et al.* (2005) identified and evaluated the impact of resources, particularly irrigation, and technology on the farm production in northwestern China. The input variables such as irrigation ratio, farm labor, fertilizer application, and farm machinery were used. Multivariate statistical analysis (correlation and regression) was used to characterize the temporal trends and spatial variation of farm output and input variables in the five provincial distracts during 1978 – 1998. Correlation analysis was used to examine the association of farm output with selected inputs, and between the inputs themselves. The correlation analysis in this study was based on Pearson’s correlation coefficient to reflect the degree of linear relationship between any two variables. The gross value of the farm production in the region increased fivefold during the study period, and was strongly associate with resource use and technological input. The gross value of farm production was significantly correlated with the irrigation ratio in Shaanxi, Gansu, and Ningxia, where the irrigation ratio was relatively low compared with the national averages. During the study period, the application of the technological inputs increased two to eightfold, and contributed about 45% in the growth of farming output in the region. Farm production was also found to be significantly correlated with labor input. Results of this study indicated that water use efficiency and irrigation management need to be improved for future agricultural development, and further advances in farm mechanization and technology application are key for increasing farm production with limited water resources in this semi-arid area.

Ghosh *et al.* (2005) studied the irrigation performance of Mahanadi Delta Irrigation Project in the State of Orissa, India based on farmers perspective. Methodology based on farmer's assessment of the utility of irrigation water supply was studied and the concept of fuzzy set theory is applied to analyses the responses from farmers concerning their perceptions of the irrigation service provided to them. Factors of the utility of water delivery service in a distribution system such as tractability, convenience end predictability were used. The tractability factor is defined as the ease with which farmers can control and satisfactorily apply water to their land. Three sub-tractability factors of quantity of water supply, point of water delivery and stream size were used. Convenience is referred to the timing of water delivery as preferred by farmers to enable them to plan their activities. Four sub convenience factors of timing of water arrival, flow rate of water, duration of water supply and frequency of getting water were studied. Predictability is related to the farmer's degree of confidence with respect to water supply service, or how much information is available to famers about the water delivery schedule and the degree of uncertainty associate with this information.

Predictability can improve water use decisions and is measured using three sub-factors: knowledge of future water supply, management decisions influenced by water supply, and certainty of water availability. The preference of quantity or timing of water supply varies between the farmers. The question of suitability of water volume and timing involves the subjective judgment of farmers. Data on flow levels are sometimes not available. Therefore, fuzzy set theory can be used to estimate the overall utility or appropriateness of a given water supply schedule according to farmers' perceptions. Fuzzy set theory is used to aggregate the opinions of all sampled farmers regarding each sub-factor and to evaluate the importance of each sub-factor with respect to appropriateness of the water supply schedule. Considering educational level of most farmers, they are likely to be more consistent in giving an imprecise verbal description than if they are asked to evaluate on a rating scale. Command area of three minors (laterals) of the branch canal was selected by random sampling method and divided into three regions: head, middle and tail following geographic criteria. Ten farmers from each of strata were selected at randomly. The farmers were interviewed as individuals. Each farmer put forward his judgments with respect to each factors and sub-factors and its importance in the form of linguistic expressions. The linguistic expressions ranged from "very good"/"very high" to "very bad"/"very low" were used. They concluded that the fuzzy set theory can be used to evaluate utility of irrigation service where the flow data are not available.

Hussain *et al.* (2006) studied irrigation-poverty linkages, and determines how and to what extent irrigation contributes to poverty alleviation, and whether there are any spatial patterns in poverty in Indonesian irrigation systems. About 60% of the total irrigated area is located in Java, with the island contributing around 60% to the national rice production. However, a large number of Javanese households still live under poverty. The present performance of irrigation is far from satisfactory as far as distributive and welfare issue are concerned. The primary data for the study was collected from the selected irrigation systems and from adjacent rainfall areas through household surveys using a detailed survey questionnaire. The sample was drawn using a multi-stage sampling method. In the first stage, each of the selected irrigation systems was purposively divided into head, middle and tail parts. In the second stage, one to three water user association (WUAs) were selected in each selected part of each system/scheme. A sampling frame was developed by obtaining a complete list of farmer members from WUAs. In the third stage, households were selected from the sampling frame through random sampling. The selected households were interviewed with a structured questionnaire for gathering data and information on various aspects such as demographics, landholdings and agriculture as well as irrigation. The survey covered all cropping seasons during the 2000 – 2001 agricultural years. The results indicated that irrigation has significant poverty reducing impacts. Improving the performance of irrigation systems by enhancing land and water productivity, diversifying cropping patterns and improving water distribution across locations would help reduce poverty in presently low productivity-high poverty parts of the systems.

Montazar and Behbahani (2007) developed and evaluated a comprehensive model of selecting optimized irrigation systems based on different criteria and parameters including physical, socio-economic, and environmental factors effecting system efficiency to improve resource exploitation for agriculture of Ghazvin Irrigation network in Iran. For their field investigation, a questionnaire was prepared and distributed among 30 local irrigation experts. The questionnaire was designed in a manner that allowed for the respondents to select from among priorities for irrigation systems and sub-systems in each of the three study regions. Ranking the irrigation systems and sub-systems in each region was based on the total sums of the values obtained from questionnaires. Fifteen criteria were adopted for the selection of irrigation systems and five criteria for the selection of irrigation sub-systems. The results from the proposed model are in good agreement with results from the field investigations. This is because various mutually excluded multivariate criteria were considered in the proposed model, which guarantees a higher quality of the final solution and enhanced consistency throughout the decision-making process.

Jahromi and Fayen (2001) stated that performance evaluation helps to determine the degree of realization of the objectives. Many objectives have to be realized in irrigation schemes. There appears to be reasonable agreement in the literature that the delivery of irrigation water should be evaluated on the dimensions of adequacy, timeliness, and equity. Other terms are also used, such as, efficiency of water use, predictability and reliability of the water supply. The parameters adequacy, equity, and reliability, are considered to be the main objectives of a water delivery system. A water delivery system can be evaluated at various levels in space (outlet, course, district, etc.) and time (day, irrigation period, season, etc.). Assessment based on different levels in space and time demonstrates the variability performance of an irrigation system and provides a clear picture of the subdivisions of the system.

Moreover, the performance evaluation of irrigation can be examined in two major components, i.e. the on-farm system, supply and distribution (off-farm) system. It is obvious that, the off-farm system should be capable of delivering water to farms with sound adequacy, efficiency, dependability, and equity. These parameters are commonly used for controlling an irrigation system performance. The performance of a system can be defined as the measurement of the degree/level of fulfilment of the established objectives (Kanber *et al.,* 2004).

Gorantiwar and Smout (2005) report productivity indicators can be measured by main gross term (total net benefits, total area irrigated, and total crop production for the single crop case); efficiency terms (net benefits per unit area irrigated, crop production per unit of area irrigated for a single crop, crop production per unit of water used for a single crop, net benefits per unit of water used, and maximum irrigated area per unit of cultural able command area). Depending on the objectives of irrigation water management in the irrigation scheme, equity can be as area allocation, water allocation, crop production and benefits generation. The parameter to be considered for equity in water allocation may vary: depth, volume and discharge. Equity should enable us to know the degree of variation in the allocation of the resources to different allocation units/farms in the irrigation scheme and the variation in allocation of the resources in different reaches of the scheme (head, mid and tail). The reliability is defined as the ability of the water delivery system and the schedule to meet the schedule demand of the crop. Flexibility is defined as the ability of water delivery schedule of the allocation plan to recover from any changes caused in the schedule. Sustainability is the performance measure related to upgrading, maintaining, and degrading the environment in the irrigation scheme. The efficiencies to be considered at different levels in the irrigation scheme are described as follow. Application efficiency or application ratio: this efficiency indicates how efficiently the water delivered to the field is applied in the field. Distribution efficiency or tertiary ratio: this is the efficiency of water distribution of canal network in the allocation unit water up to the individual field.

Norman *et al.* (2000) studied on-farm water management within a traditional, falaj irrigation system in northern Oman. In the planning and design of regional irrigation development programs, generalized assumptions are frequently made as to the efficiency of traditional surface irrigation systems. The selection of Falaj Hageer for study was based on several criteria. It is a medium-to small-sized *falaj* system (under 10 ha) which supports 30 participant farmers and is sustained by year-round spring (*any*) flow. The selection of plots well distributed within different sectors of the system (e.g. at the head-end versus the tail-end of the channel delivery system). The period water use monitoring from October 1995 to March 1996. Direct water use monitoring and informal farmer interviews were employed in the assessment of on-farm water management. Flow measuring flumes were placed at the channel water delivery outlet at each plot, and water delivery times and flow rates were recorded during each irrigation. They founded that on-farm ratios of crop water demand to irrigation supply (*D/S*) were relatively high in Falaj Hageer. The data indicate that farmers understood how to manage water carefully when using traditional surface irrigation methods, in so long as flow rates (in particular, base flow rates) can be anticipated and remain within their control.

Unal *et al.* (2004) examined the water delivery performance system at tertiary level of the Menemen Left Bank Irrigation System, in the west Turkey according to the internal indicators of adequacy, efficiency, dependability and equity indicators for the 6-month of 1999 and 2000. These indicators were calculated from spatial and temporal distribution of estimated irrigation water requirements and flow rates measured. The nine selected research areas were divided in three locations, three of which are at the head, three at the middle and three at the tail of the system. The result showed that the calculated indicator average values were poor for adequacy, dependability and equity, and fair for efficiency. The cause of the problems was affected by part from management and physical structures aspects.

Furthermore, Vandersypen *et al.* (2009) studied the performance of the irrigation water management at the tertiary level. They used field study method, random sampling, semi-structured interviews (open questions) and farmer perceptions. Interview method and techniques based on Flick: use a list of questions, checklist and viewpoints more freely and precisely. Key question for central management based on their opinion on organization, performance at tertiary area and major challenges for irrigation scheme today. For the farmers the question revolves around irrigation problems, causes, consequences and possible remedies. Data was collected by random sampling method with 9 (nine) villages selected out of a total 56 areas. In each of the villages, 4 (four) tertiary block were picked randomly. The total number of sample (n) = 36 tertiary block (contain 299 plot). Methods used to validate and complete data were through informal interview with 40 plot-holders from sub-sample and took place throughout 2004-2005. The associations between variables were tested using Spearman correlations and one-way ANOVA test using SPSS. The farmers were surveyed using question survey with scale responses using Likert answer scale. Agricultural productivity in tons of rice harvested per hectare was measured at the sample of tertiary block, from which a weighted average per tertiary block was calculated. In the process harvesting, some of the rice was lost during transportation and threshing. Field measurement and scoring based on perception and condition.

Equally Clemmens and Molden (2007) studied the quality of service delivery related to internal indicators and external indicators (water supply, yield, etc.) of project performance. To increase the external performance (output), it is important to know what changes in service or internal performance were required. They developed a qualitative approach for estimating the impact of internal performance indicators on water productivity. Data were collected to assess the performance of an irrigation project in supplying water to agricultural water user. They used questionnaires to infer internal process indicator, or indicator that suggest the quality of internal processes. The internal performance indicators were used to assign statistical value and to determine the impact on production, statistical relationships were used. The internal indicators were divided into four sub-internal indicators dealing with flexibility, reliability, equity and measurement/control of volume at level of service to individual fields, move upstream to effective control and measurement, to sub-mains and main canals. Each sub-indicator is given a score from zero (worst) to four (best) based on responses to interview questions and somewhat subjective judgments. They found that yield losses due to over irrigation of rice are not significant compared to over irrigation of other non-paddy crops. The project found that the water distribution did not produce maximum relative yield and had lower output. Substantial improvements are not possible by making big improvements at only one level within the system. Physical or management improvements have to be made to at all levels before substantial improvements in performance can be seen. They concluded that a relative indicator of adequacy was directly related to project output in \$/ha or \$/m^3 of water. However, they suggested that further research is needed to evaluate the appropriateness of this approach.

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.

2.5 On-Farm Irrigation System

On-farm irrigation is often perceive as simple, i.e. the irrigation method and the need to improve the respective irrigation efficiency, and the irrigation scheduling practices. Very often it is claimed that a definitive improvement can only be achieved when traditional methods be changed into sprinkler or micro-irrigation. However the reality is more complex. Nearly 70 % of the irrigation systems in the world are in Asia. The long term irrigation in Asia is a part of the people's culture. The environment has been modified and maintained by the man. A large part of the Asian landscapes are a consequence of irrigated agriculture, namely the paddy rice basins (Pereira, 1997).

Pereira (1997) explained a farm is a complete system for producing food and fiber. This includes many components which are managed as on unit by the farmer. The characterization of this system is very different according to the discipline that approaches the farm. However, all disciplines view the farm as the basic unit for food and fiber production, for generating the farmer's income from the labor and managerial forces devoted to farming, and for contributing to the welfare of the society.

Suryavanshi *et al.* (2002) explained the modern irrigation management system aims at high efficiency of water conveyance and appropriate methods of water application, through participatory irrigation management at each stage of irrigation development. The participatory irrigation management and efficient water delivery system to provide timely as well as adequate water supply to each farm, shall be the main focus points in the design and implementation of on-farm works. The efficient management of irrigation water for maximizing productivity requires both, firstly the efficient on farm water management and secondly the optimization of the use of water and land, through appropriate methods of water application. The efficient on-farm water management is related to water delivery system and allied works in the command area of outlet, which distributes the water to each farm. The items of works pertaining to on farm water management are termed as On-Farm Development (OFD) works.

However, the on-farm irrigation system is complex. It comprises of the supply to the fields, the irrigation scheduling, the constraints imposed by the water supply system, and the cropping system itself. Irrigation performances result from the combined effects of all these factors. The physical performance is resulted from the combination of the irrigation method (irrigation design) and the irrigation scheduling (irrigation management). Dayton-Johnson (2003) found that good management on irrigation system, either conducted by government or farmers, can influence the suitability of canal operation, infrastructure maintenance and irrigation productivity.

Clemmens *et al.* (2000) reported that the performance of on-farm management can be increased by means of appropriate application of technology, farmer education, coordination between farm, district operation and government agency programs. Moreover, they explained that improvement in farm water management must be evaluated based on technical aspects and non-technical aspects (interdisciplinary studies of farming practices) in which the strengths and weaknesses in irrigation systems and their operation can be obtained.

Besides that, Burt (1995) explained that the improvement of performance can be achieved by understanding the institutional constraints and hardware constraints as well as improving services (flexibility, equity, reliability and timeless) at all layers within the irrigation delivery system. Furthermore, Burt (2004) described that for on-farm irrigation performances, it needs the service components, flexibility as pre-requisite for on-farm investment and flexibility requirement of specific irrigation methods. The key service components of water delivery are equity, reliability, and flexibility. The flexibility subcomponents are frequency, flow rate, and duration. In general, equity and reliability are pre-requisites for improved flexibility. Farmers must be confident that water will be supplied when and how it is promised as a pre-condition for their investing in improved on-farm irrigation technologies. In order to meet this promise, a project must also have mechanisms to ensure equitable treatment among adjacent farmers – to not do so can breed anarchy and subsequent theft of water and destruction of structures. Although good equity and reliability of water delivery to the farms are pre-requisites for farmers to invest in improved on-farm irrigation management and hardware, these two service components are insufficient by themselves. Modern on-farm irrigation management (that is, the use of irrigation scheduling that matches soil and plant constraints) and modern irrigation systems also require that the water deliveries have sufficient flexibility.

However, Burt (1995) stated that some of theoretical computer model on water delivery system together with water balance concepts in the field have been developed to maximize farmer initiative and crop yield. Generally, they have little or no practical use in term of implementing a desirable schedule of water deliveries on the real time service. He added that farmers initiative is very important to increase on-farm decision, willingness to pay water fee and desire to maintain (or no destroy) project facilities. To obtain success water delivery service, water scheduling must consider the degree of flexibility (frequency, flow rate and duration) and reliability.

Burt (1996) stated that although the primary function of irrigation is to provide water delivery service for agriculture use, there have been a few significant effort made to measure the characteristic and success of this function, quality of irrigation service or conveyance manageability while low efficiencies have been documented in various projects. The management improvement can be achieve by understanding institutional constraint and hardware constraint as well as improving service (flexibility, equity, reliability and timeless) at all layers within the project delivery system. Furthermore, he defined that of farm water management is the management of water by the farmer within the field such as the design of the field irrigation system, selection of flow rate and duration in various portions of the field. The level of service can be defined as irrigation service that include factors such as specifications of water right of beneficiary, the point of the delivery, flexibility in the rate of delivery, duration and frequency. Conveyance manageability is defined as the ease in which water supply can be manipulated to respond to changing upstream and downstream condition.

2.6 Irrigation Structure Performance

According to Malano and Van Hofwegen (1999), the primary concern of farmers on irrigation supply is to produce maximum crop yield. This requires flexibility in water supply in terms of frequency, rate and duration. Besides, the farmers needed the reliability and predictability of the water supply. Therefore, they added that the irrigation authority has the responsibility to provide adequate water delivery and water distribution services 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. The organization in conjunction with users must formulate clear rules for operations and water delivery and drainage that will be embodied in a set of level of service specifications. 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. These specifications then become the norm against which the operation performance of the organization can be evaluated. Moreover, Malano and Van Hofwegen (1999) stated that the performance indicators, standards and target are indentified to enable assessment of compliance and level of performance in the delivery of service.

As reported by some researcher, maintenance of the canal system is directly related to the water delivery service performance to the farmer and resources expended. There were three possible type of performance reduction caused by physical structural deterioration. First, poor structural maintenance standard 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 networks become inequitable and unreliable (Merret, 2002). Lastly, adequacy would deteriorate as the irrigation networks degraded gradually (Vandersypen *et. al.,* 2006).

According to Brewer and Sakthivadivel (1999), most of canal deterioration in government management managed irrigation system, especially in developing countries, is caused by lack of sufficient resources of maintenance. However, this limitation can be overcome by properly conducted cost-effective analysis on the irrigation maintenance (Bos *et al.,* 2005). The importance of maintenance and operational monitoring aspect to the water supply can be found in Dayton-Johnson, 2003. He explained that the performance of good infrastructure maintenance and frequent water supply monitoring will affect indirectly the effectiveness of the irrigation supply.

Burton *et al.* (2003) defined the performance of physical structures as the degree to which the assets (i.e canal and water control structures) are able to perform the task for which it was designed. Clemmens and Molden (2007) stated that performance of irrigation system can be evaluated based on two major approaches: (1) how well service is delivered, and (2) the outcomes of irrigation in term of efficiency and productivity of resource use. Bosch *et al.* (1993) stated that the hydraulic structures in irrigation system function as a control in which the water can reach the field at the proper time and the quantities needed. Control is good when gate intake structures are available.

To ensure equitable and efficient distribution, measurement is required at the flow regulating point. However, Djibril and Diemer (2004) said that the infrastructure facility is not only the single variable that affect on the water delivery service. This is because the irrigation is not only about canals, people or crops. It is an interactive process among hydraulic, institution and biological mechanism, and the resultant whole cannot be explained by any single discipline. For this reason, Bos *et al.* (2005) stated that the optimal irrigation performance cannot be achieved through technical aspects only such as measurement of frequency, rate and duration of water supply. The institution aspects of service delivery such as the legal framework, management decision making or social attitudes, can fundamentally undermine the proper functioning of service provision form an often unseen but crucial part in their relationships.

2.7 Rapid Appraisal Process Method

The Rapid Appraisal Procedure (RAP) was originally developed by the Irrigation Training and Research Centre (ITRC) of California Polytechnic University in 1996-97 as a diagnostic and evaluation tool for a research program financed by the World Bank on the evaluation of impact on performance of irrigation systems of the introduction of modern control and management practices in irrigation. The conceptual framework of the RAP for analysis of irrigation systems performance is the following: irrigation systems operate under a set of physical and institutional constraints and with a certain resource base. The systems are analyzed as a series of management levels, each level providing water delivery service through the system's internal management and control processes to the next lower level, from the bulk water supply to the main canals down to the individual farm or field. The service quality delivered at the interface between the management levels can be appraised in terms of its components (equity, flexibility, reliability) and accuracy of control and measurement, and depends on a number of factors related to hardware design and management. With the service quality delivered to the farm and under economic, agronomic constraints, system and farmers' management produces results (crops yields, irrigation intensity, water use efficiency), while symptoms of poor system performance and institutional constraints are manifested as social chaos (water thefts, vandalism), poor condition of infrastructure, poor cost recovery and weak water users associations (Fecon, 2007).

The RAP allows qualified personnel systematic and quickly to determine key indicators of irrigation projects. Key performance indicators from RAP help to organize perceptions and facts, thereby facilitating informed decisions regarding the potential for water conservation within a project, specific weakness in project operation, management, resources and hard ware and specific modernization actions that can be taken to improve project performance. RAP has designed internal indicators under the assumption that all employees of an irrigation project only have their jobs for one reason-to provide service to customers. 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. Confidence intervals should be assigned reflecting the reality that there are always uncertainties in our data and computation techniques. In irrigation matters, one is typically concerned about 5-10% accuracy, not 0.5 -1% accuracy ranges (Burt and Fecon, 2001).

For very simple field irrigation technique, reliability and equity are crucial. Without good reliability and equity, there are generally social problems such as vandalism and non-payment of water fees. Reliability and equity, then, are the cornerstones of projects that have good social order. Some minimum level of flexibility is required. Even with the most simple irrigation method such as paddy rice, the flow rate are completely different at the beginning of the season (for land preparation), compared to when the rice crop is established. And not everyone plants at the same time, meaning that the irrigation project must have some flexibility built into it. To obtain high project efficiency, the canal system must have sufficient flexibility built into it to be able to change flows frequently in response to continually changing demands and weather.

The worksheet also introduces the concept of assigning a rating of 0 - 4 to project characteristics, each of sub components indicators contained a number of criteria or statement description and related score value. The score judged 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 (2001).

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. The external indicator were derived from data available from project files and checked for their consistency. 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. Factors affecting output (results) and symptoms from irrigation projects proposed by FAO Water Report 19. A new framework for assessing the internal process of irrigation projects were used by incorporate two major features: a Rapid Appraisal Process (RAP) and a comprehensive set of internal indicators, which when examined as a whole, indicate how and where irrigation investments should be targeted. There were many factors evaluated to determine the correlation between the economic indicator and the system including: (1) irrigation system performance (flexibility, hydrology estimates, engineering, water control, drainage, quality of construction) and (2) institutional performance (type of control, scheduling, maintenance, cost recovery, Water User Associations, support services). Field data for project visit were obtained through travelling down the canal system and interview with operators and supervisors at each level of canal and meeting with WUAs to ask questions about the quality of water delivery service to the fields. In this study, the production, water supply, and financial indicators are considered as the external indicators. Production is defined as the output of the irrigated area in term of the gross or net value of production measured at local or world prices. They found that hardware modernization can drastically improve the ease of the system operation and the degree of water delivery service provided, which influences whether a strong water user association can exist. There is excellent and realistic potential for improvement of water management and crop yield.

Okada et al. (2008) quantified effects of management and infrastructure improvements on irrigation project performance. The most important indicators of irrigation project performance are generally crop yield (ton/ha) and project irrigation efficiency (%). The main groups interested in an irrigation project are its beneficiary farmers that interested in attaining higher yield and associated water agencies that focused on both efficiency and yields. The impacts of internal evaluation factors (Efs) on irrigation project performance can be evaluated using the correlation between potential production improvement indicators (PPII). The RAP tool can be used to diagnose internal process irrigation projects for modernization using both qualitative and quantitative indicators. RAP is a combination of a comprehensive questionnaire survey and field inspection to determinate what is happening in the irrigation project both. A questionnaire was developed to ask irrigation system experts to perform pair wise comparisons of Efs. Overall score of the 16 irrigation projects were computed using global weights obtained through local weights that individual experts determined with the questionnaire. It was assumed that the RAP internal process indicators were too specific for irrigation system experts who are not familiar with them to perform pair wise comparison. Two expertise's with occupation of consultant in irrigation and water management and one as professor in agriculture engineering and water management were used as respondent with their degree qualification as doctorate and have more than 20 years experience.

2.8 Irrigation Management Performance in Indonesia

Indonesia is well known as an agricultural country with dry land and wetland. Major food crops consist of paddy, corn, cassava, sweet potato, peanut and soybean. Except the main crop paddy, the other major food crops are known as palawija (secondary crops: soybean, corn, cassava, sweet potato and mungbean). Subject to the availability of water for irrigation, paddy is cultivated in both wet and dry lands. Irrigated land is divided into four types based on its system: technical (permanent head works with sophisticated design and line construction with control structure), semi technical (less sophisticated design with structured networks), simple (technically simple construction with control water gates and unlined canal) and village (similar to simple irrigation without government interventions in management) (Pasaribu and Routray, 2005).

Pasaribu and Routray (2005) said the shortage of this crop will cause serious problems leading to political instability and social unrest. As a political commodity, a number of attempts have been made to improve rice production performance through the introduction of new high yielding varieties, a balanced application of chemical fertilizer and provision of credit. Domestic rice production was not adequate to feed the population even with a decreasing population growth rate to 1.49% per year between

1990 and 2000 (BPS-Statistics Indonesia, 2011). The national stock should be filled by importing activity to make the crop available and accessible throughout the year, although the import of rice is gradually decreasing due to an increase in domestic production.

A huge amount is spent on the purchase of rice and the dependency on import duty has been considered as the main reason to promote domestic rice production. The government commitment to increase rice production is shown through the introduction of irrigation management in a new irrigation management system (Pasaribu and Routray, 2005). The management of irrigation in Indonesia system is far from satisfactory. One of the inadequacies is poor on-farm management.

In order to improve the performance of on-farm management in Indonesia, it’s requires assessments of water service management, infrastructure, crop yield and production cost. As a result, the quality of water delivery service is determined by several elements such as adequacy (a measure of water supply ability to meet the water demand for optimal plant growth), reliability (a measure of the confidence in the irrigation system to delivery water as specified by the level of service), equity (a measure of the access to a fair share of the water resource according to the amount specified by the water right) and flexibility (a measure of ability of users to choose the frequency, rate and duration with which irrigation water is supplied) (Malano *et al.*, 1999).

2.9 Summary

This chapter described the irrigation water management and the success of irrigation water management depending on the appropriateness of planning, operation and evaluation process. The irrigation management at tertiary level can be improved towards the better use of available water through the existing irrigation networks using the technical (e.g., infrastructures) or/and non-technical aspect (e.g., establishment of water user association organization). Farmer participation in irrigation systems could make important contributions to management. Farmer participation in planning and management is a key element of most future-oriented strategies for irrigation management improvement.

Some researchers proposed 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. The adequate, reliable and equitable delivery of water in irrigation canals play an important role in the achievement of the fundamental objective of any irrigation system to control water in such a way that it increases agricultural production.

RAP is a tool used for the analysis of the performance of irrigation system. The systems are analyzed as a series of management levels, each level providing water delivery service through the system’s internal management and control processes to the individual farm or field. Internal indicators were obtained through a Rapid Appraisal Procedure (RAP). The RAP tool can be used to diagnose internal process irrigation projects for modernization using both qualitative and quantitative indicators. RAP was formed through the combination of a comprehensive questionnaire survey and field inspection to determinate what is happening in the irrigation project. The external indicator were derived from data available from project files and checked for their consistency. Productivity indicators can be measured by total net benefit, total area irrigated and total crop production for single crop case, or net benefits per unit area irrigated, crop production per unit of area irrigated for a single crop, crop production per unit of water used for a single crop. The internal indicators were calculated from spatial and temporal distribution. The selected research areas are situated in three locations at the head, middle and tail of the irrigation system of the tertiary areas. Data is collected by random sampling and by using field survey, questionnaire and interview with the respondents.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Introduction

This study is about performance of Pante Lhong technical irrigation system based on tertiary and final delivery using the application of Rapid Appraisal Process (RAP) indicator method and actual crop yield with cost production to analysis and determining feasibility of the farming. Irrigation performance assessment can be evaluated by using identified key performance indicators consisting of both internal and external indicators. The internal indicator for this research focuses on the water delivery service performance indicator and infrastructure maintenance performance indicator. The water delivery service sub components are flexibility, reliability, equity and control of flow to costumers. The identifying of the infrastructure maintenance performance conditions in the tertiary area of irrigation system in the Pante Lhong technical irrigation system was carried out through field observations and used sub component indicator. The sub component indicator of infrastructure maintenance were floor and canal bank, seepage, level of gate maintenance and availablility proper equipment. Likewise, for the external indicator in this research, there are two parameters analysis, i.e. the crop yield and production cost. In this method, the performance is evaluated using primary indicators that cover many aspects of evaluation. Figure 3.1 shows the schematic diagram of the irrigation performance indicators assessment for this research.

The characteristics of the Pante Lhong technical irrigation system has been chosen particularly for case study the canals and infrastructure for the irrigation system. This chapter explains the history of the Pante Lhong technical irrigation system and the project employee's authority in sub district office.

3.2 Determination of Internal Indicator Performance

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.

IRRIGATION PERFORMANCE ASSESSMENT INDICATORS

INTERNAL INDICATORS

1. Water Delivery Service

   Data collected at tertiary and final deliveries area. The internal indicators aspects: flexibility, reliability, equity and control of flow to customers. The judgment/score 0 to 4 will be valued base on visual condition/observation and direct communication with the respondents by surveyor.

2. Infrastructure Maintenance Condition

   The identifying of infrastructure condition in tertiary canal of irrigation system in the Pante Lhong technical irrigation system collected through field observation. The sub indicators were floor and canal bank, seepage, level of gate maintenance and available of proper equipment and staff.

   All indicators were assigned by surveyor in accordance to the RAP procedure (Table 3.1 to Table 3.3).

EXTERNAL INDICATORS

1. Crop Yield in ton/hectare(t/ha)

   Data collected based on field survey from selected respondent and location. Data on current average crop yield compared to the national average crop yield. Secondary data from BPS (Central Agency on Statistic in Indonesia) from District, Province and National Office were used for standard purpose.

2. Production Cost in Rupiah/hectare (Rp/ha or Rp/m^2)

   Data collected based on field survey from selected respondent and location as in point 1. Data on current production calculated based on:

   a. Land preparation cost; b. Growth stage cost (maintenance, fertilizer and insect); c. Harvesting cost.

   The analysis was focused on the analysis of the farming rice crop.

Figure 3.1 Schematic diagram of irrigation performance indicators assessment

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). Table 3.1 – Table 3.3 describe the details of water delivery service performance and infrastructure maintenance performance indicators which contain a number of criteria or statement description and related score value.

Table 3.1 Actual water delivery services at the tertiary canal (third canal) that providing water to its sub canals

1.1.1	Descriptions	Score	
	Sub indicator: *Flexibility Index*	Scale	Actual and State
	Location: Tertiary canal/third canal		
	Choose a value/score from 0 – 4, based on the scale/criteria below:		
1	Wide range of frequency, rate and duration, but the schedule is arranged by the downstream sub canals several times daily, based on actual need.	4	
2	Wide range of frequency, rate and duration but arranged by the downstream canal once/day based on actual need.	3	
3	Schedules are adjusted weekly by downstream operators.	2	
4	The schedules are dictated by the project office. Changes are made at least weekly.	1	
5	The delivery schedules is unknown by the downstream operators, or changes are made less frequency than weekly.	0	
1.1.2	Descriptions	Value	
	Sub indicator: *Reliability Index*	Scale	Actual and State
	Location: Tertiary canal/third canal		
	Choose a value from 0 – 4, based on the scale below:		
1	Operators of the next lower level know the flows and receive the flows within a few hours of the targeted time. There are no shortages during the year.	4	
2	Operators of the next lower level know the flows, but may have to wait as long as a day to obtain the flows they need. Only a few shortages throughout the year.	3	
3	The flow changes arrive plus or minus 2 days, but are correct. Perhaps 4 weeks of some shortage throughout the year.	2	
4	The flow changes arrive plus or minus 4 days, but are incorrect. Perhaps 7 weeks of some shortage throughout the year.	1	
5	Unreliable frequency, rate and duration more than 50% of the time and the volume is unknown.	0	

Table 3.1 Continued

1.1.3	Descriptions	Value	
	Sub indicator: *Equity Index*	Scale	Actual and State
	Location: Tertiary canal/third canal		
	Choose a value from 0 – 4, based on the scale below:		
1	Points along the canal enjoy the same level of good service.	4	
2	5% of the canal turnouts receive significantly poorer service than the average.	3	
3	15% of the canal turnouts receive significantly poorer service than the average.	2	
4	25% of the canal turnouts receive significantly poorer service than the average.	1	
5	Worse than 25% or there may not even be any consistent pattern.	0	
1.1.4	Descriptions	Value	
	Sub indicator: *Control of flows to customers of the next level*	Scale	Actual and State
	Location: Tertiary canal/third canal		
	Choose a value from 0 – 4, based on the scale below:		
1	Flows are known and are controlled within 5%.	4	
2	Flows are known and are controlled within 10%	3	
3	Flows are not known but are controlled within 10%	2	
4	Flows are controlled within 20%	1	
5	Flows are controlled within 25%	0	

Source: (Burt, 2003)
Note: maximum score is 4 and minimum score is 0.

Table 3.2 Actual water delivery service received by individual units (final delivery)

1.2.1	Descriptions	Value	
	Sub indicator: *Flexibility Index*	Scale	Actual and State
	Location: Final delivery		
	Choose a value/score from 0 – 4, based on the scale/criteria below:		
1	Unlimited frequency, rate and duration, but arranged by users within a few days.	4	
2	Fixed frequency, rate or duration, but arranged.	3	
3	Dictated rotation, but it approximately matches the crop needs.	2	
4	Rotation deliveries, but on a somewhat uncertain schedule.	1	
5	No establish rules.	0	

Table 3.2 Continued

	Descriptions	Value	
1.2.2	Sub indicator: *Reliability Index*	Scale	Actual and State
	Location: Final delivery		
	Choose a value from 0 – 4, based on the scale below:		
1	Water always arrives with the frequency, rate and duration promised. Volume is known.	4	
2	Very reliable in rate and duration, but occasionally there are a few days of delay. Volume is known.	3	
3	Water arrives about when it is needed, and in the correct amounts. Volume is unknown.	2	
4	Volume is unknown, and deliveries are fairly unreliable, but less than 50% of the time.	1	
5	Unreliable frequency, rate and duration more than 50% of the time, and volume delivered in unknown.	0	
	Descriptions	Value	
1.2.3	Sub indicator: *Equity Index*	Scale	Actual and State
	Location: Final delivery		
	Choose a value from 0 – 4, based on the scale below:		
1	All fields throughout the project and within tertiary units receive the same type of water delivery service.	4	
2	Areas of the project receive the same amounts of water, but within an area the water delivery service is somewhat inequitable.	3	
3	Areas of the project unintentionally receive somewhat different amounts of water (unintentionally), but within an area the water delivery service is equitable.	2	
4	There are medium inequities both between areas and within areas.	1	
5	There are differences of more than 50% throughout the project on a fairly wide-spread basis.	0	
	Descriptions	Value	
1.2.4	Sub indicator: *Measurement of volumes to individual units*	Scale	Actual and State
	Location: Final delivery		
	Choose a value from 0 – 4, based on the scale below:		
1	Excellent measurement and control devices properly operated and recorded.	4	
2	Reasonable measurement and control devices, average operation.	3	
3	Useful but poor measurement of volumes and flow rates.	2	
4	Reasonable measurement of flows, but not of volumes.	1	
5	No measurement of volumes or flows.	0	

Source: (Burt, 2003)
Note: maximum score is 4 and minimum score is 0.

Table 3.3 Actual infrastructure maintenance performance

	Descriptions	Value	
2.1.1	Sub indicator: *General Level of the Canal Floor and Canal Banks*	Scale	Actual and State
	Location: Tertiary canal/third canal		
	Choose a value/score from 0 – 4, based on the scale/criteria below:		
1	Excellent.	4	
2	Good. The canal appears to be functional, but it does not look very neat.	3	
3	Routine maintenance is not good enough to prevent some decrease in performance of the canal.	2	
4	Decreased performance is evident in at least 30% of the canal.	1	
5	Almost no meaningful maintenance. Major items and sections are in disrepair.	0	
	Descriptions	Value	
2.1.2	Sub indicator: *General lack of Undesired Seepage*	Scale	Actual and State
	Location: Tertiary canal/third canal		
	Choose a value from 0 – 4, based on the scale below:		
1	Very little seepage (less than 4%)	4	
2	4-8% of what enters this canal.	3	
3	9 - 15% along this canal	2	
4	16-25% along this canal.	1	
5	Extremely high levels of undesired seepage. Provides severe limitations to deliveries.	0	
	Descriptions	Value	
2.1.3	Sub indicator: *Level of Gate Maintenance*	Scale	Actual and State
	Location: Tertiary canal/third canal		
	Choose a value from 0 – 4, based on the scale below:		
1	Excellent preventative maintenance. Broken items are typically fixed within a few days, except in very unusual circumstances.	4	
2	Decent preventative maintenance. Broken items are fixed within 2 weeks. Reasonable equipment is available for maintenance operations.	3	
3	Routine maintenance is only done on critical items. Broken items are noticeable throughout the project, but not serious.	2	
4	Even routine maintenance is lacking in many cases. Many broken items are noticeable, sometimes on important structures.	1	
5	Large-scale damage has occurred due to deferred maintenance. Little or no maintenance equipment is in working order.	0	

Table 3.3 Continued

2.1.4	Descriptions	Value	
	Sub indicator: *Availability of Proper Equipment and Staff*	Scale	Actual and State
	Location: Tertiary canal/third canal		
	Choose a value from 0 – 4, based on the scale below:		
1	Excellent maintenance equipment and organization of people.	4	
2	Equipment and number of people are reasonable to do the job, but there are some organizational problems.	3	
3	Most maintenance equipment functions and the staff are large enough to reach critical items in a week or so. Other items often wait a year or more for maintenance.	2	
4	Minimal equipment and staff. Critical equipment works, but much of the equipment does not. Staff are poorly trained, not motivated, or are insufficient in size.	1	
5	Almost no adequate and working maintenance equipment is available, nor is there good mobilization of people.	0	

Source: (Burt, 2003)
Note: maximum score is 4 and minimum score is 0.

Table 3.1 and Table 3.3 have been used at the tertiary area, the value of these tables were assessed due verified though the interview surveys and field observation analysis based on RAP criteria. Table 3.2 has been used at final delivery and the value was obtained based on respondents (farmers) expectation and perception.

3.3 External Indicator Performance

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.

3.4 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. Block BPg.1 with plot Pg.1.Kn represent to upstream area, block BJb.2 with plot Jb.1.Kr represent to middle stream area and block BT.7 with plot T.7.Kr represent to downstream area 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.

3.5 The Characteristics of Pante Lhong Technical Irrigation System

The Pante Lhong technical irrigation system is located in the Bireuen City, Bireuen Regency in the Aceh Province of Indonesia and situated at 5^{o}12’18” North - 96^{o}42’06”

East. The detail of lay out location study, feature of existing and problems (canals and gates) are presented in Figure 3.2 – 3.7.

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 %).

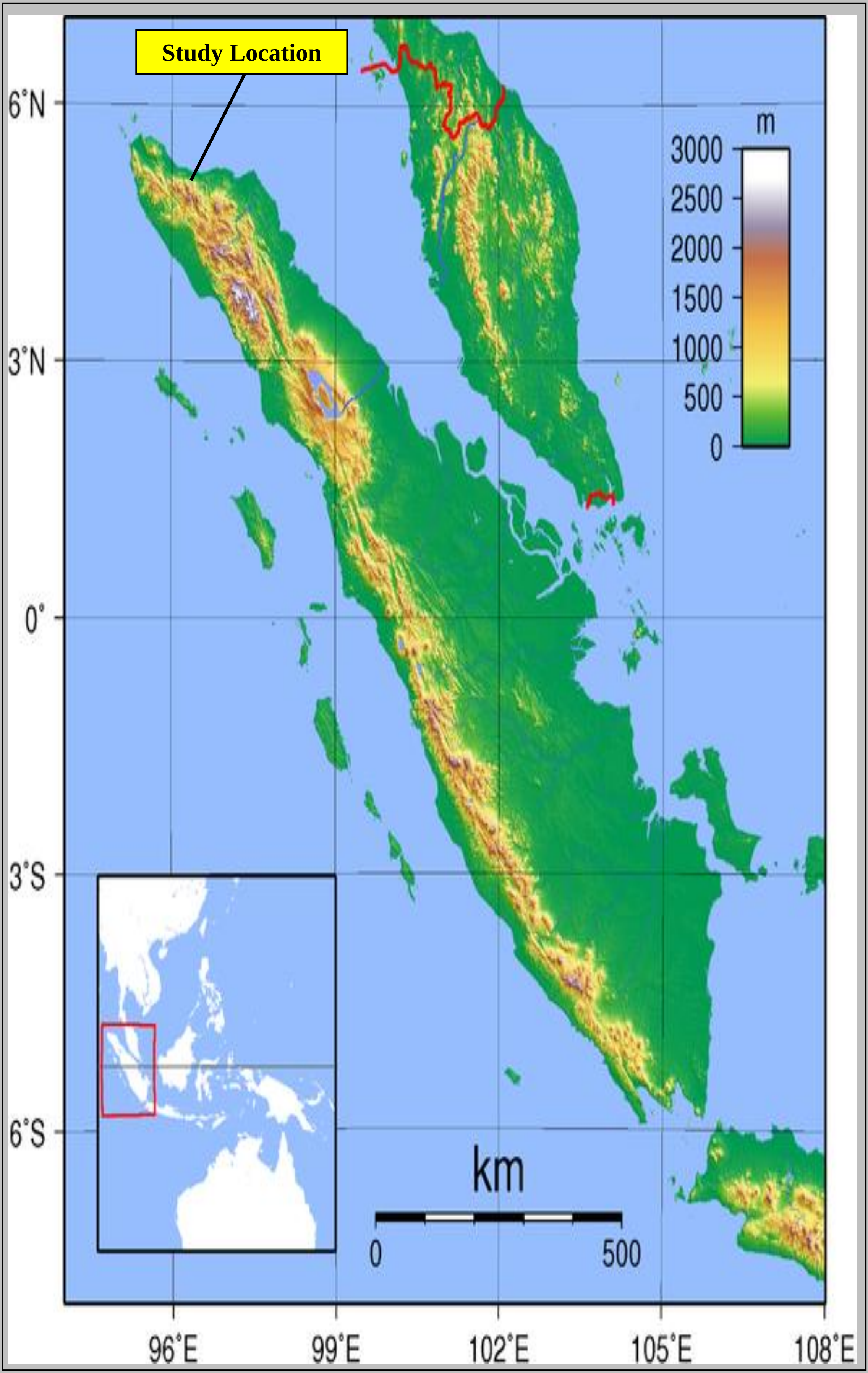

Figure 3.2 Study location in Sumatra Island map (Source: Google Maps)

Figure 3.3 Study location in Aceh map (Source: Google Maps)

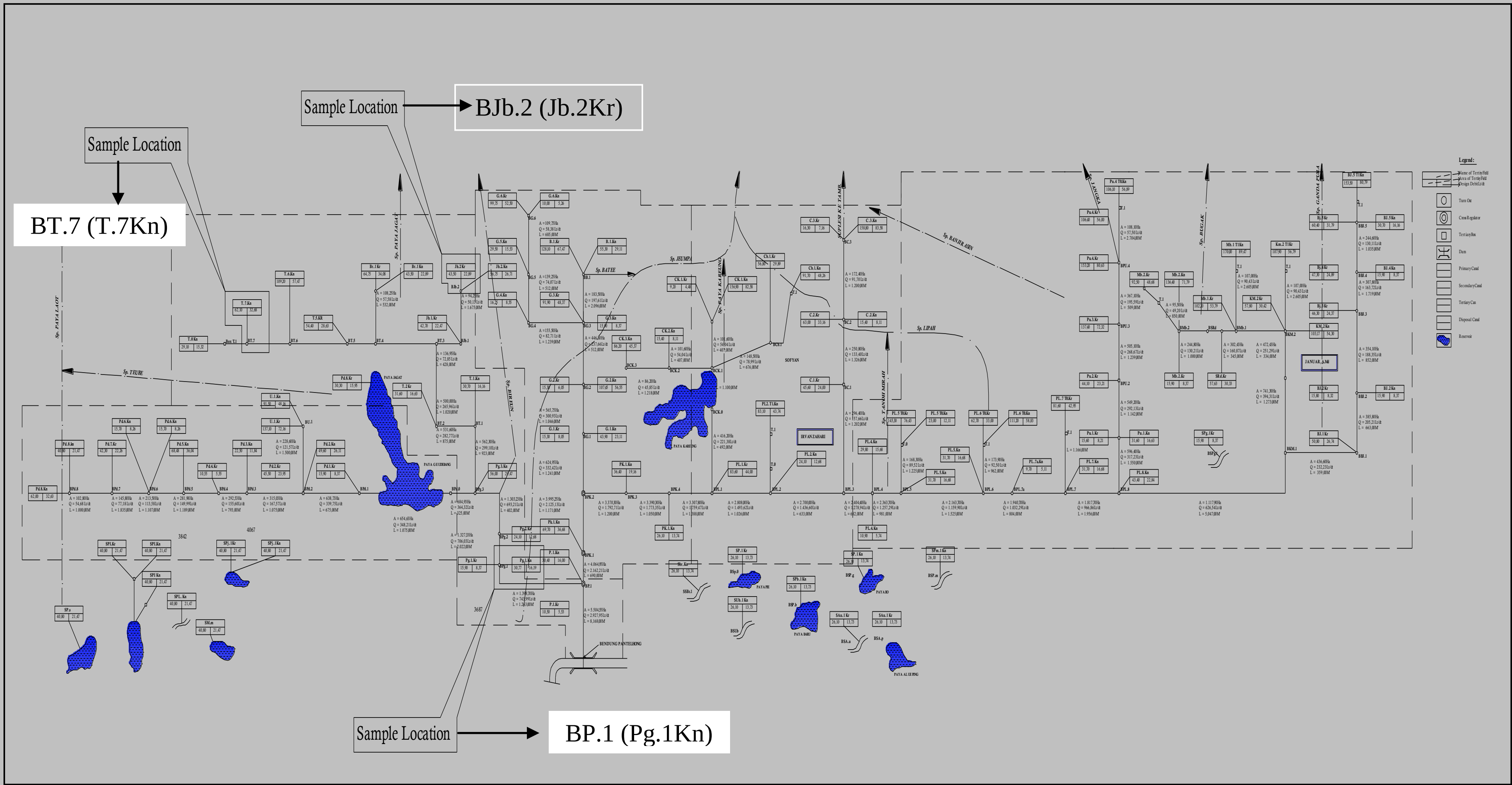

Figure 3.4 Schematic layout of Pante Lhong technical irrigation system and sample location

1. The view of weir Pante Lhong technical irrigation system

2. The view of gates water and turnout structures in Pante Lhong

3. The view of structures and gates water at tertiary level

Figure 3.5 Features of existing Pante Lhong technical irrigation system

1. Abundant water and structure damage at tertiary level

2. Missing bolt on water gate in irrigation canal

3. Broken and theft of irrigation gate

Figure 3.6 Problems encountered at site study Pante Lhong technical irrigation system

1. Missing debit adjustment in tertiary level


2. Clogged rubbish and sediment on irrigation channel


3. Overgrown weed blocking irrigation channel


Figure 3.7 Debit, sediment, clogged rubbish and overgrown problems at site study Pante Lhong technical irrigation system

For the daily activities, the authority is assisted by two irrigation office sub districts; there was Bireuen sub district irrigation office and Peusangan sub district irrigation office. At each sub district level, the canal network is supervised by a head of sub district office, currently, operated by three gate coordinators and a number of gate operators. The main systems were concrete lined materials which have a trapezoidal and flume cross section. The primary canal supply water to the two major secondary canal of the left bank and the right bank canal. The left bank secondary canal supplies water to the Paya Geudebang and the Bate secondary canal to irrigate the paddy areas 877.3 ha and 533 ha, respectively. The right bank secondary canal delivers to the Paya Kareueng and the Geudong canal systems, with the service areas of 3542.2 ha and 624.95 ha, respectively.

The irrigation water is supplied on a continuous regime basis during February and June and August to December planting seasons. To control the amount of water allocation to the downstream canal systems, the permanent off-take structures were built which consist of two types of steel plate gates. The first type is called sliding plate gate that functions to control discharge to the continuing secondary canal. The secondary type is called the Crump de Gruyter (CDG) sliding gate that is used to divert water from the secondary to the tertiary canals. The numbers of water gates in the Pante Lhong technical irrigation system are 179 units and are divided into sliding gates at 113 units and Crump de Gruyter (CDG) at 67 units. The water gates that were functional at 156 unit (87.15 %), number of gates were damaged due to lack of the maintenance at 7 units (3.91 %) and number of gates damaged due to vandalism were 16 units (8.94 %). The details of characteristics of samples study is summarized in Table 3.4 and the details of the water gates condition is summarized in Table 3.5.

Table 3.4 Summary characteristics of the Pante Lhong technical irrigation system

Particulars	Unit	Quantities
Total area :	ha	5,578
- Continuous flow method	ha	3,658
- Rotation flow method	ha	1,920
Maximum allocated discharge	m^3/s	13
Canal length	km	77.2
Primary canal	km	8.2
Secondary canals :	km	69
- Left bank	km	23.2
- Right bank	km	45.8
Diversion structures		7
- Major diversion structures		1
- Minor diversion structures		6
Water gates :		179
- Sliding gates		113
- CDG		66
Off-take structures		55
Office sub district		2
Project employees :		33
- Head of sub district		2
- Gate coordinator		6
- Staff		25

Table 3.5 Summary of water gates numbers and conditions at the Pante Lhong technical irrigation system

Location	Water Gates Number		Number of Gate Functioned	Number of Gate Damaged Due to Lack of Maintenance	Number of Gate Damaged Due to Vandalism
	Sliding Gate	CDG			
Bireuen Sub District Irrigation Office					
Primary/Secondary Canal					
Intake + BP.1	7	0	4	3	0
Sub Total-1	7	0	4	3	0
Left Canal System (LCS)/Paya Geudeubang					
BP.1 to BPg.3	14	5	18	0	1
BPd.0 to BPd.8	12	9	13	1	7
BT.1 to BT.7	11	8	19	0	0
Sub Total-2	37	22	50	1	8
Right Canal System -1 (RCS-1)/Paya Kareueng					
BP.1 to BPk.2	5	0	5	0	0
BG.1 to BG.6	11	12	22	1	0
BPk.3 to BPl.1	6	2	8	0	0
Sub Total-3	22	14	35	1	0
Sub Total (1+2+3)	66	36	89	5	8
Peusangan Sub District Irrigation Office					
Right Canal System-2 (RCS-2)/Paya Kareueng					
BPl.1 to BPl.8	28	12	31	2	7
BKm.1 to Down stream	19	18	36	0	1
Sub Total-4	47	30	67	2	8
Total (Sub Total 1+2+3+4)	113	66	156	7	16
Percentage (%)			87.15	3.91	8.94

The project employees in the Pante Lhong irrigation system consisted of two categories of staffs. The categories were permanent staffs and non permanent staffs and divided in two offices, namely the Bireuen office and Peusangan office. All positions such as head of irrigation sub districts and three gates coordinators were permanent staffs. But some of the gates operators are not permanent staffs. The total number of permanent staff was 12 persons (36.36 %) and non permanent staff was 21 persons (63.64 %). The Bireuen office had 17 staff and Peusangan had 16 staff. Most of them have had training in regional training and national training between 1 – 3 times and half of them have had regional and national training more than 3 times. The details of the characteristics of project employees are summarized in Table 3.6.

Table 3.6 Summary characteristics of project employees at the Pante Lhong technical irrigation system

Office	**Permanent Staff**	**Non Permanent Staff**	**Experience**		**Training**		
			< 5 Years	**> 5 Years**	**< 3 Times**	**> 3 Times**	**Non Training**
Sub Bireuen Irrigation Office	5	12	7	10	5	3	9
%	29	71	41	59	29	18	53
Sub Peusangan Irrigation Office	7	9	4	12	13	3	0
%	44	56	25	75	81	19	0
Total	12	21	11	22	18	6	9
%	36.36	63.64	33.33	66.67	54.55	18.18	27.27

The budget allocation since 2005 – 2008, amounted to Rp. 15.59 billions (rupiah) for the rehabilitation, maintenance and operation. Half of this budget was used for rehabilitation and maintenance in 2005. Most of canals in the Pante Lhong technical irrigation system were destroyed by the big earthquake that occurred in December 2004 (tsunami year) in Aceh. The details of rehabilitation, maintenance and operation budget of the Pante Lhong technical irrigation system are summarized in Table 3.7.

Table 3.7 Summary characteristics of rehabilitation, maintenance and operation budget of the Pante Lhong technical irrigation system

Years	**Rehabilitation (Rp.)**	**Maintenance (Rp.)**	**Operation (Rp.)**	**Total (Rp.)**
2005	7,925,597,209	643,910,173	*	8,569,507,382
2006	131,102,546	729,749,952	202,200,000	1,063,052,498
2007	4,749,737,415	*	*	4,749,737,415
2008	1,212,212,536	*	*	1,212,212,536
Total	14,018,649,706	1,373,660,125	202,200,000	15,594,509,831
Percentage (%)	89.89	8.81	1.30	100

Note * : no budget

3.6 Characteristics of Sample

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, because tertiary area very complex and in this area the farmers or water user associations have responsibility to operate, adjust, manage and organize the schedule of water and activity on-farm. In other hand, the Pante Lhong technical irrigation system is wide and large area to be studied. 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 %). The detail of categories of samples is presented in Table 3.8 – Table 3.13.

Table 3.8 Characteristics of respondents based on gender at the Pante Lhong technical irrigation system

No.	Gender	Amount	Percent (%)
1	Male	72	88.89
2	Female	9	11.11
	Total	**81**	**100**

Table 3.9 Characteristics of respondents based on level of age at the Pante Lhong technical irrigation system

No.	Level of Age (Year)	Amount	Percent (%)
1	< 30	1	1.23
2	30-45	25	30.86
3	46-60	44	54.32
4	>60	11	13.58
	Total	**81**	**100**

Table 3.10 Characteristics of respondents based on level of experience at the Pante Lhong technical irrigation system

No.	Level of Experience (Year)	Amount	Percent (%)
1	< 5	1	1.23
2	5-15	24	29.63
3	16-30	34	41.98
4	>30	22	27.16
	Total	**81**	**100**

Table 3.11 Characteristics of respondents based on level at education at the Pante Lhong technical irrigation system

No.	Level of Education	Amount	Percent (%)
1	Elementary School	38	46.91
2	Junior High School	20	24.69
3	Senior High School	15	18.52
4	Under Grad/Diploma	8	9.88
	Total	**81**	**100**

Table 3.12 Characteristics of respondents based on ownership at the Pante Lhong technical irrigation system

No.	Ownership	Amount	Percent (%)
1	Private	57	70.37
2	Rent	24	29.63
	Total	**81**	**100.00**

Table 3.13 Characteristics of respondents based on level of field size at the Pante Lhong technical irrigation system

No.	Level of Field Size (m^2)	Amount	Percent (%)
1	< 2000	28	34.57
2	2000-4000	27	33.33
3	4000-6000	13	16.05
4	6000-8000	9	11.11
5	8000-10000	3	3.70
6	>10000	1	1.23
	Total	**81**	**100.00**

3.7 Summary

Irrigation performance assessment can be evaluated by identifing key performance indicators consisting of both internal and external indicators. The internal indicators were selected from the RAP method that was considered relevant to the current assessment of the irrigation management practice performance at the canal levels. The internal indicator data were obtained based on field survey or observation on the irrigation canal network. The data for the external indicators such as crop yield and production cost were collected based on the field survey from the selected respondents and locations. The data were collected based on the qualitative and quantitative methods. Data collected based on field data were collected through field survey, deep interview as well as discussions survey from selected respondents, locations and used questionnaire.

The Pante Lhong technical irrigation system selected as the case study covered a total area of 5,578 Ha. There are two types of irrigation supplies system i.e. the continuous supply method and the rotation supply method. The continuous supply has service area of about 3,658 ha (66 %). The rotation supply method has the service area of about 1,920 ha (34 %). The operation and maintenance of the main system are a controlled by the Bireuen District Irrigation Office authority. For the daily activities, the authority is assisted by two irrigation office sub district. The number of gates that are functioning are 156 units (87.15 %) while 23 units (12.85 %) were damaged. A major part of the budget for the Pante Lhong technical irrigation system had been used for the maintenance of the irrigation system especially for the canal.

The data was focused in the continuous irrigation supply region, with the canal tertiary level 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 total number of the farmers samples were 81 farmers which were chosen randomly.

CHAPTER IV

RESULT AND DISCUSSION

4.1 Introduction

This chapter presents the result from the field survey and face to face interview with irrigation staff and farmers during a 5-months field research study period from February till June 2009 based on the application of Rapid Appraisal Process (RAP) and review of secondary data in the case study. It discusses several problems that have been found in the field when collecting data and analyzing of irrigation performance assessment indicators. Each indicator has sub indicators which contain a number of criteria or statement description. These scoring system have potential maximum values of 4 (most desirable condition) and the minimum possible values of 0 (least desirable). Subsequently, it presents the analysis of internal indicators and external indicators. These scores 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). The location of study and scheme of the Pante Lhong technical irrigation system are presented in Figures 3.2 – 3.4 (refer to CHAPTER III). The details of Left Canal System (LCS) section, Right Canal System (RCS-1) section and Right Canal System (RCS-2) section are presented in Figures 4.1 – 4.3.

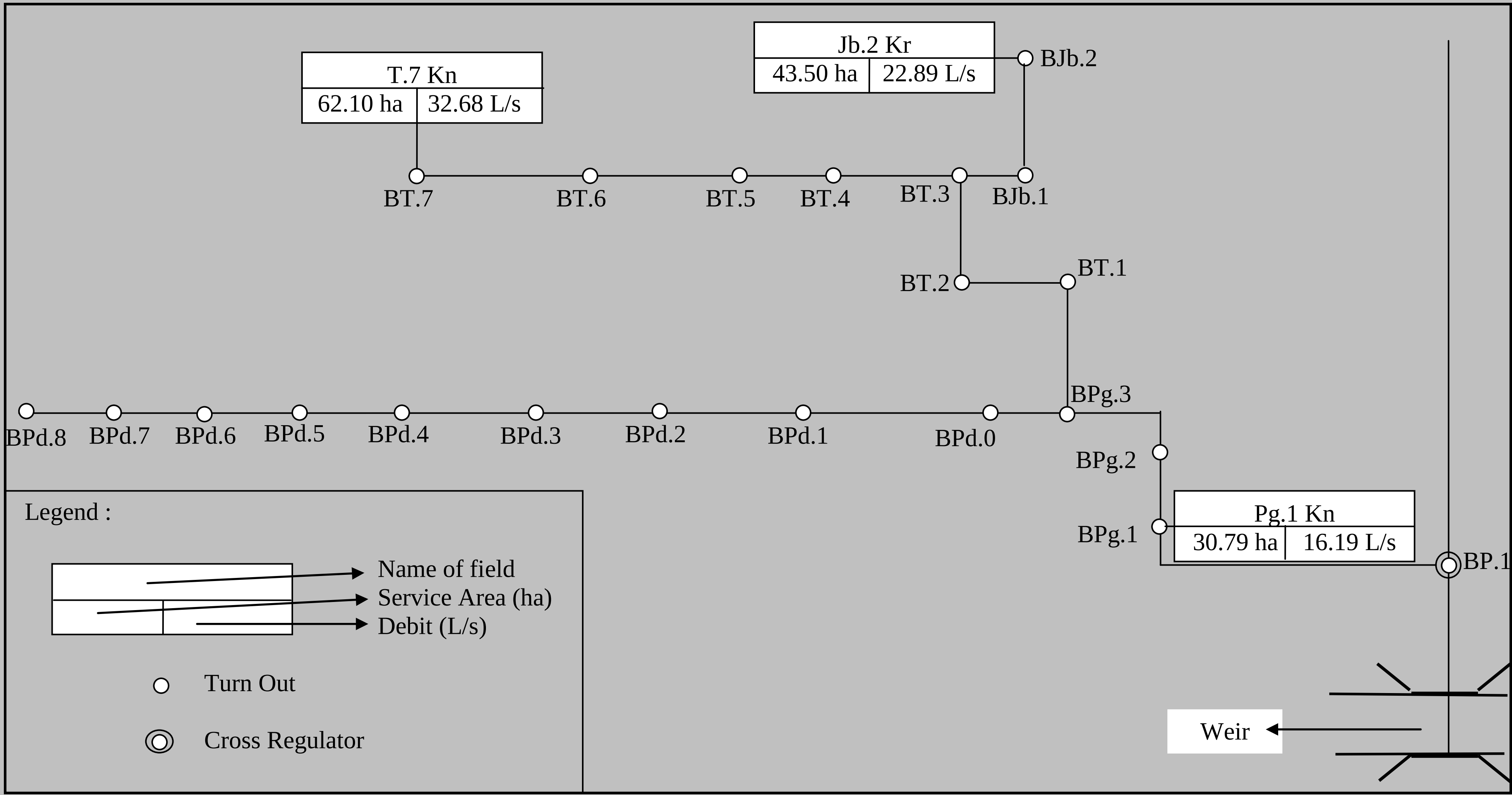

Figure 4.1 Left Canal System (LCS) Paya Geudebang Pante Lhong technical irrigation system

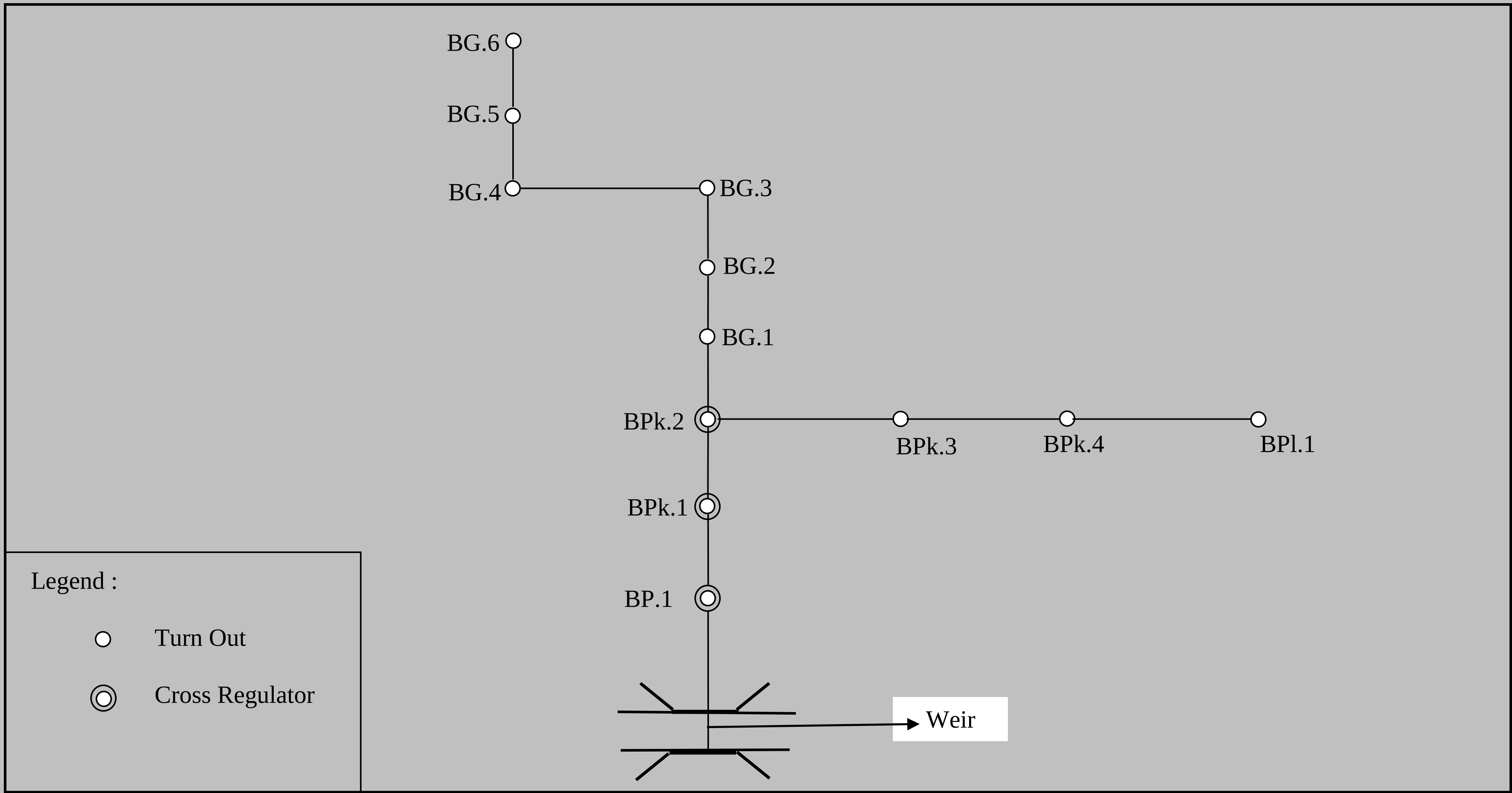

Figure 4.2 Right Canal System-1 (RCS-1) Paya Kareueng Pante Lhong technical irrigation system

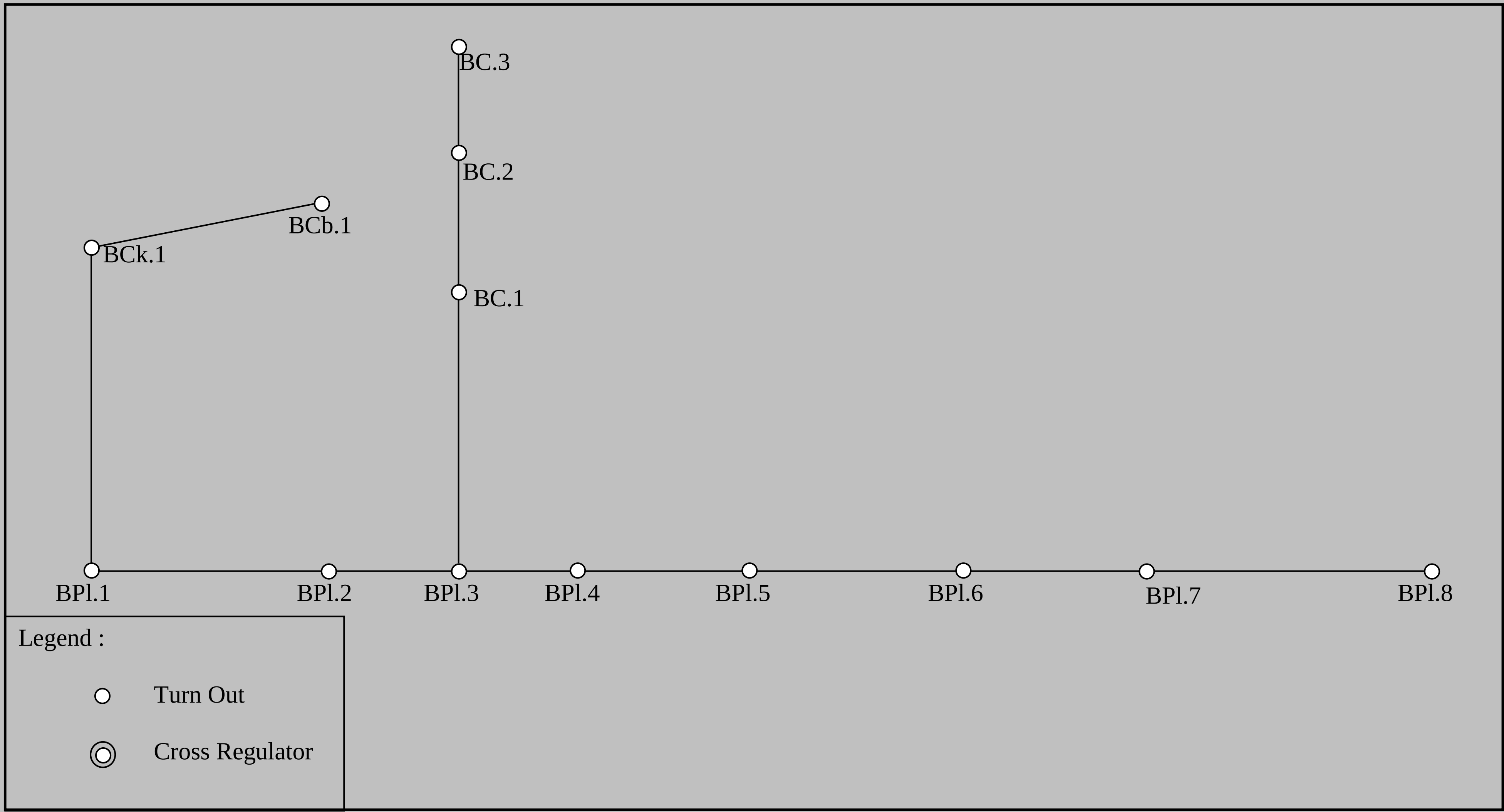

Figure 4.3 Right Canal System-2 (RCS-2) Paya Kareueng Pante Lhong technical irrigation system

4.2 Infrastructure Maintenance Performance of the System

The infrastructure maintenance is one of the RAP internal performance indicators. The sub internal indicators valued for infrastructure performance were floor and canal bank, seepage, level of gate maintenance and availability of proper equipment and staff. Table 4.1 – 4.4 and Figure 4.4 – 4.7 shows the infrastructure maintenance performances of LCS, RCS-1 and RCS-2 based on survey and measurement using RAP method. The details of sub indicators infrastructure maintenance component which contain a number of criteria or statement description and its related score values is shown in Table 3.3.

To evaluate LCS section, the LCS was divided into three sections, namely BP.1 to BPg.3, BPg.3 to BPd.8 and BPg.3 to BT.7 (refer to Figure 4.1). Each section has sub section and the detail of length and area of each section is shown in Table 4.1.

Table 4.1 Detail of length and area each section in Left Canal System (LCS) at Pante Lhong technical irrigation system

No.	Sub Section	Length (m)	Area (ha)
Section BP.1 – BPg.3			
1	Weir - BP.1	8,168	40.90
2	BP.1 - BPg.1	1,263	71.37
3	BPg.1 - BPg.2	2,022	24.10
4	BPg.2 - BPg.3	402	56.00
	Sub Total-1	11,855	192.37
Section BPg.3 – BPd.8			
1	BPg.3 - BPd.1	1,401	15.90
2	BPd.1 - BPd.2	675	95.10
3	BPd.2 - BPd.3	1,075	22.50
4	BPd.3 - BPd.4	793	10.55
5	BPd.4 - BPd.5	1,189	68.48
6	BPd.5 - BPd.6	1,107	68.40
7	BPd.6 - BPd.7	1,835	42.30
8	BPd.7 - BPd.8	1,000	102.80
	Sub Total-2	9,075	426.03
Section BPg.3 – BT.7			
1	BPg.3 - BT.1	923	30.70
2	BT.1 - BT.2	875	31.60
3	BT.2 - BT.3	1,020	136.95
4	BT.3 - BT.4	881	108.25
5	BT.4 - BT.5	459	54.40
6	BT.5 - BT.6	1,092	109.20
7	BT.6 - BT.7	882	91.20
	Sub Total-3	6,132	562.3
	Total (Sub Total 1+2+3)	**27,062**	**1180.70**

Table 4.2 Infrastructure maintenance performance at Left Canal System (LCS) at Pante Lhong technical irrigation system

No.	**Performance Indicators**	**Evaluation Section**		
		BP.1 to BPg.3	**BPg.3 to BPd.8**	**BPg.3 to BT.7**
1	Floor and canal bank	3.00	1.00	2.00
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	**3.25**	**2.50**	**3.25**

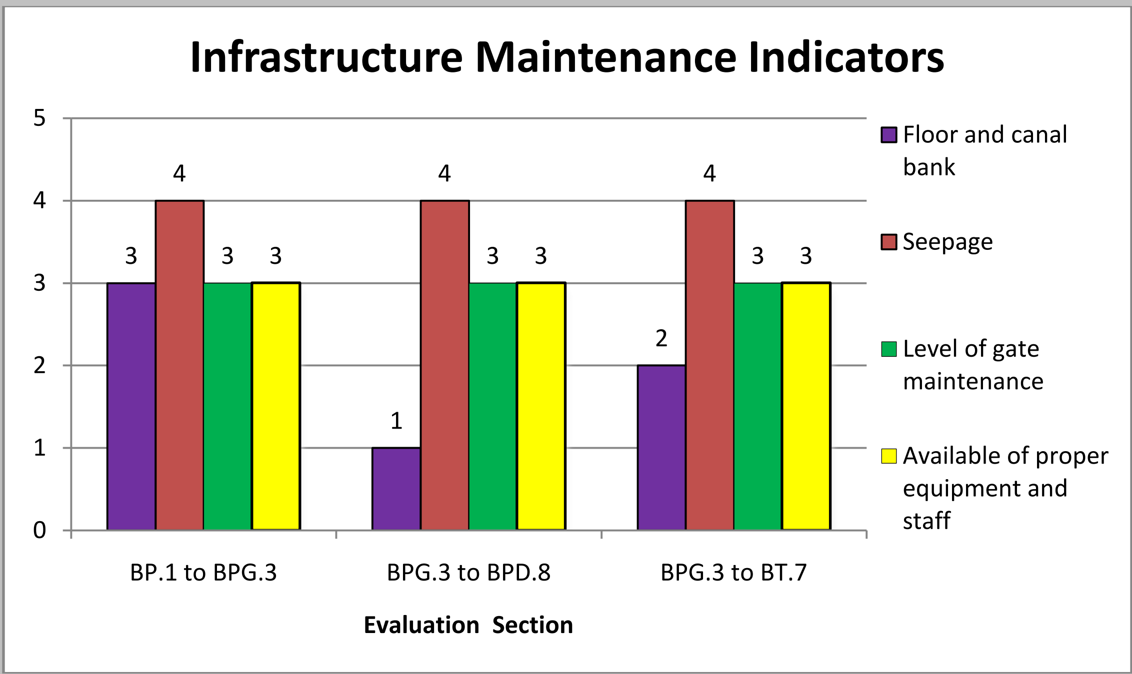

Figure 4.4 Infrastructure maintenance performances at Left Canal System (LCS) at Pante Lhong technical irrigation system

Table 4.2 shows that the result based on surveys and measurement using RAP method rating score for infrastructure maintenance performance indicator at the LCS. From the analysis of data, the average performance obtained for BP.1 to BPg.3 was 3.25 out of 4 (refer to Table 4.2). Based on the classification, the rating score performance is good. In this section, no problems were found regarding the sub indicators infrastructure maintenance component. As shown in Table 4.2, the average result of BPg.3 to BPd. 8 section was 2.5 out of 4, where this value is judged to be the quite enough according to performance standard. In this section, there were problems was found regarding the sub indicators infrastructure maintenance component (see Figure.4.4). This situation was mostly due to the insufficiency of the 1 out of 4 sub indicators to attain the maximum operation value. As shown in Figure 4.4, the result for floor and canal bank sub indicator was 1 out of 4 (section BPG.3 to BPD.8), which is very poor by the performance standard. This happened because there was waste material of work rehabilitation and it was not cleaned up to bed load and decrease performance. The average result of BPg.3 to BT.7 was 3.25 out of 4 (refer to Table 4.2). Based on the classification, the rating score performance is good and no problems were found regarding the sub indicators infrastructure maintenance component.

The average rating score value of infrastructure maintenance as the performance indicator at LCS was 3 out of 4, which is judged good by the performance criteria (refer to Table 4.2). This average rating score is obtained from the result of analysis on each canal section system that is part of the LCS. There were four sub-indicators are included in this assessment and each individual channel has its own average rating score (refer to Table 4.2). All the average rating score on each channel that is part of the LCS was evaluated and calculated into average rating scores on LCS. This result indicated that the current infrastructure network performed at approximately 75 % (3.0 out of 4) of the maximum expected operation. As shown in Figure 4.4 and Table 4.2, the result for floor and canal bank is 2 out of 4. This value is the lowest sub component performance indicator in infrastructure maintenance indicator. Based on the survey, there were found to be bed load along the canal.

For the floor and canal bank, the judgments criteria are developed based on five categories of canal bed load sedimentations conditions and their relation to the percentage of designed cross sectional area reduction. Excellent rating score of 4 is used for no sedimentation, 3 is valued for less than 5 % cross-sectional area reduction in sedimentation, 2 is judged for 5 % to 15 % reduction, 15 % to 30 % reduction is 1 and 0 is for more than 30 %. Based on the result of LCS for floor and canal bank, the result indicates 15 % to 30 % reduction and thus relates to significant the bed load problem.

The RCS-1 was divided into three sections comprising of BP.1 to BPk.2 section, BPk.2 to Bg.2 section and BPk.2 to BPl.1 (refer to Figure 4.2). Each section has sub section and the detail of length and area of each section is shown in Table 4.3. Table 4.4 and Figure 4.5 show the infrastructure performance of RCS-1.

Table 4.3 Detail of length and area each section in Right Canal System-1 (RCS-1) at Pante Lhong technical irrigation system

No.	Sub Section	Length (m)	Area (ha)
	Section BP.1 – BPk.2		
1	Weir - BP.1	8,168	40.90
2	BP.1 - BPk.1	690	69.70
3	BPk.1 - BPk.2	1,171	-
	Sub Total-1	10,029	110.60
	Section BPk.2 – BG.6		
1	BPk.2 - BG.1	1,241	59.20
2	BG.1 - BG.2	1,046	118.95
3	BG.2 - BG.3	512	107.80
4	BG.3 - BG.4	1,239	16.25
5	BG.4 - BG.5	512	29.50
6	BG.5 - BG.6	685	109.75
	Sub Total-2	5,235	441.45
	Section BPk.2 – BPl.1		
1	BPk.2 - BPk.3	1,200	36.40
2	BPk.3 - BPk.4	1,050	26.10
3	BPk.4 - BPl.1	1,592	83.60
	Sub Total-3	3,842	146.10
	Total (Sub Total 1+2+3)	**19,106**	**698.15**

Table 4.4 Infrastructure maintenance performance at Right Canal System-1 (RCS-1) at Pante Lhong technical irrigation system

No.	Performance Indicators	Evaluation Section		
		BP.1 to BPk.2	**BPk.2 to BG.6**	**BPk.2 to BPl.1**
1	Floor and canal bank	3.00	3.00	1.00
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		**3.25**	**3.25**	**2.75**

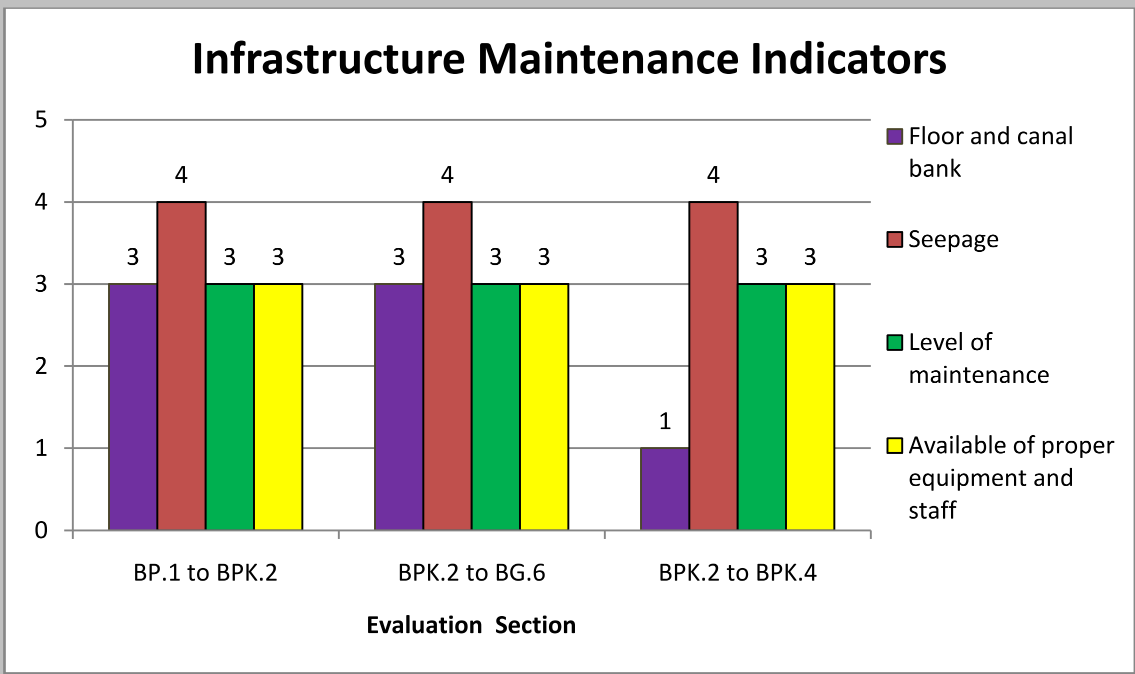

Figure 4.5 Infrastructure maintenance performance at Right Canal System-1 (RCS-1) at Pante Lhong technical irrigation system

Table 4.4 shows the result based on survey and measurement using RAP method rating score for infrastructure performance indicator at the RCS-1. According to the data analysis, the average performance of BP.1 to BPk.2 obtained that was 3.25 out of 4 (refer to Table 4.4). Based on the classification, the rating score performance is considered good. In this section, no problem was found regarding the sub indicators infrastructure maintenance component.

The average result of BPk.2 to BG.7 was 3.25 out of 4 (refer to Table 4.4). Based on the classification, the rating score performance is good and no problems were found regarding the sub indicators infrastructure maintenance component. As shown in Table 4.2, the average result of BPk.2 to BPl. 1 section was 2.75 out of 4, which this value is judged to be the quite enough according to performance standard. In this section, the problem found was regarding the sub indicators infrastructure maintenance component (see Figure.4.6). This situation was mostly due to the insufficiency of the 1 out of 4 sub indicators to attain the maximum operation value. As shown in Figure 4.5, the result for floor and canal bank sub indicator was 1 out of 4, which is very poor by the performance standard.

The average rating score value of infrastructure performance at RCS-1 was 3.08 out of 4 (Table 4.4) or indicating that RCS-1 is operated and managed with 77 % of the expected serviceability. This average rating score is obtained from survey and measurement with the RAP method and average score of each canal system that is part of the RCS-1. According to the performance criteria, this value is judged as good. The excellent rating score of 4 was obtained for seepage sub indicator (see Figure 4.5). Figure 4.5 shows that at BPk.2 to BPl.1, the sub indicator performance for floor and canal banks score value is 1 which is 25 % (1 out of 4) of the expected performance value. This result showed there are significant problems with bed load with 15 % - 30 % cross sectional area reduction in sedimentation.

The RCS-2 was divided into three sections comprising of BPl.1 to BCb.1 section, BPl.3 to BC.3 section and BPl.1 to BPl.8 (refer to Figure 4.3). Each section has sub section and the detail of length and area of each section is shown in Table 4.5. Table 4.6 and Figure 4.6 show the infrastructure performance of RCS-2.

Table 4.5 Detail of length and area each section in Right Canal System-2 (RCS-2) at Pante Lhong technical irrigation system

No.	Sub Section	Length (m)	Area (ha)
	Section BPl.1 – BCb.1		
1	BPl.1 – BCk.1	1,592	267.70
2	BCk.1 – BCb.1	676	148.50
	Sub Total-1	2,268	416.20
	Section BPl.3 – BC.3		
1	BPl.3 – BC.1	1,202	45.60
2	BC.1 – BC.2	1,326	78.40
3	BC.2 – BC.3	1,200	172.40
	Sub Total-2	3,728	296.40
	Section BPl.1 – BPl.8		
1	BPl.1 – BPl.2	1,026	24.10
2	BPl.2 – BPl.3	633	-
3	BPl.3 – BPl.4	682	40.70
4	BPl.4 – BPl.5	981	200.00
5	BPl.5 – BPl.6	1,525	213.00
6	BPl.6 – BPl.7	804	123.00
7	BPl.7 – BPl.8	1,956	43.40
	Sub Total-3	7,607	644.20
	Total (Sub Total 1+2+3)	**13,603**	**1,356.80**

Table 4.6 Infrastructure maintenance performance at Right Canal System-2 (RCS-2) at Pante Lhong technical irrigation system

No.	Performance Indicators	Evaluation Section		
		BPl.1 to BCb.1	BPl.3 to BC.3	BPl.1 to BPl.8
1	Floor and canal bank	1.00	2.00	1.00
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		**2.75**	**3.25**	**2.50**

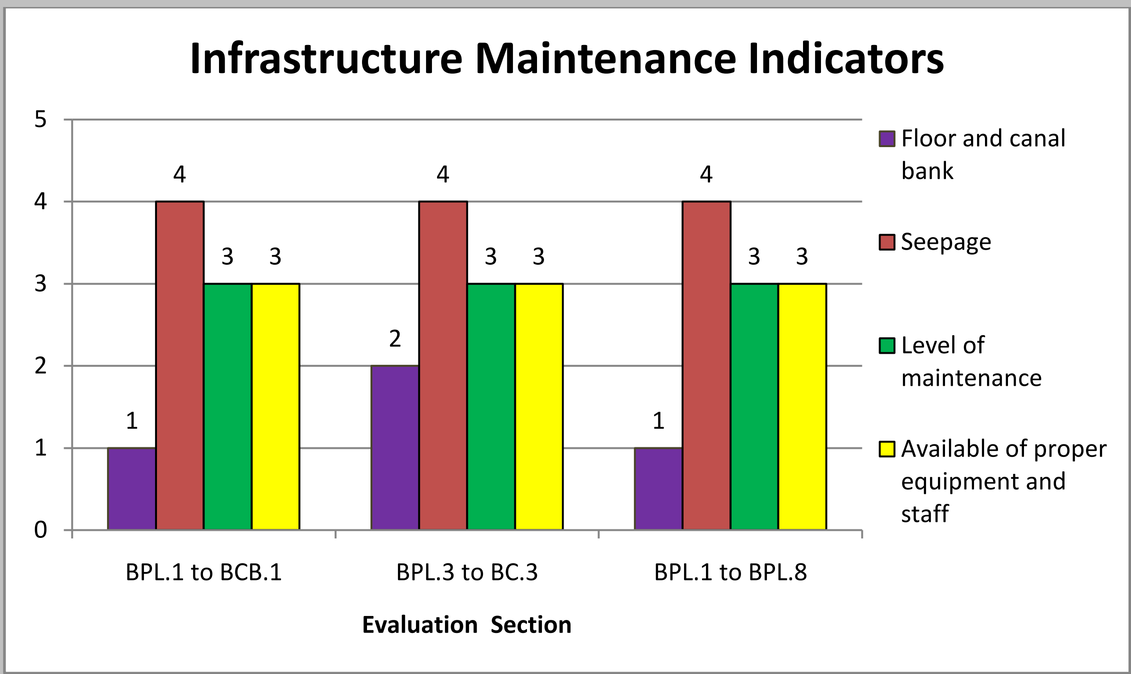

Figure 4.6 Infrastructure maintenance performance at Right Canal System-2 (RCS-2) at Pante Lhong technical irrigation system

Table 4.6 shows the result based on survey and measurement using RAP method rating score for infrastructure performance indicator at the RCS-2. From the data analysis the average performance of BPl.1 to BCb.1 was 2.75 out of 4 (refer to Table 4.6). Based on the classification, the rating score performance is quite good. In this section, the problems found were related to the sub indicators infrastructure maintenance component and the problem in floor and canal bank sub indicator. The result of BPl.3 to BC.7 was 3.25 out of 4 (refer to Table 4.6). Based on the classification, the rating score performance is good and no problems were found regarding the sub indicators infrastructure maintenance component. As shown in Table 4.6, the result of BPl.1 to BPl. 8 section was 2.75 out of 4, where the value is judged to be the quite enough according to performance standard. In this section, the problem found was related to the sub indicators infrastructure maintenance component (see Figure.4.6). This situation was mostly due to the insufficiency of the 1 out of 4 sub indicators to attain the maximum operation value. As shown in Figure 4.6, the result for floor and canal bank sub indicator was 1 out of 4, which is very poor by the performance standard.

Figure 4.6 shows the infrastructure maintenance performance for the RCS-2 section which show different performance values compared to LCS and RCS-1 section. This average rating score was obtained from survey and measurement with the RAP method and average score of each canal system that is part of the RCS-1. According to Table 4.3, the average score value of RCS-2 was 2.83 out of 4 which is 70.75 % of the expected service ability. This rate is judged as being quite enough in term of performance. The excellent rating score of 4 was obtained for seepage sub indicator (see Figure 4.6). As shown in Figure 4.6, the result for floor and canal bank sub-component indicator at BPL.1 to BPL.8 and BPL.1 to BCB.8 were 1. These values are judged to be very poor, respectively according to the performance standard. Based on these result, the most problematic aspect is bed load.

Table 4.7 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**

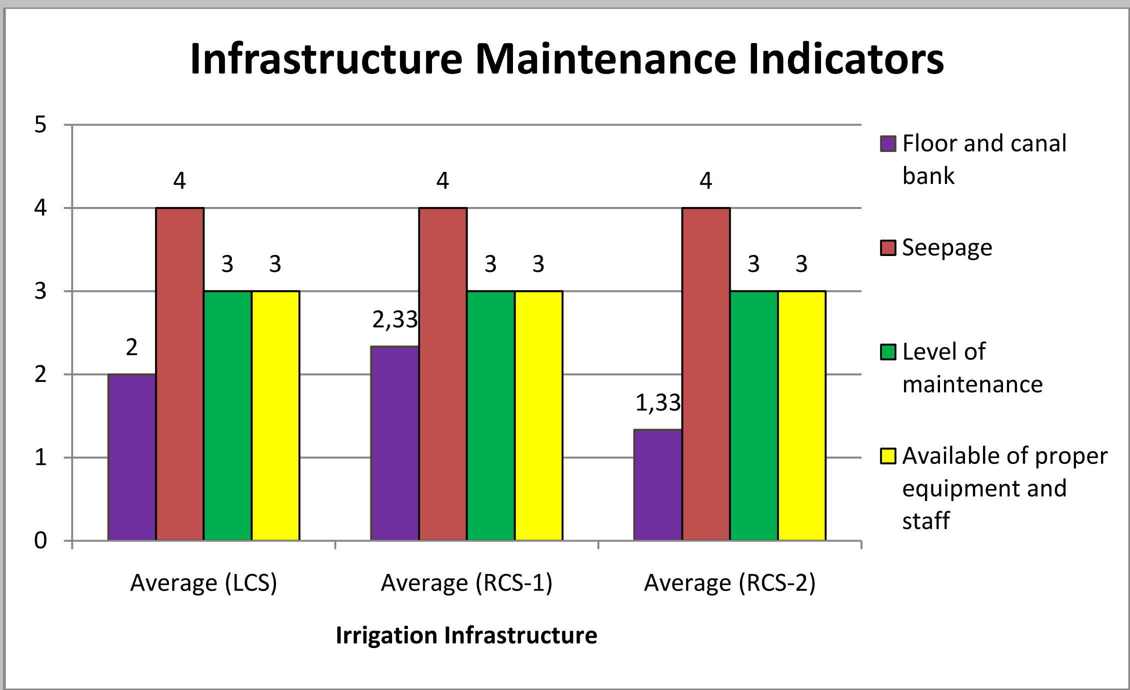

Figure 4.7 Average infrastructure maintenance performances Pante Lhong technical irrigation system

The average value for the infrastructure performance indicator was 2.97 out of 4 which is about 74.25 % of expected serviceability (see Table 4.7), and the rate is judged as being quite enough by the performance criteria. This average result was obtained from the analysis of average performance of LCS, RCS-1 and RCS-2. Figure 4.7 and Table 4.7 show that the infrastructure has poor (1.89 out of 4) performance on the floor and canal bank while, three other sub indicators have a good score of 3 (out of 4) to excellent performance score of 4. 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. For the lined canal, there are some concrete cracks that causes the reduction of water level or water depth (4 %, 5 % to 9 %, 10 % to 15 % and more than 16 % is valued with a ranking score of 4, 3, 2, and 1 respectively). 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 (refer to Figure 3.5 – 3.7). 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 (refer to Figure 3.5 – 3.7).

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 (US$ 70,659) and Rp. 729 million rupiahs (US$ 80110) in 2005 and 2006, respectively. During these years, the authority spent a total of Rp. 1.3 billion rupiahs (US$ 142,857) or equivalent to Rp. 246 thousand rupiahs/ha (US$ 27/ha). This value is 1.64 times higher than the national maintenance standard cost of Rp. 150 thousand rupiahs/ha (US$ 16.5). 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 occuring 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.

4.3 Water Delivery Service Performance of the System

At this stage of evaluation, a series of indicators and sub indicators were selected from the RAP performance standard. The internal indicator performance was water delivery service and the sub internal indicators performance were flexibility, reliability, equity and control of flow to costumers. An analysis was carried out to obtain the impact of the canal network performance on the delivery service performance. The analysis was focused on the continuous irrigation supply in the tertiary system delivery service and final delivery service (refer to 1.4 Scope of Research). The tertiary area are very complex and in this area the farmers or water user associations have responsibility to operate, adjust, manage and organize the schedule of water and activity on-farm. In continuous irrigation supply method, no water shortage was found during both paddy planting seasons and the farmers may withdraw water every day from off-take structures. The following sections describe the results that had been discovered through the survey of water delivery service performance at LCS section. The result is presented in Table 4.8 and Figure 4.8.

Table 4.8 shows that the result based on surveys, measurement and interview with the farmer and field staff using RAP method rating score for water delivery service performance indicator at the LCS and the score as average score section from each sub section. The details of sub indicators water delivery service which contain a number of criteria or statement description and related score value can be referred to Table 3.1. To evaluate of this section, the LCS was divided into three sections comprising of BP.1 to BPg.3 section, BPg.3 to BPd.8 section and BPg.3 to BT.7 (refer to Figure 4.1). From the analysis of the data, the average performance obtained for BP.1 to BPg.3 was found to be 2.75 out of 4 (refer to Table 4.8). Based on the classification, the rating score performance is quite enough. In this section, the problem found was regarding the sub indicators water delivery service performance component (see Figure.4.8). This situation was mostly due to the insufficiency of the 1 out of 4 sub indicators to attain the maximum operation value. As shown in Figure 4.8, the result for control of flow to customers sub indicator was and 0.5 out 4, which is worse by the performance standard.

In tertiary area, the farmers have the responsibility to operate, manage and organize the schedule of water and activity on-farm of the irrigation system. Generally, the water was abundant and debit was not adjusted. Besides that, some of the water gate was mostly due to theft (refer to Figure 3.7). Overall, the performance was quite enough because the other sub indicators (reliability n equity) had maximum performance.

Table 4.8 Water delivery service performance at the LCS section tertiary canal

No.	**Performance Indicators**	**Evaluation Section at Tertiary Canal**		
		BP.1 to BPg.3	**BPg.3 to BPd.8**	**BPg.3 to BT.7**
1	Flexibility	2.50	2.50	2.50
2	Reliability	4.00	4.00	4.00
3	Equity	4.00	4.00	4.00
4	Control of flow to customers	0.50	0.50	0.50
Average		**2.75**	**2.75**	**2.75**

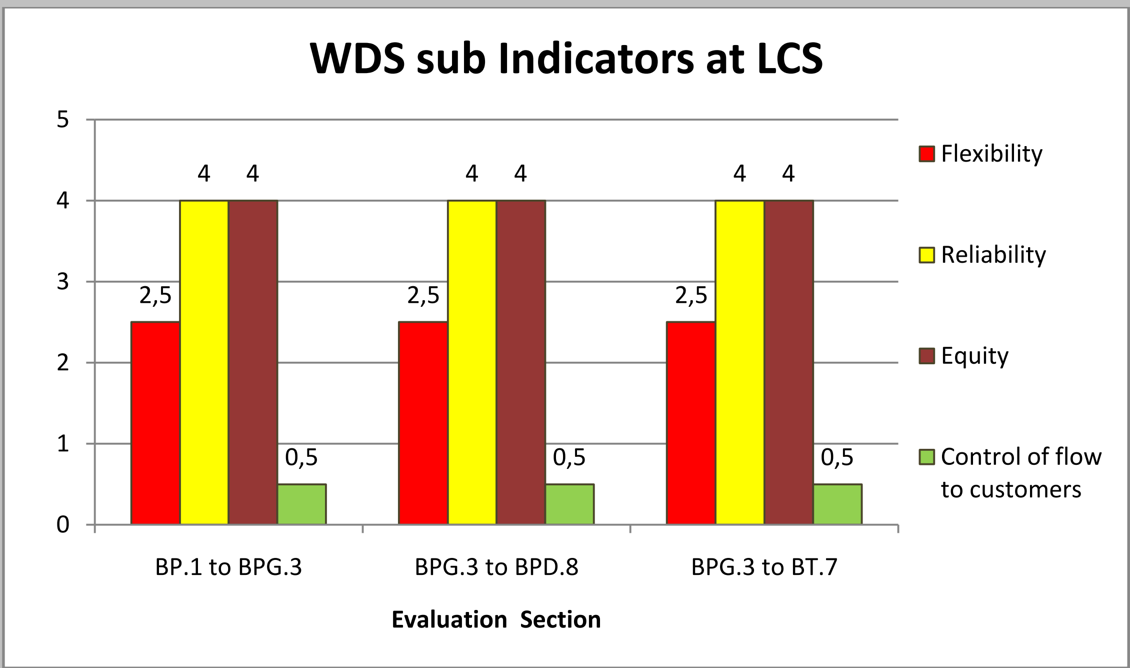

Figure 4.8 Water delivery service performance at LCS section tertiary canal

Table 4.8 and Figure 4.8 show the evaluation section from each canal at the LCS sector tertiary canal. This average rating score is obtained from result of analysis on each canal section system that is part of the LCS and the score was 2.75 out of 4 (performed at 68.75 % of the maximum expected operation). This value is categorized quite enough according to performance standard. In this section, the problem found was regarding the sub water delivery service component (see Figure 4.8). This situation was mostly due to the insufficiency of one sub indicators to attain the maximum operation value. The result sub indicator control of flow to customers was 0.5 out of 4, which is considered worse by the performance standard. This has happened because the farmers weren't set the debit of water. They said to set the debit water every day didn't effective and busy. Furthermore, there was gates uncompleted equipment to set the debit caused by damaged and stolen. The average result of BPg.3 to BT.7 was 2.75 out of 4 (refer to Table 4.5). Based on the classification, the rating score performance is quite enough and problems were found regarding the sub indicators water delivery service component (see Figure 4.8).

Table 4.9 and Figure 4.9 show the performance of water delivery service at the RCS-1 section. Table 4.9 shows the result based on survey, measurement and interview with the farmer and field staff using RAP rating score for water delivery service indicator at the RCS-1. From analysis of the data, the average performance obtained for BPl.1 to BCb.1 was 2.0 out of 4. This score and condition same with section of BPk.2 to BPk.4. Based on the classification, the rating score performance is enough. In this section, the problem was found related to the sub indicators water delivery service performance component; equity and control flow to customers. The equity problem caused by water user association wasn't assertive to manage whom using the water in tertiary area. Majority field in this area, flow and drain the water in field by plot to plot (not using canal or drainage) and could be the problem in downstream field. The water user association should manage and uniformity usage the water in each plot and area. The same reason with other section, the poor performance of sub indicator control flow to customers because there was gates uncompleted equipment to set the debit caused by damaged and stolen (refer to Figure 3.6 - 3.7).

Table 4.9 Water delivery service performances at the RCS-1 section tertiary canal

No.	Performance Indicators	Evaluation Section at Tertiary Canal		
		BP.1 to BPk.2	BPk.2 to BG.6	BPk.2 to BPl.1
1	Flexibility	2.50	2.50	2.50
2	Reliability	4.00	4.00	4.00
3	Equity	1.00	4.00	1.00
4	Control of flow to customers	0.50	0.50	0.50
Average		**2.00**	**2.75**	**2.00**

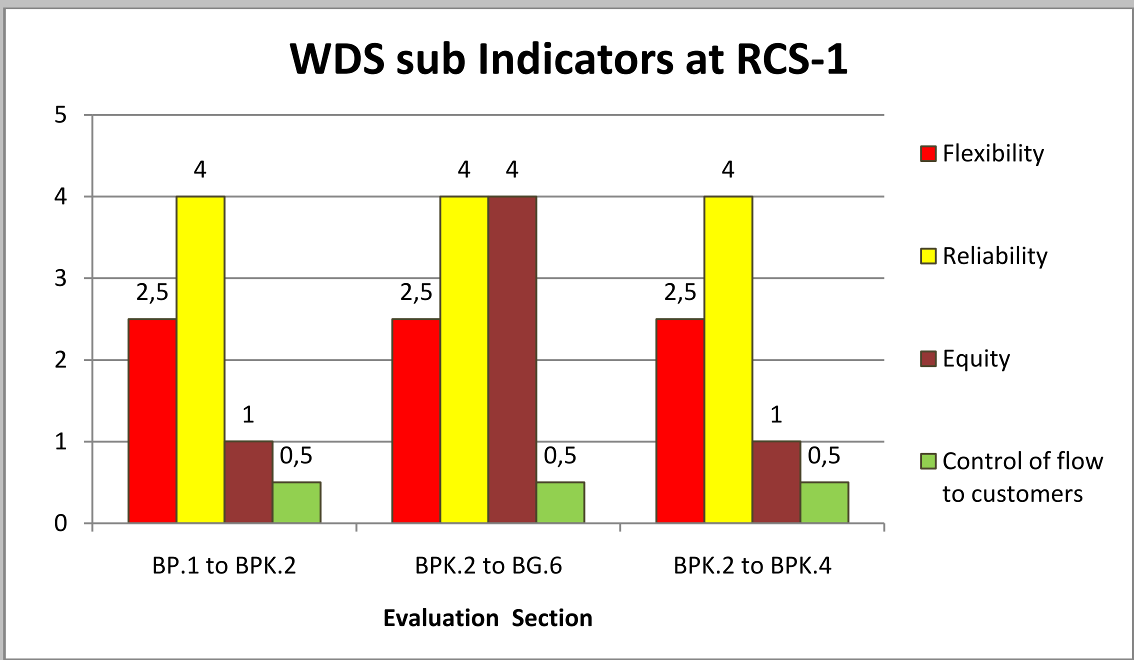

Figure 4.9 Water delivery service performances at the RCS-1 section tertiary canal

As shown in Table 4.9, the average result of BPk.2 to BG. 6 section was 2.75 out of 4, where this value is judged to be the quite enough according to performance standard. The problem was found related with water delivery service component this situation was mostly due to the insufficiency of the 1 out of 4 sub indicators to attain the maximum operation value. As shown in Figure 4.9, the result for control of flow to customers was 0.5 out of 4, which is worse by the performance standard. Same reason with above section, responsibility and unavailability of gate component still the problem.

Figure 4.9 shows the current values of four water delivery service performance sub indicators of the RCS-1 section. This average rating score is obtained from result of analysis on each canal section system that is part of the RCS-1 with the RAP method and average score of each canal system that is part of the RCS-1. The average score value of this performance was 2.25 out of 4 (Table 4.9). According to the RAP performance standard, this rate can be judged as enough in term of performance. This result indicates a performance of 56.25 % (2.25 out of 4) from maximum expected operation. It can be seen that one out of four sub indicators produced a rating score value of less than 2 which performed less than 12.5 % of the expected value. The sub indicator which obtained a performance of less than 12.5 % is the control of flow to costumers. The excellent rating score of 4 out of 4 is obtained in terms of reliability. For the flexibility and equity sub indicators, each have a ranking score value of 2.5 out of 4 and 2 out of 4 which can be categorized as quite enough and enough performance, respectively.

Table 4.10 Water delivery service performance at RCS-2 section tertiary canal

No.	Performance Indicators	Evaluation Section at Tertiary Canal		
		BPl.1 to BCb.1	**BPl.3 to BC.3**	**BPl.1 to BPl.8**
1	Flexibility	2.50	2.50	2.50
2	Reliability	4.00	4.00	4.00
3	Equity	4.00	4.00	1.00
4	Control of flow to customers	0.50	0.50	0.50
Average		**2.75**	**2.75**	**2.00**

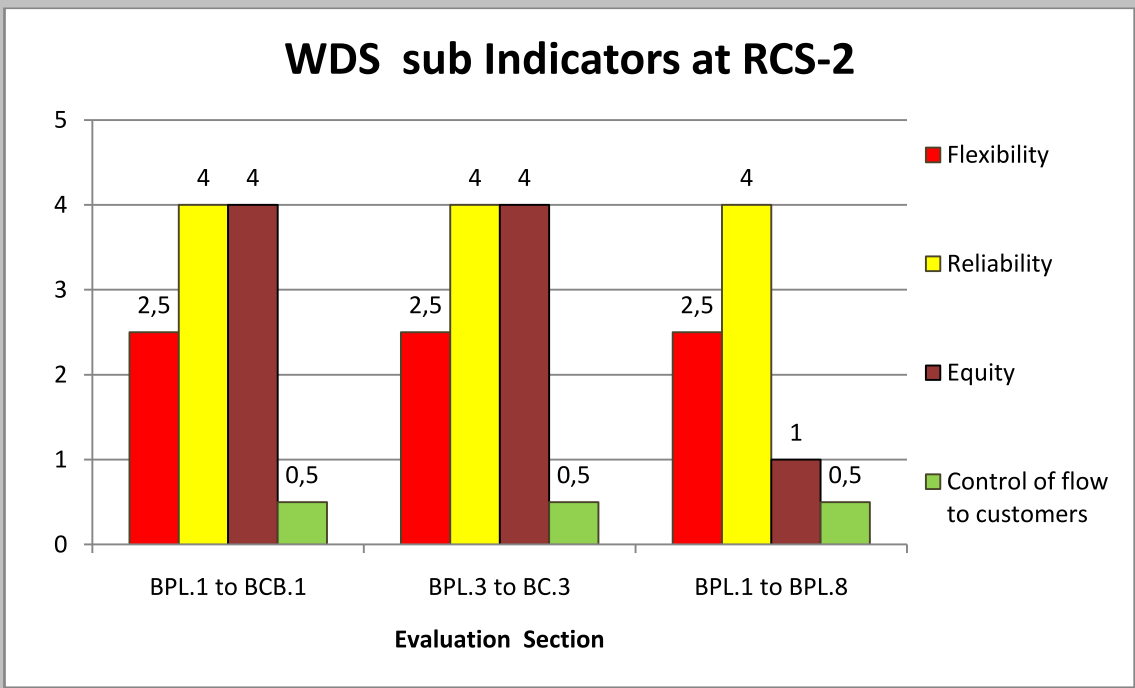

Figure 4.10 Water delivery service performance at RCS-2 section tertiary canal

Table 4.10 shows the result based on survey, measurement and interview with the farmer and field staff using RAP method rating score for water delivery service performance indicator at the RCS-2. The RCS-2 was divided into three sections comprised of BPl.1 to BCb.1 section, BPl.3 to BC.3 section and BPl.1 to BPl.8 (refer to Figure 4.10). From the analysis of the data, the average performance obtained for BPl.1 to BCb.1 was 2.75 out of 4 and the rating score performance is quite enough. In this section, the problem was found regarding the sub indicators water delivery service performance component. The poor performance of control of flow to customers sub indicator influence the performance of this section. These were performance and condition same with section BPl.3 to BC. 3. The average results of BPl.3 to BC. 3 section was 2.75 out of 4, which this value is judged to be the quite enough according to performance standard. The problem in this sub indicator caused by the farmer didn't want to adjust the water in gates.

The average result of BPl.1 to BPl.8 was 2.0 out of 4 (refer to Table 4.10). Based on the classification, the rating score performance is enough and problems were found regarding the sub indicators water delivery service component (see Figure.4.10). This situation was mostly due to the insufficiency of the 1 out of 4 sub indicators to attain the maximum operation value. As shown in Figure 4.10, the result for control of flow to customers was 0.5 out of 4, which is worse by the performance standard.

Figure 4.10 shows that different performance values at the RCS-2 section was observed. This average rating score is obtained from result of analysis on each canal section system that is part of the RCS-2. The excellent rating score of 4 was obtained for the reliability sub indicator. The average score value for the operational performance was 2.50 out of 4, which can be judged as quite enough which is 62.50 % of the maximum expected operation. This is mainly due to the poor performance of the control of flow to customers sub indicators, which scoring 0.5 out of 4 or 12.5 % of the expected value. The flexibility and equity sub indicators have a ranking score value of 2.5 and 3 respectively, which can be categorized as quite enough and good performances, respectively. Figure 4.11 and Table 4.11 shows the current water delivery service performance of the Pante Lhong irrigation system at the tertiary level from each canal/section.

Table 4.11 Water delivery service performance irrigation at the tertiary level

No.	Performance Indicators	Water Delivery Service at Third Canal (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**

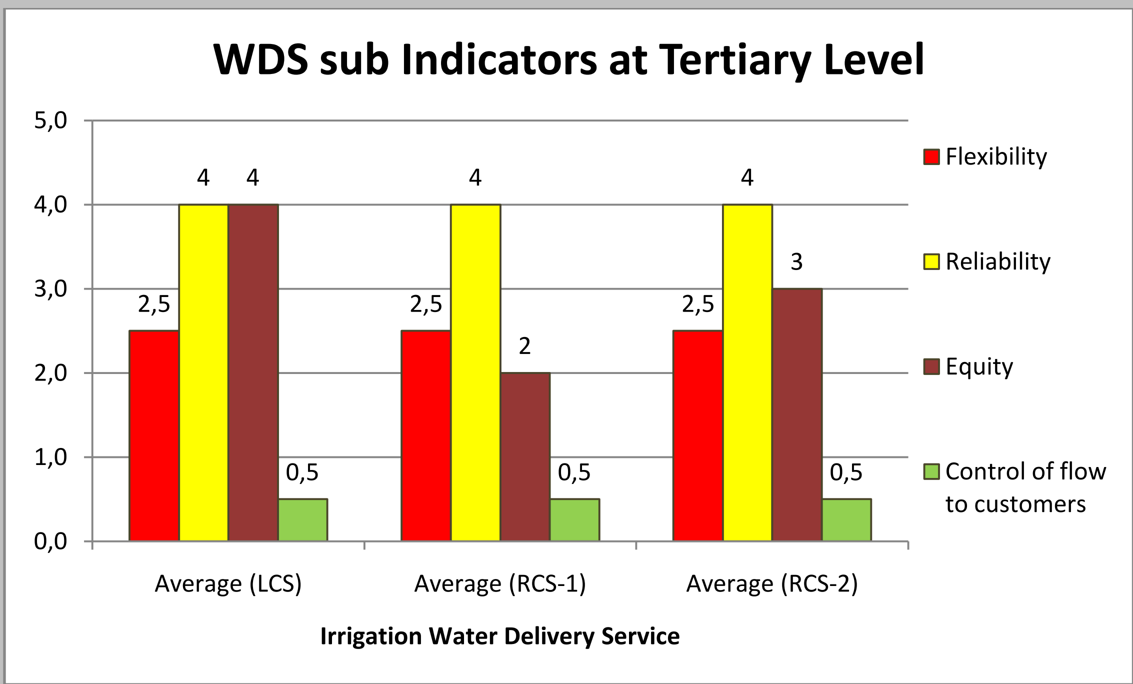

Figure 4.11 Water delivery service performance irrigation at the tertiary level

Figure 4.11 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 4.11, 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. The overall problems in the tertiary level were responsibility of adjusting the debit in gate and some gates have the problem with stolen case.

The final delivery is located after the tertiary block at the end section of irrigation system. The tertiary block selected as the final delivery were BPg.1 in upstream, BJb.2 in the middle stream and BT.7, downstream. The result of the final delivery is presented in Table 4.12 and Figure 4.12.

Table 4.12 Water delivery service performance irrigation at final delivery

No.	Performance Indicators	Water Delivery Service at Final Delivery		
		BPg.1	**BJb.2**	**BT.7**
1	Flexibility	2.50	2.50	2.50
2	Reliability	4.00	4.00	4.00
3	Equity	4.00	4.00	4.00
4	Measurement of volumes delivered	1.00	0.50	0.50
	Average	**2.75**	**2.75**	**2.75**

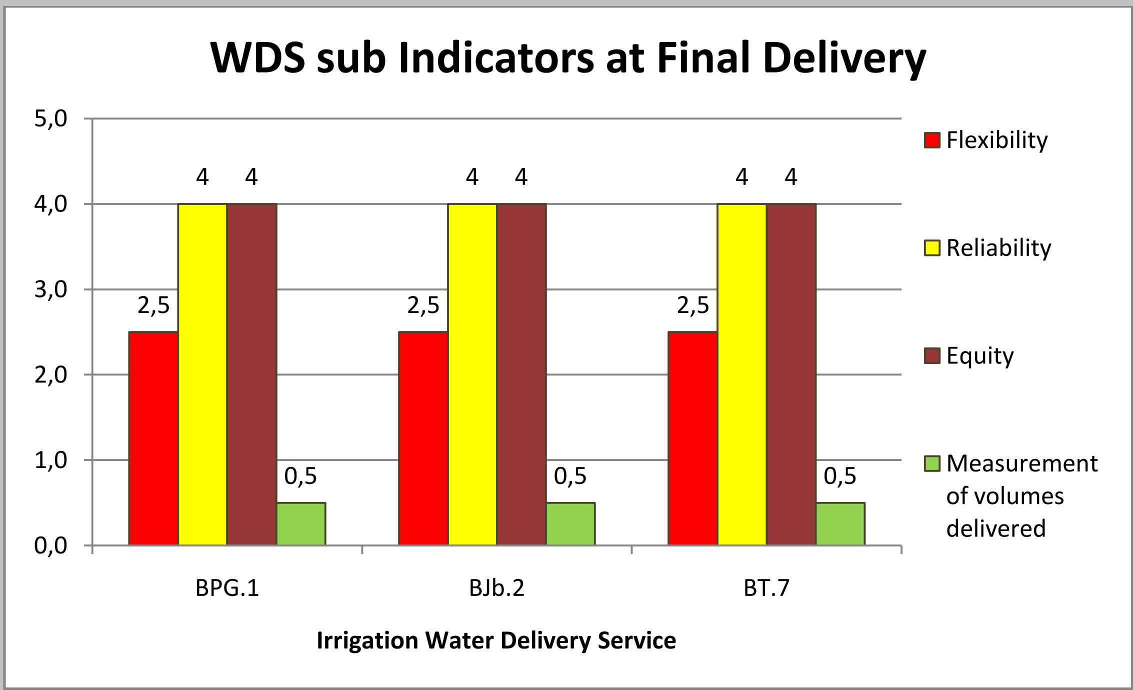

Figure 4.12 Water delivery service performance irrigation at final delivery

Table 4.12 shows that the result based on surveys, measurement and interview with the farmer using RAP method rating score for water delivery service performance indicator at the final delivery. The detailed of sub indicators water delivery service which contain a number of criteria or statement description and related score value refer to Table 3.2.

The result obtained were from the analysis for average performance of plot BPg.1, BJb.2 and BT.7. The entire plot obtained the same result based on the criteria in Table 3.2 (see Table 4.12).

The average value of water delivery service indicator at the final delivery was 2.75 out of 4. This result indicated that the current water delivery service indicator at each final delivery sector performed at 68.75 % (2.75 out of 4) of the maximum expected operation and the rate is judged as being quite enough by the performance criteria. The flexibility, reliability and equity sub indicators achieved the rating score values between 2.5 and 4 out of 4, which is judged as quite good to excellent according to the performance standard. The flexibility is measured using gate depth and duration of operation data and field operation information data obtained from field survey. In continuous flow method, the system has a wide range of frequency, rate and duration. The water schedule is set by WUA at the downstream canal based on the paddy growth and this defines the flexibility criteria. This supply method is operated with unknown actual water requirement but matches approximate water requirement of the paddy plant.

The reliability of the continuous flow system is given a score at 4.0 meaning the farmers received water within a few hours of the targeted time. To access this indicator, the data was developed from field survey, interview with gate operators on the time schedule of water supply. The score value of equity continuous flow system is 4.0, meaning all canal systems downstream receives water without facing a water shortage problem. Data is obtained from measuring the water supply and also from interviews with gate operators and farmer during field surveys. As shown in from Table 4.12 and Figure 4.12, the results for measurement of volumes delivered are 0.5 (sub indicator values), its rating score value was less than 1 which is very poor, performing less than 12.5 % of maximum target service delivery. This value is judged as bad, according to the performance standard. These are not water measurements conducted at gate, gate calibration, standard of procedure and gate measurement. The field survey indicates that much water excess in the drainage system was observed visually as 20 % oversupply. The value of 0.5 is relevant.

Based on the above evaluation, inability of the system to perform at the expected level of service is mainly due to the control structures failure to deliver intended flow rate to the downstream costumers as indicated by the very low rating score of 0.5. The main reason is due to the fact that the water requirement was not calculated, application of fixed supply method and no water measurement was done at the gate structures. It means that the frequency, rate and duration schedule is adjusted by the downstream gate operators/gate keepers weekly or even more at longer intervals. Generally, it depends on the fluctuation of water used by farmers.

Therefore, although the water was abundantly available at the sources but the system was unable to perform at maximum flexibility (2.5 out of 4) and produced overflow of approximately 20 to 25 % as indicated by the amount of the water excess found in the drainage canal system during operation. In general, the results show that the performance of the water delivery service is a measure of internal processes in which the impact the physical canal and water control conditions are factors, and it showed how the authorities actually operated, maintained and managed the irrigation system.

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.

In relation to the interviews, it was found that the field staff with permanent status or as public servants was 36.36 %, while 63.64 % were working under yearly contract status (Table 3.6). Most of them upgraded their status usually based on length of service (more than 5 years). From the investigation, it was found that the social aspect is considered important in relation to the indicators performance. This is due to the fact that their status relates to the amount of monthly payment, where the contract staff received less in comparison to the permanent staff. As a result, some of them had part time activities to overcome their financial problem. The field staff performance is directly or directly related to the on-farm irrigation performance. Dayton-Johnson (2003) found that good management on the irrigation system, either conducted by government or farmers, influence the suitability of the canal operation, infrastructure maintenance and irrigation productivity.

4.4 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. All of the respondents were located in the continuous supply area. The details of the respondents are provided in APPENDIX B.

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 2007 -2009. The data from each farm was collected and average for each tertiary block and is divided into three groups, namely upstream, midstream and downstream. More details of average rice production of farmers in the Pante Lhong technical irrigation system from each location were obtained during the 2007 – 2009 as presented in the Tables 4.13 – 4.15 and Figures 4. 13 – 4.15.

Table 4.13 Average crop yield of rice at the Pante Lhong technical irrigation system in 2007

Description	**Crop Yield (Ton/Ha) 2007**			
	Upstream	**Middle**	**Downstream**	**Average**
Pg.1.Kn (BPg.1)	4.563	4.734	4.039	4.445
Jb.2.Kr (BJb.2)	3.315	2.643	4.845	3.601
T.7.Kn (BT.7)	2.768	3.092	2.931	2.930
Total				**3.659**

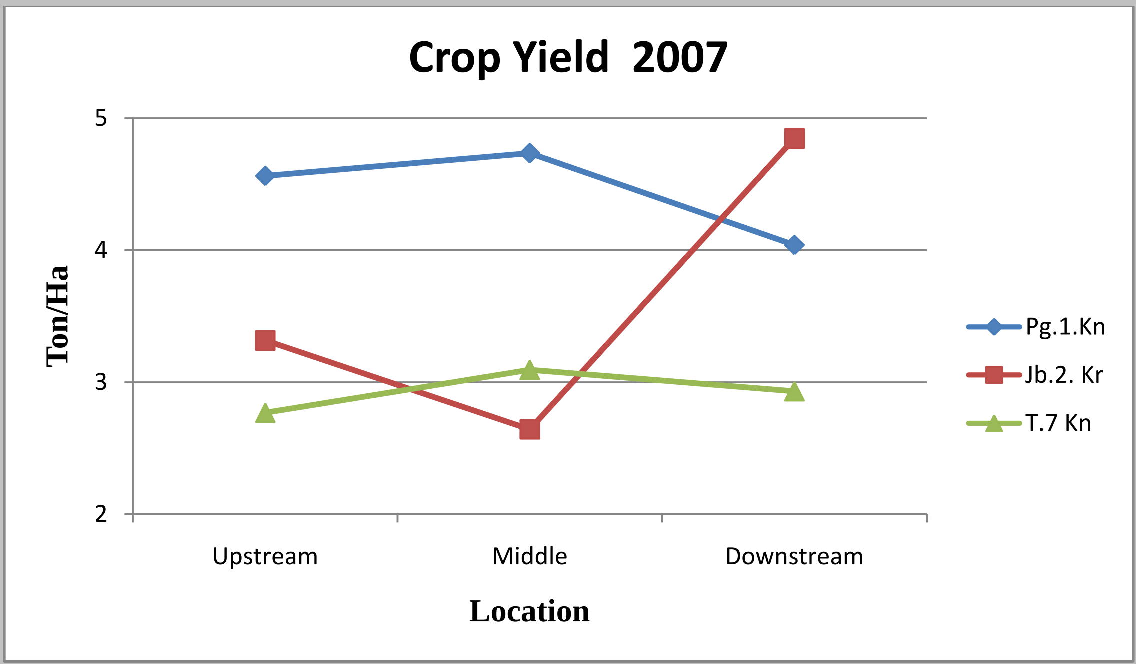

Figure 4.13 Average crop yield of rice at the Pante Lhong technical irrigation system in 2007

The data was collected through field observation, face to face interview and questionnaires and each block consist of 27 farmers. The detail of categories of samples is presented in Tables 3.8 – 3.13 and the details of the respondents are provided in APPENDIX B. The average crop yield of each tertiary block is different and dependant on location. The average crop yield of plot Pg.1.Kn representing upstream area was 4.45 ton/ha of 2007 (Table 4.13). The crop yield of plot Pg.1.Kn showed the highest result when compared with other tertiary blocks (Figure 4.13). The lowest crop yield block was at plot T.7.Kn. This is caused by the presence of pests, diseases in the field and damaged irrigation canals causing non-optimal distribution of water. The overall average crop yield of rice in 2007 amounted to 3.659 ton/ha.

Table 4.14 Average crop yield of rice the Pante Lhong technical irrigation system in 2008

Description	**Crop Yield (Ton/Ha) 2008**			
	Upstream	**Middle**	**Downstream**	**Average**
Pg.1.Kn (BPg.1)	4.432	4.860	3.913	4.402
Jb.2.Kr (BJb.2)	3.306	2.676	4.777	3.586
T.7.Kn (BT.7)	2.675	2.820	2.870	2.789
Total				**3.592**

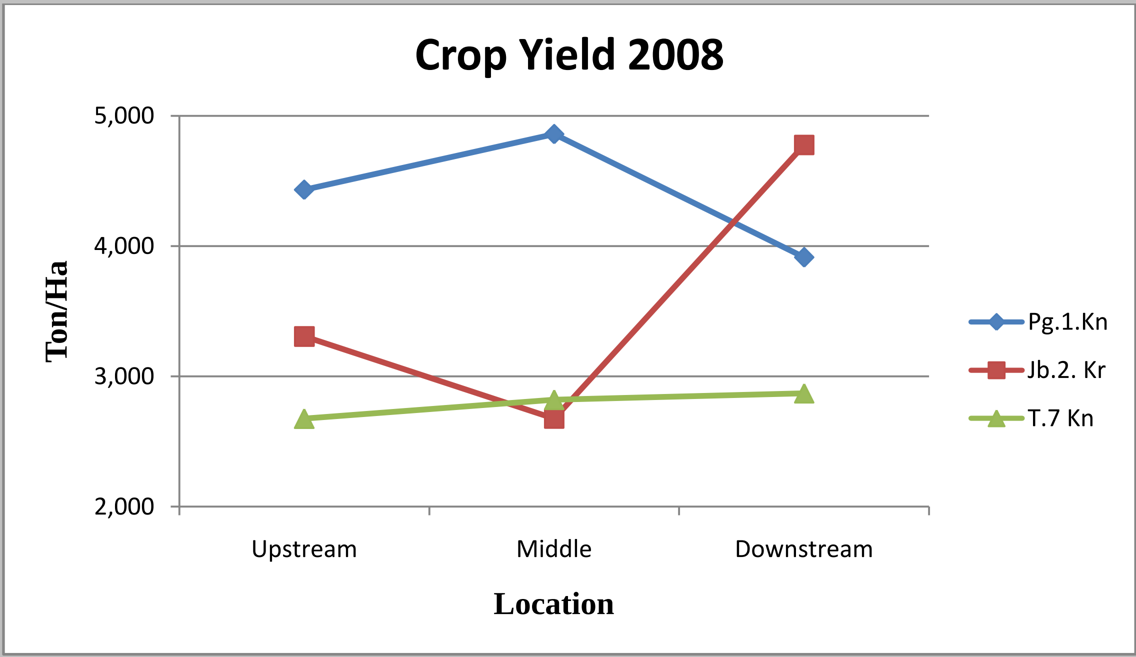

Figure 4.14 Average crop yield of rice the Pante Lhong technical irrigation system in 2008

Table 4.14 shows the average crop yield of rice in 2008 was 3.592 ton/ha and this result is lower than average crop yield of 2007. Based on the interview with farmers, the decrease in crop yield is caused by the attack of rats, use of different paddy seeds and worm infections. The highest average crop yield was in plot Pg.1.Kn and the lowest average crop yield was found in plot T.7. Kn.

Table 4.15 Average crop yield of rice the Pante Lhong technical irrigation system in 2009

Description	**Crop Yield (Ton/Ha) 2009**			
	Upstream	**Middle**	**Downstream**	**Average**
Pg.1.Kn (BPg.1)	4.386	4.813	4.292	4.497
Jb.2.Kr (BJb.2)	3.749	3.518	5.159	4.142
T.7.Kn (BT.7)	2.955	3.186	3.162	3.101
Total				**3.913**

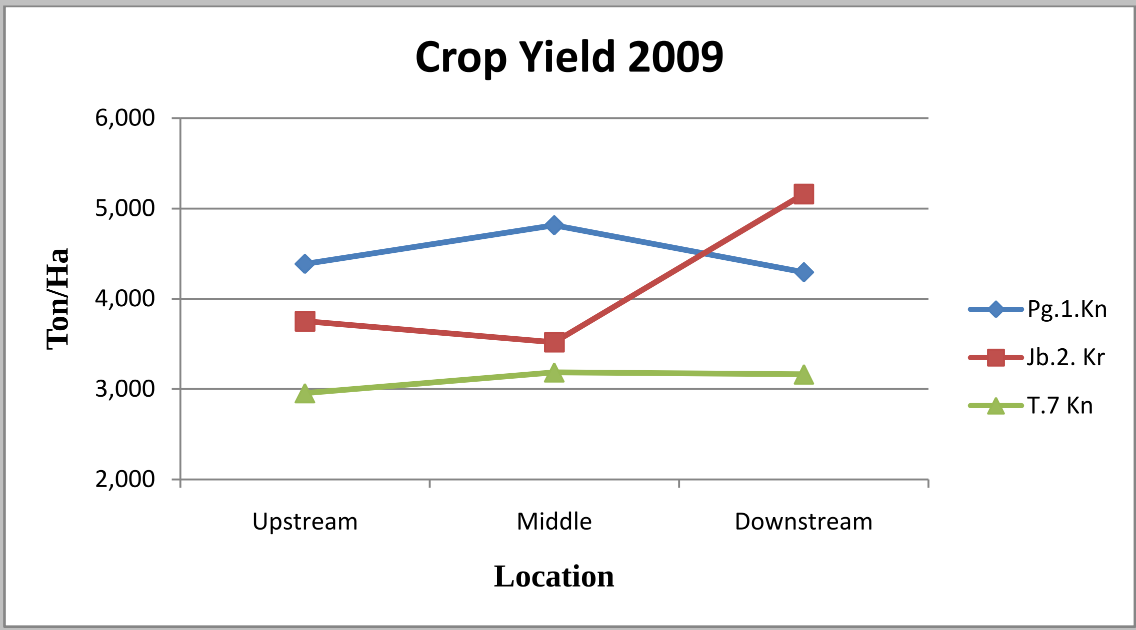

Figure 4.15 Average crop yield of rice the Pante Lhong technical irrigation system in 2009

The average crop yield of rice for 2009 was 3.913 ton/ha (Table 4.15). The result for that year, tended to be higher in productivity and better when compared to the results of the previous two years. The highest average productivity was obtained at the plot Pg.1.Kn and the lowest average value at plot T.7.Kn. Nevertheless, there remains the problem faced by the farmers. Rehabilitation also has an impact on rice crop yield.

Based on the result above year (2007 - 2009), Pg.1.Kn receives more yield than other plots. The usage of superior seed gives impact for the production of crop yield. Majority of resulted farmers in plot Pg.1.Kn have bought superior seed to increase their production. It has in higher cost for land preparation cost and total production cost. 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 average crop yield of the Pante Lhong technical irrigation system since years 2007 – 2009 below if comparison with local crop yield (Bireuen), regional crop yield (Aceh) and crop yield national (Indonesia). The comparison data obtained from Central Agency on Statistic in Indonesia (BPS-Indonesia) and the detail of average crop yield between the Pante Lhong technical irrigation system with other crop yield is shown in Table. 4.16

Table 4.16 Comparison of the average crop yield of rice during 2007 – 2009 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	2007	3,66	4,31	4,25	4,71
2	2008	3,59	4,33	4,26	4,89
3	2009	3,91	4,43	4,33	5,00

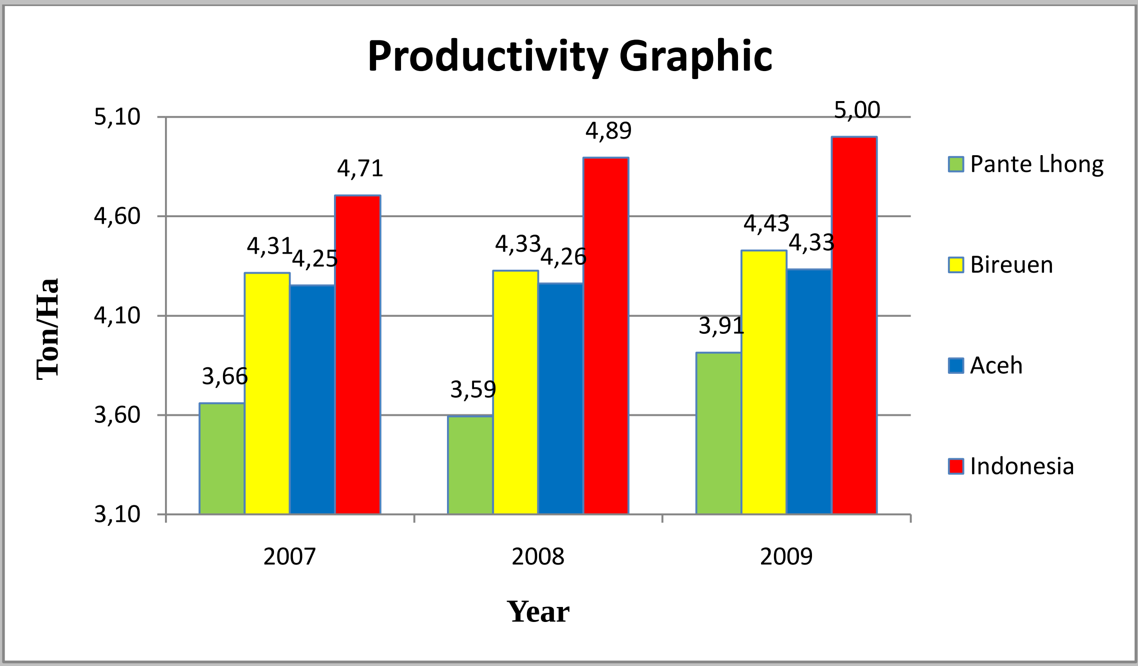

Figure 4.16 Comparison of average crop yield of rice during 2007 – 2009 between the Pante Lhong technical irrigation system, local (BPS-Aceh, 2010), regional and national crop yield (BPS-Indonesia, 2010)

Figure 4.16 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 (Figure 4.16). 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 behaviour, 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 Figure 4.16, from 2007 to 2009, 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.

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.

4.5 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 details samples are provided in APPENDIX B.

Tables 4.17 – 4.20 and Figures 4.17 – 4.20 shows the production cost and average production cost based on the land preparation cost, growth stage cost and harvesting cost at each of the location and section area (upstream, middle and downstream) of the Pante Lhong technical irrigation system. The unit measurement used is Rp/m^2 due to the diversity of size and shape of fields. Table 4.17 and Figure 4.17 show the result of land preparation cost in each location.

Table 4.17 Production cost based on land preparation at the Pante Lhong technical irrigation system

Description	**Production Cost of Land Preparation (Rp/m^2)**		
	Upstream	**Middle**	**Downstream**
Pg.1.Kn (BPg.1)	101	112	78
Jb.2.Kr (BJb.2)	70	65	90
T.7.Kn (BT.7)	42	46	36

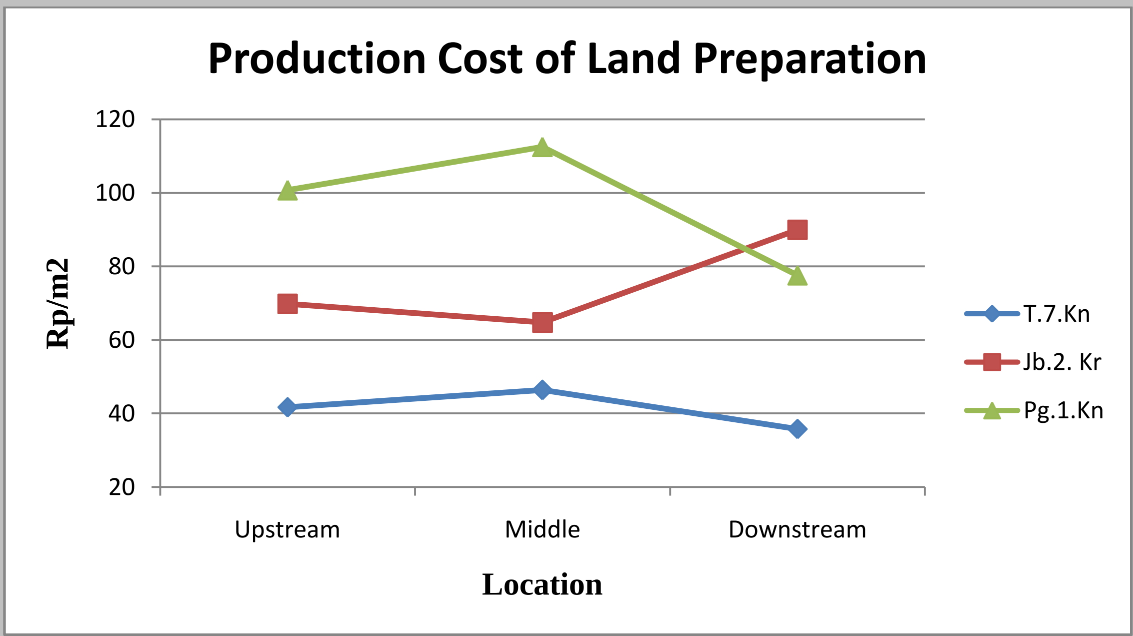

Figure 4.17 Production cost based on land preparation at the Pante Lhong technical irrigation system

Table 4.17 shows that the highest cost of land preparation is located at Pg.1.Kn, where the average cost of is Rp. 97/m^2 or Rp. 970,000/ha and the lowest average cost is Rp. 41/m^2 or Rp. 410,000/m^2 at T.7.Kn. These results were illustrated in Figure 4.17. 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 good/best quality seed crops and some had used their own seeds obtained from their crops. That caused the land preparation cost can be so different. 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 location 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. The detail of land preparation cost is presented in APPENDIX B (Table B.7 – B.9).

Table 4.18 Production cost based on growth stage at the Pante Lhong technical irrigation system

Description	**Production Cost of Growth Stage (Rp/m^2)**		
	Upstream	**Middle**	**Downstream**
Pg.1.Kn (BPg.1)	336	375	308
Jb.2.Kr (BJb.2)	221	176	258
T.7.Kn (BT.7)	137	114	103

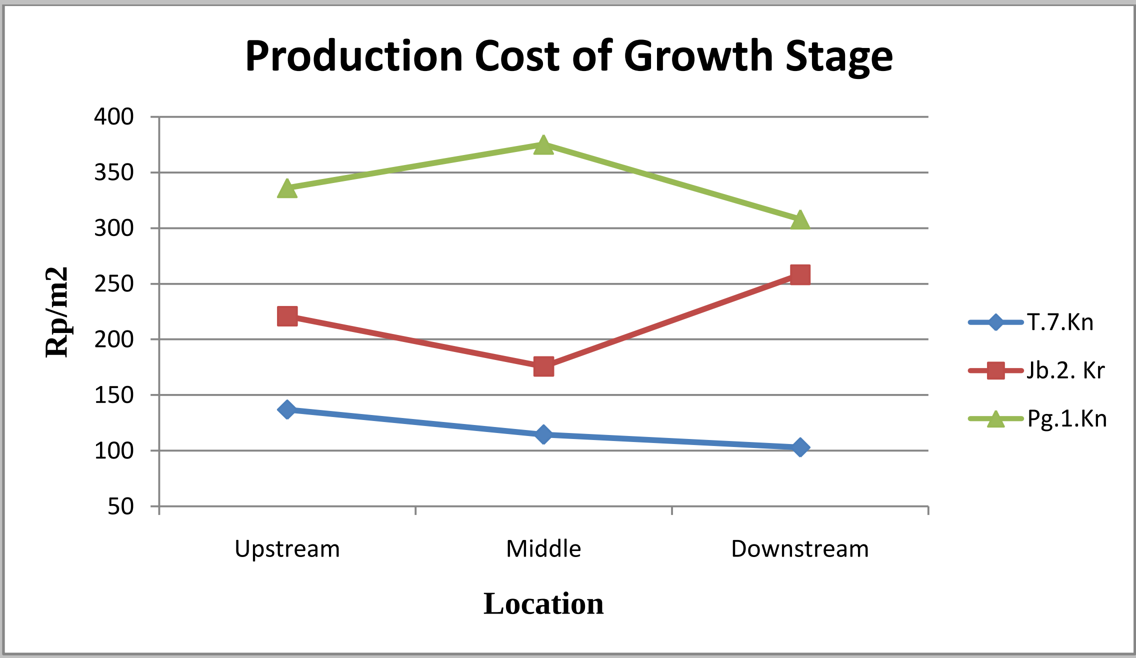

Figure 4.18 Production cost based on growth stage at the Pante Lhong technical irrigation system

The growth stage cost is shown in the Table 4.18 and Figure 4.18. Maintenance of field and seed, fertilizer and insecticide is generally done by the farmers themselves. Although some do so by paying to other farmers. Table 4.18 shows that the average cost of growth stage is Rp. 225/m^2 (US$ 0.02/m^2) or Rp 2,250,000/ha (US$247.25/ha). The highest cost is at plot Pg.1.Kn and the lowest cost is at plot T.7.Kn, which is shown in Figure 4.18. The cost difference is generally caused by the differences in amount of treatments and types of fertilizers as well as seeds and land. Occasionally, when the water overflows or floods the field, the field dike needs to be repaired. Location of fields which is far from human settlements have contributed to the problem of controlling events in the fields, with necessary additional costs are in maintenance. The purpose of fertilizers is to fertilize crops and increase rice production. The growth stage cost involve maintenance cost, fertilizer cost and insecticide cost. The differences are due to the cost caused by fertilizer, if two or more fertilizers are used and problem with disease could result higher cost. Most of them pay on credit and the resulting on high overall cost. Where else some of farmers use organic fertilizers which reduce the productivity cost. In addition, the use of pesticides by farmers, especially for plants is affected by pests and plant diseases cost contributing the costs at the growth stage.

Table 4.19 Production cost based on harvesting at the Pante Lhong technical irrigation system

Description	Production Cost of Harvesting (Rp/m^2)		
	Upstream	Middle	Downstream
Pg.1.Kn (BPg.1)	162	188	141
Jb.2.Kr (BJb.2)	126	87	127
T.7.Kn (BT.7)	101	64	47

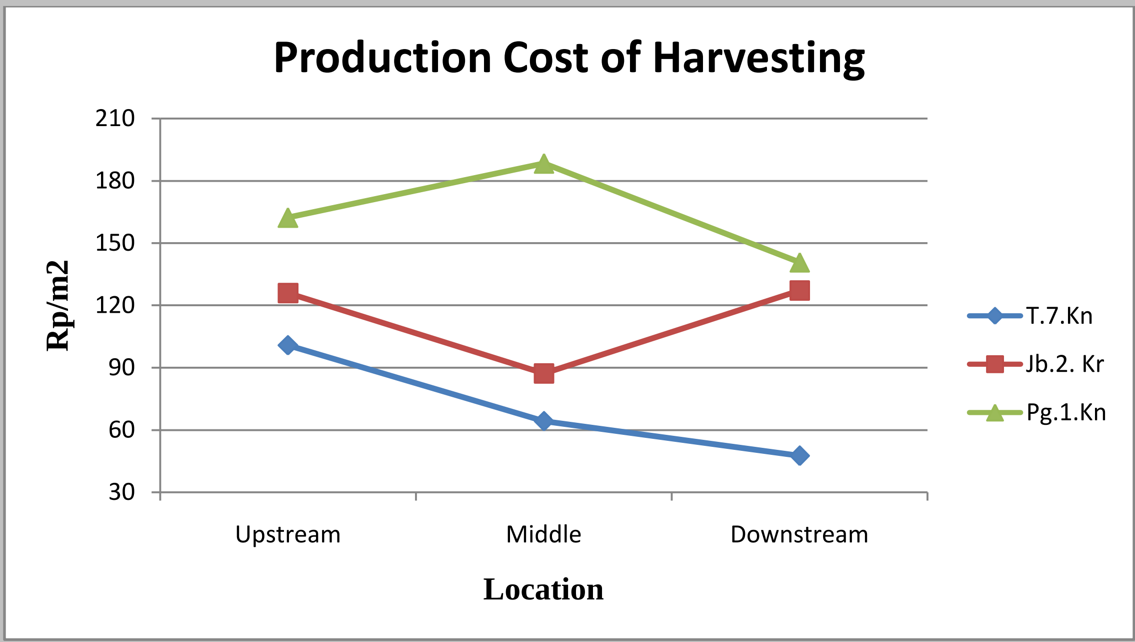

Figure 4.19 Production cost based on harvesting at the Pante Lhong technical irrigation system

Figure 4.19 shows the production cost based on harvesting in each plot, where the highest level of harvesting cost is at the plot Pg.1.Kn and the lowest level is at the plot T.7.Kn. The highest cost is Rp. 164/m^2 (US$ 0.02) and the lowest cost is Rp. 71/m^2 (Table. 4.19) The average cost for this item is Rp. 116/m^2 (US$ 0.01/m^2) or Rp. 1,160,000/ha (US$ 127.50). Most farmers do their own cutting and transporting of rice from the fields to the road or home, although there are farmers who hire one or two other peoples or even more to help cut and transport the daily payroll system. The total cost for cutting, threshing, transporting rice from the fields to the road or home and daily salaries, depends on bargaining and condition of farmers at harvest time. Differences in the harvesting cost, depends on the result of production of farmers especially threshing. The ratio of comparison for threshing rice to farmer is 16 kg : 1 kg. Another factor is the cost of transport, which depended on the distance of the location of the fields to the house or factory. Furthermore, after a total yield of the crop is established, then every farmer spends dues as a water fee of 5 kg of rice to rice fields covering an area of 1000 m^2 under dan10 kg of rice when the vast rice fields above 1000 m^2 each harvest. It is paid through the water user association, which will be used for irrigation and farmers' interests.

Figures 4.18 - 4.19, show that the pattern and trend graphs are similar, where plot Pg.1.Kn is found to have the largest production cost for each item and line graphs plot T.7.Kn is located at the bottom (least cost production), while plot line Jb.2.Kr, is located in the middle between Pb.1.Kn and T.7.Kn. This pattern is related to the level of production costs, which is the highest at the top of the charts. The production costs are found to be directly related to yield, the higher costs incurred for the cost of production, especially in land preparation cost items and growth stage cost item results the higher field (refer to Table 4.13 – 4.16). The use of good seed, good maintenance as well as proper fertilization will increase the production. Another thing to be considered is the location of the fields, where the location directly affects the cost of transportation. The fields located far from the settlement/village, require a higher level of supervision and maintenance. Therefore the cost is much higher than the fields closer to settlements and urban areas.

Table 4.20 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**

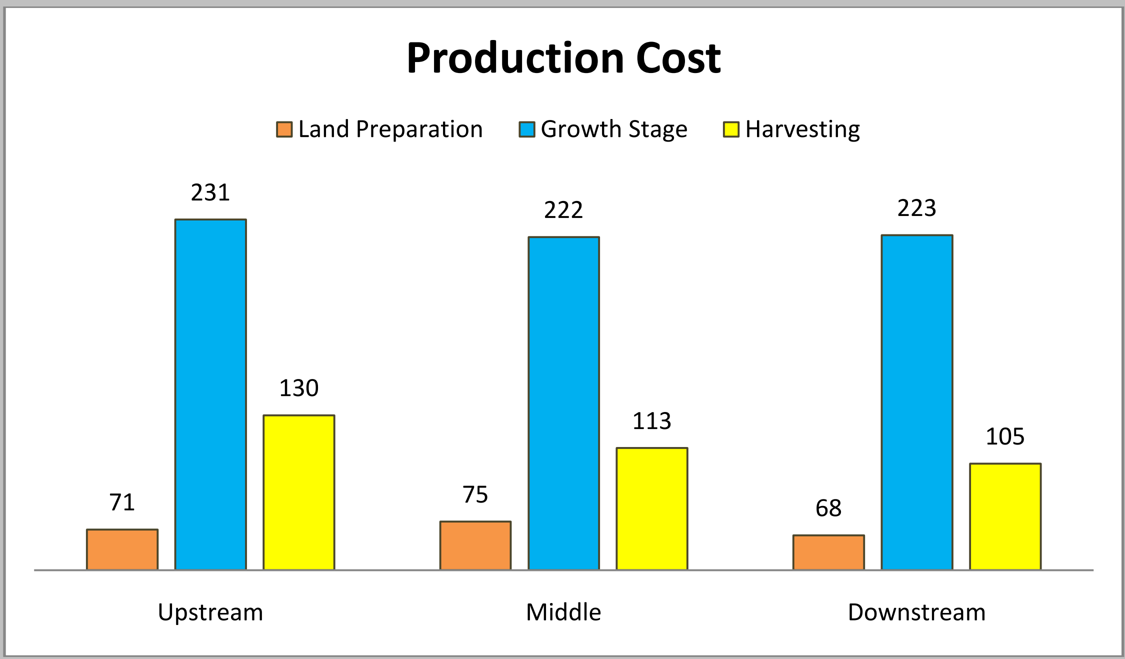

Figure 4.20 Production cost of the Pante Lhong technical irrigation system

The average production cost of the Pante Lhong technical irrigation system is Rp. 412.67/m2 (US$ 0.05/m2) (Table 4.20) or Rp. 4,126,700/ha (US$ 453.48/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 (US$ 453.48/ha) 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).

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 4.16). The range price of rice in 2009 is between Rp. 2,600/kg - Rp. 3,400/kg (US$ 0.28/kg – US$ 0.37/kg) depending on market condition and the middle value taken is Rp. 3,000/kg (US$ 0.33/kg). Accordingly, the income gained is Rp. 11,730,000 (US$1,289) 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 (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.

4.6 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. The detailed calculation of R/C, BEP and ROI are shown below.

4.6.1 Revenues and Costs Ratio (R/C)

In this research, the efficiency used is calculated as the coefficient ratio of revenues and costs (R/C). Based on this comparison it is found that the R/C ratio is 2.84 meaning that it is feasible to perform farming and the farmer will gain profit for Rp. 2,840 (US$ 0.31) of each Rp, 1.000 (US$ 0.11) issued. The detail calculation of the Revenues and Costs Ratio (R/C) is presented in Table 4.21.

4.6.2 Break Even Point (BEP)

According to Sudrajat (2000), the analysis of Break Even Point (BEP) is when the total revenues equals the total cost. This is to show how many products should be sold or how much revenue should be obtained to cover for the cost of production. Following the concept of BEP, the total cost equals to revenues and the price of rice used is the market price. Hence the production of rice should cover the cost of production which is 1375.57 kg for one hectare. This result is derived from the cost of production divided by the market price. The minimum field required in order to achieve the BEP is 3,518 m^2. This is lower than the largest field of the Pante Lhong technical irrigation system. The detail calculation of the Break Even Point (BEP) is presented in Table 4.19.

Table 4.21 Calculation of Revenues and Costs Ratio (R/C)

No.	**Description**	**Amount**
(1)	Average cost production/investment (C)	Rp. 4,126,700/ha
(2)	Market price (2009)	Rp. 3,000/kg
(3)	Crop yield (2009) 3.910 ton/ha	3,910 kg/ha
(4)	Average income/revenues (R) : (2) x (3)	Rp. 11,730,000/ha
(5)	Average profit : (4) – (1)	Rp. 7,603,300/ha
(6)	Calculation of Revenues and Costs Ratio (R/C) : (4) / (1)	2.84 > 1*

Note * : if result more than 1, the product is feasible and acceptable

Table 4.22 Calculation of Break Even Point (BEP)

No.	Description	Amount
(1)	Average cost production/investment (C)	Rp. 4,126,700/ha
(2)	Irrigation service area	5,578 ha
(3)	Market price (2009)	Rp. 3,000/kg
(4)	Crop yield (2009) 3.910 ton/ha	3,910 kg/ha
(5)	Minimum production of rice : (1)/(3)	1,375 kg/ha
(6)	Minimum large field required in 1 ha : (5)/(4)	0.352*

Note * : if result less than 5,578 , the product is feasible and acceptable

4.6.3 Return Of Investment (ROI)

To see the potential of farming/growing rice especially in its ability to provide income and incentives to farmers, is to use the Return of Investment (ROI) analysis approach. ROI is equal to income after-tax, before interest divided by the total investment. Farming for one year, for an acre of land in accordance with the price of rice in 2009, obtained 156.61 % ROI. The detail calculation of the Return of Investment (ROI) is presented in Table 4.23.

Table 4.23 Calculation of Return of Investment (ROI)

No.	Description	Amount
(1)	Average production (2009)	3.910 ton/ha
(2)	Average production in one year (twice crop yield) (Q)	7.820 ton/ha
(3)	Market price (2009) (P)	Rp. 3,000/kg
(4)	Average cost production (C)	Rp. 4,126,700/ha
(5)	Average cost production in one year (twice crop yield) (TC)	Rp. 8,253,40/ha
(6)	Revenues in one year (R) : Q x P = (2) x (3)	Rp. 23,460,000/ha
(7)	Profit in one year : R – TC = (6) – (5)	Rp. 15,206,600/ha
(8)	EIAT = Earnings before Interest After Tax	
	EIAT = Profit – (Profit x Tax 15 %)	Rp. 12,925,990/ha
(9)	ROI : EIAT / TC = (8) / (5)	156.61 %/ha
(10)	Refer to Table 3.13 (more 50 % level of field size is 3000 m^2)	0.3 ha
(11)	$ROI_{0.3}$	46.98 %

To evaluate 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. Farming for one year for an acre of land in accordance with the price of rice in 2009, obtained 156.61 % ROI (refer Table 4.23). When the ROI is compared with the farm loan interest rates of 10.5% for a year, rice farming is still very profitable. But with 0.3 hectares of land ownership (more 50% level of field size and refer Table 3.13), using the method of rice farming, the ROI comparison of actual ROI then the value is 45.98 % (refer Table 4.23).

This figure is clearly not competitive and is to be considered in the determination of credit. In other words, when used in commercial credit interest, these figures clearly cannot be justified by the banks to get credit. This requirement will be stronger when calculated with the economic needs of farm families is included.

Moreover, in order to calculate the feasible income level for farmers then the number of family members and the amount of consumption of rice in one year must be known. The detail calculation of the feasible income level for farmers is presented in Table 4.24.

Table 4.24 Calculation of feasible income level for farmers

No.	**Description**	**Amount**
(1)	Average consumption level rice per capita in Aceh (2009)	130 kg/year
(2)	Average number of people per household in Bireuen (2009)	4.58 people
(3)	Total rice consumption (2009) : (1) x (2)	596 kg/year
(4)	Buy rice	Rp. 1,788,000/year
		Rp. 149,000/month
(5)	Market Price (2009)	Rp. 3,000/kg
(6)	Profit in one ha in one year (refer to Table 4.20 point 7th)	Rp. 15,206,600/ha
(7)	Profit for area 0.3 ha: 0.3 x (6)	Rp. 4,561,980/year
		Rp. 380,165/month
(8)	Income balance in month = (7) – (4)	Rp. 231,165/month

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$16.37/month). Land area used as the basic assumptions to calculate the income eligibility level is 3000 m^2 or 0.3 ha, because more than 50% farmers have the fields 3000 m^2 (Table 3.13). Based on Table 4.24, the average income of farmers per year in is Rp. 23,460,000/ha (US$ 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 Style and Marino (2002) 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 (Clemmens and Molden, 2007). Therefore improvements of various aspects and indicators are needed for the well being of the farmer and his family.

4.6 Summary

The average value of the infrastructure maintenance performance was 2.97 out of 4, meaning the system performed at about 74.25 % of the targeted service delivery. This rate is judged as being quite enough by the performance standard, with the main contributing factor caused by the bed load in the canal system. The average value of the delivery service indicator was 2.5 out of 4 or about 62.5 % of target service delivery and the average value of water delivery service indicator at the final delivery was 2.75 out of 4 and performed at 68.75 % of the maximum expected operation. These results indicate that current water delivery service indicator at each level is judged as being quite enough by the performance criteria. The inability of the system to perform at the expected level of service is mainly contributed by the failure of control structures to deliver the intended flow rate to the downstream costumers as indicated by the very low rating score value.

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 (US$ 0.05/m^2) (Table 4. 17) or Rp. 4,126,700/ha (US$ 453.48/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 (US$ 25.40/month).

CHAPTER V

CONCLUSIONS AND RECOMENDATIONS

5.1 Conclusions

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 is 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 of performance of an irrigation system. 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. This value demonstrated a sufficient routine maintenance for canal network is required by the irrigation authority. However, the floor and canal bank (sub indicator) has a rating score value of less than 2 which is less than 50 % of the maximum possible value, which is judged as poor. The performance of the Pante Lhong technical irrigation is still below target.

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. These findings indicated that satisfactory reliability of service and equity sub indicators were achieved through the practice of oversupply. However, for the sub indicator of flow to the next level sub performance was only at 12.5 % of the expected performance which is judged as rather low. The performance of the Pante Lhong technical irrigation is still below target.

3. The average value of water delivery service indicator obtained at the final delivery was 2.75 out of 4. This result indicate that the current water delivery service indicator at each final delivery sector performed at 68.75 % of the maximum possible operation and the rate is judged as being quite enough by the performance criteria. The performance of the Pante Lhong technical irrigation is below target. The results for measurement of volume delivered were less than 1 constituting a very poor performance which was equivalent to less than 12.5 % of the expected value.

4. 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.

5. 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, 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.

6. 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.

Based on the conclusions obtained above, all the objectives set for this research as referred to in section 1.3 have been fully carried out and the results successfully achieved.

5.2 Recommendations

The recommendation given will be presented in two sections where the first section is related to the research scope finding, it's for future works that can be carried out. The following recommendation can be given:

1. For future research, to improve the findings the number of locations, sample and respondents should be increased. More data can then be analyzed and used where the results obtained would be more representative of the actual scenario.

2. For improvement on the research of rotation supply method, the institutional aspects related to the staffs and water user association should included in the assessment as part of the internal indicator of irrigation systems.

3. The present study manages to collect data for a period of two growing seasons. As an enhancement to the data collection it is suggested that it be carried out for more number of growing seasons, i.g. 4 numbers. This will improve the evaluation for comparative performance and the output in each cropping season.

Based on the research in the Pante Lhong technical irrigation system and the results, further recommendation related to the farming activities is outlined as below:

1. The Pante Lhong technical irrigation system has to increase its performance with proper evaluation of the irrigation system component to achieve the target production and the target service performance.

2. The use of RAP method depended on the understanding of the operator surveyor of the content of the RAP and knowledge of irrigation. However, the later value will be subjective to engineering interpretation.

3. There should be further research on the Pante Lhong technical irrigation system using other methods and systems, for comparison to be made between the methods used and relevance of its applicability.

4. The irrigation assessment especially for large irrigation (more than 3000 ha) is necessary to determine the extent of regulation, use, and maintenance of the water. Improvements in strategic planning and enhancements in irrigation performance will increase the efficiency in water use and thus increase the food production which are important dimensions of food security.

Hopefully the findings conclusions, recommendations and suggestions obtained and outlined may be useful input for further research, and to provide improve knowledge and contribution in evaluating and increasing the production of irrigation system.

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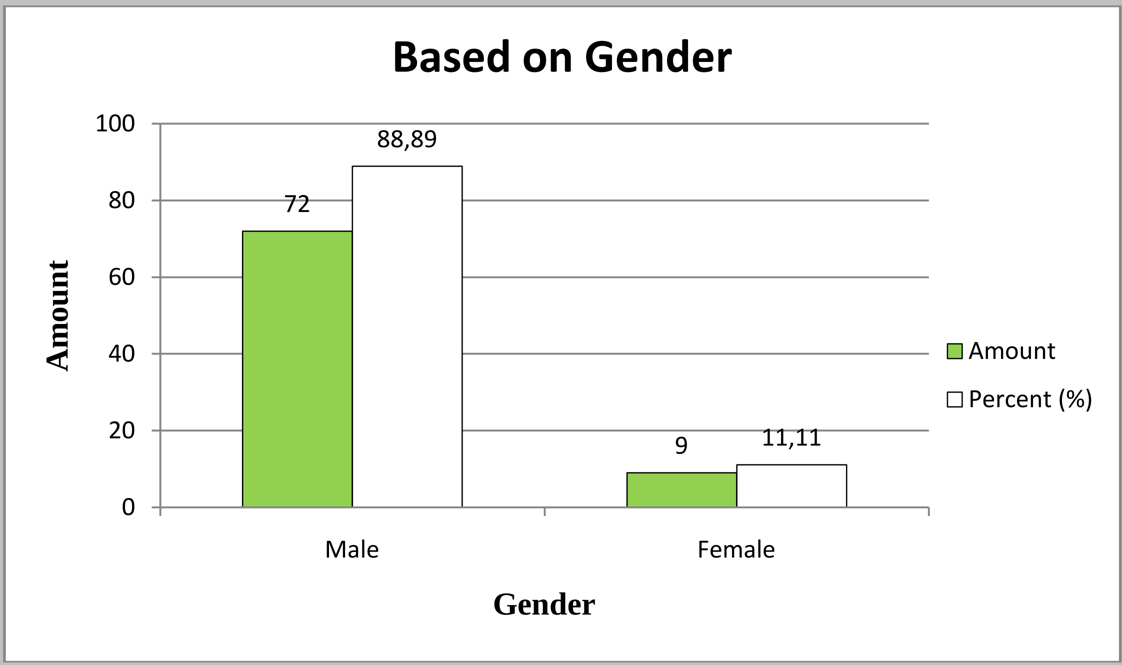
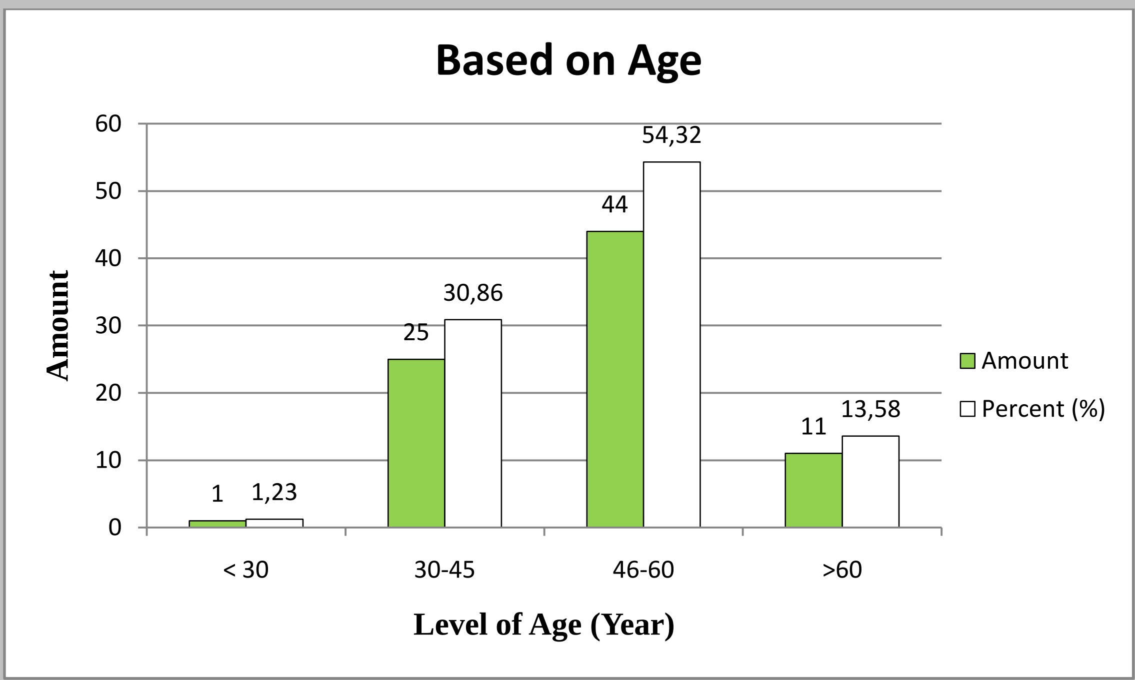
APPENDIX A

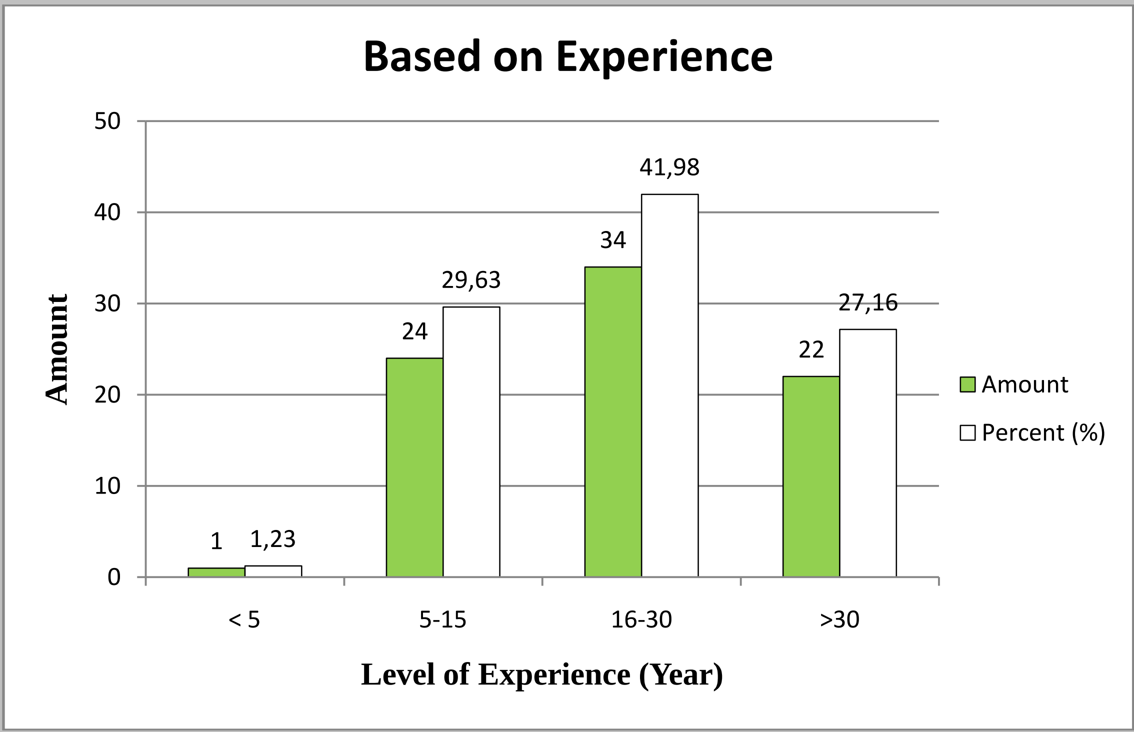
A.1 SAMPLE BASE ON GENDER



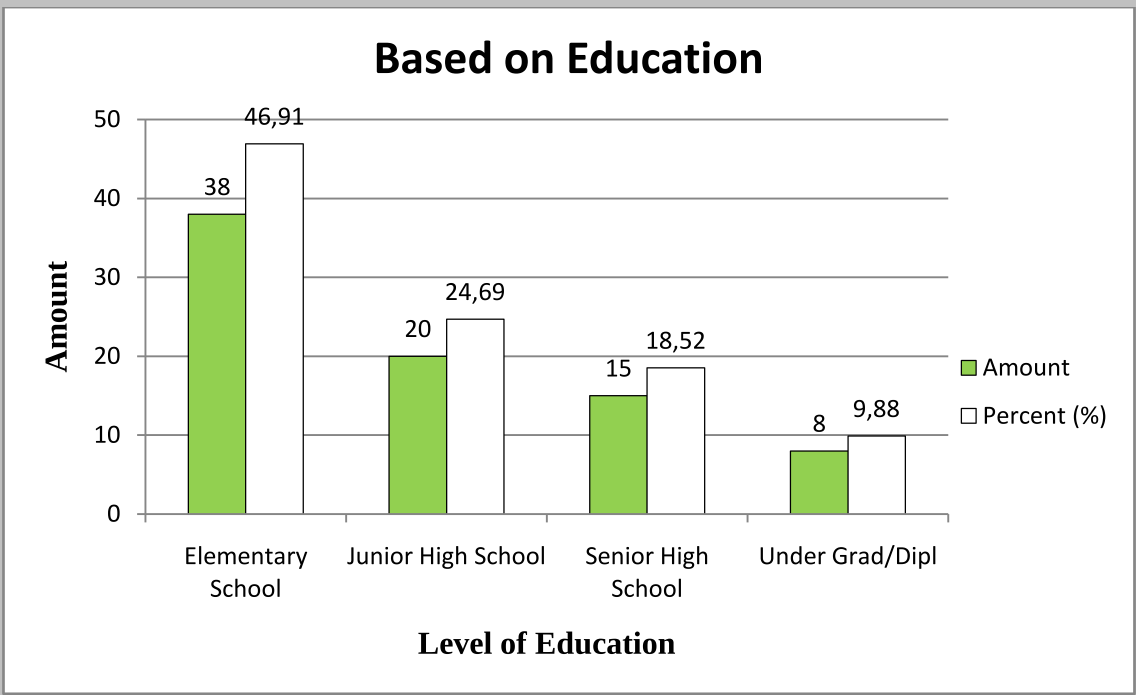
A.2 SAMPLE BASE ON LEVEL OF AGE



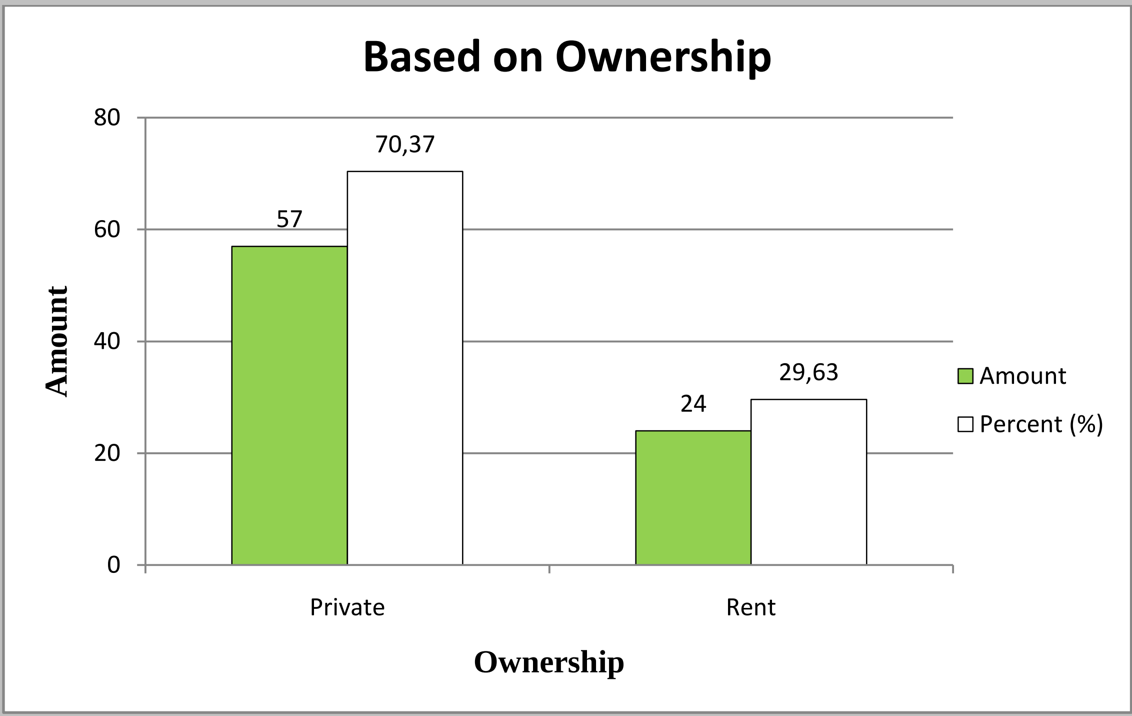
A.3 SAMPLE BASE ON LEVEL OF EXPERIENCE



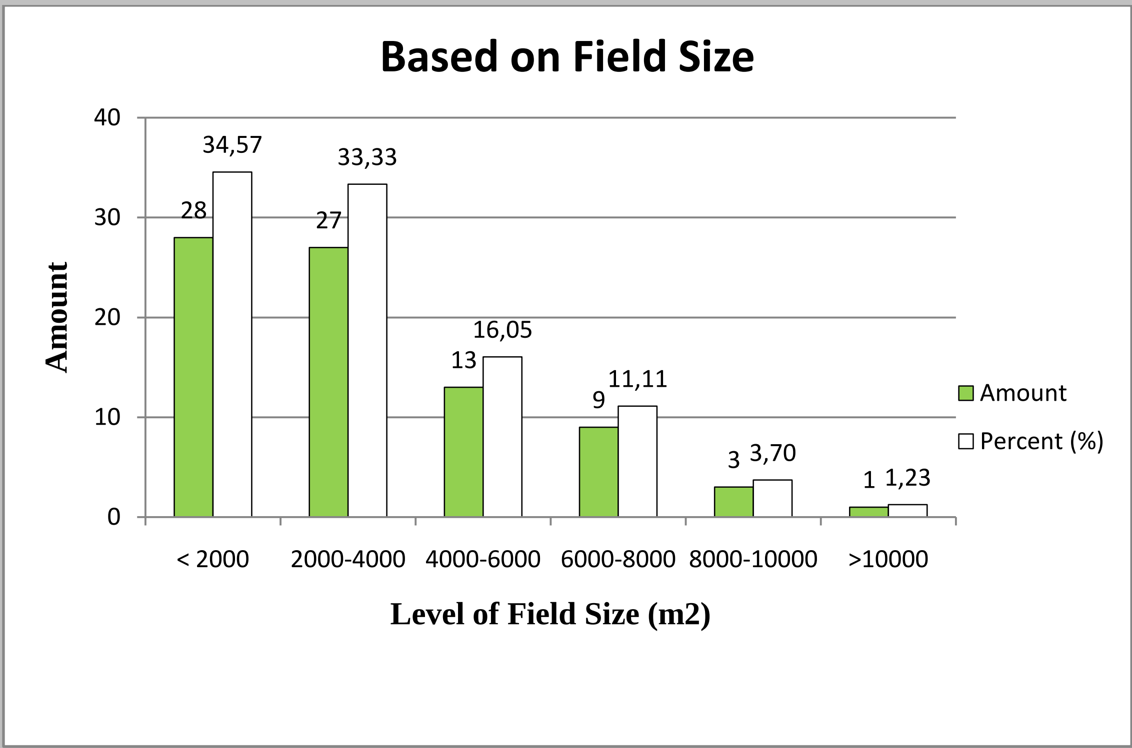
A.4 SAMPLE BASE ON LEVEL OF EDUCATION



A.5 SAMPLE BASE ON OWNERSHIP



A.6 SAMPLE BASE ON LEVEL OF FIELD SIZE



APPENDIX B

B.1 SAMPLE SURVEY AT BT.7 KUALA SUB DISTRICT

Number	Village	Location		Name	Age (Year)	Education	Experience (Year)	Ownership	Field Size (m^2)
01	Mon Jambe	Upstream	BT.7	Aisyah Daud	60	Elementary School	30	Private	1000
02	Laksamana	Upstream	BT.7	Ibrahim Alamsyah	45	Elementary School	25	Private	3000
03	Laksamana	Upstream	BT.7	Manawiyah Daud	50	Senior High School	20	Private	3000
04	Laksamana	Upstream	BT.7	Baharuddin Mahmud	41	Senior High School	20	Private	1800
05	Mon Jambe	Upstream	BT.7	Lukman Main	49	Senior High School	30	Private	2500
06	Mon Jambe	Upstream	BT.7	Karimuddin	60	Junior High School	25	Private	4000
07	Laksamana	Upstream	BT.7	Jafar Mahmud	60	Elementary School	40	Private	4000
08	Laksamana	Upstream	BT.7	Husaini	60	Elementary School	35	Private	3000
09	Laksamana	Upstream	BT.7	Rusli Yahya	55	Elementary School	35	Private	4000

B.1 CONTINUED

Number	Village	Location		Name	Age (Year)	Education	Experience (Year)	Ownership	Field Size (m^2)
01	Mon Jambe	Middlestream	BT.7	Nurdin Alamsyah	50	Elementary School	25	Private	8000
02	Mon Jambe	Middlestream	BT.7	H. Bahrum	55	Elementary School	15	Private	1900
03	Mon Jambe	Middlestream	BT.7	Ismail Ibrahim	38	Senior High School	20	Private	4000
04	Mon Jambe	Middlestream	BT.7	Muhtadin Nurdin	37	Senior High School	15	Private	7000
05	Mon Jambe	Middlestream	BT.7	Rajali Adam	60	Senior High School	35	Private	3000
06	Laksamana	Middlestream	BT.7	Syammah Kasyah	45	Elementary School	20	Private	1000
07	Mon Jambe	Middlestream	BT.7	Baihaqi Ibrahim	48	Junior High School	28	Private	4000
08	Mon Jambe	Middlestream	BT.7	Idris Ibrahim	30	Junior High School	15	Private	3000
09	Mon Jambe	Middlestream	BT.7	Samsul Bahri Ismail	50	Elementary School	30	Private	2000
01	Mon Jambe	Downstream	BT.7	Buk Mur	55	Senior High School	30	Private	12000
02	Mon Jambe	Downstream	BT.7	Karnaini Salihin	60	Elementary School	30	Private	1800
03	Mon Jambe	Downstream	BT.7	Fatimah Abdullah	50	Elementary School	35	Private	7000
04	Mon Jambe	Downstream	BT.7	M. Nasir A. gani	40	Senior High School	20	Private	6000
05	Mon Jambe	Downstream	BT.7	Mardani Umar	40	Elementary School	15	Private	6000
06	Mon Jambe	Downstream	BT.7	M. Taib Abdullah	55	Senior High School	30	Private	6000
07	Mon Jambe	Downstream	BT.7	Muhammad Hamzah	39	Elementary School	7	Private	1400
08	Mon Jambe	Downstream	BT.7	Yusuf Ismail	55	Elementary School	35	Private	8000
09	Mon Jambe	Downstream	BT.7	Anwar Zainon	50	Elementary School	30	Private	2000

B.2 SAMPLE SURVEY AT BJb.2 KUALA RAJA SUB DISTRICT

Number	Village	Location		Name	Age (Year)	Education	Experience (Year)	Ownership	Field Size (m^2)
01	Kr. Juli Barat	Upstream	BJb. 2	Budiman Ahmad	40	Elementary School	10	Rent	1000
02	Kr. Juli Barat	Upstream	BJb. 2	Tarmi Syah	53	Elementary School	30	Rent	3000
03	Kr. Juli Barat	Upstream	BJb. 2	Isa Saman	64	Junior High School	50	Rent	2600
04	Kr. Juli Barat	Upstream	BJb. 2	Hamzah Rani	51	Elementary School	35	Rent	3000
05	Kr. Juli Barat	Upstream	BJb. 2	Rusli Ibrahim	55	Elementary School	35	Rent	6000
06	Kr. Juli Barat	Upstream	BJb. 2	Jufri Taib	55	Elementary School	35	Private	1500
07	Kr. Juli Barat	Upstream	BJb. 2	Rasyidi	42	Elementary School	30	Rent	3500
08	Kr. Juli Barat	Upstream	BJb. 2	Ridwan Yahya	39	Elementary School	25	Rent	1900
09	Kr. Juli Barat	Upstream	BJb. 2	M. Taib Saman	68	Elementary School	38	Rent	5000

B.2 CONTINUED

Number	Village	Location		Name	Age (Year)	Education	Experience (Year)	Ownership	Field Size (m^2)
01	Kr. Juli Barat	Middlestream	BJb.2	Edwar	57	Under Graduate	25	Private	1200
02	Kr. Juli Barat	Middlestream	BJb.2	Zainal Syamsyah	55	Elementary School	12	Private	5200
03	Kr. Juli Barat	Middlestream	BJb.2	Rusli Ibrahim	50	Elementary School	20	Rent	4000
04	Kr. Juli Barat	Middlestream	BJb.2	Muriadi	38	Senior High School	7	Rent	2400
05	Kr. Juli Barat	Middlestream	BJb.2	Usman Piah	52	Elementary School	40	Private	3000
06	Kr. Juli Barat	Middlestream	BJb.2	Isbeni	38	Junior High School	10	Private	2500
07	Kr. Juli Barat	Middlestream	BJb.2	Bukhari	45	Elementary School	15	Private	4000
08	Kr. Juli Barat	Middlestream	BJb.2	M. Saleh	51	Junior High School	30	Rent	2000
09	Kr. Juli Barat	Middlestream	BJb.2	Zulhelmi	55	Elementary School	15	Private	1800
01	Kr. Juli Barat	Downstream	BJb.2	Suryadi	42	Senior High School	5	Private	1500
02	Kr. Juli Barat	Downstream	BJb.2	Arizal Fahmi	58	Junior High School	38	Private	5500
03	Kr. Juli Barat	Downstream	BJb.2	Junaidi Usman	37	Junior High School	10	Rent	2500
04	Kr. Juli Barat	Downstream	BJb.2	Hamriza	33	Senior High School	3	Rent	2000
05	Kr. Juli Barat	Downstream	BJb.2	Idris Budiman	55	Elementary School	30	Private	2500
06	Kr. Juli Barat	Downstream	BJb.2	Ramli Syam	46	Elementary School	20	Rent	1200
07	Kr. Juli Barat	Downstream	BJb.2	Mawardi	39	Junior High School	11	Private	3500
08	Kr. Juli Barat	Downstream	BJb.2	Mahdi Yahya	35	Elementary School	10	Private	1100
09	Kr. Juli Barat	Downstream	BJb.2	Rusli Piah	55	Elementary School	45	Rent	1200

B.3 SAMPLE SURVEY AT BPg.1 JULI SUB DISTRICT

Number	Village	Location		Name	Age (Year)	Education	Experience (Year)	Ownership	Field Size (m^2)
01	Meunasah Keude II	Upstream	BPG.1	Marjuki	41	Senior High School	20	Private	1500
02	Meunasah Tambo	Upstream	BPG.1	Usman Puteh	69	Elementary School	50	Rent	3500
03	Tambo Tanjong	Upstream	BPG.1	Rusmaini Ismail	60	Junior High School	30	Private	1500
04	Juli Tanjong Tambo	Upstream	BPG.1	Jafar Abu Bakar	60	Junior High School	40	Private	3000
05	Meunasah Tanjong	Upstream	BPG.1	Rasyidah	50	Elementary School	10	Private	700
06	Juli Keude II	Upstream	BPG.1	Muhammad Ali	68	Senior High School	25	Private	3500
07	Juli Keude II	Upstream	BPG.1	Mahyiddin Ibrahim	67	Senior High School	35	Private	5000
08	Meunasah Tanjong	Upstream	BPG.1	Kamaliah Ali	60	Diploma	30	Private	1000
09	Meunasah Tanjong	Upstream	BPG.1	Imum Nasir	57	Junior High School	10	Rent	1800

B.3 CONTINUED

Number	Village	Location		Name	Age (Year)	Education	Experience (Year)	Ownership	Field Size (m^2)
01	Tambo Tanjong	Middlestream	BPG.1	Jafaruddin	56	Senior High School	30	Private	8000
02	Tanjong	Middlestream	BPG.1	Maimun Ibrahim	42	Senior High School	15	Private	2000
03	Tanjong	Middlestream	BPG.1	Razali Abd. Rahman	45	Senior High School	10	Private	1200
04	Meunasah Baroe	Middlestream	BPG.1	Mustafa Dadeh	65	Under Graduate	15	Private	7000
05	Tambo Tanjong	Middlestream	BPG.1	Rusli Ibrahim	63	Junior High School	45	Rent	900
06	Meunasah Tambo	Middlestream	BPG.1	Marzuki	42	Under Graduate	15	Private	700
07	Tambo Tanjong	Middlestream	BPG.1	Hasballah Daud	76	Elementary School	40	Rent	3000
08	Mon Jambe	Middlestream	BPG.1	Mustafa Umar	70	Diploma	42	Private	1200
09	Meunasah Tambo	Middlestream	BPG.1	Helmiadi	25	Elementary School	10	Rent	2000
01	Meunasah Setui	Downstream	BPG.1	Zainal Daud	53	Diploma	30	Private	1400
02	Meunasah Setui	Downstream	BPG.1	Abdurrahman AB	65	Senior High School	20	Rent	4000
03	Juli Setui	Downstream	BPG.1	Adnan	56	Elementary School	35	Private	6000
04	Meunasah Setui	Downstream	BPG.1	Suryadi A. Gani	50	Diploma	20	Rent	5000
05	Meunasah Setui	Downstream	BPG.1	Derwin Abidin	57	Junior High School	20	Rent	2000
06	Meunasah Setui	Downstream	BPG.1	M. Taib Abdullah	55	Senior High School	30	Private	6000
07	Meunasah Tambo	Downstream	BPG.1	Fuadi Yusuf	36	Senior High School	5	Rent	800
08	Meunasah Setui	Downstream	BPG.1	Nazarli Ar	62	Elementary School	35	Private	1300
09	Meunasah Setui	Downstream	BPG.1	Jufri Jafar	53	Under Graduate	12	Private	1000

B.4 CROP YIELD AT BT.7 KUALA SUB DISTRICT

No.	Name	Production (Kg)												Kg/m²
		2007				2008				2009				
		I	II	Average	Kg/m²	I	II	Average	Kg/m²	I	II	Average	Kg/m²	
01	Aisyah Daud	700	700	700	0.70	700	700	700	0.70	700	700	700	0.70	0.70
02	Ibrahim Alamsyah	700	640	670	0.22	700	640	670	0.22	700	640	670	0.22	0.22
03	Manawiyah Daud	700	660	680	0.23	800	700	750	0.25	700	660	680	0.23	0.25
04	Baharuddin Mahmud	560	540	550	0.31	700	600	650	0.36	700	600	650	0.36	0.36
05	Lukman Main	700	600	650	0.26	700	600	650	0.26	800	640	720	0.29	0.29
06	Karimuddin	700	700	700	0.18	800	800	800	0.20	800	800	800	0.20	0.20
07	Jafar Mahmud	450	450	450	0.11	450	550	500	0.13	550	640	595	0.15	0.15
08	Husaini	1200	800	1000	0.33	400	400	400	0.13	600	600	600	0.20	0.33
09	Rusli Yahya	640	600	620	0.16	640	600	620	0.16	640	600	620	0.16	0.16
01	Nurdin Alamsyah	720	730	725	0.09	740	800	770	0.10	850	720	785	0.10	0.10
02	H. Bahrum	1500	1300	1400	0.74	1000	1000	1000	0.53	1300	1300	1300	0.68	0.74
03	Ismail Ibrahim	800	760	780	0.20	800	760	780	0.20	800	760	780	0.20	0.20
04	Muhtadin Nurdin	740	700	720	0.10	760	700	730	0.10	760	700	730	0.10	0.10
05	Rajali Adam	800	820	810	0.27	700	800	750	0.25	800	900	850	0.28	0.28

B.4 CONTINUED

No.	Name	Production (Kg)												Kg/m²
		2007				2008				2009				
		I	II	Average	Kg/m^2	I	II	Average	Kg/m^2	I	II	Average	Kg/m^2	
06	Syammah Kasyah	720	540	630	0.63	540	580	560	0.56	600	540	570	0.57	0.63
07	Baihaqi Ibrahim	860	880	870	0.22	880	770	825	0.21	900	860	880	0.22	0.22
08	Idris Ibrahim	700	740	720	0.24	700	740	720	0.24	700	740	720	0.24	0.24
09	Samsul Bahri Ismail	600	600	600	0.30	720	720	720	0.36	600	700	650	0.33	0.36
01	Buk Mur	700	700	700	0.06	680	700	690	0.06	700	700	700	0.06	0.06
02	Karnaini Salihin	1200	1200	1200	0.67	1100	1100	1100	0.61	1200	1300	1250	0.69	0.69
03	Fatimah Abdullah	700	740	720	0.10	700	740	720	0.10	700	740	720	0.10	0.10
04	M. Nasir A. gani	560	600	580	0.10	640	660	650	0.11	820	740	780	0.13	0.13
05	Mardani Umar	600	600	600	0.10	600	600	600	0.10	800	700	750	0.13	0.13
06	M. Taib Abdullah	3200	3200	3200	0.53	2400	3400	2900	0.48	3600	3400	3500	0.58	0.58
07	Muhammad Hamzah	900	800	850	0.61	800	800	800	0.57	800	900	850	0.61	0.61
08	Yusuf Ismail	780	780	780	0.10	780	800	790	0.10	760	760	760	0.10	0.10
09	Anwar Zainon	700	800	750	0.38	900	900	900	0.45	800	800	800	0.40	0.45

B.5 CROP YIELD AT BJb.2 KUALA RAJA SUB DISTRICT

No.	Name	Production (Kg)												Kg/m²
		2007				2008				2009				
		I	II	Average	Kg/m²	I	II	Average	Kg/m²	I	II	Average	Kg/m²	
01	Budiman Ahmad	600	800	700	0.70	600	800	700	0.70	800	1000	900	0.90	0.90
02	Tarmi Syah	500	500	500	0.17	500	500	500	0.17	400	240	320	0.11	0.17
03	Isa Saman	1200	1100	1150	0.44	1400	1640	1520	0.58	1600	1560	1580	0.61	0.61
04	Hamzah Rani	-	-	-	-	-	600	600	0.20	540	600	570	0.19	0.20
05	Rusli Ibrahim	640	800	720	0.12	600	760	680	0.11	600	700	650	0.11	0.12
06	Jufri Taib	700	700	700	0.47	700	400	550	0.37	700	700	700	0.47	0.47
07	Rasyidi	1400	1400	1400	0.40	1600	1600	1600	0.46	2000	500	1250	0.36	0.46
08	Ridwan Yahya	500	360	430	0.23	600	400	500	0.26	540	700	620	0.33	0.33
09	M. Taib Saman	600	700	650	0.13	600	640	620	0.12	560	600	580	0.12	0.13
01	Edwar	-	-	-	-	-	-	-	-	850	720	785	0.65	0.65
02	Zainal Syamsyah	-	-	-	-	2400	1840	2120	0.41	960	1800	1380	0.27	0.41
03	Rusli Ibrahim	920	450	685	0.17	520	720	620	0.16	640	600	620	0.16	0.17
04	Muriadi	800	800	800	0.33	800	680	740	0.31	800	800	800	0.33	0.33
05	Usman Piah	700	700	700	0.23	700	500	600	0.20	550	700	625	021	0.23

B.5 CONTINUED

No.	Name	Production (Kg)												Kg/m²
		2007				2008				2009				
		I	II	Average	Kg/m²	I	II	Average	Kg/m²	I	II	Average	Kg/m²	
06	Isbeni	720	720	720	0.29	410	700	555	0.22	800	720	760	0.30	0.30
07	Bukhari	700	700	700	0.18	700	700	700	0.18	700	700	700	0.18	0.18
08	M. Saleh	780	760	770	0.39	740	840	790	0.40	860	800	830	0.42	0.42
09	Zulhelmi	-	-	-	-	-	500	500	0.28	600	1100	850	0.47	0.47
01	Suryadi	660	700	680	0.45	640	720	680	0.45	700	640	670	0.45	0.45
02	Arizal Fahmi	2400	2000	2200	0.40	2500	2020	2260	0.41	3000	2700	2850	0.52	0.52
03	Junaidi Usman	760	760	760	0.30	760	740	750	0.30	760	800	780	0.31	0.31
04	Hamriza	-	-	-	-	1200	1160	1180	0.59	1170	600	885	0.44	0.59
05	Idris Budiman	760	840	800	0.32	700	500	600	0.24	600	700	650	0.26	0.32
06	Ramli Syam	740	840	790	0.66	740	840	790	0.66	740	800	770	0.64	0.66
07	Mawardi	700	560	630	0.18	700	760	730	0.21	900	760	830	0.24	0.24
08	Mahdi Yahya	800	800	800	0.73	700	740	720	0.65	800	780	790	0.72	0.73
09	Rusli Piah	1000	1000	1000	0.83	920	960	940	0.78	800	920	860	0.72	0.83

B. 6 CROP YIELD AT BPG.1 JULI SUB DISTRICT

No.	Name	Production (Kg)												Kg/m^2
		2007				2008				2009				
		I	II	Average	Kg/m^2	I	II	Average	Kg/m^2	I	II	Average	Kg/m^2	
01	Marjuki	700	700	700	0.47	700	560	630	0.42	700	600	650	0.43	0.47
02	Usman Puteh	1200	2800	2000	0.57	1200	1600	1400	0.40	1400	1200	1300	0.37	0.57
03	Rusmaini Ismail	640	640	640	0.43	600	560	580	0.39	700	640	670	0.45	0.45
04	Jafar Abu Bakar	1600	1800	1700	0.57	1600	2000	1800	0.60	1700	1900	1800	0.60	0.60
05	Rasyidah	600	560	580	0.83	600	560	580	0.83	600	560	580	0.83	0.83
06	Muhammad Ali	600	700	650	0.19	600	600	600	0.17	600	600	600	0.17	0.19
07	Mahyiddin Ibrahim	-	800	800	0.16	-	800	800	0.16	-	700	700	0.14	0.16
08	Kamaliah Ali	-	-	-	-	540	560	550	0.55	500	300	400	0.40	0.55
09	Imum Nasir	800	800	800	0.44	900	800	850	0.47	1000	1000	1000	0.56	0.56
01	Jafaruddin	600	700	650	0.08	640	640	640	0,08	600	700	650	0.08	0.08
02	Maimun Ibrahim	880	960	920	0.46	960	800	880	0,44	1400	1480	1440	0.72	0.72
03	Razali Abd. Rahman	720	900	810	0.68	700	840	770	0,64	720	740	730	0.61	0.68
04	Mustafa Dadeh	740	700	720	0.10	760	700	730	0,10	760	700	730	0.10	0.10
05	Rusli Ibrahim	740	900	820	0.91	740	740	740	0,82	800	700	750	0.83	0.91

B.6 CONTINUED

No.	Name	Production (Kg)												Kg/m²
		2007				2008				2009				
		I	II	Average	Kg/m²	I	II	Average	Kg/m²	I	II	Average	Kg/m²	
06	Marzuki	320	320	320	0.46	260	280	270	0.39	360	260	310	0.44	0.46
07	Hasballah Daud	-	-	-	-	-	1800	1800	0.60	1400	800	1100	0.37	0.60
08	Mustafa Umar	660	660	660	0.55	660	660	660	0.55	660	660	660	0.55	0.55
09	Helmiadi	1100	1100	1100	0.55	1400	1600	1500	0.75	1300	1200	1250	0.63	0.75
01	Zainal Daud	800	1000	900	0.64	800	1060	930	0.66	900	800	850	0.61	0.66
02	Abdurrahman AB	1000	500	750	0.19	740	600	670	0.17	800	700	750	0.19	0.19
03	Adnan	500	700	600	0.10	550	750	650	0.11	500	650	575	0.10	0.11
04	Suryadi A. Gani	700	700	700	0.14	700	620	660	0.13	600	600	600	0.12	0.14
05	Derwin Abidin	500	500	500	0.25	500	540	520	0.26	500	500	500	0.25	0.26
06	M. Taib Abdullah	3200	3200	3200	0.53	2400	3400	2900	0.48	3600	3400	3500	0.58	0.58
07	Fuadi Yusuf	560	560	560	0.70	560	500	530	0.66	560	600	580	0.73	0.73
08	Nazarli Ar	-	-	-	-	-	-	-	-	700	800	750	0.58	0.58
09	Jufri Jafar	825	530	677.5	0.68	680	625	652,5	0.65	735	700	718	0.72	0.72

B.7 PRODUCTION COST AT BT.7 KUALA SUB DISTRICT

No.	Name	Land Preparation Cost (Rp.)		Growth Stage Cost (Rp.)			Harvesting Cost (Rp.)	Total Production Cost (Rp.)	Price (Rp.)
		Seed	Land Preparation	Maintenance	Fertilizer	Insect			
01	Aisyah Daud	-	100,000	180,000	155,000	70,000	299,000	804,000	Consumption
02	Ibrahim Alamsyah	-	80,000	150,000	67,000	28,000	265,000	590,000	3,500
03	Manawiyah Daud	87,500	120,000	170,000	98,000	164,000	325,000	964,500	3,000
04	Baharuddin Mahmud	-	80,000	180,000	42,500	85,000	215,000	602,500	3,000
05	Lukman Main	-	55,000	110,000	43,000	60,000	15,000	283,000	Consumption
06	Karimuddin	-	110,000	178,000	90,000	28,000	231,000	637,000	3,000
07	Jafar Mahmud	-	110,000	190,000	46,500	42,500	295,000	684,000	3,100
08	Husaini	-	100,000	180,000	120,000	40,000	265,000	705,000	3,000
09	Rusli Yahya	-	100,000	180,000	111,000	67,000	265,000	723,000	3,000
01	Nurdin Alamsyah	52,500	120,000	172,500	210,000	105,000	276,000	591,000	360,000
02	H. Bahrum	40,000	130,000	170,000	130,000	181,000	120,000	431,000	235,000
03	Ismail Ibrahim	-	110,000	110,000	195,000	122,500	71,000	388,500	419,000
04	Muhtadin Nurdin	-	120,000	120,000	145,000	129,500	103,500	378,000	155,000
05	Rajali Adam	60,000	120,000	180,000	135,000	176,000	60,000	371,000	345,000

B.7 CONTINUED

No.	Name	Land Preparation Cost (Rp.)		Growth Stage Cost (Rp.)			Harvesting Cost (Rp.)	Total Production Cost (Rp.)	Price (Rp.)
		Seed	Land Preparation	Maintenance	Fertilizer	Insect			
06	Syammah Kasyah	35,000	70,000	105,000	110,000	82,000	5,000	197,000	15,000
07	Baihaqi Ibrahim	-	80,000	80,000	140,000	77,000	67,000	284,000	165,000
08	Idris Ibrahim	-	110,000	110,000	135,000	48,000	37,000	220,000	220,000
09	Samsul Bahri Ismail	-	80,000	80,000	40,000	94,000	91,000	225,000	75,000
01	Buk Mur	21,000	100,000	121,000	194,000	91,000	68,000	353,000	225,000
02	Karnaini Salihin	50,000	125,000	175,000	140,000	95,000	82,000	317,000	255,000
03	Fatimah Abdullah	50,000	125,000	175,000	170,000	92,000	90,000	352,000	235,000
04	M. Nasir A. gani	40,000	120,000	160,000	180,000	115,000	113,000	408,000	125,000
05	Mardani Umar	-	130,000	130000	390,000	155,000	44,000	589,000	205,000
06	M. Taib Abdullah	-	-	-	-	-	-	-	-
07	Muhammad Hamzah		65,000	65,000	170,000	103,000	30,000	303,000	155,000
08	Yusuf Ismail	-	80,000	80,000	165,000	126,000	-	291,000	40,000
09	Anwar Zainon	60,000	110,000	170,000	200,000	255,000	52,000	507,000	125,000

B.8 PRODUCTION COST AT BJb.2 KUALA RAJA SUB DISTRICT

No.	Name	Land Preparation Cost (Rp.)		Growth Stage Cost (Rp.)			Harvesting Cost (Rp.)	Total Production Cost (Rp.)	Price (Rp.)
		Seed	Land Preparation	Maintenance	Fertilizer	Insect			
01	Budiman Ahmad	-	80,000	80,000	170,000	100,000	55,000	325,000	240,000
02	Tarmi Syah	-	120,000	120,000	140,000	39,000	59,000	238,000	275,000
03	Isa Saman	-	110,000	110,000	175,000	278,000	102,000	555,000	325,000
04	Hamzah Rani	75,000	110,000	185,000	190,000	137,000	64,500	391,500	190,000
05	Rusli Ibrahim	80,000	110,000	190,000	230,000	76,000	100,000	406,000	235,000
06	Jufri Taib	135,000	143,000	278,000	430,000	230,000	170,000	830,000	370,000
07	Rasyidi	120,000	110,000	230,000	520,000	260,000	258,000	1.038,000	600,000
08	Ridwan Yahya	80,000	110,000	190,000	240,000	132,500	117,500	490,000	215,000
09	M. Taib Saman	-	110,000	110,000	205,000	81,000	37,500	323,500	215,000
01	Edwar	72,000	150,000	222,000	225,000	125,000	135,000	485,000	350,000
02	Zainal Syamsyah	-	110,000	110,000	110,000	113,500	104,500	328,000	245,000
03	Rusli Ibrahim	50,000	110,000	160,000	180,000	119,000	76,000	375,000	235,000
04	Muriadi	-	110,000	110,000	255,000	82,000	107,000	444,000	285,000
05	Usman Piah	-	110,000	110,000	270,000	100,500	114,000	484,500	35,000

B.8 CONTINUED

No.	Name	Land Preparation Cost (Rp.)		Growth Stage Cost (Rp.)			Harvesting Cost (Rp.)	Total Production Cost (Rp.)	Price (Rp.)
		Seed	Land Preparation	Maintenance	Fertilizer	Insect			
06	Isbeni	120,000	110,000	230,000	182,000	150,000	100,000	432,000	120,000
07	Bukhari	-	100,000	100,000	240,000	75,000	92,000	407,000	115,000
08	M. Saleh	42,000	110,000	152,000	230,000	99,500	38,000	367,500	255,000
09	Zulhelmi	-	110,000	110,000	220,000	72,000	96,000	388,000	95,000
01	Suryadi	70,000	110,000	180,000	180,000	134,000	153,000	467,000	305,000
02	Arizal Fahmi	-	130,000	130,000	180,000	177,500	159,000	516,500	85,000
03	Junaidi Usman	-	110,000	110,000	200,000	144,000	142,000	486,000	275,000
04	Hamriza	62,000	110,000	172,000	150,000	103,500	136,000	389,500	285,000
05	Idris Budiman	70,000	110,000	180,000	140,000	107,000	110,000	357,000	190,000
06	Ramli Syam	100,000	130,000	230,000	220,000	180,000	90,000	490,000	240,000
07	Mawardi	80,000	110,000	190,000	200,000	105,000	50,000	355,000	195,000
08	Mahdi Yahya	-	125,000	125,000	230,000	170,000	82,000	482,000	270,000
09	Rusli Piah	-	125,000	125,000	240,000	145,000	140,000	525,000	115,000

B.9 PRODUCTION COST AT BPg.1 JULI SUB DISTRICT

No.	Name	Land Preparation Cost (Rp.)		Growth Stage Cost (Rp.)			Harvesting Cost (Rp.)	Total Production Cost (Rp.)	Price (Rp.)
		Seed	Land Preparation	Maintenance	Fertilizer	Insect			
01	Marjuki	70,000	100,000	170,000	320,000	325,000	144,000	789,000	215,000
02	Usman Puteh	-	100,000	100,000	320,000	186,000	72,000	578,000	425,000
03	Rusmaini Ismail	102,000	100,000	202,000	290,000	205,000	62,000	557,000	279,000
04	Jafar Abu Bakar	50,000	100,000	150,000	450,000	235,000	84,000	769,000	255,000
05	Rasyidah	110,000	100,000	210,000	184,000	230,000	25,000	439,000	245,000
06	Muhammad Ali	70,000	120,000	190,000	225,000	110,000	70,000	405,000	285,000
07	Mahyiddin Ibrahim	-	100,000	100,000	340,000	205,000	178,000	723,000	195,000
08	Kamaliah Ali	50,000	100,000	150,000	200,000	62,000	32,000	294,000	265,000
09	Imum Nasir	-	100,000	100,000	560,000	188,000	196,000	944,000	340,000
01	Jafaruddin	80,000	100,000	180,000	280,000	208,000	155,000	643,000	410,000
02	Maimun Ibrahim	200,000	100,000	300,000	310,000	375,000	111,000	796,000	165,000
03	Razali Abd. Rahman	84,000	100,000	184,000	240,000	420,000	150,000	810,000	335,000
04	Mustafa Dadeh	26,000	100,000	126,000	225,000	106,000	150,000	481,000	245,000
05	Rusli Ibrahim	160,000	100,000	260,000	220,000	262,000	102,000	584,000	290,000

B.9 CONTINUED

No.	Name	Land Preparation Cost (Rp.)		Growth Stage Cost (Rp.)			Harvesting Cost (Rp.)	Total Production Cost (Rp.)	Price (Rp.)
		Seed	Land Preparation	Maintenance	Fertilizer	Insect			
06	Marzuki	-	100,000	100,000	230,000	120,000	90,000	440,000	240,000
07	Hasballah Daud	80,000	100,000	180,000	230,000	297,000	152,000	679,000	240,000
08	Mustafa Umar	-	110,000	110,000	195,000	122,500	71,000	388,500	419,000
09	Helmiadi	70,000	100,000	170,000	335,000	173,000	144,000	652,000	305,000
01	Zainal Daud	-	100,000	100,000	212,000	134,000	100,000	446,000	255,000
02	Abdurrahman AB	140,000	180,000	320,000	440,000	162,500	135,000	737,500	170,000
03	Adnan	-	110,000	110,000	195,000	122,500	71,000	388,500	419,000
04	Suryadi A. Gani	40,000	100,000	140,000	205,000	255,000	136,000	596,000	265,000
05	Derwin Abidin	60,000	100,000	160,000	210,000	260,000	140,000	610,000	245,000
06	M. Taib Abdullah	110,000	100,000	210,000	1,140,000	373,000	413,000	1,926,000	555,000
07	Fuadi Yusuf	-	100,000	100,000	180,000	195,000	24,000	399,000	245,000
08	Nazarli Ar	70,000	100,000	170,000	210,000	244,000	80,000	534,000	225,000
09	Jufri Jafar	30,000	100,000	130,000	330,000	100,000	120,000	550,000	225,000