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Cost-effective Asset Management Planning for the Sustainable Future of Rural Irrigation Systems

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To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

ABSTRACT

Around the world water and land available for agriculture is reducing while pressure to increase production is increasing. Efficient and adequate irrigation systems are a vital element in balancing this equation. Irrigation systems in many developing countries are having problems with low performance due to poor or deferred maintenance of their irrigation infrastructures. This in turn adversely affects the sustainability of irrigation and hence adequate food production. Those running irrigation systems must be able to respond to these challenges by managing and maintaining irrigation systems at their best in order to utilise these increasingly scarce natural resources efficiently and wisely, and also cost effectively. This thesis presents a process of irrigation asset management that assists user-manager groups to manage and maintain their irrigation systems effectively.

The thesis reports details of the process of developing improved asset management planning (AMP) for a transferred tertiary level irrigation system in rural Indonesia which has been turnover from government to user/farmers group such as Water User Associations (WUAs). A tertiary irrigation network is one that leads directly from a secondary channel system to the irrigated land. It consists of water supply channels, drainage channel networks and associated infrastructure attached to the networks.

There are numerous asset management processes advocated by a variety of international bodies. This study began by examining these systems and their practicality and utility for user/manager groups such as WUAs as they exist in Indonesia. The appropriate and suitable AMP was developed by adopting, developing and extending various aspects of these systems and was developed through three basic stages.

The first stage was carried out to assess the existing performance of typical Indonesian irrigation systems using case studies. This stage is the major component of the AMP and needed to be done to determine how productively the water and land are being used for agriculture. The performance assessment were analysed through Rapid Appraisal Process (RAP) and Benchmarking, a farmers' opinion survey and asset condition survey.

The results obtained from the first stage were further analysed in the second stage to examine the sustainability of the existing irrigation system cases studied using a Triple Bottom Line sustainability assessment. This was carried out to assess of the current demand for irrigation and to measure how well this is being achievement not only in terms of financial performance (profit) but also in terms of environmental and social performance. Incorporation of these assessments was to get an overall balanced picture of the condition of existing irrigation systems in Indonesia.

These system performance and sustainability assessments were based on independent measurements carried out for this study, of quantitative data and systematic sampling of farmers in Lampung province. Irrigation systems throughout Indonesia have been turnover from government to user/farmer organisations (Water User Associations). The performance and sustainability of irrigation system cases studied were typically below their full potential and did not perform to design capacity. Although these systems could satisfy the farmers' immediate needs there was potential for improving performance (increasing number of harvests) by establishing an asset management system that could be used by the WUA.

Also included in the second stage, was a review of a set of physical and managerial interventions that could potentially be implemented to improve the performance and sustainability of the irrigation system as well as the viability and priority of the interventions. These interventions were drawn from suggestions made by experts. The Physical interventions were a set of proposed options to modernise the irrigation system. The managerial interventions were a set of proposed approach to improve irrigation system management, procedures, and communication by improving participatory in irrigation management.

The review of these proposed interventions was carried out by integrating the results from a stakeholders' opinion survey with a TBL viability framework. The integration of these two methods was designed to identify an alternative solution that was not only robust but also preferred by the stakeholders of the irrigation system. Stakeholders included government bodies (provincial, districts and local technical implementation unit or UPTD), consultants and WUAs. The stakeholders' opinion survey was assessed using the simple pairwise comparison questionnaires and matrix analysis. The results showed that the physical changes that required large capital cost were less desirable and the managerial changes that give WUAs (Water User

Associations) greater authority less favoured by all stakeholders.

Finally in the third stage the investigations and findings from stages 1 and 2 were combined with two additional sets of data to produce the improved AMP. The two new data sets incorporated were: (a) data acquired from the latest project implemented by the Government of Indonesia (the Participatory in irrigation Sector Project, PISP) to rehabilitate the tertiary level from 2005 to 2012, and (b) the specific and essential elements suggested by internationally recognise experts and organisations. All combined these gave the improved sustainable and cost-effective AMP for WUAs to use which consists of: budget priorities (set routine management, operation and maintenance costs), budget planning (set rehabilitation of irrigation system), and short, medium and long-term investment planning.

The improved AMP developed in this study provides an appropriate way of running irrigation systems in an efficient, cost-effective and sustainable way and can be used by any owner/user organisation such WUAs which do not have any previous experience in running management, operation and maintenance asset of irrigation system. It also helps them to focus their efforts in achieving an improved irrigation system performance and sustainability.

To ensure that the improved AMP can be successfully used by the WUA, it is necessary to have appropriate legal enforcement, government legislation and regulation in place. Successful implementation also requires government assistance to provide technical support such as training and promoting effective and viable user associations. Successful implementation of the improved AMP may take several years but will have positive long term sustainable benefits. If budget and short-term planning by farmers is successfully achieved, greater responsibility can be allocated to farmers in the future.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY AND ABBREVIATION

AAMCoG	: the Australian Asset Management Collaborative Group
ACPs	: Asset Condition Profiles
ADB	: Asian Development Bank
AHP	: Analytical Hierarchy Process
AMP	: Asset Management Plan/Asset Management Planning/Asset Management Procedure
AMS	: Asset Management Strategy/ Asset Management System
ANCID	: Australian National Committee of ICID
ARD	: Agriculture and Rural Development
ASCE	: American Society of Civil Engineer
AWDS	: Actual Water Delivery Service
AWP	: Annual Works Program
Balai PSDA	: *Balai Pengembangan Sumberdaya Air* (Basin Water Resources Management Unit)
BAPPENAS	: *Badan Perencanaan Nasional* (the National Planning Bodies)
BOD	: Biological Oxygen Demand
BPS	: *Biro Pusat Statistik* (Central Bureau of Statistics)
Bupati/regent	: a governing official of *kabupaten*/regency
BWRM	: Basin Water Resources Management Project
CAPEX	: Capital Expenditures
CIEAM	: Cooperative Research Centre for Integrated Engineering Asset Management
COD	: Chemical Oxygen Demand :
DGWR	: the Directorate General of Water Resources
DISPENDA	: *Dinas Pendapatan Daerah* (the Local Revenue Service)
DO	: Dissolve Oxygen
ECw	: average irrigation water salinity
ELECTRE	: ELimination Et Choix Traduisant la REalité or ELimination and Choice Expressing REality
ETo	: Potential evapotranspiration
FAO	: Food and Agriculture Organization
FMISs	: Farmer Managed irrigation Systems

GASB	: Governmental Accounting Standard Board
GRI	: Global Reporting Initiative
Gubernur	: a governing official ranking under the head of state
IBRD	: The International Bank for Reconstruction and Development
ICID	: International Commission on Irrigation and Drainage
IDTO	: Irrigation Development and Turnover
IF	: Importance Factor
IIS	: Institute of Irrigation Studies, University of Southampton, United Kingdom (UK)
IMP	: Irrigation and Maintenance Policy
IMT	: Irrigation Management Transfer
INPRES	: *Instruksi Presiden* (Presidential Instruction)
IPTRID	: International Programme for Technology and Research in Irrigation and Drainage
IRS	: the Internal Revenue Service
ISAF	: Irrigation Sustainability Assessment Framework
ISF	: Irrigation Service Fee
ITRC	: The Irrigation Training and Research Center
IWMI	: International Water Management Institute
JBIC	: Japan Bank for International Cooperation
JICA	: The Japan International Cooperation Agency
JIWMP	: The Java Irrigation and Water Resources Management Project
Kepmen	: *Keputusan Menteri* (Ministrial Decree)
Keppres	: *Keputusan President* (Presidential Decree)
KPI	: Key Performance Indicators
LCC	: Life Cycle Cost
LoS	: Level of Service
MAUT	: Multi Attribute Utility Theory
MCDA	: Multi Criteria Decision Analysis
MEA	: Modern Equivalent Asset
MIPs	: Maintenance Intervention Parameters
MOHA	: Ministry of Home Affairs
MOM	: Management, Operation and Maintenance
MPW	: the Ministry of Public Works

O&M : Operation and Maintenance

OPEX : Operation Expenditures

P3A/GP3A/IP3A(WUA/WUAF)
: *Perkumpulan Petani Pengguna Air/Gabungan Perkumpulan Petani Pengguna Air/Induk Perkumpulan Petani Pengguna Air* (Water User Association/Water User Association Federation)

Pelita : *Pembangunan Lima Tahun* (short-term development designed by Five-Year Development Program during the reign of the New Order in Indonesia)

Pengembangan Irrigasi Desa
: the Village Irrigation Development Project

PIM : Participation in Irrigation Management

PISP : Participatory in Irrigation Sector Project

PJP : *Pembangunan Jangka Panjang* (long-term development designed by 25-Year Development Program during the reign of the New Order in Indonesia)

PP : *Peraturan Pemerintah* (Government Regulation)

PRA : Participatory Rural Appraisal

PTPA/PPTPA : *Panitia Tata Pengaturan Air/Panita Pelaksana Tata Pengaturan Air* (Provincial Water Resource Management Implementation Committee /Basin Water Resource Management Implementation Committee)

PWRS : the Provincial Water Resources Services

PWRS : the Provincial Water Resources Services

RAP : Rapid Appraisal Process

RIS : annual relative irrigation supply

RWS : annual relative water supply

SDR : Social Discount Rate

SMART : Simple Multi-attribute Ranking Technique

SOS : Standard of Service

SPSS : Statistical Package for Social Science

SWDS : Stated Water Delivery Service

TBL : Triple Bottom Line

TDS : Total Dissolved Solids

UK : United Kingdom

Ulu-ulu and *Ili-ili* : Tradition-based water arrangements for paddy fields such as *Subak* (Bali and Lombok), *Panriahan Pamokkahan* (North

Sumatra), *Panitia Siring* (South Sumatra and Bengkulu), *Ulu-ulu Desa/Ulu-ulu Pembagian/Ulu-ulu vak* (Central Java), Ili-ili (East Jawa), Tuo Banda/Siak Bandar (West Sumatra), Raksabumi (West Java), Malar/Ponggawa (Sumbawa), Tudung Sipulung (South Sulawesi), and kejruen Blang (Aceh)

UNEP	: the United Nations
UNEP	: the United Nations Environment Programme
UNESCO	: the United Nations Educational, Scientific and Cultural Organization
UPTD	: *Unit Pelaksana Teknis Daerah* (Local Technical Implementation Unit)
USA	: United States of America
USAID	: United States Aid
WAC	: Worst Allowable Condition
WATSAL	: Water Sector Adjustment Loan
WDS	: Water Delivery Service
WHO	: World health Organization
WISMP	: Water Resource and Irrigation Sector Management Project
WUAFs	: Water User Association Federations
WUAs	: Water User Associations

CHAPTER 1. INTRODUCTION

1.1 Background

Agricultural irrigation plays an important role in ensuring global food security. By maintaining current levels of agricultural production, the livelihoods of millions of people are ensured. Without effective agricultural irrigation management, a country's national economy would become vulnerable, people would starve and social unrest would ensue.

Irrigation systems in rural Indonesia are generally river run-off type systems; therefore water can be scarce in dry seasons. The water runoff is diverted from reservoirs to paddy fields through irrigation channels. Although it can be said that Indonesia currently has abundant rainfall, it is facing issues that require consideration. These include climate change, availability of irrigation water and land, population growth and expanding cities. There are also a number of competing needs for water for agriculture between domestic users and industry, along with environmental concerns. All of these factors may jeopardise the future availability of water. Since rice crops consume vast amounts of water, it has become a global imperative to increase the productivity of land and the supply of water in irrigated areas.

In addition to the problems above, irrigation in Indonesia faces other problems such as ageing irrigation systems, increasing Operation and Maintenance (O&M) costs and low O&M cost recoveries, a lack of government financing for irrigation, and diminishing reservoir capacities due to sedimentation. The problems illustrate the causes of poor performance of irrigations systems in general. Low land productivity is the result and this in turn adversely affects the sustainability of irrigation.

In order to improve productivity, irrigation systems require asset maintenance and upgrading to the highest standards. Furthermore, improved irrigation performance and sustainability could be achieved by more effective asset management. Asset management provides particular operating standards at an agreed level of service in the most cost-effective and sustainable manner. As a result, the performance of both low and adequately productive irrigation systems may be improved and sustained. Since 1988, the Indonesian government has been implementing a "transfer policy", i.e. transferring O&M of tertiary level irrigation system to Water User Associations and Water User Association Federations (WUAs and WUAFs). The latest implementation in WUAs institutional arrangements is to run WUAs as business organisations. The policy is aimed at making WUAs capable of financing irrigation assets independently at tertiary levels. In the future, it is expected that all irrigation systems from upstream to downstream could be funded independently by WUAs.

Since the deteriorating condition of assets was identified after the Turnover project ended, the effectiveness of this trend needs to be reviewed with respect to service delivery, production efficiency, financial performance and environmental impact. There is a need to assess the condition of the assets of existing irrigation systems in rural Indonesia, and to develop an improved, sustainable, cost-effective Asset Management Planning (AMP).

Unfortunately, there is a lack of adequate, reliable and current irrigation statistics in Indonesia in general. Only a few of the irrigation systems in Indonesia have their performance levels accurately evaluated. Therefore, in an effort to achieve the ultimate objectives of this thesis, a set of stages is proposed.

The improved, sustainable, and cost-effective AMP developed in this thesis covers the management, operation, and maintenance of systems which have been turnover to the WUAs and WUAFs. It consists of physical improvements planning and management improvements. The AMP developed also requires activities that assess, monitor and regulate over time, the condition of government-owned irrigation infrastructure. The procedure is a valuable mechanism for focusing the attention of WUAs and WUAFs on sustaining and enhancing the condition of irrigation infrastructure. When this objective is achieved, expanding the scope of WUAs authority can be executed.

1.2 Research Objectives and Significance

Based on the issues raised above, the objectives of this research that are developed and explained in detail in Chapter 2 are as follows:

Objective 1:

The Objective 1 was aimed at assessing the performance of existing irrigation system since it is the first stage and major component of the AMP. Case studies of rural irrigation systems in Indonesia have been used to to provide a detailed picture of the general current performance of existing irrigation systems in Indonesia. To gain a more in-depth understanding of performance problems in existing systems, performance will be assessed by incorporating methods of Rapid Appraisal Process (RAP) and Benchmarking, an opinion survey, and an asset survey.

RAP and Benchmarking is a method that has been accepted internationally and has proven to be reliable in analysing irrigation performance related to service delivery, production efficiency, financial efficiency and environmental impact. However, this method only pays attention to benchmarking the irrigation performance and process. Therefore, in this research, a farmers' opinion survey was conducted to gather information regarding farmers' perceptions of the existing irrigation services provided by the government, along with farmers' preferences for irrigation services in the future. An asset survey was also carried out to gather data on the current condition of irrigation assets.

In general, the performance assessment results show that the irrigation system have low performance and fail to achieve the current service targets.

Objective 2:

There is a very close relationship between an irrigation system's sustainability and the various aspects of its performance. Objective 2 was aimed at further assessing the performance of the irrigation system within the framework of sustainability and to find out the most viable, adequate and preferred approaches to improve the triple bottom line (TBL) sustainability of the Indonesian irrigation system in the future.

In irrigated agriculture, sustainability can only be achieved if the resources that are necessary for the conduct of irrigated agriculture continue to be available. RAP and Benchmarking assesses the benefits from irrigation as production outcomes that are usually produced at the great expense of environmental resources. However, this method only pays little attention to environmental performance. Therefore, the incorporation of a sustainability assessment into the performance assessment is advisable, to provide a means of demonstrating the economic, social and environmental sustainability of the irrigation system.

The analysis then continued to examine performance issues and its causes, and interventions/corrective actions necessary. These included the managerial and physical changes required to improve irrigation performance and sustainability. The viability of the intervention/corrective actions was studied by integrating a stakeholders' opinion survey and the TBL sustainability framework. The integration of these two methods intended to establish a better improved method of assessing sustainability. The alternative solutions to improve irrigation performance and sustainability resulting from these assessments would not only be robust but also be taken up with enthusiasm by the stakeholders of irrigation systems since it involves the stakeholders opinion survey. Stakeholder opinion was assessed using the Simple Pairwise Comparison Questionnaires and Matrix Analysis with the results then used to weigh the viability of the interventions/corrective actions against the TBL sustainability framework.

The result shows that the most viable, adequate and preferred approaches to improve the TBL sustainability of the Indonesian irrigation system in the future are a moderate improvement in the management or moderate improvement in infrastructure that do not require high investment costs. The outcomes of Objective 2 provided adequate bases for developing the improved, sustainable, and cost-effective AMP for tertiary level irrigation system which is operated and maintained by Water User Associations.

Objective 3:

The purpose of Objective 3 was to develop an appropriate AMP that would enable WUAs in rural Indonesia to manage the assets of a turnover irrigation system in the best/most cost-effective and sustainable way in order to achieve sustainability goals. The AMP activities were based on the importance of the proposed corrective actions gained from the previous objective.

AMP outcomes aim to meet requirements such as reliability, manageability, financial viability and physical sustainability. An AMP is also required to give effect to equity, productivity and environmental concerns. It should consider aspects such as constraints, priority of alternative strategies, and sources and realistic levels of funding. Ultimately, an improved, sustainable, and cost-effective AMP model was developed that incorporated: budgetprioroties, budget planning, shor-term, medium-term and long-term planning. To be successful in implementing the long-term planning, WUAs still require government assistance to provide technical support as well as financial and institutional supports.

Overall this improved, sustainable, and cost-effective AMP will lead WUAs to independently fund the management, O&M of irrigation system and improving irrigation performance and sustainability.

This research is significant for a number of reasons. Firstly, it is a timely study coinciding with the implementation of a participatory approach to irrigation projects in Indonesia, namely the WISMP (Water Resources and Irrigation Sector Management Project) and the PISP (Participatory Irrigation Sector Project). The research aims to contribute to knowledge development by scholarly research and case studies and by adding to the emerging participatory approach of government with WUAs as business organisations.

Secondly, this research examines performance, and reviews the sustainability of irrigation systems by incorporating several methods to gain a more in-depth understanding. This will potentially contribute to the improvement of methods and frameworks for assessing irrigation performance and sustainability, especially in rural areas. Performance and sustainability indicators relate to service delivery, production efficiency, financial performance, and environmental impact performance. These indicators enable precise, appropriate, fast, efficient, and economical approaches in assessing irrigation system performance and sustainability and the recommendations can be applied by irrigation authorities.

Finally, this research provides a process for the development of an AMP for a rural irrigation system in which the management, O&M at tertiary level irrigation system has been turnover from the government to the WUAs in the most cost-effective and sustainable way. It is expected that the improved, sustainable, and cost-effective AMP could also be implemented in other parts of Indonesia and other developing countries.

1.3 Scope of Study

1.3.1 General Description of Study Site

In the Province of Lampung, there are approximately 732 (2.19% of national) irrigation systems that cover about 295,000 (3.95% of national) hectares of cropland. The policy of water resource efficiency in the Province of Lampung is concentrated on the development of irrigation, swamp area, reservoirs, and small ponds. The primary irrigation systems are the Way Sekampung System which has a potential area of 66,591 hectares, and the Way Seputih system which has a potential area of 20,201 hectares. The irrigation area is divided into three categories, namely large (> 3,000 hectares), medium (1,000 to 3,000 hectares), and small (<1,000 hectares). Large irrigation areas cover 214,150 hectares; medium irrigation areas cover 24,140 hectares; and small irrigation areas cover 56,700 hectares.

The Province of Lampung was chosen as the case study area for a number of reason. Firstly, it is one of the most reliable rice producers in Indonesia and has the potential for further development. Secondly, irrigation in Lampung is a fascinating mix of old, new, rehabilitated, planned, and abandoned irrigation systems. The large range of age of assets becomes a challenge in prioritising assets repairs and renewal. Thirdly, since this province became a destination for colonisation and transmigration program in the past, a variety of traditional rice farming practices and tradition-based water arrangements used by the farmers according to their origins are to be found here. Fourtly, previous studies on irrigation are generally carried out in Java. However, when compared with other irrigation systems throughout Indonesia, irrigation systems in Java are generally well developed. Therefore, this province better represents the average condition of Indonesia's irrigation systems.

In addition to these, it is a coincidence that from 2005 to 2012, the province was granted permission to carry out WISMP and PISP projects. These projects were aimed at consolidating the successful reform of irrigation, decentralise the management of irrigation systems, sustain the investments in the past, increase yields of irrigated crops and economic growth, and reduce rural poverty. The PISP also funded the rehabilitation works of tertiary level of irrigation system case studies which was designed to ensure that the deferred maintenance cycle is broken and that irrigation systems performance is maintained at or close to the original design level. Moreover, the projects also integrated the growing need for a Participation in Irrigation Management (PIM) with financial constraints of the districts. The involvement of the WUAs in the execution of rehabilitation funded by the projects will hopefully make the WUAs financially independent. Therefore, this research could utilise some data from these projects.

The study area covers 11 irrigation systems (large, medium and small) across the Way Seputih and Way Sekampung River catchment areas of the District of Central Lampung, the District of South Lampung, and the District of Tanggamus (*see Figure 4.2*). For further discussion throughout the remainder of this thesis, the irrigation system case studies are mentioned as the irrigation system.

This research would review only the basic function of irrigation systems that is to supply water for irrigation. The discussion emphasises the tertiary levels of the system as they are farmer-managed. The primary and secondary levels of irrigation are not emphasised in the discussion since they are responsibility of the irrigation authority, however some indicators requires the primary and secondary levels are incuded in the analysis.

1.3.2 Research Scope and Stages

In order to achieve the research objectives, the scope of studies to be performed are as follows:

1. Preliminary study

   The preliminary study consists of activities such as defining systems and functions; selection of locations for surveys (study areas), establishing the preliminary data, acquiring permission to conduct research in the particular study areas, establishing survey teams, and conducting preliminary visits. The visits were made to: case study sites, stakeholders involved in the case studies such as government bodies, provincial and local irrigation authorities and staff, consulting and contracting organisations involved in the systems, and WUA heads and farmers.

2. Assessing system performance

   Performance assessment explicitly defines the condition and performance of the assets as a baseline against which to measure future condition and performance. The performance assessment survey utilised (1) RAP and Benchmarking as developed by Dr Charles Burt from the Irrigation Training and Research Centre (ITRC) - California Polytechnic State University, (2) an opinion survey to obtain better insight into the opinions and preferences of farmers, and (3) an asset condition survey aimed at assessing the extent, function, condition, value, and performance of the individual asset (Objective 1).

3. Assessing system sustainability

   Assessing system sustainability involves a review of the relationship between existing asset performance, and management structure and operational procedures regarding system sustainability. The TBL sustainability assessment of existing irrigation systems was then integrated into the performance assessment to assess the economic, social and environmental sustainability dimensions of irrigation systems.

4. Assessing the viability of proposed alternatives for interventions

   In order for an irrigation system to be sustainable, physical and managerial adjustments must be implemented. The analysis weighed up the viability of interventions through a stakeholder opinion survey which utilised a Simple Pairwise Comparison Questionnaire and Matrix Analysis and scored interventions according to a TBL sustainability viability framework for irrigation.

5. The Asset Management Planning

   An improved, sustainable, and cost-effective AMP for a transferred irrigation in rural areas was then developed for WUAs in rural Indonesia. Since the thesis reviewed the institutional arrangements for a turnover irrigation under WUAs, it therefore proposes:

   - physical and managerial changes under WUAs institutional arrangements, including defining the level of service to be provided by WUAs;
   - improved AMP of a transferred irrigation systems in rural areas considers aspects such as efficient O&M, needs based budgeting and budget constraints, sources and realistic levels of funding and the likelihood to increase irrigation service fees (ISF) for cost recovery;
   - building a cost model and time frame of AMP implementation.

1.4 Thesis Overview

The remainder of the thesis is arranged as follows:

Chapter 2 presents a review of previous reports on methods and assessments of irrigation system performance, models of irrigation management arrangements and asset management, and factors that influence the sustainability of irrigation.

Chapter 3 sets out and examines the stages involved in achieving the research objectives along with the methodology used for gathering information and data during the field survey. This includes farmer opinion surveys, performance assessment surveys and stakeholder opinion surveys. The chapter presents the methodology used to analyse existing irrigation system performance and sustainability, farmer opinions and preferences on irrigation and drainage services, and stakeholder opinions on proposed physical and managerial interventions/corrective actions. It also presents the TBL viability of the proposed corrective actions, along with an appropriate AMP to enable WUAs in rural Indonesia to manage the assets of a turnover irrigation system in the best/most cost-effective and sustainable way.

The results and discussion of Objective 1 of the research are given in Chapter 4. The chapter was aimed at assessing the performance of existing irrigation systems in rural Indonesia. It consists of the results of assets condition assessment, the irrigation system performance assessment, and the farmer opinion survey.

Chapter 5 presents the results and discussion of the research carried out to achieve Objective 2, which was to assess the sustainability of the irrigation system and the viability of a set of proposed corrective actions to improve irrigation system sustainability. The work reported in this chapter consists of assessing the sustainability of existing irrigation systems by integrating the TBL sustainability assessment to find out the TBL performance issues and causes, and the interventions (physical and managerial corrective actions) needed to improve irrigation performance and sustainability in the future. A subsequent opinion survey was taken of stakeholders to obtain preferences regarding corrective actions, and to assess the viability of alternatives. The outcomes will obtain the most viable and appropriate alternative strategies to be implemented to improve the sustainability of irrigation systems in the future. A decision-making framework with robust criteria will be used to help the system's decision makers in their selection of projects.

Chapter 6 presents the results and a discussion of Objective 3, aimed at developing an improved, sustainable, and cost-effective AMP model that enables WUAs in rural Indonesia to manage the assets of a turnover irrigation system in the best/most cost-effective and sustainable way based on the importance of the proposed corrective actions.

Chapter 7 provides summaries and conclusions to this study, followed by a set of recommendations for implementation of improved, sustainable, and cost-effective AMP that can be applied to irrigation systems in Indonesia and countries with similar irrigation systems and for future work. It is expected that by implementing this plan, WUAs eventually capable of independently fund the management, O&M of the irrigation infrastructure in order to achieved improved irrigation productivity while maintaining and enhancing the sustainability of irrigated land and water resources.

CHAPTER 2. REVIEW OF LITERATURE AND RESEARCH OBJECTIVES

2.1 Introduction to Literature Review

Irrigation is the backbone of rural economies in large parts of developing countries. According to the Food and Agriculture Organisation (FAO) of the United Nations (UN), the world's irrigation systems produce 40% (by weight) or 60% (on a dollar basis) of the world's food supply, and crop production in developing countries is projected to increase 175% by 2030. However, issues of irrigation water and land sustainability threaten production. Water consumption by agriculture (almost entirely for irrigation) accounts for 82% of human-based water consumption. Irrigation is the primary reason why many of the world’s major natural water bodies like rivers, lakes and aquifers are shrinking so rapidly. On the other hand, large-scale reallocation of irrigation water to other uses due to human population growth is predicted to cause annual global losses of 350 million metric tonnes of food production by 2025 (FAO, 2002). In many areas of Indonesia, there is increasing evidence of water shortage during the dry season.

Cropland sustainability issues relate to the decline of irrigated areas. From 1950 to 1981, the world’s grain areas expanded from 587 million hectares to a historical peak of 732 million hectares due to the growth in irrigation which brought arid land under cultivation and facilitated double cropping for countries with moderate climates. However, some crops were not ecologically sustainable and grainland shrank to 647 million hectares in 2002, for various reasons such as eroding soils, dustbowl formation, water shortages, desert encroachment and even the conversion of land into fish ponds, housing, roads, etc. (FAO, 2002). In Indonesia, it is estimated 2.5 million hectares (approximately 1.5%) of paddy fields have been lost over the last 20 years without an equivalent replacement. Each year, 188 thousand hectares of agricultural fields are converted for alternate uses (Irawan, 2005) such as housing (30%), industry or other crops such as palm oil (65%), and other uses (5%) (Widjanarko, 2006).

With the world’s grainland area changing relatively little over the last half-century but with the population more than doubling, grainland per person dropped by more than half from 1950 to 2000 (FAO, 2002). In India, farms that averaged 2.7

hectares in 1960 are less than half that size today. In Indonesia, the average farm size is currently only 0.5 hectares. In Egypt, Malaysia, and Rwanda, it is predicted in 2050 that the grainland per person will be scarcely half the size of a tennis court (FAO, 2002). Millions of inherited plots are so small that their owners are effectively landless. It is a challenge to eradicate hunger in a world of water shortages, eroding soils and shrinking grainland area.

With increasing concern over the sustainability of irrigation water and land availability, there is a global imperative to make efficient use of these limited resources. Irrigation systems must be able to serve an increasingly productive agriculture, resources must be managed efficiently and wisely, and costing must be effective. Some of the biggest threats to irrigation in Indonesia are ageing, deferred maintenance, and rehabilitation of irrigation assets, caused primarily by lack of adequate maintenance funding. These problems have created severe constraints on performance resulting in ineffectual use of water and land for agriculture, which in turn has threatened the sustainability of irrigation systems. For example, the rice production of Karawang remains at 10% of its optimal potency due to the degradation of the Tarum irrigation system (Kompas Magazine, 2002). Therefore, the challenge of future irrigation sustainability is to improve the performance of the systems which can lead to increased productivity of water and land, which in turn guarantees their sustainability.

To overcome the problems, the government of Indonesia has implemented project schemes to improve the performance of existing systems by involving farmer participation in managing irrigation water and irrigation assets. According to the International Water Management Institute (IWMI) (2007), the reasons for improving the performance of existing systems and adding new irrigation are:

- to improve equity and reduce poverty in rural areas,
- to keep up with global demand for agricultural products and adapt to changing food preferences and societal demand,
- to adapt to urbanisation, industrialisation, and to increase funding allocation to the environment to reduce environmental damage, increase ecosystem service and enhance water and land productivity,
- to respond to climate change.

Reforming water management has become a priority and it can be achieved by:

- increasing water productivity in irrigated areas along with value per unit of water by integrating multiple uses - including livestock, fisheries, and domestic use in irrigated systems,
- increasing annual irrigation water supply by making innovations in system management, developing new surface water storage facilities, and increasing groundwater withdrawals and the use of waste water (IWMI, 2007).

Increasing water productivity in irrigated areas and value per unit of water and increasing annual irrigation water supply can be achieved through better asset management. Private industry has been implementing asset management programs for some years. However, it is only in recent times that public utilities have been interested in applying AMP to their infrastructure. Currently, many water agencies see asset management as a viable alternative for improving the financial and service performance of facilities in irrigation asset systems in Australia, New Zealand, the Netherlands, UK, Vietnam and Albania.

The Government of Indonesia implements a farmer participation approach in managing irrigation water and assets. Unfortunately, it is difficult to sustain this. Formal water user associations WUAs often quickly disappear immediately after a project is completed and local irrigation management quickly reverts to previous patterns (Bruns and Helmi, 1996). This paper presents the investigations into and steps to be taken to improve irrigation system performance and sustainability in rural areas by developing an improved, sustainable, and cost-effective AMP through a participatory approach.

Section 2.2 presents the background to the development of asset management of irrigation infrastructure. Section 2.3, 2.4, 2.5 and 2.7 present assessments carried out to determine irrigation performance and sustainability level, included interventions options to improve irrigation performance and sustainability and the need to apply those principles in the management of irrigation systems in Indonesia. Section 2.7 presents the process of developing an improved, sustainable, and cost-effective AMP of transferred irrigation system. Section 2.8 presents the summary of literature review, and the development of justification and objectives of the research.

2.2 Irrigation Infrastructure Asset Management

The economic and social welfare of the community rely heavily upon the availability of robust infrastructure. Basically, infrastructure is defined as a structural element in an economy that supplies the basic services in the economy to business and households. Normally, infrastructure is a long-lived assets that are stationary in nature and can be preserved for a significantly greater number years than most capital assets. A sound infrastructure demonstrates a massive investment over decades or longer.

Management of infrastructure sustains its economic serviceability. More and more public utilities are following the steps of the private sector by applying asset management to their infrastructures. This section presents the concept of infrastructure asset management and application of asset management in the irrigation sector, historical development of irrigation management transfer and application in Indonesia, and simplified and improved AMP for a transferred irrigation system.

Asset management has been described in various ways by a number of experts such as Davis (2007) and Burton *et. al*. (2003). The following is a definition by Moorhouse:

> "Asset management is the systematic and structured combination of management, financial, economic, and engineering practices that apply to physical assets over their whole life cycle, with the objective of providing the required level of service in the most cost-effective manner" (Moorhouse, 1999).

Asset management practices, objectives and functions or goals are also defined varies by them. Malano, George and Davidson (2005) stated that the ultimate aim of an asset management program or (AMP) is to deliver an agreed level of service at the least possible cost while ensuring sustainability of the asset base. According to Malano, Chien, and Turral (1999), AMP must be representing the most cost-effective program needed to meet the current and future level of service provision.

The core components of an AMP implemented by the Water Utility Operations Division of the Santa Clara Valley Water District, California are as follows: asset inventory, condition assessment, risk assessment, identification of levels of service, renewal/replacement schedule, and financial analysis and funding (Yep, 2008).

Subsequently, an asset management strategy (AMS) explains the detailed efforts in implementing an asset management program. Davis (2007) stated that an AMS assists the individual to:

- know exactly what assets you have (i.e., those you are responsible for operating, monitoring, and/or maintaining),
- know precisely where your assets are located,
- know the condition of your assets at any given time,
- understand the design criteria of your assets and how they are properly operated and under what conditions,
- develop an asset care (maintenance) program that ensures each asset performs reliably when it is needed, and
- perform all of these activities to optimise the costs of operating your assets and extending their useful life to that called for by the initial design and installation (or beyond).

While, the Institute of Irrigation Studies (IIS), the University of Southampton, UK (1995) referred the stages in developing an asset management plan as asset management planning.

Since the process of implementing an AMS involves various expertise such as finance, engineering and operations, it also requires legal enforcement, government legislation, regulation, and funding, financial reporting standards, physical security, and best management practice initiatives in the utility infrastructure.

AMP has proven to successfully increase the performance and financial position of private industry. In recent times public utilities have been interested in applying AMP to their infrastructure, including water agencies and irrigation authorities.

This section presents the concept of infrastructure asset management and application of asset management in the irrigation sector, historical development of irrigation management transfer and application in Indonesia, and simplified and improved AMP for a transferred irrigation system.

2.2.1 Introduction to Irrigation Infrastructure Asset Management

Irrigation plays an important role in the development of countries where agriculture makes up the main sector of the economy. An irrigation and drainage infrastructure consists of a large number of individual assets spread over a very wide area such as dams, channels, control structures, etc. Irrigation asset management is described as:

> "... A strategy for the creation or acquisition, maintenance, operation, rehabilitation, modernization and disposal of irrigation and drainage assets to provide an agreed level of service in the most cost-effective and sustainable manner" (Malano and Hofwagen, 1999).

The Institute of Irrigation Studies (IIS), University of Southampton, UK(1995) provides useful steps in developing AMP for irrigation infrastructure which includes:

- defining system and function,
- defining sampling to represent the irrigation system,
- establishing the environmental, legal and development context,
- assessing system performance – achieved levels of service, how these fit with present and future requirements and what infrastructure adjustments are needed,
- management studies: studying operation and maintenance (O&M) – a parallel review of the organisation and its procedures,
- conducting an asset survey – analysis of historical capital expenditure (capex) and operational expenditure (opex) as a basis for future projections.
- developing cost model for future asset management activities, and
- presenting the AMP.

For developing countries, irrigation system performance and sustainability improvements are achieved through a participatory approach. The following section explores the significance of asset management to be used in a transferred irrigation system. Hencefoward, the term AMP used in this thesis generally refers to the asset management planning.

2.2.2 Historical Development of Irrigation Management Transfer

Basically, there are six non-governmental organisational models used for managing irrigation systems around the world: public utility, local government, irrigation district, mutual company, private company, contractor and farmers through water user associations (WUAs). Each organisational model for a water service entity has different governance and different sources of financing, and management capacities.

However since the 1980s, there has been a paradigm shifting government-managed irrigation infrastructure assets to participatory irrigation management (PIM). As cited from Bruns and Helmi (1996), the World Bank (1996) defines participatory development as:

> "a process through which stakeholders can influence and share control over development initiatives, and over the decisions and resources that affect themselves".

Participation may range from offering information and opinion during a consultation process, to fully enable farmers, women and men, to act as the principal decision makers in all or most project activities.

PIM can be defined as the transfer of responsibility and authority for irrigation management by the government to farmers or other local, non-government entities. This process has been referred to as irrigation management transfer (IMT) or 'turnover' in Indonesia and by various names in other countries (Vermillion, 1997).

The USA, France, Colombia and Taiwan adopted PIM from the 1950s to the 1970s. Subsequently since the 1990s, PIM became a national strategy in developing countries such as Asia and North Africa. This phenomenon arose from the Rio de Janeiro Earth Summit 1992 recommendations that water should be treated as economic goods, water management should be decentralised and farmers and other stakeholders should play an important role in the management of natural resources, including water (Vermillion, 1997).

Developing countries are characterised by government-managed systems especially in the era of the green revolution. Subsequently, these countries adopt the the concepts of PIM under WUA institutional arrangement. The following table shows several concepts of PIM under WUA institutional arrangements.

Table 2.1. Range of institutional arrangements for PIM

Activity	**Full agency control**	**Agency O&M (users' input)**	**Shared management**	**WUA owned (agency regulation)**	**Full WUA control**	**Irrigation management company/board**
Regulation	Agency	Agency	Agency	Agency	WUA	Agency
Ownership of structures & assets	Agency	Agency	Agency	WUA	WUA	Company
O&M responsibility	Agency	Agency	Both	WUA	WUA	Company
Collection of water charges	Agency	Agency	Both	WUA	WUA	Company
Unit of representation	Agency	WUA	WUA	WUA	WUA	Company and users committee
Country cases	Most developing countries	Srilanka, Thailand, Vietnam, Philippines	Andhra Pradesh, Turkey, Albania	Mexico, Dutch Water Boards, Japan	New Zealand, FMIS schemes in Nepal, Ground Water irrigation	France, China, Australia, United States

Source: (IWMI, 1999)

This management model involves a process of transferring the management, and O&M of the irrigation and drainage system to WUAs. The government retains its administrative role but it also requires reform. This would ensure greater equity in access to water resources, the fostering of investments to reduce poverty, and the protection of ecosystem services essential to the livelihood of the impoverished. Since the objective of PIM is to reduce government expenditure and improve irrigation performance (especially improve productivity and stabilise deteriorating irrigation system), PIM is becoming increasingly popular due to government funding constraints.

The government has a crucial play in the irrigation sector, being responsible for the day-to-day management of dams, regulate river flows, and partial operation of the transferred irrigation system whilst operation, management and water distribution lies with the farmers. PIM keeps administrative and operational requirements as low as possible and the number of control structures in the channels to a minimum. However, the government must also provide a simplified system to match local capabilities and resources which can be built on and developed over time. The government can promote effective and viable user associations through trainings, assigning roles and responsibilities and extending technical support pertaining to the management of the irrigation system.

Farmer involvement in the planning, design and construction of irrigation systems allows the systems to be built around 'best use' principles, promotes farmer's satisfaction with physical facilities and develops farmer's sense of ownership. It is a useful way to improved the irrigation system performance in terms of the reliability of the water supply. It also allows the farmer to see where their money and labour is going and eases the acceptance and payment of water charges on the part of the user. They become responsible for the water that is delivered and the irrigation services rendered. It is expected that at the end, farmers can then irrigate more land along with higher cropping intensities.

A review of the impact of participation in irrigation management (PIM) in some developing countries by Vermillion (1997), showed that PIM had potential benefits, but results varied from country to country (*see Appendix A.2*). He also found that there is remarkably little information about the outcome of transfer programs on overall government spending in developing countries since most studies only document government spending for O&M, especially at the system level. In addition to this, a study by Johnson & Reiss (1993) on a lift irrigation system turnover to a WUA in Indonesia showed that the cost of pumped water increased five to seven times after turnover, and the deterioration of the pumps was accelerated.

On the other hand, according to Vermillion (1197), the devolution of small-scale irrigation management networks to users creates a sense of belonging, the upkeep of physical hardware is improved, financial discipline is established, and fee collection, cost recovery, and regulation are enhanced, excessive water use is reduced and overall efficiency, sustainability and productivity are improved. This takes the pressure off the government in terms of a reduction in subsidies and manpower.

Oad (2001) suggested that future irrigation policy reform should empower WUAs to improve O&M in order to increase the productivity of irrigated agriculture. In the context of better management, WUAs would also consolidate existing irrigation systems for optimum use of available land and water resources. He suggested alternative strategies for future PIMs include diversifying agriculture, implementing water user rights, and participating in water basin management. In addition, WUAs will become business enterprises, irrigation management will be contracted, farmers will be provided finance for irrigation development, and the O&M will be re-engineered. Other elements include needs-based budgeting, ISF, turnover programs, efficient O&M, programming and monitoring systems, integrated basin water resource management, project-benefit monitoring and evaluation, and the study of cost-effective rehabilitation and modernisation of irrigation systems.

In developing improved, sustainable, and cost-effective AMP for transferred systems, the strategies and elements mentioned above should be incorporated into the planning.

2.2.3 Turnover Program in Indonesia

Turnover program is one of the elements mentioned previously that should be incorporated into the AMP. The following are the history of irrigation development and irrigation transfer policy implementation in Indonesia and in the Province of Lampung.

2.2.3.1 Irrigation Development in Indonesia and the Province of Lampung

Irrigation of rice fields in Indonesia, particularly in Java and Bali, has been practised since ancient times. Irrigation was developed during the period of Hindu Rulers around the end of the first millennium. Hindu cultural inheritances on irrigation is the traditional system *Subak, Ulu-ulu, Ili-ili, Tuo Banda, Siak Bandar,* and many more such organisations throughout Indonesia. These societies are agricultural planning unit, autonomous organisation and in some places are religious organisation although its central role is on water management.

Modern irrigation systems were introduced by the colonial rulers in the middle of nineteenth century. In the colonial era, Netherlands Colonial Government took an interest in irrigation works especially in Java. The first canal was built during the period of 1739 to 1758 was the '*Oosterlokkans*'. Since then, the Government has continued to take active interest in irrigation development. Probably the most modern system of the 19th century was that on the Brantas River of eastern Java constructed in 1857. The major works constructed in Java consist of diversion weirs, storage works, pumps, etc. At the turn of the last century, diversion projects were considered quite adequate.

Most of the irrigation systems constructed during the colonial period were good in the quality of construction. Therefore in the post-colonial period, these irrigation systems has been maintained and developed. During the Green Revolution era - when the importance of a second crop to meet the needs of the growing population became apparent - the government implemented a strategy for increasing food production based on intensive irrigation of the lowlands through massive investments in the irrigation infrastructure. This was particularly the case with reservoirs which stored the west monsoon flows for use during dry periods for irrigation of a second crop. A systematic and planned development of irrigation (rehabilitation and improvement) was undertaken in 1969 with the launching of the country's First Five-Year Development Plan (*Pelita I*).

The time span from the first *Pelita* to the fifth *Pelita*, the first long-term development, was known as *Pembangunan Jangka Panjang* I (PJP I). The country subsequently continued with a second twenty-five-year development (1994-2019), termed PJP II, in April 1993 with *Pelita* VI. The emphasis of this development period was on sustainable development and management of water resources. Water resources have now been elevated to a full-sector level and policies are directed towards promoting more effective and efficient management of water resources in an integrated manner. Greater emphasis is now placed on sustaining self-sufficiency in rice and on the O&M of water resources infrastructure. According to the International Commission on Irrigation and Drainage, by the end of *Pelita* VI in 1999, Indonesia was ranked 12th and accounted for 1.62% of the total of irrigated areas in the world. Irrigation is well developed in Java and Bali (54.72%), but much less so on the other islands of Indonesia (ICID, 1999).

In the province of Lampung, irrigation is mix of old, new, rehabilitated, planned, and abandoned irrigation systems. Modern irrigation structures are still built into systems which were planned in the 1930s by the colonial government. Irrigation works were constructed in the Lampung area from the early 20th century to support colonisation (i.e., to decrease population pressure on Java). The first efforts were focused on building main structures such as weirs and intakes. Many of these weirs are still in use. During *Pelita*, a significant project implemented in Lampung was the Way Seputih and Way Sekampung Irrigation System. The Way Seputih and Sekampung irrigation areas were first developed from about 1935 with the construction of the Argoguruh weir on the Sekampung river to serve 20,600 hectares.

Since then, many irrigation development carried out in the Province of Lampung, among other things are the Way Rarem project. It is one of the key projects for the economic development of the North Lampung Region that started during the Third *Pelita* to provide modern irrigation facilities to a net irrigation area of 22,000 hectares. The project includes the construction of a reservoir with a catchment area of 328 km^2 and effective storage capacity of 56.9 million m^3 (Framji, Garg, and Luthra, 1982).

Practically all irrigation works are designed to supply water to the rice fields. There are three types of irrigation designated: 'technical', 'semi-technical', and 'peoples' irrigation'. Technical irrigation systems are large works of a permanent nature, constructed and operated by a government agency. Semi-technical irrigation systems are minor works, either permanent or temporary, constructed by the government and operated by the farmers themselves. People's irrigation systems are minor works with temporary or no weirs, constructed by the farmers. In addition to these, based on the decision of the Minister of Public Works KEPMEN PU No.

390/KPTS/M/2007, the management authority of irrigation areas is divided into district, province, and central government authorities.

2.2.3.2 The Irrigation Management Turnover Policy in Indonesia

Traditionally, there are two basic patterns of community-driven irrigation systems in Indonesia, namely village community irrigation systems and autonomous community-driven irrigation systems. Irrigation management of the village community irrigation system, dominant in hilly areas and parts of the coastal alluvial plain of Java, is an integral part of village administration. Management flexibility depends on the water levels in the canal, and range from a much decentralised practice to a centralised system.

Autonomous community-driven irrigation systems such as *Subak, Ulu-ulu, Ili-ili, Tuo Banda, Siak Bandar,* and many more such traditional systems throughout Indonesia are local and intensely democratic in nature which is quite different from irrigation systems at the moment which are governed top-down by the irrigation authorities. For example, the *Subak* system in Bali is a water control system which is open to society, and the proportional division of water at each bifurcation point is the reflection of justice and democracy for its members. The *Subak* also utilises technology which, for the people, demonstrates a harmonious relationship between people, natural resources and God. In the past, traditional irrigation societies have proven successful manage irrigation water democratically.

In modern irrigation system, there was an increased emphasis on improving PIM by the 1980s. Since then, a variety of legislations and projects launched to define the reform of the objectives, policies, legislations, institutional readjustments that focuses on food security, sustainable water use, and improved water-related environments.

As cited from Vermillion et. al. (1999), the two main regulations regarding the Irrigation and Maintenance Policy (IMP) are INPRES No. 2/1984 on 'Guidance to Water Users Associations (WUAs)', Irrigation Operation and Maintenance Policy (1987), and INPRES No. 42/1989 on 'System of Turnover of Small Scale Irrigation System and Management Authority to WUAs'. These were the basic regulations which provided guidelines for the establishment of WUAs in tertiary units or village irrigation areas; the introduction of efficient O&M, special maintenance and irrigation service fees (ISF); and the turnover of responsibility for O&M to WUAs of small-scale systems. Irrigation systems were divided into three categories depending on their condition and management responsibility.

Activities to turnover irrigated areas were implemented in 1988 under the Sederhana Project, which was funded by USAID. The program was adopted by the government of Indonesia based on the Government Policy Statement of 1987 on the Operation and Maintenance of Irrigation Systems. The statement provided a new direction for the irrigation subsector and the mandates were:

- to turn over the management of all public irrigation systems: from intake to drainage facilities, in systems smaller than 500 hectares; or tertiary level irrigation system (infrastructure network from secondary canal offtakes that serves as irrigation water service in tertiary level irrigation system that supply water directly to the paddy fields) to WUAs,
- to establish an ISF for farmers in all public irrigation systems, with WUA participation in fee collection and identification of O&M,
- to introduce more efficient O&M procedures into public irrigation systems that were developed as irrigated agriculture by farmers, in the on-farm water management project.

The policy was undertaken to alleviate government costs for the irrigation subsector while enabling farmers to sustain and improve the productivity of irrigated agriculture through the mobilisation of farmers' local resources.

A tertiary development program has been introduced to enable better water management and water distribution at the farm level. While the construction of tertiary networks is, in principle, considered as the responsibility of the farmers, the government assists in these networks with a view to expediting and improving water management at the farm level. In addition, the operation and management of WUA tertiary networks has been reorganised. Improved O&M of the main irrigation networks aims to achieve a more effective use of irrigation water (rotational irrigation, etc.) with a view to increase cropping intensity.

From 2005 to 2012, the Indonesian government carried out the WISMP (Water Resources and Irrigation Sector Management Project) and PISP (Participatory Irrigation Sector Project). The PISP is funded by the Asian Development Bank (ADB) and implemented in 25 *kabupaten* (districts) in six provinces. Subprojects which were selected and coordinated by the government and the World Bank are: Banten, Central Java, East Java, West Java, Lampung, and South Sulawesi.

The reform of the irrigation sector by the government has been successfully implemented and the outlook is positive. Therefore, the immediate objectives of the PISP and WISMP were to sustain decentralisation of the management irrigation systems and increase yields of irrigated crops. The project implemented the growing need of the PIM approach and will accommodate the constraints of districts according to financial, level of institution, technical and management capabilities. The goal of the project was to increase economic growth and reduce rural poverty in 25 districts of rural Indonesia. One of the programs of the PISP is to rehabilitee the tertiary level of irrigation systems which were designed to ensure that the deferred maintenance cycle is broken and that irrigation systems performance is maintained at or close to the original design level (The DGWR, 2005).

The stages of irrigation development and irrigation policy change in Indonesia are presented in *Appendix A.3*.

In developing the improved, sustainable and cost-effective AMP, the transfer policy that recognise the existence of traditional irrigation societies into WUAs should be incorporated into analysis. Therefore, case studies selected were technical irrigations since they are constructed and operate by government agencies and they involve farmers' participation at tertiary levels. The case studies should also consist irrigations of district (small), province (medium), and central (large) governments authorities to accommodate the type of irrigation systems exists. Moreover, in order to present an up-to-date results, the case studies selected for this research also were the objects of PISP implementation since the project provided an up-to-date secondary data.

2.2.4 The Asset Management Planning (AMP) for Transferred Irrigation System

According to Burton *et al.* (2003), the simplified asset management procedure for a transferred irrigation systems is a relevant and applicable procedure to the conditions experienced in a transferred irrigation system. It consists of activities that assess, monitor, and regulate the infrastructure condition and the MOM of government-owned irrigation that have been transferred to WUAs and WUAFs. The procedure is a valuable mechanism for focusing the attention of WUAs and WUAFs on sustaining and enhancing the condition of the irrigation infrastructure. He added that applying asset management at the transfer stage can be beneficial since it allows:

- identification and audit of all infrastructure assets,
- identification of water user desired levels of service,
- identification of the cost of maintaining the system over time commensurate with the agreed level of service provision,
- water user understanding of the relationship between infrastructure condition and system performance, and
- development and ownership of water user and irrigation service providers, and an understanding of the relationship between fee payment and service provision.

Burton *et al*. (2003) explained that one of the benefits of the asset management process is that it requires stipulation of the standards against which performance will be measured, and agreement as to the desired level of service. Making this explicit facilitates communication between the irrigation service provider and the water user.

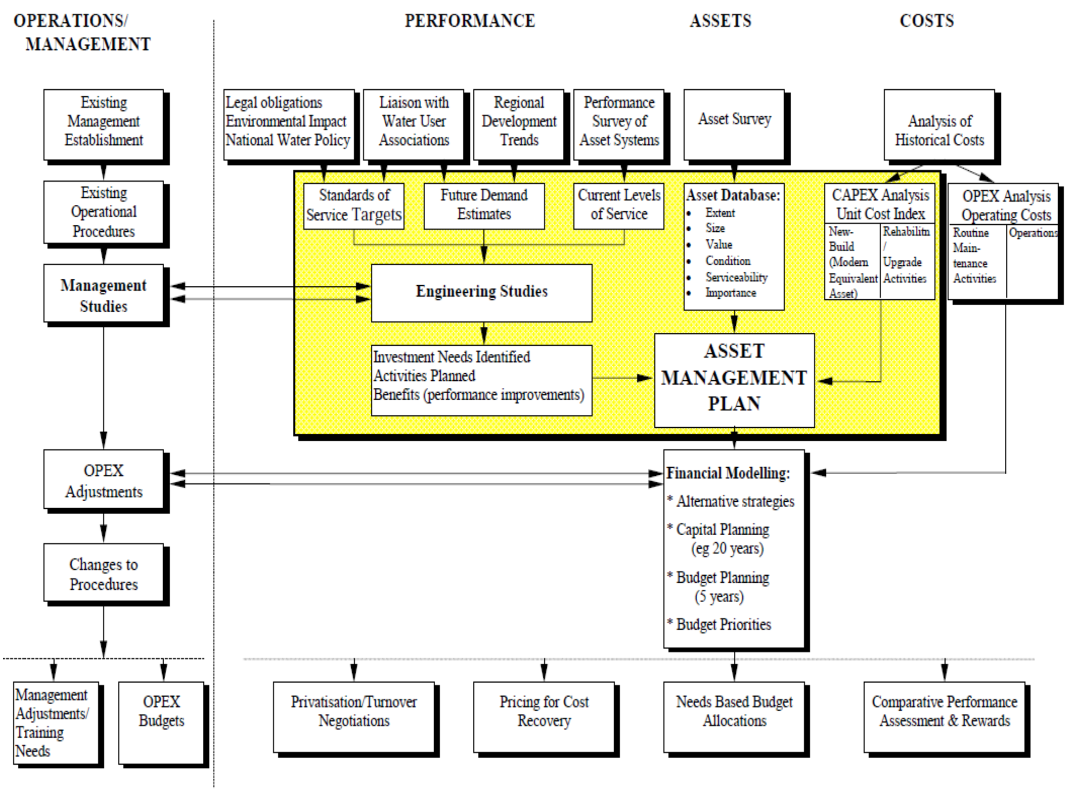


Figure 2.1. Principal elements of AMP for irrigation

Source: (Institute of Irrigation Studies -University of Southampton, 1995)

Figure 2.1 illustrates the principal elements of the basic stages of building an applicable AMP for irrigation systems in the developing countries as proposed by the IIS are as follows: carrying out an asset survey, assessing system performance and performance issues, management studies, developing cost model, and presenting the AMP.

According to the IIS, an AMP in Indonesian context, should consider aspects of: needs based budgeting, ISF, efficient O&M, programming and monitoring system, integrated basin water resources management, project benefit monitoring and evaluation, and cost effective rehabilitation and modernisation of irrigation system research study.

2.2.5 Summary of Irrigation Infrastructure Asset Management

Section 2.2.1, 2.2.2, 2.2.3 and 2.2.4 have demonstrated that asset management is a systematic, structured and auditable combination of managerial, financial, economic, and engineering practices that apply to physical assets over their whole life cycle, with the objective of providing the required level of service in the most cost-effective manner while ensuring the sustainability of the asset base and resource utilisation.

Asset management, which has been implemented successfully in a wide variety of infrastructures, becomes an alternative to improve the financial and service performance of irrigation systems. These systems have a very long life cycle (several decades or even more) and might involve a combination of repair, maintenance and rehabilitation. (*See Appendix A.1 for a more complete summary of asset management reviews by researchers*).

An AMP or AMS of irrigation system is a comprehensive cost-effective investment program for meeting the current and future level of service provisions. The AMP should have the capability to quickly store, retrieve and manipulate information on specific assets in a format that is appropriate for day-to-day management and for strategic investment decisions. Management information systems must provide financial, structural and hydraulic information of assets.

Indonesia is characterised by a government-managed system, but since the 1980s Indonesia has been implementing a participatory approach in irrigation. There is a need to review alternative strategies for future PIMs and implementing an appropriate AMP in order to improve Indonesia irrigation performance and sustainability in the future. Since an appropriate AMP should facilitate the Government Policy Statement of 1987 (turn over, establish an ISF, and introduce more efficient O&M) mentioned in Section 2.2.3.2 as well as consider aspects of needs based budgeting, programming and monitoring system, integrated basin water resources management, project benefit monitoring and evaluation, and cost effective rehabilitation and modernisation of irrigation system, therefore the AMP developed is an improved, sustainable, and cost-effective AMP.

The IIS (1995) provides guidelines for the preparation of AMP for irrigation infrastructure in developing countries that facilitates the element of turnover. Therefore, in achieving this thesis research to develop an improved, sustainable, and cost-effective AMP for a transferred irrigation system, the IIS guidelines were utilised. The stages in developing the improved AMP are as follows: carrying out an asset survey, assessing system performance and performance issues, management studies, developing cost model, and presenting the AMP.

2.3 Irrigation Performance Assessment

Performance assessment is an essential component that enables the management process to function effectively and efficiently. According to Gorantiwar and Smout (2005), performance assessment of irrigation systems has gained attention since the late 1980s due to the common view that resources (land and water) in irrigation systems are not being managed appropriately.

The following summarises the use of performance assessment as suggested by Kloezen and Garces-Restrepo as cited from Sakhtivadivel, *et.al*. (1999):

- for management: to inform a manager of the status of system performance and, in conjunction with other indicators, to help identify the corrective actions to improve performance within that system;
- for improved understanding and diagnosis: to help managers, policy makers, researchers, and farmers better understand how a system operates and to point to means to improve the system;
- for comparison: to compare performance within and across a system to gauge the health of the system relative to other similar systems; and
- for intervention impact assessment: to study whether interventions lead to desired results, so that successful interventions can be repeated and unsuccessful ones revised or discarded.

The following section reviews the concept, purpose and types of performance measures, performance indicators and standards, and the procedures proposed to assess irrigation performance.

2.3.1 Introduction to Irrigation Performance Assessment

Svendsen and Small (1990) define irrigation systems as:

- "… a set of physical and institutional elements employed to acquire water from a naturally-concentrated source (such as a natural channel, depression, drainage way, or aquifer), and to facilitate and control the movement of the water from this source to the root zone of land devoted to the production of agriculture;
- "… *human intervention to modify* the spatial or temporal distribution of water occurring in the natural channel, depression drainage ways or aquifers and to manipulate all or parts of this water for the production of agricultural crops".

Institutions refer to the rules governing social behaviour and defining relationships among the actors in an irrigation system. They may operate informally (such as notions of water rights or negotiation) or in a structured and formal manner (as in the form of bureaucratically organised irrigation departments or chartered WUAs).

According to Small and Svendsen (1990), an irrigation system can be divided into three subsystems, namely: acquisition, distribution and application. They explained further that the recurrent activities of existing irrigation systems involve utilising inputs in various internal transformation processes that lead, sometimes via the production of intermediate outputs, to the production of final outputs. These outputs, interacting with the larger environment, result in the system's impact on that environment. Stakeholders of irrigation systems view the purposes of irrigation systems disparately. They conceptualise the purpose of irrigation based on the directness of their relationship to the activities of irrigation within a nested means and ends framework as set out in Table 2.2:

Table 2.2. Irrigation purposes as nested means and ends

Level of end	Means	End
Proximate	Operation of irrigation facilities	Supplying water to crops
Intermediate-1	Supplying water to crops	Sustained increase in agricultural productivity Increased incomes in rural sector
Intermediate-2	Sustained increase in agricultural productivity Increased incomes in rural sector	Rural economic development
Intermediate-3	Rural economic development	1. Improved livelihoods of rural people 2. Sustained socio-economic
Ultimate		Development of entire economy

Source: (Svendsen and Small, 1990)

As a system, Small and Svendsen (1990) defined irrigation boundaries in domains such as institutional, physical, and political-economic. There are three types of physical boundaries which are defined as the design area, service area, and net irrigated area. The design area is the area that the system was intended to serve when the plans were developed, whilst the service area is the area provided with water distribution facilities at the time of construction. The design area is usually larger than the service area because of the emergence of unforeseen physical, social, and/or political problems during the planning process that prevent the entire design area from being provided with irrigation facilities. The net irrigated area is the area that is actually supplied with irrigation services once the system is operational and this is specified on a seasonal basis. For example, the net irrigated area in the wet season might be considerably larger than in the dry season.

Irrigation system performance involves of a large number of activities during the irrigation process, namely: planning, design, construction, operation, maintenance of facilities, and the application of water to the land. A variety of other support activities such as personnel management and support, equipment management, financial management and accounting, and resource mobilisation are needed to permit and facilitate the execution of irrigation process activities.

The initiation of an irrigation system is characterised by an intensive period of planning, design, and construction. These activities also happen at times of expansion, improvement and rehabilitation throughout the life of the system. However, the functional process of operation, maintenance, and water application as well as support activities, happen continuously throughout the life of the system.

Performance assessment is possible for each individual process or a combination of processes, however, the methods and measures appropriate for assessing one process may be very different to those for assessing another. According to Small and Svendsen (1990), the performance of a system depends on two activities: 1) the acquisition of inputs and the transformation of inputs into intermediate and final outputs, and 2) the impacts of these activities on the system itself (internal) and on the external environment.

The performance and existence of an irrigation system are also greatly dependent on human behaviour. Most irrigation systems are characterised by the existence of some central coordinating agency responsible for making and implementing key decisions affecting the acquisition and distribution subsystem.

This agency typically has a formal structure; however, the structure may be informal in small irrigation systems. The performance of irrigation systems is strongly influenced by the behaviour of this coordinating agency.

Based on the discussion above, the review of irrigation performance assessment in this thesis is focused on the recurring activities associated with the functional activities of O&M, and with supporting activities on the distribution sub system. The structured and formal manners that rule operation irrigation system in primary and secondary level and informal manners that are applied in tertiary level are also addressed. The thesis also analyse the acquisition of inputs and its the transformation to outputs, as well as its impact internally and externally.

2.3.2 The Concept of Assessing Irrigation Performance

Many different models to explain the performance of an organisation have been proposed in the literature. These include the goal-oriented model (rational system) and natural system model. According to Small and Svendsen (1990), the goal-oriented model of performance is useful in evaluating the effect of modifying irrigation agency operations, since this model views irrigation as existing for the purpose of producing a service that can be either consumed directly or used as an input in another production process. The purposes of the system are defined by powerful individuals and groups who are ‘owners’ of the system. For irrigation systems that are heavily subsidised from general tax revenue, the entire community can be viewed as the ‘owners’, and goals are set throughout the political process. Therefore, this model emphasises that performance is related to the degree to which a system attains its goals.

The goal-oriented model takes into account subjectivity, criterion of performance, levels of evaluation and values and goals of society, individuals or interested groups. It also looks at purposes of performance assessment, types of performance measures, standards and comparisons of performance among systems and it incorporates a time dimension into performance evaluations.

The performance of a system is determined by its measured levels of achievement using one or several parameters. These parameters are considered as indicators of the system’s goals (Turral, Malano, and Chien, 2002). According to Koç (2007), a performance indicator is basically a quantitative measure of an aspect of irrigation standards which helps to evaluate and monitor irrigation efficiency.

Performance indicators can be used in a number of distinct ways depending on the user; farmers, water managers, policy makers, researchers, and the general public.

Fundamental normative indicators of irrigation performance widely used to assess irrigation performance include depth-related measures (adequacy, equity and timeliness), farm management-related measures (tractability, convenience and predictability), and water quality-related measures (temperature, sediment content, salt content, nutrient content, toxics and pathogens).

Gorantiwar and Smout (2005) classified performance measures into allocative and scheduling types. The allocative type performance measures are those which need to be attended to primarily during the allocation of resources in the planning stage. The allocation of resources influences the area to be irrigated and the net return, which affects overall productivity and equity. Scheduling type performance measures deal with the temporal or intra-seasonal distribution of resources to different users, which are prepared according to allocation plans. The schedule should illustrate that water deliveries need to be adequate in planning and operation, reliable when in operation, and flexible and sustainable. Hence scheduling type performance measures consist of adequacy, reliability, flexibility, efficiency, and sustainability. These two performance measures could also be grouped into: economic (productivity), social (equity), environment (sustainability), and management (reliability, adequacy, efficiency, and flexibility).

Since the availability of water and land for agriculture, particularly in developing countries, is shrinking rapidly with the growth of cities and industries, irrigated agriculture must improve its utilisation of these increasingly scarce resources. Consequently, the performance of an irrigation system is assessed to determine the productivity of water and land use in agriculture. Le Grusse *et al.* (2009) characterise performance as:

- the water-saving techniques and the technical and economic efficiency actually observed on the farm (at field level plus as an aggregate for the whole holding),
- the efficiency of the existing water allocation system in the face of the liberalisation of crop choices (at farm level).

He also suggested that performance indicators must be analysed from hydraulic, agricultural, economic, and environmental points of view and must be transferable from field level to farm level.

The intended service (or product) being delivered by an irrigation organisation to its customers (the water users) depends on an 'agreed level of service'. The organisation needs to have the legal authority to make service level agreements and each level of management requires a separate agreement. A service level agreement generally specifies: the service that will be provided, the payment for these services, the procedures to check whether services and payment are made as agreed, the authority to settle conflicts, and the procedure to update and improve the agreement.

Malano, Burton, and Makin (2004) suggested applying benchmarking as a standard or point-of-reference against which performance should be assessed. Benchmarking activities to test irrigation and drainage system processes can provide valuable insight into how well the system is performing in all areas of service delivery and resource utilisation. According to a study conducted by Lee (2000), benchmarking in the irrigation and drainage sector must deal primarily with public sector organisations and three characteristics require consideration:

- irrigation and drainage service providers operate in a natural monopoly environment,
- irrigation and drainage entail complex and interacting physical, social, economic, technical and environmental processes,
- performance of irrigation and drainage system is site specific.

The essence of the benchmarking process is the comparison between the organisation or process under study and a similar organisation or process (Malano, Burton, and Makin, 2004).

In 2002, the Australian National Committee of ICID (ANCID) proposed a metric-quantitative benchmarking that consisted of a set of 65 performance indicators in four key management areas as follows: system operation, environmental issues, business processes, and financial (Parsinejad, Yazdani, and Ebrahimian, 2009).

To perfect metric-quantitative benchmarking, the World Bank promoted the concept of holistic benchmarking that combines performance and process benchmarking. The RAP and Benchmarking was published in 2001 by the World Bank Irrigation Institution Window which was developed by Burt (2001). It consists of 46 performance indicators (external indicators) that cover: water balance, finance, agricultural productivity and economics, and environmental performance.

For irrigation, a clear distinction needs to be made between the performance of the system (that is the irrigation and drainage network, the fields, the crops, the farmers etc.) and that of the system (the irrigation and drainage network alone).

In summary, there are many different models to explain performance of an organisation. The goal-oriented model is widely used to assess the irrigation system performance. The model assesses the performance of a system by measuring its levels of achievement in one or several parameters. These parameters are known as indicators of the system's goals. These indicators are basically a quantitative measure of an aspect of irrigation standards which helps to evaluate and monitor irrigation efficiency. Since the RAP and Benchmarking offers a holistic and sophisticated methods for assessing the performance of irrigation system, this thesis utilises this method to asses the existing irrigation system performance. The detailed discussion for this method is discussed further in *Section 2.3.4.2*.

2.3.3 Review of Irrigation System Performance Indicators

As mentioned above that performance of a system can be measured by performance indicators. Many researchers have proposed performance indicators for the assessment of irrigation systems (*see Appendix A.4*). These indicators basically can be grouped into:

1. Operational performance and water balance

   Operational performance is concerned with the routine implementation of the agreed (or pre-set) level of service that specifically measures actual inputs and outputs on a regular basis. Researchers differentiate the irrigation performace indicators into: fundamental normative, service quality (*see Appendix Table A.5.1*) and water quality performance indicators. They also differentiate indicators used to assess irrigation and drainage. However, the indicators used to assessed main system are similar with secondary and tertiary channel.

   Operational performance includes hydraulic performance (Le Grusse *et al.*, 2009), water delivery performance (Cakmak *et al.*, 2004; Frija *et al.*, 2009; Malano and Davidson, 2009), service delivery performance (Ulhaq, 2010; Ghazouani *et al.*, 2009; Malano, Burton, and Makin, 2004), and physical performance (Kuscu, Demir, and Korukçu, 2009).

2. Physical performance associated to condition and maintenance of irrigation assset

   Physical and maintenance performance assesses the functional condition of the asset. To assess the condition of irrigation asset a set of condition criteria or a set of functional condition of asset can be specified (Murray-Rust *et al*., 2003). In addition to applying the condition criteria of assets described above, a scale of criteria ratings can also be applied (Malano, Chien and Turral, 1999 and Malano, George and Davidson, 2005) (*see Appendix Table A.5.2*). Furthermore, an importance factor (IF) to each asset can be utilised to provides an indication of its relative importance and the consequence of its failure (Queesland Government, 2001) (*see Appendix Table A.5.3*). Ultimately, the Institute of Irrigation Studies (IIS, 1995) integrate the criteria for condition grades with serviceability grades of asset (*see Appendix Table A.5.4*).

3. Agricultural productivity, financial and economic

   According to Intizar (2007), there is a direct benefit, indirect benefit, overall benefit, and added value benefit of irrigation. Since it is not easy to assess the indirect benefit, overall benefit and added value benefit of irrigation, the performance assessment generally focuses on the direct benefits of irrigation i.e., agricultural productivity. A range of factors at farm level, system level and policies can influence the net productivity benefits of irrigation. Perry (2009) stated that in assessing how productively water is used it is necessary to distinguish between biomass (the total production of vegetative matter) and yield (the production of grain, fruit or tuber).

4. WUAs organisation and accountability (associated with intervention, irrigation policy reform, and turnover policy)

   Presently, the government of Indonesia is implementing a policy which empowers and strengthens WUAs by instituting a system that formally and legally recognises the rights of WUAs to manage public water (including collection of ISF for the water provided). This allows the expansion of the rights of WUAs to institute proper O&M programs by involving WUAs in the design and construction of system rehabilitation, and expanding their role as enterprise organisations (the DGHE, 2005). WUAs as business organisations/enterprises are able to use profits from sideline enterprises to maintain financial stability and to cover their costs in the face of constantly increasing expenditure, by actively exploring alternative revenue avenues.

The impacts of turnover that need to be examined according to researchers are financial sustainability (*see Appendix Table A.5.5*), hydrological efficiency, and economic changes under the WUA management. However, it is not easy to assess the impacts of turnover on hydrological efficiency, and economics as well as government savings. Therefore, in general researchers commonly examined the impacts of turnover on financial performance at tertiary level of irrigation system under the WUA management that is the cost of irrigation to farmers, the level of management personnel (often the largest MOM cost) of WUAs, the level of water charges and collection rates, budget solvency, and revenue sources. Financial performance evaluations of WUAs are useful to improve their financial and management performance. A study by Oad (2001) suggested that a strong WUA is an excellent indicator and predictor of improved O&M performance.

5. Sustainability

Irrigation today requires a balance between the competing demands of agriculture and ecosystems. The concern about competition for water and the future balance between supply and demand for food makes the irrigation specialist talks about improving efficiency since irrigation is commonly described as a low value and wasteful use of water. Perry *et. al.* (2009) stated that conventionally, water use efficiency is defined as a productivity term (output of crop per unit of water consumed). Instead, he defined water use efficiency as yield divided by applied water. It is essential for irrigation to increase the productivity per unit area or save the water for the same productivity.

(The summary of performance indicators by researchers can be seen in *Appendix A.5*).

It is essential that indicators discussed above are as much as possible are used to assessed the performance of an irrigation system to get a complete picture of the condition of the irrigation system. Later in Section 2.3.4, it is known that most but not all of these indicators are covered by RAP and Benchmarking. To assess the physical performance associated to condition and maintenance of irrigation assset, an asset survey is needed. In addition to these, an an opinion survey is also needed to assess some aspects of WUAs, intervention, irrigation policy reform, and turnover policy on an irrigation system.

2.3.4 Procedures for Assessing Irrigation Performance

There are two main models of procedures to assess the performance of irrigation that are widely accepted today, namely IPTRID guidelines and RAP and Benchmarking. The IPTRID guidelines was sponsored by FAO and the RAP and benchmarking is sponsored by the World Bank. The following is the comparison between the two procedures.

2.3.4.1 The International Program for Technology and Research in Irrigation and Drainage (IPTRID) Guidelines

The IPTRID guidelines were published by IPTRID (International Program for Technology and Research in Irrigation and Drainage) in 2001. The guidelines resulted from the initiative launched jointly by the World Bank, ICID (International Commission on Irrigation & Drainage), FAO/IPTRID and IWMI (International Water Management Institute) to promote benchmarking as a management tool which would support a broader initiative to reform management within the irrigation and drainage sector of many developing countries. The IPTRID guidelines have become a key standard for the implementation of benchmarking in the irrigation and drainage sector. Countries that have used the guidelines to assess their irrigation performance include Australia, China, Mexico, and India.

The guidelines include the collection, processing, and analysis of data for assessing irrigation and drainage sector performance. There are three primary interests of irrigation systems outlined by IPTRID:

1. Service delivery (covering two areas of service provision):
   - the adequacy with which the organisation manages the operation of the irrigation delivery system to satisfy the water requirements of users (system operation), and
   - the efficiency with which the organisation uses resources to provide this service (financial performance).
2. Productive efficiency: measures the efficiency with which irrigated agriculture uses water resources in the production of crops and fibre.

3. Environmental performance: measures the impact of irrigated agriculture on land and water resources.

Thus performance indicators that are proposed for use in the benchmarking exercise are linked to these three domains and their inputs, processes, outputs and impacts.

The IPTRID guidelines consist of a set of 33 recommended performance indicators relating to:

- system operation, 11 indicators
- financial administration, 8 indicators
- productive efficiency, 8 indicators
- environmental management, 6 indicators

(*See Appendix A.6 the benchmarking indicators of IPTRID*)

2.3.4.2 Rapid Appraisal Process (RAP) and Benchmarking

Performance benchmarking answers the following question; "What is the level of performance of this system in various key areas?". In contrast, process benchmarking answers the question "What are the processes and factors that result in this level of performance?". The World Bank promotes the concept of holistic benchmarking that combines performance and process benchmarking. This led to publication of the Rapid Appraisal Process (RAP) and Benchmarking by the World Bank Irrigation Institution Window in 2001 (Irrigation Training and Research Centre, California Polytechnic State University). It is a diagnostic tools which was developed by Burt that can guide the selective improvement of the internal workings – hardware or management– of an irrigation system. They examine external input such as water supply, and outputs such as water destination (crop evapotranspiration, surface runoff, etc.).

To be effective, RAP and Benchmarking needs to be applied by well-trained and experienced hydraulic engineers. It is a one to two week process of data collection and analysis both in the office and the field. It provides a systematic examination of the hardware and processes used to convey and distribute water internally to all levels within the project (from the source to the fields). External indicators and internal indicators are developed to provide:

- a baseline of information for comparison against future performance after modernisation,
- benchmarking for comparison against other irrigation projects, and

- a basis for making specific recommendations for modernisation and improvement of water delivery services.

(Burt, 2001).

RAP and Benchmarking consists of 46 performance indicators (external indicators) that cover:

- water balance, 21 indicators
- finance, 8 indicators
- agricultural productivity and economics, 9 indicators
- environmental performance, 8 indicators

(*See Appendix A.6 the external performance indicators, internal process indicators, water balance indicators, financial indicators, agricultural indicators and environmental Indicators of RAP and Benchmarking*).

Table 2.3 provides a summary of the differences between the IPTRID Guidelines and RAP and Benchmarking methods:

Table 2.3. Differences between the IPTRID and RAP methods

IPTRID Guidelines	RAP and Benchmarking
Quantitative	Quantitative and qualitative
Metric: performance benchmarking	Rapid diagnostic tool: performance and process benchmarking
Implemented by well-trained engineer	Implemented by well-trained engineer
33 performance indicators	46 performance indicators (external) and internal indicators
Case: Maharashtra, Mexico, Australia, China	Case: Cambodia, China, India, Indonesia (Lak Bok & Lodoyo), Nepal, Phillippines, Thailand, Vietnam, and Lao PDR (laos)

Table 2.3 indicates that the RAP and Benchmarking method is more sophisticated, efficient and widely implemented than the IPTRID Guidelines and is recommended for future research. Further assessment of RAP and Benchmarking and IPTRID Guidelines differences can be seen on *Appendix A.6*.

2.3.5 Summary of Irrigation Performance Assessment

Performance assessment is an essential component that enables the management process to function effectively and efficiently. Performance of a system is represented by its measured levels of achievements in one or several parameters. These parameters are considered as indicators of achievement of a system's goals. Performance measurement may focus on a system's impact, on its output, or on its internal process. Any design to improve performance of an irrigation system requires assessment of the performance before and after the introduction of the change along with evaluation of performance against a chosen standard.

Since the RAP and Benchmarking is more sophisticated and efficient than IPTRID guidelines, this thesis utilised the RAP and Benchmarking in assessing irrigation system performance. Later in Section 2.4 and Section 2.5 are discuss opinion survey of stakeholders and asset condition survey that are need to accompany the RAP and Benchmarking to establish an in-depth analysis on the current performance level of an irrigation system.

2.4 Assessing the Opinions and Preferences of Users of Irrigation Water

In most cases, according to Ghosh, Singh and Kundu (2005), performance evaluation criteria of an irrigation system have relied on large-scale input and output indicators, and farmers often receive the least attention in a performance assessment. However, it is important to consider irrigation as a service provided to farmers. A set of criteria for partial performance evaluation of irrigation systems needs to incorporate the perspective of the farmer. This section reviews the concept, objectives, techniques and methodology applied to assess farmer opinion.

2.4.1 Introduction to Assessing Farmer Opinion and Preference

According to Svendsen and Small (1990), irrigation projects are promoted as engines of agricultural growth; however, dissatisfaction is widespread in developing countries since performance continues to run below potential. This situation has resulted in interventions directed at improving irrigation performance. Interventions include managerial changes, physical changes, and combinations of the two. Managerial interventions focus on the introduction of a set of 'improved' practices in the operation of an individual irrigation system. While physical interventions can include the lining of channels, installation of measuring and recording devices, and comprehensive rehabilitation programs. For people involved in a 'management transfer policy' the objectives of measuring and quantifying opinions are to:

- assist farmers to exert some influence on policies that affect their lives and economies,

- assist project planners in identifying the project components that are most likely to satisfy the concerns of affected farmers,
- provide a balanced view of alternative strategies and estimate differences of opinion between farmers, including monitoring a change of opinion, and
- provide a means of continuing mixed (quantitative and qualitative) evaluation of peoples' reaction to the impact of a project.

Furthermore, Svendsen and Small (1990) explained threis significant differences exist between group perspectives regarding irrigation system performance. The concerns of system agency managers tend to be geographically broad (entire irrigation system), impersonal (trend towards physical and agronomic factors such as the area watered, irrigated area harvested, and total system output per unit land or water, rather than income consideration), and short-term (staff rotations amongst systems every few years limits time for action and accountability). In contrast, farmer concerns tend to be more local (rest solidly on their own holdings), more personal (immediate and direct economic welfare, hardship, and privation), and longer-term (sustainability of agricultural operation). However, there remains little information about the opinions of other stakeholders, such as: government officers, consulting and contracting organisations, and agriculture extension workers.

2.4.2 The Concept of Assessing Farmer Opinion and Preference

Ghosh, Singh, and Kundu (2005) stated that among the different stakeholders of irrigation systems, farmers are the most fundamental, due to their agricultural output requiring extensive irrigation. In most cases, performance evaluation criteria of an irrigation system has relied on large-scale input and output indicators, and farmers often receive the least attention in performance assessment. Since it is important to consider irrigation as a service provided to farmers, a set of criteria for the partial performance evaluation of irrigation systems must consider the farmer's perspective.

Abernethy, Jinapala, and Makin (2001) explained that opinion surveys that cover issues personally affecting farmers are used to obtain better insight into the hopes of the people most affected by irrigation systems. By taking better account of farmer needs, it is possible to increase local support, co-operation, and benefit.

It is the opinion of Svendsen and Small (1990) the primary concern of farmers, with regard to irrigation, is output measurement, in this instance being the nature and quality of irrigation services delivered to them. Impact measurement is also important (the direct impact on services received in production and income that affect their livelihood and well-being). Moreover, according to Ghazouani et al. (2009), farmer perception about irrigation water management performance and economic impact includes practices, beliefs, and knowledge. Farmer perception of irrigation water management performance takes account of the following parameters:

- operational (water delivery) performance indicators: adequacy/sufficiency, reliability/predictability, tractability/convenience/flexibility, and equity;
- asset condition and maintenance performance indicators: farmer perception on canal condition and infrastructure conditions;
- production efficiency/agricultural performance indicators: farmer perception on yields and income;
- economic/financial performance indicators: farmer perception of changes in irrigation costs;
- environmental impact performance: farmer perception on soil productivity; and
- management and organisational performance and effectiveness of the WUA: irrigation authority, local management, and WUA organisation, management and staff.

For irrigation system experiencing as an object of a project, noteworthy to test farmer different perceptions on the parameters discussed above before and after the project implemented.

Since it is current policy to perform WUAs as business organisation, it is worthwhile to test farmers opinion on WUAs organisational feasibility/viability, management efficiency, and a support system for O&M of the irrigation system:

1. Feasibility of organising the WUA as a business enterprise
    - economic motivation
    - dissatisfaction with existing management
    - local management capacity and group orientation
    - financial and technical feasibility

2. Organisational viability
   - farmer support to the organisation
   - adequacy of fees paid by farmers to the organisation
   - external legal recognition and political acceptance of the organisation
3. Management efficiency
   - the perceived effort needed by farmers to arrange water deliveries to their fields
   - the responsiveness of irrigation management staff to farmer suggestions and concerns
4. Support system

2.4.3 Methods of Assessing Farmer Opinion and Preference

Quantitative and/or qualitative methodologies can be used to measure the opinions of people about issues that affect them closely regarding the irrigation system and other kinds of water development projects.

Abernethy, Jinapala and Makin (2001) explained aspects such as technique/methodology, preparation of questionnaires, and analysis of findings have to be considered in measuring the opinion of rural people who are affected by water-related projects. An easy and quick method is preferred, as it tests and measures the opinions of large samples of the community. A large sample size is required to reliably analyse subsets to investigate variations according to determinant factors such as age, gender, location and household size. A reliable and economical method enables projects to be adjusted to provide satisfaction to the beneficiaries. The method can also be used among communities where there are high rates of illiteracy.

Based on these requirements, in designing the questionnaire, the following should be considered carefully:

- it should be as short as possible: based on a brief interview, seeking opinions via 10 to 15 questions/statements,
- it can be used among communities with a low-medium level of education,
- it must reliably investigate variations of opinion according to possible determinant factors such as age, gender, location and household size,
- it must use reliable and economical methods, and
- questionnaires should be in written/spoken in the local language.

In assessing user opinion about irrigation system performance, data should be gathered at system level and farm level using secondary data or questionnaires.

Studies reporting farmer opinion surveys on irrigation issues closely affecting them are presented in *Appendix A.7.*

2.4.4 Summary of Assessing the Opinion of Irrigation Water Users

Reported works on farmer opinion surveys generally used a quantitative design with a questionnaire method. Aspects including the technique/methodology, preparation of questionnaires, and analysis of findings have to be considered when determining the opinion of rural people who are affected by water-related projects.

Quantitative method is used because it is an easy, quick and economical method; and a reliable and capable of analysing large sample size subsets containing variations of possible determinant factors such as age, gender, location or household size is necessary. The questionnaires should be in the local language, designed to be as short as possible, and consider the respondents might have low education level.

It is also aimed to capture the farmer's opinion and discourse on the current level of service, perceived differences in service levels before and after project execution, expectation of future service levels and willingness to bear the consequences of possible upgrades to service levels and/or infrastructure.

2.5 Assessing the Irrigation System Sustainability and Performance Issues

American Society of Civil Engineer/the United Nations Educational, Scientific and Cultural Organisation (ASCE/UNESCO) (1998) defines a sustainable water system as the one that is designed and managed to contribute fully to the objectives of society, now and in the future, while maintaining ecological, environmental, engineering and hydrological integrity.

Since the availability of water and land for agriculture, particularly in developing countries, is shrinking rapidly with the growth of cities and industry, an increasingly efficient and cost-effective irrigation system must be developed that makes the best use of scarce natural resources. This can be achieved through improved asset management and by assessing system performance and sustainability.

By assessing the current levels of system performance and sustainability, the key feature of performance issues can be determined.

This section reviews the concept, objectives, methods, and frameworks in assessing the irrigation system sustainability.

2.5.1 Introduction to the Triple Bottom Line (TBL) Sustainability Assessment

Sakthivadivel *et al*. (1999) stated that performance must be assessed to improve system operations and to determine progress against strategic goals as an integral part of performance-oriented management. It is also necessary to assess the general health of a system, the impact of interventions, the diagnosis of constraints threats and institutional strengths. A performance assessment should be able to better understand its own determinants and be comparable with other systems or with the same system at a different time. Currently, sustainability reporting is an important process used to improve organisational performance. Sustainability criteria for measuring organisational (and societal) success commonly integrates ecological (planet) and social (people) performance indicators in addition to ascertaining financial performance (profit). According to Abernethy (1994), sustainability can only be achieved if the resources that are necessary for the conduct of irrigated agriculture continue to be available. The major resources that must be assembled and maintained are water, land, labour, energy and finance.

There is a very close relationship between an irrigation system's sustainability and the various aspects of its performance. The relatively straightforward approach of using selected core indicators (i.e., the IPTRID guidelines or RAP and Benchmarking) is attractive. Unfortunately, these approaches, in dealing with complex natural resource socioeconomic systems like agriculture, have failed to live up to expectations. Currently, the most widely used assessment looks at the net benefit from irrigation in relation to production outcomes, which is often at the expense of environmental resources. However there is considerable pressure on irrigators and water supply authorities not only to improve their performance and demonstrate beneficial effects in the economic dimension but also socially and environmentally. Triple Bottom Line (TBL) reporting provides a means of showing the public that irrigated agriculture can be sustainable (Christen *et al*., 2006).

2.5.2 Methods of Assessing Sustainability

Currently, sustainability reporting is an important process to improve the sustainability of an organisation including irrigation. The triple bottom line (TBL) was a concept proposed by John Elkington in 1995. The TBL is an expanded spectrum of values and criteria for measuring organisational (and societal) success that takes into account ecological and social performance in addition to financial performance. Because of its goal of sustainability, the TBL is famously described as 'people, planet, and profit'.

2.5.2.1 The Triple Bottom Line (TBL)

The 'people' (or human capital) of 'people, planet, and profit' refers to fair and beneficial practices for human labour, the community, and the region in which a TBL organisation conducts its business. The 'planet' (or natural capital) refers to sustainable environmental practices. The 'profit' refers to the economic value created by the organisation after deducting the cost of all inputs, including the cost of tied up capital. TBL demands that profit in the private sector cannot be interpreted as simply traditional corporate accounting profit plus social and environmental impacts but it must 'profit' or 'benefit' all of the entities/stakeholders involved. TBL became the dominant approach for public sector full cost accounting. Some organisations have adopted TBL voluntarily and some by law, whereas some have advocated 'sustainable corporation' benefits such as tax breaks. However, legislation permitting a corporation to adopt TBL is still under consideration in some jurisdictions. In Australia, TBL was adopted as a part of the State Sustainability Strategy, and accepted by the government of Western Australia, but its status is increasingly marginalised and remains in doubt. The Global Reporting Initiative (GRI) provides a frequently referenced guide for TBL reporting.

Figure 2.2 displays the 'people, planet, and profit' sustainability indicators used for corporate.

Figure 2.2. The three dimensions of corporate TBL sustainability (Stapledon, 2012)

As cited from Shepheard *et al*. (2006), according to Elkington (1998) and Vanclay (2003), TBL provides both a model for understanding sustainability and a system of performance measurement, accounting, auditing and reporting. The TBL concept provides a dual function as a model for business management planning/implementation and a framework for reporting that places business in the context of widely accepted approaches to sustainability within society.

However, in the irrigation industry, an appropriate framework for TBL reporting does not exist. The Global Reporting Initiative (GRI) clearly identifies its limitation and emphasises the need to use additional sustainability assessments. To measure sustainability in a complex system, a structured approach is appropriate to identify the main issues of concern for stakeholders, or the objectives relating to sustainability, and it then should address these objectives using selected indicators and performance measures. Adopting this approach, the Sustainability Challenge Project has developed an irrigation sustainability assessment framework (ISAF) (Shepheard *et al*., 2006).

For application in irrigation that requires a balance between the competing demands of agriculture and ecosystems that should address the current challenges of water scarcity or over-supply, salinity, modernisation, efficiency and environmental water management. In addition to these issues, as discuss later in *Chapter 5.2*, this thesis tries to incorporate the three dimensions of corporate TBL sustainability by Stapledon as shown in Figure 2.2 into the TBL sustainability framework developed to assess the TBL sustainability of irrigation systems.

2.5.2.2 The Triple Bottom Line (TBL) Framework for Assessing Irrigation Sustainability

The Sustainability Challenge Project of the Cooperative Research Centre for Irrigation Futures was developed to understand and promote irrigation sustainability through TBL reporting by irrigation water managers around Australia. The project provides an adaptive framework and methodology for improved TBL reporting by irrigation organisations (both rural and urban). This provides a means of measuring the sustainability of the environmental, economic and social issues of concern to stakeholders. Since it is an adaptive framework and methodology, it is possible to modify the assessment framework for application by other irrigation-related organisations. The structured framework and methodology consists of four tiers as shown in Table 2.4 and Figure 2.3.

Table 2.4. Four Tiers of Irrigation Sustainability Assessment Framework (ISAF)

ISAF tier level	Associated GRI level
1. Sustainability principles,	Vision and strategy
2. High-level objectives,	Category
3. Component trees to define operational objectives, and	Aspect
4. Indicators and performance measure	Performance indicators

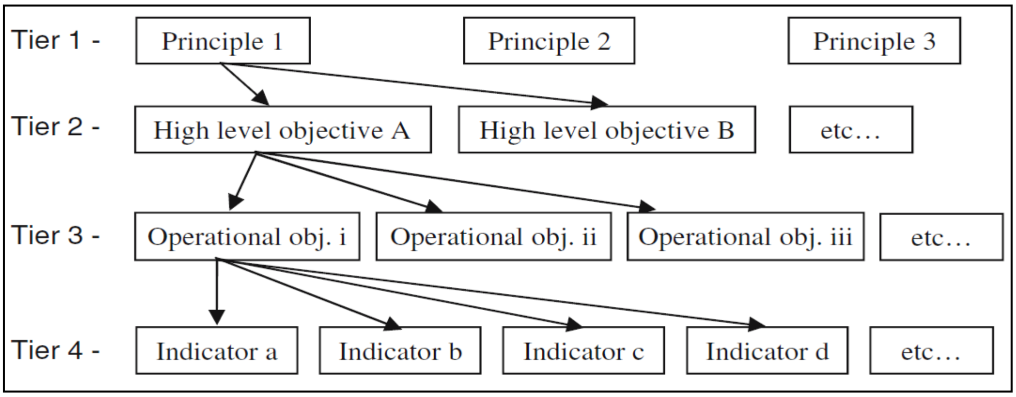


Figure 2.3. Four tiers of Irrigation Sustainability Assessment Framework (ISAF) (Christen *et al.*, 2006)

Based on the illustrations given by Stapledon (*see Figure 2.2*) and ISAF as well as by considering the indicators described by the RAP and Benchmarking, the three dimensions of TBL sustainability indicators for irrigation should consist of the followings:

People

A TBL irrigation system conceives a reciprocal social structure in which the well-being of authority, staff, farmer, WUA and communities interests are interdependent. In particular, a TBL irrigation system should contribute to the strength and growth of its community with such things as economics, health care and education. Quantifying this bottom line is relatively new, problematic and often subjective.

Planet (Environmental Impact Sustainability)

Irrigation projects can have large benefits, but the negative side effects are often overlooked. Irrigation systems draw water from the river and distribute it over the irrigated area. The installation and operation of a system has a negative impact on the environment since it changes hydrological conditions (direct, indirect and complex) as well as intricate subsequent impacts.

Planet indicators refer to sustainable environmental practices. A TBL irrigation system endeavours to benefit the natural order of the environment as much as possible or at the least to do no harm to or minimise the environmental impact. TBL irrigation systems carefully manage the consumption of resources and non-renewable fuel in an efficient and effective manner; including the use of water, land, energy, and construction materials, reducing water and carbon footprints, and disposing of toxic drainage in a safe and legal manner.

Currently, the cost of disposing of non-degradable or toxic waste from irrigation is borne financially and environmentally by the residents along the rivers. Ecologically destructive practices, such as excessive consumption of water, and the use of chemical fertilisers and pesticides that damage or deplete resources are avoided by TBL irrigation systems. An environmentally sustainable irrigation system is more profitable in the long run, and irrigation systems with an environmental impact should at least bear part of the responsibility of toxin disposal.

Profit

Irrigation plays a fundamental role in increasing agricultural production and diversification, rural employment, and food security. In this study, irrigation infrastructure is generally financed by the Central Government, apart from the tertiary channels which are financed by beneficiaries through a cost-sharing system.

The aim is to develop technically and financially self-sufficient WUAs who are responsible for the O&M of irrigation infrastructure, and to enhance farmer investment in irrigation infrastructure by regularising water rights, and taking into account water availability and water use efficiency.

Based on these, the ISAF for irrigation system sustainability principle is summarised as illustrate in Table 2.5 (a more detailed on the ISAF for the irrigation systems sustainability can be seen on *Appendix A.8*)

Table 2.5. The four tier of ISAF for the irrigation systems sustainability

<table>
<tr><th colspan="4">ISAF Tier Level</th></tr>
<tr><th>Tier 1 - Sustainability Principle</th><th>Tier 2 - High Level Objective</th><th>Tier 3 - Components Trees to Define Operational Objectives</th><th>Tier 4 - Indicators and Performance Measures</th></tr>
<tr><td rowspan="4">PROFIT</td><td>Water balance, productivity</td><td rowspan="11">The components of operational objectives to be achieved</td><td rowspan="11">The associated indicators and performance measures of the RAP and Benchmarking plus additional sustainability indicators and permormance measures that are not covered by RAP and Benchmarking</td></tr>
<tr><td>Financial, economic, and socioeconomic sustainability</td></tr>
<tr><td>Asset sustainability</td></tr>
<tr><td>Business Management</td></tr>
<tr><td rowspan="3">PLANET</td><td>Enhance appreciation of farmers to the value of water</td></tr>
<tr><td>Managing consumption in an efficient and effective manner</td></tr>
<tr><td>Maintenance of hydrological functions, ecosystem and biodiversity in system and basin level (reduce the impact of irrigation on the environment)</td></tr>
<tr><td rowspan="4">PEOPLE</td><td>Irrigation authority staff</td></tr>
<tr><td>Farmers</td></tr>
<tr><td>WUAs</td></tr>
<tr><td>Community</td></tr>
</table>

2.5.3 Summary of Assessing Irrigation System Sustainability

TBL assessment becomes a complement to the performance assessment (RAP and Benchmarking, opinion survey, and asset condition survey) to demonstrate that irrigated agriculture has beneficial effects not only in the economic dimension but also in the social and environmental dimension.

The literature states that successful accomplishments of ‘people, planet and profit’ objectives are also crucial for the sustainability of an irrigation system. A set of indicator sustainability issues that need to be addressed in a particular system is based on specific indicators of performance, threats and institutional strength. However in the irrigation industry, an entirely appropriate framework for TBL reporting does not exist.

To measure sustainability in a complex system, a structured approach should be adopted to identify the main issues of concern to stakeholders and/or the objectives relating to sustainability. The adaptive framework and methodology for improved triple bottom line reporting by irrigation organisations (both rural and urban), which provides a means of measuring the sustainability of the environmental, economic and social issues of concern to the stakeholders are based on the illustrations given by Stapledon (*see Figure 2.2*) and the four tier of ISAF proposed by Christen *et al*. as well as considering the indicators described by the RAP and Benchmarking. The TBL framework can be used firstly to analyse the existing system performance issues and its causes, and assess the viability of strategies to improve irrigation system performance and sustainability.

2.6 Assessing the Condition of Assets and Improvement Priority

According to Mc. Loughlin (1988), irrigation systems that could be kept running and kept up to a certain operating standard to maintain current levels of agricultural production and to ensure the livelihood of millions of people. Failure of the system causes drastic economic problems and leads to social disorder. In recent times, many developing countries have experienced a decline in irrigation system capabilities and performance due to the underfunding of O&M of irrigation assets.

Generally, the identification of future asset rehabilitation, and the reconstruction, repair, renewal, prioritisation and funding of these liabilities can be among the greatest challenges faced by irrigation agencies. The identification of future asset rehabilitation, reconstruction, repair, and renewal requires a survey to assess the current condition and performance of assets. The asset survey aims to assess the extent, function, condition, value, and performance of the individual asset, and maintenance priorities or replacement strategies.

The followings are the methods of assessing the condition of assets and the methods of prioritising the irrigation system improvements.

2.6.1 Assessing the Condition of Asset

As described in Section 2.5.1.2, there are several methods might be applied to assess the condition of asset. It is conclude that, this thesis utilises the IIS method since it provides a thorough assessment of the condition of the assets and its ability to perform its function (serviceability). This type of assessment assists expenditure priorities to be more likely to keep the asset functional rather than merely maintain their appearance. It also show how well individual asset meets current and projected standards of service. If a large area of irrigation and drainage is to be surveyed, asset survey representative areas can be taken and extrapolated to provide information for the whole base.

The aim of the asset renewal strategy is to identify and choose the optimum asset for a particular service and this would include optimising both the technical and financial options to improve the performance of assets. Options may include, among others: do nothing, continue to maintain the asset, or rehabilitate or modernise the asset (Tran *et al.*, 2003).

Increasing the performance and sustainability of an irrigation system is critical, particularly where it has been assessed as weak (the weakness being often due to persistent budget constraints).

2.6.2 Methods of Analysing Prioritisation of Irrigation System Improvements: Pairwise Comparison and the Triple Bottom Line Viability Assessment

Burt and Styles (2004) stated that the broad goals of modernisation (system improvement, rehabilitation, reconstruction, repair, and renewal) are to achieve improved irrigation efficiency and better crop yield. Other improvements would result in less damage to channels from uncontrolled water levels, a more efficient labour force, greater social harmony and an improved environment as the result of fewer diversions or better quality return flows. As stated by the Institute of Irrigation Studies at the University of Southampton (1995), adjustments to the infrastructure and to management practice aim to achieve:

- corrections to existing performance shortfalls/issues/problems,
- changes which will conform to new standards,
- changes in response to altered demand,
- greater overall financial efficiency,
- trade-offs between capital (capex) and operational (opex) expenditure, and
- institutional reforms (*e.g.* turnover or privatisation).

The decision to maintain or renew assets depends on establishing weightings or priorities for evaluation factors and criteria. Since there is a limit to the ability of people to compare rank and evaluate alternative accurately and consistently, multi criteria decision analysis (MCDA) techniques can help to assess the most preferable portfolio of options.

There are several MCDA techniques. ELECTRE (ELimination Et Choix Traduisant la REalité or ELimination and Choice Expressing REality), PROMETHEE and TOPIS are generated in Europe and widely known as outranking techniques which is rooted in set theory. On the other hand, AHP (Analytical Hierarchy Process), SMART (Simple Multi-attribute Ranking Technique), and MAUT (Multi Attribute Utility Theory) are generated in America and are based on operation research and programming theory.

In general, the difference between MCDA techniques according to Carden (2006) are attributable to how they deal with the challenge of commensurability, compensability and reversibility as well as how they deal with aggregate objective data measured on different scales and subjective judgement of experts and decision makers. However, he added, the overwhelming majority of these techniques deal with compare, rank and evaluate large numbers of criteria and alternatives accurately and consistently via the use of pairwise comparison. Based on this review, this thesis is going to utilise the simple pairwise comparison to prioritise the irrigation system improvements.

According to Carden (2006), the simplest way to shorten the task of evaluating and/or prioritising asset management is with simple pairwise comparisons. Since the ability to make consistent comparisons rapidly declines as the numbers of alternatives grow and the simple pairwise comparison methods are a reliable and robust way of eliciting preferences from decision makers and weighting criteria, these methods are widely accepted and used internationally.

In this thesis, the simple pairwise comparison is used in conjuction with stakeholders opinion survey. Stakeholder opinion survey is a method to obtain the preferences of stakeholders on the options of improvements. The basic principals in developing the questionnaires of stakeholders' opinion survey are similar with farmers' opinion survey. The questionnaires take into account aspects such as: ease of choice (select one of the two), reliable and economic, and use the local language. The population surveyed was carefully chosen based on the importance of their role in the irrigation system. The respondents interviewed individually at their place of work.

The priorities for interventions also can be assessed through its achievement on the TBL sustainability parameters/goals. Ilemobade (2009) utilised aspects of the TBL of technical and economic aspects, social, institutional and legal aspects, and environmental aspects. These two methods can be combined to complement each other. The purpose of incorporating these two methods is to establish the priority that not only viable but also favoured by stakeholders.

2.6.3 Summary of Assessing the Asset Condition of a System

Asset surveys are needed to gather information about the current condition of assets and to establish maintenance or replacement strategies. Identifying the condition of an asset might utilise quantitative and qualitative criteria. Since the IIS provides a more sophisticated method to assess the asset condition, it is recommended for future research.

Based on the asset condition assessment along with the results establish by the RAP and Benchmarking, farmers opinion survey, and the TBL sustainability assessment, a set of adjustments to the infrastructure and to management practice are then proposed. Since the simple pairwise comparison questionnaires and matrix are the easiest way to determine priority of adjustments to the infrastructure and to management practice preferred by the stakeholders of irrigation system, it is recommended to be applied for future research.

2.7 Developing an Asset Management Planning (AMP) for a Transferred Irrigation System

The improved, sustainable, and cost-effective AMP for transferred irrigation system (at tertiary level) was developed by following the guidelines for the preparation of an AMP for irrigation infrastructure in developing countries developed by the IIS, University of Southampton, UK. The cost model for the AMP was developed by considering the efficient O&M of the assets, as well as the aspects of needs based budgeting, ISF and turnover.

2.7.1 Turnover, Management and Physical Upgrade, and Desired Level of Service (LoS)

The common problems relating to irrigation and drainage in Indonesia as cited from the ICID (International Commission on Irrigation and Drainage) Report by Abernethy, Jinapala, and Makin (2001) are:

- irrigation development has been oriented only for self-food sufficiency, this leads to lack of food diversification and very high dependency on rice,
- land conversion from irrigation to business, industrial, and settlement areas in Java threatens self-food sufficiency,
- irrigation development in Java could not be implemented optimally,
- the implementation of development did not effectively take into account aspects such as water quantity and quality, system sufficiency, and farmer involvement in planning, implementation, and O&M of irrigation,
- performance of the irrigation ssystems decreases due to deterioration of the system,
- minimal government finance limits the lifetime and O&M of systems,
- most of the irrigation systems take water directly from streams (without reservoirs). The system is not reliable and is dependent upon seasonal variation.

In addition to the problems above, according to Ertsen and Pradhan (2004), irrigation in Lampung is faced with problems due to its higher water allowance in comparison to Java. Estimating water demand has been an issue in Lampung since colonial times. Initial water demands were high because of excessive infiltration. Land preparation in virgin land required excessive initial water use due to the high percolation rates of new and porous soils. However, even though water demand stabilised after some years, demand remained relatively high where the soil remained sandy. Water demand eventually lowered and became stable due to the process of the seepage of fine soil particles into the soil layer below the root zone. Building up a better water-retaining layer is one solution, although it can easily take 10 years, with a typical formation period of 5 years. This phenomenon was recognised as early as the 1930s in a study by Wehlburg that stated that normal water requirements at the stable condition were 1.26 L/s/ha. A later report defined capacities as 1.65 L/s/ha (wet) and 1.89 L/s/ha (dry).

Since 1980s, Indonesia has been implementing PIM. According to Bruns and Helmi (1996), the most important challenge in the development of PIM is identifying the best approach for equal water distribution and irrigation system maintenance. In addition to the challenge mentioned above, the challenges to sustain PIM program are:

- formal WUAs can rapidly disappear after project completion and local irrigation management reverts back to the previous format,
- the disappearance of formal WUAs has been contributed to by a lack of mechanisms to support them. Once community organisers have left a project then WUAs may find difficulty in carrying out government instructions,
- the sustainability of irrigation systems relies on a policy framework that is focused directly on improving and sustaining participation in key tasks (equal distribution of water and maintaining irrigation infrastructure),
- there is a lack of information regarding the effects of PIM on irrigation performance, crop yields and the lives of farmers,
- monitoring is not sufficient to show improvements in irrigation performance over time,
- a lack in available resources results in the problems encountered with irrigation systems monitoring and evaluation, and
- one option available to improve the monitoring of irrigation O&M in participatory efforts is a clearer focus on key performance indicators ensuring equal water distribution and irrigation structure and canal maintenance.

Despite the pitfalls, participatory irrigation projects have been shown to demonstrate benefits, including: improved planning, sharing of costs, improved water distribution, work capacity, support from legal frameworks and policies that promote participation. In future PIM projects, the following considerations have been suggested by Bruns and Helmi (1996):

1. Diversifying agriculture

   Rice production offers lower and declining returns to farmers. A more reliable source of income would be obtained from horticultural crops. There is an increasing demand to diversify agriculture and develop agricultural business strategies. New government policies would allow farmers to select their own crops, despite the movement to maintain rice production.

According to Bjornlund, Nicol and Klein (2007), the economic efficiency of water use on farms depends on total returns from crops grown under irrigation (yield times output price), the cost of inputs, and the on-farm water use efficiency. Switching from lower to higher value crops can increase economic efficiency of water use.

On the other hand, diversification adds to the complexity of irrigation systems. Greater reliability and flexibility may be required to locally distribute water according to farmers' needs. Farmer participation is also necessary to improve information gathering and management capacity.

2. Water user rights and participation in basin management

   Increasing competition for water requires more strategies to reallocate water to other agricultural sectors. WUA participation in basin water management is required to deal with water reallocation and quality. Clearer allocation of water rights could reduce conflict and facilitate trading and compensation arrangements for reallocation and efficient water resource utilisation.

3. WUAs as business enterprises

   The aim of PIM projects has always been to improve farmer income, but objectives have not been focused on income generation. One approach would be to develop WUAs as business enterprises, so that members could respond to specific business opportunities such as fisheries, joint purchase of agricultural inputs, crop marketing, and electric power generation.

4. Contracting for irrigation management

   The turnover of smaller irrigation systems is generally more successful; however, it is more problematic for larger irrigation systems incorporating multiple villages and systems in commercialised areas close to major towns. In these areas, busy farmers are more reluctant to contribute labour, and more willing to pay for O&M services. The O&M contractual approach might allow users to hire their own technical specialists to operate larger irrigation systems.

5. Farmer financing for irrigation development

   Legal institutional arrangements for WUAs enable farmers to collectively borrow funds to finance irrigation development. Effective rural micro-finance programs will only be sustainable if accomplished through banks or other financial institutions which have a strong incentive to ensure the best selection of borrowers and repayment of loans. Since subsidies may be scarce, irrigation districts should provide farmers with a legal framework for borrowing without subsidies.

6. Re-engineering O&M

   Whilst the turnover of smaller irrigation systems has been successful, there are still delays in the turnover of larger systems. This is due to a shortage of staff, vehicles, and communication equipment along with constraints in the operational budget. Farmers are often requested to assist with the maintenance and operation of larger systems, however, they do not have the capacity and resources to contribute successfully. The government must retain the authority to supervise water allocation. Re-engineering of irrigation management should focus on how to accomplish the equal distribution of water to farmers.

For irrigation systems, the level of service can be differentiated into the levels of service of supplying irrigation water and drainage and the level of service of physical assets. The level of service of supplying irrigation water is highly dependent on the level of service of physical assets. Physical assets contribute to meeting farmers' needs for access to irrigation water and these, typically, are interconnected channel networks of composite assets. The components of these assets can be separately maintained, renewed, or replaced so that the required level and standard of service of an asset network is sustained. In general, the components and the assets, if properly maintained, have 25 years of useful life (*see Table 2.10 in Section 2.7.4.1*).

Management and physical upgrade and turnover of tertiary level irrigation system are intended to improve the level of service of existing irrigation systems, minimise costs, and maximise benefits.

2.7.2 Needs based Budgeting and Budget Constraints, Sources and Realistic Levels of Fundings (ISF)

According to IIS (1995), needs based budgeting in the irrigation sector is intended to target available funds more effectively. Budgets are prepared on a detail bottom-up basis and are established in the setting of five-year budget plan and budget priorities on the AMP.

There are no clear standards for optimising maintenance expenditure in economic terms. Attention can be focused on apparent needs for repair and improvements such as the canal lining, rather than routine maintenance. However, this can result in an overestimate of available O&M funds. The easiest way to estimate the needs-based O&M budget for Irrigation Service Plans is to use previous similar project expenditure data.

In addition to the problems, it is common perception that the existing ISF as the main source of available funds for O&M tertiary level irrigation systems are inadequate to cover full O&M. Further discussion on ISF is presented in the following section

2.7.3 Cost of Service, Irrigation Service Fee (ISF) and Efficient Operation and Maintenance (O&M) of Tertiary Level Irrigation Systems

In the past, according to Hellegers (2006), water has been viewed as a free resource, and access to clean water as a basic right of human beings. However, there is an increasing trend to treat irrigation water as an economic good. Indeed, water is treated thus when it is scarce and cannot satisfy the demands of different users, and if there is inadequate funding for development, maintenance, and operation of irrigation networks. Viewing water as an economic good is not about setting the appropriate nor should water be allocated according to competitive market prices.

Environmental degradation caused by the utilisation of water indicates a failure to recognise the true value of water. The irrigation sector is the largest consumer of water in the world (approximately 70 – 80% of all water used). Water has financial, socioeconomic and environmental implications, as well as social, cultural and religious value. It is the opinion of Hellegers (2006) that there are two useful instruments for resolving competition for water resources amongst water users:

- analytical instruments: to help predict and interpret the implications of various allocation procedures e.g. cost-benefit analysis and cost-effectiveness analysis; and
- economic instruments: to assist in guiding users towards socially desirable outcomes (influencing behaviour indirectly by providing incentives to use water more efficiently) e.g. water pricing, taxes, subsidies, tradeable water rights, rationing, and crop-based and area-based charges.

The price, value and cost of water must be differentiated. The ‘price’ of water is the amount paid by users of water. The ‘value’ of water has many definitions since it varies across time, space, and use (crop, stage of growth, soil type, etc.). Meanwhile, the ‘cost’ of water is the cost of providing the service to the consumer.

According to Oad (2001), pricing water for cost recovery could play a significant role in encouraging more equitable and productive use of water by farmers. It is also useful, according to Sampath (1992), for determining the levels of demand and supply and the amount of resources invested. The specific functions that irrigation water pricing performs are:

- to reduce demand, i.e., to influence the efficiency (productive use and conservative use of water) with which irrigation water is supplied and controlled;
- to effect the equity of distribution in terms of income and cost recovery;
- to fund O&M; and
- to recover investment costs.

Since water is a complicated natural resource (Perry, 2001), it is unrealistic to hope that water pricing will balance the supply and demand of water and stabilise the environmental impact. The value of water is complicated because it is difficult to allocate and measure, and its actual losses and salt load are not easy to determine.

Sampath (1992) stated that water pricing methods vary considerably across developing countries and within a country they vary between one irrigation system and another. Charging for water usage results in many conflicting factors, such as economic efficiency, cost recovery, revenue maximisation, regional equity, and ability to pay, environmental cost avoidance, and demand management.

According to Perry (2001), the pricing of water is also restricted by physical, economic and political constraints. In most developing countries, the agricultural sector is politically sensitive and/or dominant. Water is viewed as a complicated political resource because:

- farmers are an important political constituency,
- the price increases have a significant impact on demand, and
- the price can result in political issues.

It is impossible to formulate a pricing structure that can serve the multiple objectives of water charges and hydrological situations. Measuring and controlling a volume-related charge requires a massive investment in physical, legal, and administrative infrastructure. It also needs to be supported by legal, regulatory, operational, and economic requirements. However, according to Sampath (1992), most pricing methods are based on financial rather than economic considerations and are determined by the amount needed to recover the cost of O&M at a minimum. The objective is to provide a service to users at reasonable cost. Irrigation charges might include one or more of the following:

- water are charged based on volume or other measures,
- water rate per hectare dependent on the kind and extent of crop irrigated, the season, etc.,
- additional land tax, based on the increased benefit derived annually by access to irrigation,
- levy from the increase in land value accrued from providing irrigation,
- annual charges per acre of the irrigable area, whether water was actually taken for irrigation or not,
- annual cost of maintenance and operation, and
- indirect financing mechanisms.

Furthermore, Sampath (1992) explained that irrigation charges can lead to countries being more concerned and preoccupied with setting price levels rather than instituting a price structure that will accomplish the most efficient use of scarce irrigation water. Unfortunately, most developing countries do not follow marginal cost pricing or a formal pricing procedure. Pricing systems often act as a disincentive to efficient water use. Moreover, many Asian countries have failed to make the necessary policy changes required to recover the costs of their irrigation systems.

WUAs are a mechanism for introducing user incentives and they can play a key role in the management of small irrigation systems. An ISF is established at the tertiary level for use by WUAs to support tertiary O&M activities. ISF collection is aimed to generate and allocate sufficient funds to operate and maintain transferred irrigation systems. In order to establish a workable ISF rate, Vermillion and Johnson (1990) proposed the following options for collection of water charges from water users:

- payment on a per hectare (area) basis,
- the payment on a quantity in m^3 (volume) basis (a) per system, (b) per tertiary unit, and (c) per individual user, and
- payment on an output (economic productivity per unit area) basis.

In Indonesia, according to Gerard (1992), where there are very few dry periods, water availability during the wet season is not an issue for most schemes. However, during the dry season water availability is an important factor affecting the level of service provided to farmers. He suggested that for the purposes of the ISF, the service level should cover the following:

- delivery of water to all tertiary units in an equitable manner based on crop water demands (timing and amount of deliveries), field irrigation practices (flow rates that can be efficiently handled by farmers), and based on the agreed-upon cropping calendar;
- timely disposal of drainage water; and
- facilitating the distribution of water in tertiary blocks, as they relate to user acceptance of the service to the tertiary gate.

The followings are the ISF rates applied in several countries.

Table 2.6. ISF rates of several countries

Country/ region	Pricing methods	ISF rate	ISF as % of income	Collection rate (%)	Percentage of cost recovered	Water source	Additional information
Gujarat, India	n.a.	n.a.	37	n.a.	Low	Deep tubewell	Electricity is heavily subsidised.
Haryana, India	Area-based	US$2.5/ha	0.5	>90	Full O&M cost recovery	Dams	33% of ISF could fully recover the O&M cost.
Maharashtra, India (1984)	n.a.	n.a.	n.a.	58 - 67	n.a.	n.a.	No link between ISF and O&M.
Sindh, Pakistan	Area-based	US$2 - 8/ha	2	<30	Low (part of the O&M)	Three barrages	ISF is to low to cover the O&M costs.
Pakistan (2001)	Area and crop-based	Rs2.04 to 3.09 according to crop	n.a.	30 - 35	n.a.	Gravity flow	ISF collected goes to provincial treasury.
Bangladesh (1998)	n.a.	n.a.	n.a.	3 - 10	Low	n.a.	ISF were levied in only 6 from 15 of the major irrigation systems.
Nepal (1984)	n.a.	n.a.	n.a.	20	n.a.	n.a.	No link between ISF and O&M.
Sri Lanka (1984)	n.a.	n.a.	n.a.	8	n.a.	n.a.	No clear responsibility for O&M.
Philippines (2001)	Area-based-crop, US$77/year/ hectares	n.a.	n.a.	58	46% of the O&M	n.a.	n.a.
Jordan (1999)	An assume discharge rate	Very low	n.a.	n.a.	50% of the O&M	n.a.	n.a.
Tunisia (1991)	n.a.	Very low	n.a.	n.a.	44 - 76% (70% on average)	n.a.	Non-financially autonomous public agency.
Turkey (2004)	The two-part water charging	n.a.	n.a.	76	32 - 50	n.a.	Capital cost recovery is low.
Haouz, Morocco	Volumetric	n.a.	7	60 - 70	Full O&M cost recovery + 40% capital cost recovery	Dam	O&M cost = $30/ha/yr, full cost including capital repayment and depreciation = $54/ha/yr.
Tadla, Morocco	n.a.	n.a.	15	70 - 80		Dam	O&M cost = $127/ha/yr, full cost including capital repayment and depreciation = $150/ha/yr, ISF collected exceeds the O&M costs.
Botswana (1994-95)	Block-pricing	Very low	n.a.	n.a.	35 to 45% of the O&M	n.a.	n.a.
Argentina (1997)	Area-based	Very low, $70/ha/year	n.a.	70	12% of O&M	n.a.	Fee collection managed jointly by the government and the WUAs.
Jaiba project, Brazil (1997)	The two-part water charging	n.a.	n.a.	66	52	n.a.	K1 reflects project capital cost, $3.69/ha/month, accounts for26% of the total cost, is paid to the sponsoring federal agency; K2 represents fixed O&M costs and variable costs, is supposed to cover all O&M costs, $10.11/m3, is paid to the awUAs districts.
Columbia (1996)	n.a.	n.a.	n.a.	76	52% of the O&M	n.a.	ISF collection managed by the WUA.
Italy (1997)	Area-based	Very low	n.a.	n.a.	60%	n.a.	n.a.
Macedonia	Area-based	n.a.	n.a.	42	n.a.	n.a.	n.a.

Source: (Easter and Liu, 2005)

There are three alternative asset management approaches suggested by the Australian Asset Management Collaborative Group (2008):

1. Option A - The annual maintenance costs are low, but the annual capital costs are relatively high. This option allows assets to deteriorate quickly with minimal maintenance before replacement. This scenario could be expected in a situation where maintenance costs come out of a local revenue budget but capital costs are centrally controlled.
2. Option B - The annual maintenance costs are high in order to prevent the deterioration of assets, but the annual capital cost of sustaining the standard of service (SOS) is low. Whilst the asset life is longer, delaying or avoiding the cost of replacement requires more frequent and expensive maintenance and repair in order to sustain the SOS. This scenario could be expected in a situation where it is difficult to justify replacement expenditure, or where the prioritisation system favours improvement projects.
3. Option C - Minimises the whole-life cost of providing the required SOS (i.e., the optimum balance between maintenance and replacement costs). This scenario is most likely in an organisation that is operating with effective asset management with clear responsibilities for whole-life costs, and sound information systems to support the best asset management decisions based on the whole-life cost. A historical record of past expenditure, coupled with a forecast of expenditure to sustain the SOS, is a solid foundation on which to establish life cycle cost (LCC).

The turnover of management of tertiary level irrigation systems to WUAs means that WUAs are now fully responsible for assets and management at this level. In order to successfully manage tertiary irrigation assets, WUAs must use the Option C approach. Option C helps WUAs to ensure, where possible, that available funds are spent on planning, purchasing and installation, O&M, and renewal of tertiary level irrigation assets in a cost-effective way. Unfortunately, up until now, WUAs have been following Option A. In addition, appropriate records have not been kept of past expenditure and asset condition over time.

2.7.4 Cost Model/Economic Analysis

Economic efficiency and fiscal sustainability demand that the capital costs of irrigation infrastructure should eventually be recovered from water users and this will allow long-term use of fund for investment. At the moment, the general consensus among governments and financial institutions is that the user should pay for the O&M costs and for a majority of capital costs.

Some countries have implemented this policy, including Australia, where water utility bills recover the full service costs. While in New Zealand, water agency is required to depreciate assets and a cost-benefit analysis is used in asset management. Unfortunately, according to Sampath (1992), in developing countries water is provided as a free service or pricing systems do not support the most efficient use of scarce irrigation water.

In general, irrigation agencies set up the O&M program to maintain the standards of the channel/drainage system at a design level. The cost components of an irrigation system, generally consist of:

- capital investment activities: costs associated with the works undertaken to rehabilitate, upgrade, extend, or improve existing system infrastructure,
- system operating costs: typical costs associated with the operation of the system including staff costs, equipment costs, transport etc.,
- routine maintenance costs: costs related to operation over time with a particular pattern of capital investments for deteriorating assets and operations enabling observation of the trend in costs to prepare the operating expenditure (opex) budget,
- replacement and renewal costs: replacement and renewal of irrigation system assets, and
- depreciation: in the economic analysis of a project, depreciation should be considered.

(Mc. Loughlin, 1988).

The following tables are costs of irrigation in some countries reviewed by experts:

Table 2.7. Cost of irrigation

Country	Costs (US$)		Income (US$)					
	Capital costs/ha	O&M costs/ha	Irrigation service fee, % of O&M costs	Collection rates, %	Supplement income, % of O&M costs	Tax to government (land tax)	Amount received by public agencies	Benefit recovery ratio,%
Indonesia	3,000	10 - 35	Varying rates to cover the full O&M cost of the tertiary facilities	n.a.		Very limited	n.a	8 - 21
Nepal	3,000	10 - 35	60	20		Very limited	n.a	5
Philippines	3,000	10 - 35	121	62			n.a	10
Thailand	3,000	10 - 35	Not levied			10/ha/year	n.a	8
Korea	8,000 – 11,000	145 - 230	93	98	28		n.a	26 - 33

Source: (Small, Adriano, and Martin, 1986)

Table 2.8. Capital cost

Country	Small scale communal projects	Medium and large projects
Indonesia	800	1,500 – 3,000
Korea	4,000 – 7,500	8,000 – 11,000
Nepal	-	(1,500 – 2,600)[a]
		(2,000 – 6,600)[b]
Philippines	500	1,000 – 2,500
Thailand	50 - 500	1,500 – 3,000

[a] Based on figures for area commanded
[b] Based on figures for area actually irrigated
Source: (Small, Adriano, and Martin, 1986)

Table 2.9. Comparison between costs required to actual costs

Country	Cost component		Author	Year
India	O&M,	$4-8/ha (allocated)	Desai & Jurriens	1992
		$10-17/ha (prescribed)		
	Maintenance 20% of O&M budget		Skutch	1998
	Construction & rehabilitation	$2,300/ha (in 1989 dollar)	Svendsen & Gulati	1995
	O&M	<$20/ha		
	Water charge collection rate	Decline		
Indonesia		$18-28/ha (requirements)	Skutch	1998
		$5-13/ha (actual expenditure)		
Pakistan		$5.7/ha (requirements)	Skutch	1998
		$2.7/ha (actual)		

Source: (Shivakoti, G.P. et al., 2005)

The cost model is used to compare alternatives for investment strategies. The specific purposes of the cost model according to the IIS are to:

- value existing assets (in terms of the 'Modern Equivalent Asset' value),

- provide unit costs for capital investment activities (as determined from engineering studies), and
- quantify operational and maintenance costs.

The benefits of an irrigation system are more difficult to determine than costs. There are direct and indirect benefits, and tangible and intangible benefits. Direct and tangible benefits come from water charges and water savings. Indirect and tangible benefits cover positive environmental effects, flood control, agriculture, irrigation and fisheries etc. The most important areas of benefit, according to Mc. Loughlin (1988) relate to:

- the well-known operational relationship between O&M spending and farm production. It is important to assume that the water saved (or no longer lost) by improved O&M is beneficial,
- where and how benefits arise when 'saved' water (additional m^3 of water) reaches farmer turnouts.

2.7.4.1 Useful Life, Depreciation and the Salvage Value

Infrastructure assets are generally designed using LCC principles, and it is important to develop a realistic estimate of asset life. The life of an asset is the period during which an asset or property is expected to be usable for the purpose it was acquired.

Assets reach the end of their useful life for various reasons such as: functional suitability, capacity and utilisation, cost and efficiency, safety and compliance, and location. The life of an asset depends on a number of factors that include type of material, construction methods, design, criteria, location, loading, pressure, environmental conditions and level of maintenance. These factors may or may not correspond with an item's physical or economic life. The useful life of an asset can be defined as:

- the period of time during which the asset provides its designated level of service within the required budget, or
- the period of time prior to an asset becoming technologically obsolete, or
- the period of time prior to an asset no longer being required.

Table 2.10 identifies the useful life of various assets.

Table 2.10. Indicators of useful life

Asset type	Depreciation life/useful life (years)
Weir	Civil: 50 M&E: 10
Head regulator	Civil: 25 M&E: 10
Cross regulator - fixed crest - gates - stop logs - flume	Civil: 25 M&E: 10
Measuring structure	25
Canal: linings - earth - masonry - concrete tile - clay	Civil: 25 M&E: 10
Hydraulic structure - aqueduct - culvert - drop structure - escape structure	Civil: 25 M&E: 10
Supplementary structure - bridge - cattle dip	Civil: 25 M&E: 10
Access roads	Civil: 25

Source: (Institute of Irrigation Studies -University of Southampton, 1995)

Depreciation is the systematic allocation of the depreciable amount of an asset over its useful life. It refers to two very different but related concepts:

- a decline in the value of assets, and
- an allocation of the cost of tangible assets to periods in which the assets are used.

There are methods to justify the depreciation life of various asset types and component elements. The methods reflect the pattern in which the asset's future economic benefit is expected to be consumed. For infrastructure assets held by the local government, the future economic benefits are the services provided to the local government community.

Methods for calculating depreciation are generally based on either the passage of time or the level of activity (or use) of the asset. Other methods include straight-line depreciation, declining balance, sum-of-years digits, units-of-production depreciation, units-of-time depreciation, group depreciation, and composite depreciation methods. Straight-line depreciation calculations are currently considered inappropriate for determining the annual consumption of infrastructure assets. The modified approach options are condition-based assessments and the infrastructure consumption approach.

Calculation of depreciation based on condition was pioneered by the NSW Roads and Traffic Authority. Condition-based depreciation is a variant of the straight-line depreciation method that calculates the remaining value of the asset and its depreciation over the remaining life of the asset. It results in a series of straight-line segments that approximate to the convex degradation curve that is expected for infrastructure assets, and is a closer representation of the actual pattern of asset degradation than the straight-line approach (Burns, 2002).

At the time of asset recognition it is necessary to determine what its value will be at the end of its useful life. Salvage value or residual value is the estimated value that an asset will realise upon its sale at the end of its useful life. The value is used in accounting to determine depreciation, and in the tax system to determine deductions. The expected residual can be estimated from the owning and managing of similar assets or it can be determined by a regulatory body such as the IRS[1].

The determination of salvage value is important since it is used in conjunction with the purchase price and accounting to determine the amount by which an asset depreciates within each period. Too high a residual value will result in depreciation and the value of the asset being understated. On the other hand, if the residual value estimate is too low, this will result in higher depreciation in the annual income statement which is undesirable from the perspective of achieving the optimum allocation of scarce resources.

2.7.4.2 Asset Valuation and Discount Rate

A formal asset management system should provide information on asset condition or performance. A method widely utilised to value assets is the Modern Equivalent Asset (MEA). The MEA value is the cost, at current price, of a modern asset of equivalent function not necessarily replicating the existing asset in precise detail. The gross MEA value is the full amount needed to provide such an asset at the current time. The net MEA value allows for the depreciation of asset value over its life. The relationship between the condition of an asset and its nominal depreciated value needs to be determined for use within the Cost Model (Institute of Irrigation Studies -University of Southampton, 1995).

[1]The IRS is the organisation that services the taxation of all Americans headquartered in Washington, D.C.

As suggested by AAMCoG (2008), assets with similar performance characteristics, environmental and/or operational conditions and design, can be pooled into an asset group. General performance trends are established for the asset group using regression analysis. This is achieved by plotting asset condition information (obtained from historical and current condition surveys) on the vertical axis and the age of assets at the time of survey (or since the last major rehabilitation was performed) on the horizontal axis.

According to Rambaud and Torrecillas (2005), cost-benefit analysis is the main tool for determining the economic value of public projects such as irrigation. However, the issues surrounding determination of the discount rate include:

- choosing a 'correct' discount rate,
- using a unique discount rate or different discount rate,
- determining whether the discount rate will/will not be constant over time.

The discount rate refers to the computational present value of an asset. The discount rate that is applied to a public project is commonly classified as a social discount rate (SDR). The social discount rate defines the 'appropriate value of r' for use in computational analysis for social investment. It is a measure used to help guide the decision to divert funds to social projects. Since it is not easy to determine the SDR, it is the subject of debate in determining the true benefit of certain projects, plans, and policies.

As cited in Rambaud and Torrecillas (2006), Weitzman stated that discount rates are uncertain and persistent, and assuming that the SDR is constant over time is inappropriate in a world with ever-increasing environmental concerns. A social rate of return is not only lower than the private rate of return but is expected to decline systematically over time (Burt and Styles, 2004). The SDR can be determined on the basis of zero discount rates, constant discount rates, or time-declining discount rates. Table 2.11 shows the discount rates that are applied in some countries:

Table 2.11. Current discount rates in practice

Country	*Agency*	*Discount rate (per cent)*
Philippines		15[a]
India		12[a]
Pakistan		12[a]
International Multi-lateral Development Banks	World Bank	10–12[a]
	Asia Development Bank	10–12[a]
	Inter-American Development Bank	12[a]
	European Bank for Reconstruction and Development	10[a]
	African Development Bank	10–12[a]
New Zealand	Treasury and Finance Ministry	8[g]. From 1982 to 2008 it was 10[abf]
Canada	Treasury Board	8[c]. From 1976-2007 was 10 (and test 8–12 per cent)[ab]
China (People's Republic)		8[a]
South Africa		8 (and test 3 and 12 per cent)[d]
United States	Office of Management and Budget	7 (and test 3 per cent). Used 10 per cent until 1992.[a]
European Union	European Commission	5 From 2001–2006 was 6 per cent[a]
Italy	Central Guidance to Regional Authorities	5[a]
The Netherlands	Ministry of Finance	4 (risk free rate).e
France	Commissariat General du Plan	4. From 1985-2005 used 8 per cent[ab]
United Kingdom	HM Treasury	3.5 (declining to 1 per cent for costs and benefits received more than 300 years in the future) from 2003.[a] From 1969–78 used 10 per cent[a]
Norway		3.5. From 1978–98 used 7 per cent[ab]
Germany	Federal Finance Ministry	3. From 1999–2004 used 4 per cent[ab]
United States	Environmental Protection Agency	2–3 (and test 7 per cent)[a]

[a] Zhuang et al. (2007, table 4, pp. 17-18, 20). [b] Spackman (2006, table A.1, p. 31). [c] Treasury Board of Canada (2007, p. 37, 1998, p. 45). [d] South African Department of Environmental Affairs and Tourism (2004, p. 8). [e] van Ewijk and Tang (2003, p. 1). [f] Use of the 10 per cent rate by New Zealand government departments is confirmed by Young (2002, p. 12); Abusah and de Bruyn (2007, p. 4). [g] New Zealand Treasury (2008) recommends a default rate of 8 per cent (after adjusting the market risk premium of 7 per cent for gearing).

(Source: Harrison, 2010)

A positive net present value of a project's social costs and benefits over time indicates that a project is efficient or raises wealth. It suggests that the benefit outweighs the use of resources that were displaced from other sectors.

2.7.4.3 Life Cycle Cost Analysis and Cost-Benefit Analysis

Life cycle cost (LCC) is an economic model viewing the project life span. LCC is the total cost of ownership costed over the life of an asset, commonly referred to as the "cradle to grave" or "womb to tomb", and includes the cost of acquisition, operation, maintenance, conversion/upgrade/renewal, and decommission. It encompasses the total cost estimates from inception to disposal of assets as determined by analytical studies. It can also be viewed as an estimate of the total costs in annual time increments during the project life with consideration for the monetary value of time. The objective of an LCC analysis is to choose the most cost-effective approach from a series of alternatives to achieve the lowest long term cost of ownership.

Cost-benefit analysis is an approach used in economic decision making. It helps to appraise or assess the case for a project, program, or policy proposal. The process involves weighing the total expected costs against the total expected benefits of one or more action(s) in order to choose the best or most profitable option.

Benefits and costs are often expressed in monetary terms, and are adjusted for the cost of time. All values are expressed as their 'present value'.

Cost-benefit analysis is often used by governments to evaluate the desirability of a given intervention. It is an analysis of the cost-effectiveness of alternative interventions to determine whether the benefits outweigh the costs. The aim is to measure efficiency of the intervention relative to the status quo. The costs and benefits of an intervention are evaluated in terms of the public's willingness to pay for them (benefits) or willingness to pay to avoid them (costs). Inputs are typically measured in terms of opportunity costs (their value in being put to the best alternative use). The guiding principle is to list all parties affected by an intervention and place a monetary value on the effect on their welfare. The process involves determining the value of initial and ongoing expenses and the expected return on investment.

2.7.5 Asset Management Planning (AMP) Presentation

The AMP consists of activities that assess, monitor, and regulate the condition of government-owned irrigation infrastructure over time; the MOM of which has been transferred to WUAs and WUAFs. It is a valuable mechanism for focusing the attention of WUAs and WUAFs on sustaining and enhancing the condition of the irrigation infrastructure.

Eventually, AMP outcome is desired to meet requirements such as reliability, manageability, financial viability and physical sustainability. Therefore, the financial modelling process is one of reviewing and refining the provisional investment program presented in the AMP. Financial modelling considers the constraints and allows prioritisation in terms of:

- alternative strategies,
- capital planning (20 years),
- budget planning (5 years),
- budget priorities (investment priorities) (5 years), and
- sources and realistic levels of funding (ISF, subsidies, etc.)

In addition to these time frames, an agreed level of service at tertiary level should be negotiated and established between farmers as service users who have to pay for this service and WUAs as service providers. The level of service consists of the levels of service of supplying irrigation water and drainage and the level of service of physical assets. The level of service of supplying irrigation water is highly dependent on the level of service of physical assets at tertiary level and the level of service of supplying irrigation water and the level of service of physical assets at higher level.

Eventually, in order to maintain the sustainability of implementing the improved, sustainable, and cost-effective AMP for O&M irrigation at tertiary level by WUAs, government support in strengthening the local resources and monitoring to show improvements in irrigation performance over time are needed. Since as mentioned in Section 2.7.1, based on previous experience, the WUAs activities often disappeared after a project was completed because of the support for them was no longer available.

2.7.6 Summary of Developing an Asset Management Planning (AMP) for a Transferred Irrigation System

There is an increasing demand that farmer water users should pay for the O&M costs and for a majority of capital costs of irrigation. In general, the cost components of an irrigation system consist of: capital, system operating, routine maintenance, replacement and renewal, and depreciation costs. Identification of future asset costs can be among the greatest challenges faced by irrigation agencies. The cost model for the AMP for a transferred irrigation system must consider elements such as useful life, depreciation, salvage value, asset value, and discount rate. The life cycle analysis and the cost-benefit analysis are useful tools to determine whether the benefits outweigh the costs. The AMP of a transferred irrigation system should also consider aspects of turnover, ISF, needs based budgeting, and timeframe of AMP.

2.8 Development of Justification of Objectives

Indonesia irrigation systems suffer from low performance, which eventually adversely affects their sustainability. Improved irrigation performance and sustainability can be achieved through better asset management. In brief, the basic stages of building a potential application of AMP for irrigation in the developing countries as proposed by the IIS are: carry out surveys, assess the performance and performance issues, and assess the physical and managerial interventions needed to improve irrigation performance and sustainability, and assemble and present the AMP.

2.8.1 Overview of Reported Work and Development of Project Objectives

Section 2.2 has demonstrated that asset management is a comprehensive program to manage assets over their whole life cycle, with the objective of providing the required level of service in the most cost-effective manner while ensuring the sustainability of the asset base and resource utilisation. An improved, sustainable, and cost-effective AMP for a transferred system is suitable to improve Indonesia irrigation performance and sustainability in the future since Indonesia is adopting a participatory approach in irrigation.

The IIS provides guidelines for the preparation of AMP for irrigation infrastructure in the developing countries that facilitate the element of turnover. The stages in developing the improved, sustainable, and cost-effective AMP are as follows: carrying out an asset survey, assessing system performance and performance issues, management studies, developing cost model, and presenting the AMP.

Section 2.3, 2.4 and 2.6 have shown that performance assessment is an essential component of developing an AMP. The RAP and Benchmarking provide a useful method in assessing the external indicators and the internal process (performance) of irrigation system. In addition to these, to establish an in-depth analysis of the current performance level of an irrigation system, an opinion survey and asset condition survey need to be done to complement the RAP and

Benchmarking. Since the IIS provides a more sophisticated method to assess the asset condition, it is recommended for future research. Whereas for farmers opinion survey, a quantitative design with a questionnaire method is recommended by Abernethy, Jinapala and Makin (2001) to be used in future research since it is an easy, quick, reliable, economical method that can be used among community with high rates of illiteracy.

Based on these reviews of the literature, ***Objective 1*** for this research is: assesses the performance of existing irrigation systems in rural Indonesia.

Subsequently, section 2.5 has shown that there is a very close relationship between an irrigation system's sustainability and the various aspects of its performance. The RAP and Benchmarking only illustrates the net benefits to production outcome from irrigation and gives little attention to the natural resources that are sacrificed. The TBL sustainability assessment is complementing which is not covered by performance assessment (RAP and Benchmarking, opinion survey, and asset condition survey) to establish an advance analysis, not only on the current performance level but also sustainability level of an irrigation system.

Unfortunately, in the irrigation industry, an entirely appropriate framework for TBL reporting does not exist. Therefore based on the literature review, an improved TBL framework is developed that cover aspects: profit (water balance, productivity and efficiency; financial, economic and socioeconomic; asset sustainability; and business management), planet (enhance appreciation of farmers to the value of water; managing consumption in an efficient and effective manner; and maintenance of hydrological functions and reduce the impact of irrigation on the environment), and people (irrigation authority staff, farmers, WUAs and communities).

The findings from the existing performance and sustainability assessment then can be used to analyse existing system performance issues and its causes and to determine the physical and managerial interventions needed to improve irrigation system performance and sustainability.

Section 2.6 has explained that the priority of physical and managerial interventions can be determined through a stakeholders' opinion survey and a TBL sustainability viability framework assessment. The combination of the two methods is recommended for future research to obtaine the most viable intervention which is also most preferred by stakeholders. The stakeholder' preference can be tested using the simple pairwise comparison questionnaires and matrix, since it is the easiest way to determine priority. The most robust intervention option is obtained by utilising the stakeholders' opinion results to weight the physical and managerial interventions against a TBL sustainability viability framework.

Therefore, based on these reviews of the literature, ***Objective 2*** for this research is: assesses the sustainability of the existing irrigation system, assesses the performance and sustainability issues, its causes, and proposes alternative of physical and managerial interventions to improve irrigation performance and sustainability, and assesses the viability of these interventions.

Section 2.7 has demonstrated that the AMP of a transferred irrigation system should consider aspects of turnover, ISF, needs based budgeting, and timeframe of AMP. The improved, sustainable, and cost-effective AMP for transferred systems should also be developed based on the most robust interventions needed to improve irrigation performance and sustainability. The cost model for the AMP for a transferred irrigation system must consider elements such as useful life, depreciation, salvage value, asset value, and discount rate. Since, there is an increasing demand that irrigators should pay for the O&M costs and for a majority of capital costs of irrigation, the AMP should consider the sources and realistic levels of funding. Eventually, the improved, sustainable, and cost-effective AMP that enables WUAs to manage tertiary level irrigation system asset in the most cost effective and sustainable way only covers the budget priorities (investment priorities) (5 years), and budget planning (5 years).

Based on these discussions of the literature, ***Objective 3*** for this research is: to develop an improved, sustainable, and cost-effective AMP model that enables WUAs to manage the assets of a transferred irrigation system in the most cost-effective and sustainable way.

2.8.2 Research Stages

In order to achieve the ultimate research goal, the research utilise the basic stages of developing a potential application of AMP for irrigation in developing countries as proposed by the IIS. The basic stages consist of: defining system and function, defining sampling to represent the irrigation system, carry out the asset survey, assess system performance and sustainability to identify major problem areas that could adversely affect irrigation system performance and assess the priority of physical and management interventions needed to improve irrigation performance and sustainability, management studies, and assembling and presenting the AMP. The methodologies used for conducting research and the stages are discussed further in Chapter 3.

The AMP for transferred irrigation system developed from this research will contribute to encouraging farmers in rural Indonesia to reduce water consumption for growing crops, and it could help WUAs in rural Indonesia to improve water and irrigation asset management. It is expected that the most cost-effective way to manage irrigation systems could be implemented in other parts of Indonesia and other developing countries.

CHAPTER 3. METHODOLOGY

3.1 Introduction to Methodology

Section 2.8 set out the objectives of this thesis: to determine the most appropriate approaches of improving the performance and sustainability of the existing irrigation systems in rural Indonesia. Achievement of this aim involved three research stages as illustrated in the following flowchart:

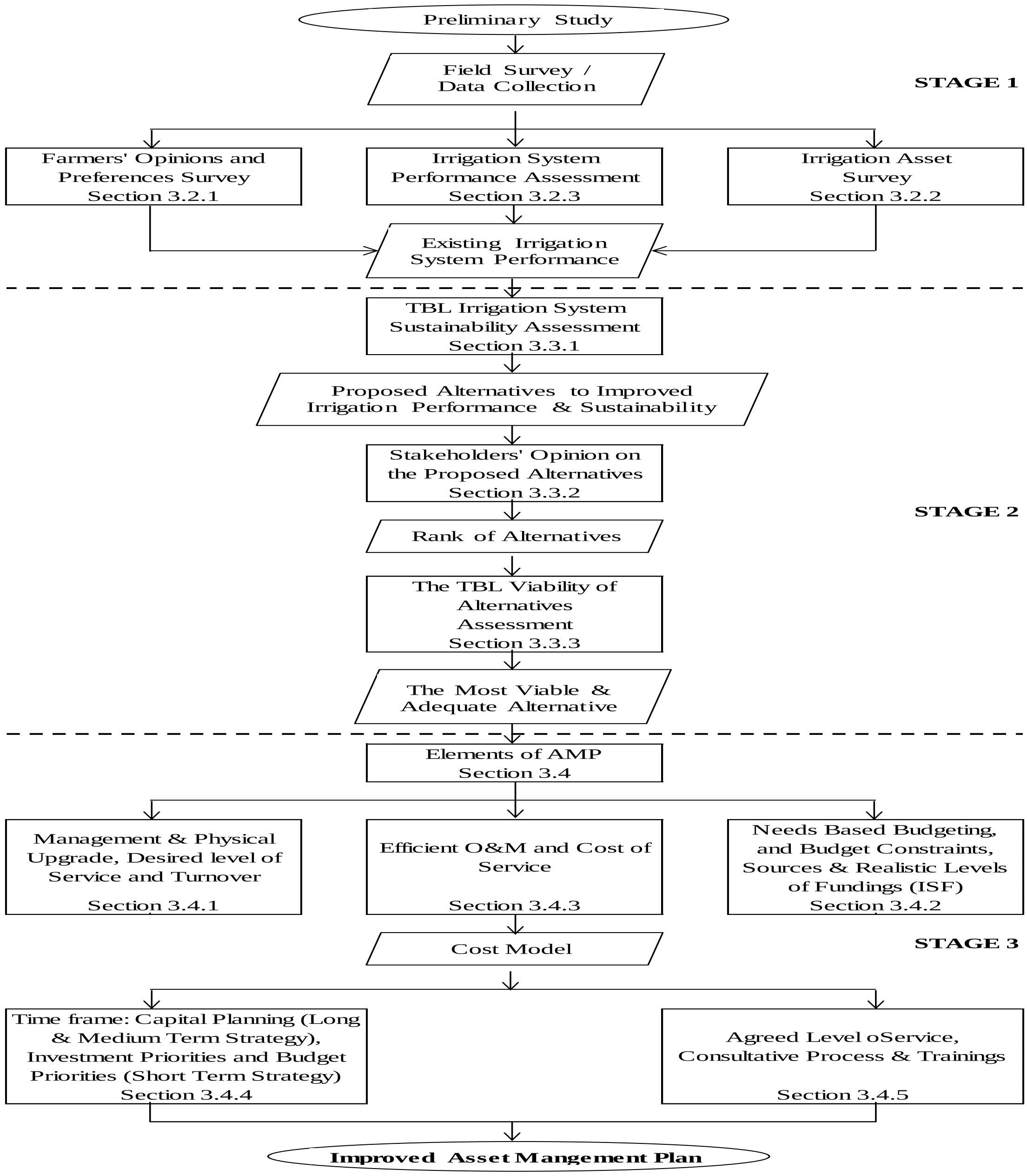


Figure 3.1. Stages of research

This chapter will describe the stages of the research, along with the in-depth methodology used to achieve the research objectives. Discussion will encompass the following:

Section 3.2 presents the methods used for assessing the performance of existing irrigation systems in rural Indonesia that consists of: preliminary investigation, asset condition survey, RAP and Benchmarking survey, and farmers' opinion.

Section 3.3 presents the methods used for assessing the sustainability of the existing irrigation system and assessing the alternative of physical and managerial interventions to improve irrigation performance and sustainability that consists of: TBL sustainability assessment, stakeholders' opinion survey and TBL viability assessment on the proposed alternatives.

Section 3.4 presents the processes of developing an improved, sustainable, and cost-effective asset management planning (AMP) for a transferred system that enable WUAs manage the assets of tertiary level of irrigation system.

Section 3.5 presents the summary of the stages and methods utilised in the research.

3.2 Objective 1: Assessing the Performance of the Existing Irrigation System in Rural Indonesia

Objective 1 assesses the performance of existing irrigation systems in rural Indonesia, using an internationally accepted method relating to performance in: service delivery, production efficiency, and financial and environmental impact performance of the turnover irrigation system. Performance was also assessed through a survey of farmers' opinions and preference regarding their satisfaction with irrigation services provided by the government of the day; and an asset survey to assess the asset condition and their service ability.

There were some steps required prior to the achievement of Research Objective 1. Data was collected sequentially and methodically to ensure validity and reliability. Collection began with a preliminary investigation and was then followed by a preliminary visit and fieldwork.

Preliminary investigation consisted of determining the functions of irrigation systems to be investigated, the case studies to be selected, and the preparation needed prior to field works such as the survey team, official paperworks needed, preliminary/secondary data to be established, and preliminary visits to case studies. Further discussion on preliminary investigation is in Chapter 4.

Fieldwork consisted of farmer opinion, condition of irrigation assets survey, and system performance surveys. In the fieldwork activities, the researcher will be accompanied on site by a member of the operating staff familiar with the day-to-day running of the part of the system concerned and a member of the WUA board/village leader.

3.2.1 The Farmer Opinion Survey

A survey research approach was chosen as it established trends in a large population of individuals. According to Creswell (2005), survey are procedures in which a researcher administers a survey or questionnaires to a small group of people (called the sample) in order to identify trends in attitudes, opinions, behaviours, or characteristics of a large group of people (population). The survey design requires greater access to the site as typically the researcher travels to the site and interviews people or observes them.

The farmer opinion survey was aimed to gather the opinions (discourse, perception, satisfaction) of the people affected by 'management transfer policy' and to obtain better insight into their wishes. By taking better account of those wishes in the planning and monitoring of the project, the chances of local support, co-operation, and benefit are increased.

There are methodologies, technique, preparation of questionnaires, and analysis of findings has to be considered in the opinion survey as described in Section 2.4.

The procedure of collecting quantitative data

1. Defining the target population

   As mentioned before, the systems investigated were the irrigation systems in rural areas with the discussion focusing on the tertiary channels, although the primary and secondary channels are not excluded. Eleven irrigation systems in the Province of Lampung were investigated. The surveyed population consisted of farmers who came from those irrigation systems, representing farmers in the large, medium, and small irrigation systems, and upstream, middle and downstream plot along the irrigation channels.

2. Specifying a sampling frame

   A successful statistical practice is based on focused problem definition. The sampling frame identifies and measures possible items in the population and must be representative of the population. This research studied the opinion and preference of farmers of the systems in order to identify farmer opinion, preference, and satisfaction about irrigation and drainage service, irrigation asset condition, management practice, WUA, farmer income and water measurement and tariff against the following criteria:

   - current level of service,
   - differences before and after participatory program was launched,
   - expectation of the level of service in the future,
   - willingness to bear the consequences (of service fee is raised) if the level of service is upgraded.

3. Specifying a sampling method

   An irrigation system serves an area of thousands of hectares. For example, in Indonesia, small irrigation systems serve an area of close to 1,000 hectares, medium irrigation systems, approximately 1,000 to 3,000 hectares, and large irrigation systems, more than 3,000 hectares. Consequently, sampling is an important aspect of data collection which is suitable to survey the performance and the opinion of farmers in irrigation systems.

   Sampling is the part of statistical practice concerned with the selection of an unbiased or random subset of individual observations within a population of individuals intended to yield some knowledge about the population concerned, especially with regard to making predictions based on statistical inference. The main advantages of sampling are that the cost is lower, data collection is faster, and because the data set is smaller it is possible to ensure homogeneity and to improve the accuracy and quality of the data. Determining the correct sample size requires information on the size of the population, the desired level of error, and the desired level of confidence.

   A probability sampling system is one in which every unit in the population has a chance (greater than zero) of being selected in the sample, and this probability can be accurately determined. The combinations of these traits make it possible to produce an unbiased estimate of population totals, by weighting sampled units according to their probability of selection. One of the methods of probability sampling is stratified sampling.

A sample size of stratified sampling utilises proportionate allocation or optimum allocation. Proportionate allocation uses a sampling fraction in each of the strata that is proportional to that of the total population. This research will utilise proportionate allocation, and the population will reflect the proportion of farmers in the head, middle, and the tail-end of irrigation systems.

Stratified random sampling is used where the population embraces a number of distinct categories. The frame can be organised by these categories into separate 'strata'. Each stratum is then sampled as an independent sub-population, out of which individual elements can be randomly selected. The benefits of stratified sampling are:

- dividing the population into distinct, independent strata enables researchers to draw inferences about specific subgroups that may be lost in a more generalised random sample,
- utilising this method can lead to more efficient statistical estimates,
- it is more convenient than aggregating data across groups,
- since each stratum can be treated as an independent population, the different sampling approach can be applied to different strata, enabling researchers to use the approach best suited for each strata.

Based on the area coverage of the irrigation systems, the stratification/subdividing of the study area for the research are set out in Table 3.1.

Table 3.1. Stratification of samples in the study areas

Small irrigation system		Medium irrigation system		Large irrigation system		Total
Irrigation system	Irrigated Area (ha)	Irrigation system	Irrigated Area (ha)	Irrigation system	Irrigated Area (ha)	
W. Ilihan Balak	384	W. negara ratu	1153	W. Pengubuan	3501	
W. Muara Mas I	343	W. Padang ratu	750			
W. Muara Mas II	48	W. Tipo Balak	941			
W. Muara Mas III	78					
W. Muara Mas	157					
W. Sri katon	325					
W. Tipo Lunik	356					
Total	1691		2844		3501	8036
% area	21.04		35.39		43.57	100

4. Obtain different types of permits

   The types of permission required for the survey are from or for:

   - the university (*see ethical issues*),
   - institutions or organisations: provincial and local irrigation authorities in the Province of Lampung,
   - specific sites: WUAs of the specific sites, and
   - a participant or group of participants (*see consent of participants*).

   The official letters of permission are presented in *Appendix B.1.*

5. Obtain informed consent of participants (farmer respondents)

   Prior to the distribution of questionnaires, the interviewers were required to read the consent form for the interviewees and asked as to their willingness to serve as objects of study (*see Appendix B.1.2*).

6. Ethical issues

   This research was carried out with regard to ethical issues that are tightly controlled by Curtin University (see *Appendix B.1.1* Form C Application for Approval of Research with Low Risk (Ethical Requirements) from the Office of Research and Development, Human Research Ethics Committee, Curtin University).

The design of questionnaire forms

Preparations were made in advance of the survey, these being:

1. Design of questionnaires

   Based on Abernethy, Jinapala and Makin (2001) suggestion (*see Section 2.4.3*), the questionnaire was designed as follows:

   - keep as short as possible: based on brief interview, seeking opinions of 12 statements in 68 questions,
   - use simple close-ended questions that can be used among communities with low to medium educational background: a choice of a or b,
   - ensure reliability in investigation of variations of opinion according to possible determinant factors: such as age, gender, location or landplot size,
   - use reliable and economical methods that enable the researcher to implement and adjust: quantitative statistical analysis methods,
   - questionnaires should be in local language: which is Bahasa Indonesian.

The questionnaire was designed to capture farmer opinion and discourse on the current irrigation level of service, perception of differences in service levels before and after the project was executed, expectation on the level of service in the future, and preferences if the irrigation service level was enhanced or infrastructure upgraded. The 12 statements and their related parameters are illustrated in the following table:

Table 3.2. Parameters for farmer opinion survey

NO	INDICATORS
FARMERS' PREFERENCES AND OPINIONS	
Operational Performance Indicators	
1	Irrigation service: adequacy/sufficiency, rate, timeliness, flexibility, equity (current level of service, the difference of service before and after transfer, expectation on the level of service in the future)
2	Drainage Service: ability of the property to dispose of drainage excess water into the collector system (current level of service, the difference of service before and after transfer, expectation on the level of service in the future)
3	Willingness to bear the consequences if service levels improved
Infrastructure Assets Condition	
4	Asset conditions: current condition, condition before and after transfer, expectation on the asset condition in the future
5	Willingness to bear the consequences if infrastructure upgraded
Management Practices	
6	Management: standard of service, standard of assets' maintenance, standard of rehabilitation/renewal/improvement of assets (current standard, the difference of standard before and after transfer, expectation on the standard in the future)
7	Staff: the degree of agency staffs' effort to arrange water delivery, the degree of responsiveness from agency staff, ease of communication between user and agency staff, and the degree of responsiveness from government to improve knowledge/ agricultural practice/ irrigation practice for farmer (current condition, condition before and after transfer, expectation on the asset condition in the future)
8	Willingness to actively involve in government program if it is provide
9	Water measures practice and water tariff: current practice & tariff, diference of practice & tariff before and after transfer, expectation on the practice & tariff in the future
Water User Association	
10	Effectiveness of WUA's organisation to accommodate farmers's needs: current, the diference before and after transfer, expectation on the future
11	Willingness to involve/contribute to WUA
Farmers' Income	
12	Satisfactory on: crop pattern/agricultural practice, productivity of your land/yield, and annual income from agricultural activities (current condition, diference before and after transfer, and expectation for the future)

2. Pre-test of questionnaire

The questionnaire was tested before it is used to collect data to ensure that the respondents respond the questionnaire as as expected. After the testing phase, any adjustments were made/questions reformulated to improve the respondent's understanding.

3. Opinion survey

An individual survey is better to capture individual points of view rather than interviewing larger groups which tend to produce synchronised mutually agreed upon responses. While, on-farm interviews help farmers to keep to the point and also enable the interviewer to check the farmers' discourses through field observations. However, for efficiency of time and expenses of the survey, the surveys were carried out in conjunction with the WUA regular monthly meetings which take place in the village halls. It was arranged with the help of the water authority local staff and WUA heads. The selected farmers were interviewed based on semi-individual and semi-direct on–farm (in the village). Semi-individual means that an interviewer guided a group of five to seven farmers in answering the questionnaires. While semi-direct on-farm means that the interviews were carried out at regular monthly meeting schedule of WUAs which were held in their village halls. (The complete questionnaire form for the opinion survey is given in *Appendix B.2.*)

Analysing and interpreting quantitative data

The type of data and measures gathered from the farmer opinion and preference survey consisted of factual information that measured the performance of the irrigation systems in the case studies. The data was analysed using a descriptive statistic test (cross tabulation and frequencies), with the Statistical Package for Social Science (SPSS). The results are presented in tables and charts and further discussions on the Farmers' Opinion are presented in the Chapter 4.

3.2.2 The Asset Survey

For the irrigation asset survey, secondary data on the pre-existing condition of assets was available from the consultants and relevant irrigation authorities. However, some of this data was not up to date, therefore the asset surveys was needed to check whether the available data was inline with current condition. The methodology of assessing the condition of assets and the methods of prioritising the irrigation system improvements is discussed in Section 2.6.1.

The selection of methodology

The methodology of the asset survey adapts the procedures developed by the IIS, University of Southampton, UK. The procedure was chosen firstly because it provides a comprehensive result of the condition of assets since it distinguish between asset condition and serviceability. It was also chosen because it provides preliminary guidelines for preparation of an AMP for irrigation infrastructure in the developing countries. The technique was derived from the UK water industry and was trialed in Yogyakarta, Indonesia to examine its potential application to irrigation in developing countries. Based on these considerations, it is expected that this method can provide a proper results of the assessment of the irrigation system.

Defining asset type, components, condition and serviceability

The unit measure of the assets will most commonly be the ‘number present’ or for linear assets such channels ‘length’ in kilometres. Assets are classified according to type and distinguished by ‘function’ at the first level and structural similarity at the second level.

Components of assets are defined in order to facilitate condition assessment when different components may be subject to different degrees of deterioration. An asset’s condition score is acquired by weighting the individual scores of its components and then adding them. The weighting factor suggested for a component is the proportion of its value to that of the asset as a whole.

A differentiation is made between the general condition of an asset and its ability to perform its function (serviceability). A number of grades between one and four were imposed to score the condition and serviceability of the existing irrigation systems (*see Appendix Table A.5.4*).

The type of asset surveyed, functions to be assed, components to check, and condition and serviceability ratings were based on IIS (1995) and the forms used for the asset survey was adapted as required to differences in the field (*see Appendix B.3*).

Design of survey forms

Based on the instructions given by the IIS, the asset survey was carried out as follows:

1. The survey will begin at the top of the system and work along its length. At least one route will be followed to the ‘bottom/tail end’ of the system (i.e., to the lowest point of interest within the AMP),
2. The assets are grouped and assessed as illustrated in the *Appendix B.3.1*, and the forms used for the asset survey are given in *Appendix B.3.2,*

3. A pair of surveyors work together to follow any section of the system (e.g. a primary or a secondary canal) through from top to bottom. Where branches occur, one branch will be completed before another is started.

Analysing and interpretating asset condition data

The condition of an asset are valued with Modern Equivalent Assets MEA to distinguish assets of differing condition and to give an indication of the likely cost associated with restoration. This information can be used for setting priorities in the rehabilitation and modernisation of irrigation assets in order to achieve efficient operation and maintenance (O&M) costs in the future. The discussion on the existing asset condition is presented in the Chapter 4, and further analysis on the O&M future spending plan (the asset management plan) on tertiary assets is presented in Chapter 4.

3.2.3 The Rapid Appraisal Process (RAP) and Benchmarking Survey

The system performance survey was carried out by reference to the Rapid Appraisal Process (RAP) and Benchmarking. The RAP and Benchmarking provides a holistic benchmarking that combines performance and process benchmarking. It measures performances both quantitatively and qualitatively in 46 external performance indicators (21 water balance indicators, 8 financial indicators, 9 agricultural productivity and economic indicators, and 8 environmental performance indicators), and internal indicators. It is internationally acceptance and has been used to asses the irrigation performance in most Asian countries and Latin America and Australia (*see Table 2.3 of the Section 2.3.4.2*).

Procedures for assessing irrigation condition and performance

Since the RAP and Benchmarking procedure only requires 1 – 2 weeks of collection and analysis of data both in the office and in the field, it is easy to apply as it also provides tools, detailed guidelines, and examples of how to use the tools. It is reliable and feasible as a procedure to assess irrigation performance in the study area.

The procedure consists of 12 worksheets that fall into two general types - input worksheets and summary worksheets. Input worksheets consist of worksheets numbered 1, and 5 to 11, while summary worksheets consist of worksheets numbered 4, and 12 to 14. Worksheet 1 is addressed by RAP and Benchmarking of external indicators which are summarised in Worksheet 4. Worksheets 5 to 11 identify the key factors of internal indicators and these are summarised in Worksheet 12 (*see Appendix B.4.1* for Worksheets for RAP and Benchmarking).

Burt (2001) gives guidelines on the application of RAP and Benchmarking, suggesting the following procedures:

1. It begins with a prior request for information such as cropped areas, flow rates into the project, weather data, budgets, and staffing, that can be assembled by the irrigation project authorities,
2. Upon arriving at the project, that data is organised and project managers are interviewed regarding missing information and their perceptions of how the project functions,
3. Travel down and through the canal network, talking to operators and farmers, and observing and recording the methods and hardware that are used for water control.

With this systematic diagnosis of the project, many aspects of engineering and operation become very apparent (Burt, 2001).

The external and internal indicators RAP and Benchmarking can be seen in *Appendix B. 4.2, and B.4.3*.

Analysing and interpretating RAP and Benchmarking data

Burt (2001) explained the process examines external input such as water supply, and outputs such as water destination (crop evapotranspiration, surface runoff, etc.). It provides a systematic examination of the hardware and processes used to convey and distribute water internally to all levels within the projects (from the source to the fields).

Meanwhile, the internal indicators, according to Burt (2001), review how the irrigation system actually works – what the instructions are, how water is physically moved throughout the canal/pipeline system, what perceptions and reality are, and other items such as staffing, budgets, and communication. Review of these items will immediately identify weaknesses and strengths in the irrigation system.

Appendix B.4 Table B.4.4 show the RAP and Benchmarking external indicators definitions, formulae, and the source of data. Calculation of the external and internal indicators data was done using the 14-Excel spreadsheets as shown by *Appendix B.4.1*. Further discussion on the analysis and findings of Research Objective 1 is presented in the Chapter 4.

3.3 Objective 2: Assessing the Sustainability of Future Indonesian Irrigation Systems

Assessing system sustainability entails reviewing the relationship between existing asset performance and management structure, and operational procedures regarding the system's sustainability. However, the relatively straightforward approach of using selected core indicators (i.e., RAP and Benchmarking), in dealing with complex natural resource socioeconomic systems like agriculture, have failed to live up to expectations since it looks at the net benefit from irrigation in relation to production outcomes only. The production outcome often achieved at the expense of environmental resources. Therefore, there is considerable pressure on irrigators and water supply authorities not only to improve their performance and demonstrate beneficial effects in the economic dimension but also socially and environmentally. Triple Bottom Line (TBL) reporting provides a means of showing the public that irrigated agriculture can be sustainable.

Unfortunately, even though TBL reporting or sustainability reporting are becoming a part of improving the sustainability of organisations around the world at the moment, however, in the irrigation industry, an appropriate framework for TBL reporting does not exist. The Sustainability Challenge Project of the Cooperative Research Centre for Irrigation Futures proposed an adaptive framework and methodology for improved TBL reporting by irrigation organisations (both rural and urban) (Christen, *et. al*., 2006). Since it is an adaptive framework and methodology, it is possible to modify the assessment framework for application by other irrigation-related organisations. This research modified the framework as set out in the Section 2.5.2.2.

The assessment also includes an appraisal of system performance problems/issues and its causes, and it quantifies the causes of the issues/problems. The sustainability assessments utilised the rating of: below compliance, compliance and beyond compliance/best practice to determine the sustainability of the irrigation systems. These assessments were aimed at determining the physical and managerial interventions/corrective actions/adjustment needed to improve irrigation system performance and sustainability.

3.3.1 The Triple Bottom Line (TBL) Sustainability Assessment

Defining the sustainability indicator frameworks

As discussed in Section 2.5, in order for an organisation to be sustainable it must take into account ecological and social performance in addition to financial performance (social, financial, and environmental aspects of organisation performance). However, since in the irrigation industry an entirely appropriate framework for TBL reporting does not exist, therefore an adaptive framework which was based on the illustrations given by Stapledon (*see Figure 2.2*), the four tier of ISAF (*see Figure 2.3*) and the RAP and Benchmarking indicators (*see Appendix B.4.4*) was developed. This framework can be used firstly to analyse the existing system performance problems/issues and its causes, and assess the viability of strategies to improve irrigation system performance and sustainability. A summary of the modified sustainability indicators framework as defined in Section 2.5.2.2 can be seen in *Appendix A.8*.

Analysing and interpretating The Triple Bottom Line Sustainability Data

The TBL assessment was carried out by integrating the findings from the Farmers' Opinion Survey, the Asset Condition Survey, and the RAP and Benchmarking Assessment into the TBL sustainability frameworks. The ratings are subject to aspects of the TBL framework for the existing irrigation systems is below compliance, compliance, and beyond compliance. The assessment also reviewed performance issues and causes and the results provided a set of physical and management interventions/corrective actions to improve irrigation performance and sustainability in the future.

The discussion on the TBL sustainability assessment is presented in the Chapter 5.

3.3.2 The Stakeholders Opinion Survey

Stage 1 (Assessment of Current Systems, see section 3.2) indicated the interventions including managerial changes and physical changes needed to improve irrigation performance and sustainability. The stakeholders of irrigation systems were then questioned regarding their preferences on managerial and physical intervention/corrective actions. The stakeholders opinion survey was aimed to identify the alternative strategies that are most likely to satisfy the concerns of affected farmers and provide a balanced view of alternative strategies among stakeholders (*see Appendix A.7).*

The procedure of collecting data

The stakeholders' opinion survey was conducted to obtain preferences on the proposed intervention/corrective strategies and to prioritise these strategies. It was also aimed to establish weightings or priorities for the evaluation of alternatives.

The basic principals of stakeholders' opinion survey are similar with farmers' opinion survey as described in Section 2.4. The respondents were carefully selected non-randomly based on their role of importance in the irrigation systems. Each irrigation system case study is represented by the WUAs leader; each of local irrigation authority (UPTD) is represented by the UPTD's head office. It coupled with irrigation authority staff representatives from both provincial and district/Kabupaten, the provincial board planning staff representatives, and consultants and contracting organisations who have long worked together to develop irrigation systems. The respondents interviewed individually in their offices/places of work.

The type and number of stakeholders interviewed are shown in the Table below:

Table 3.3. Type of stakeholder respondents

Category		**No. of respondents**	**Description of respondents**
Consumers	WUAs	11	Representatives of WUAs from each case study irrigation system. Farmers' water users are direct consumers of irrigation water provided by by the government. At tertiary and quarternary levels, the operation, maintenance, renewal, finance, and management responsibility of the systems fall on a financially autonomous WUAs.
The irrigation authority/decision makers	The Provincial planning boards (Bapeda Propinsi)	2	The provincial/district planning board has primary functions of which is to formulate technical policy of the provincial/district regional planning, and to monitor, evaluate and report the implementation of the planning.
	The district planning boards (Bapeda Kabupaten)	2	
	Irrigation authority	5	The principal implementing agencies of irrigation systems at provincial level is the Provincial Departments of Public Works, and at district/kabupaten level is the District Department of Public Works.
	The Unit Pengelola Teknis Daerah (UPTD)/the local technical implementation unit	5	Representatives of the 5 UPTDs that serve the 11 case study irrigation systems. The UPTD responsible for the day-to-day operation and management of an irrigation system
Consultant	Local consultants	17	The consultants who have many years of experience in helping the irrigation authorities in planning irrigation projects in the case study irrigation systems.
Total respondents		**42**	

The design of questionnaires forms

To test and measure the stakeholders' preferences on interventions/actions, an easy and quick method of the Simple Pairwise Comparison Questionnaires (*see Section 2.6.2*) was chosen since this method simply required the decision makers to compare the two alternatives at a same time. This method was used by the South East Queensland Regional Water to analyse its strategy in 2009 (Carden, 2006). It is the simplest way to reduce the task of evaluating and/or prioritising alternatives. It simply compares two alternatives at the time rather than all the possible options. This method works in the following way: A decision maker/stakeholder is confronted with a set of alternatives. He/she then simply compares alternative A with all the others, but one at a time, i.e. A is compared to B, and then A is compared to C, etc. When alternative A has been compared to all others, he/she repeats this process for alternatives B, C, etc.

The opinion survey questionnaires were carefully developed by taking into account aspects such as: ease of choice (select one of the two), reliability and economy, local language of Bahasa Indonesian. It consisted of three statements related to managerial interventions and three statements related to physical interventions. This was developed into 15 questions that simply asked the decision makers to compare two alternatives at the same time (*see Appendix B.5*).

Analysing and interpreting the data

As explain Section 2.6.2, simple pairwise comparison is more superior than other MCDA techniques in term of dealing with with compare, rank and evaluate large numbers of criteria and alternatives accurately and consistently. Therefore, the questionnaires were then analysed using the Simple Pairwise Comparison Questionnaire and Matrix Analysis as shown below:

Table 3.4. Example of simple pairwise comparison matrix

		Alternatives					**Number of times alternative dominates**
		A	**B**	**C**	**D**	**E**	
Alternatives	**A**		a	a	a	a	4
	B			b	d	e	1
	C				d	e	0
	D					e	2
	E						3

Implies decreasing order of importance: A, E, D, B, C.

(Source: Carden, 2006)

The matrix generates an ordinal and cardinal output. Ordinal output informs decision makers of the order of importance of each alternative: e.g., A is more important than E. Cardinal output refers to the relative scale of the importance of alternatives: e.g., A is four times more important than B. The cardinal output can be used to derive the weightings of each alternative. This is achieved by normalising the results of the level of dominance of each alternative, which is a simple arithmetic process (Carden, 2006).

Further discussion on the Stakeholders Opinion analysis and findings are presented in the Chapter 5.

3.3.3 Assessing the Viability of Proposed Interventions against the Sustainability Indicators Frameworks Assessment

In making choices to determine the physical and managerial interventions/corrective actions/adjustment to be implemented, it is important to establish weightings or priorities for the evaluation factors, criteria, and alternatives that are considered. There are some forms of Decision Analysis Techniques that can be used to assess the most preferable portfolio of options.

Choices (approaches) that require balancing conflicting objectives of people, planet and profit are among today's most challenging decisions. Although many techniques exist for helping decision makers to select among project alternatives, it is not easy to identify the TBL aspects based on clearly articulated stakeholder values and then using this information to create policy alternatives. Therefore, the priority options and the weight of options gained from the previous analysis needs to be tested further with regard to the different aspects of the TBL to determine viability. The higher the value obtained by an action, the more viable, therefore the action can be regarded as the most suitable and appropriate option to be implemented.

The Triple Bottom Line sustainability viability assessment framework

The framework of the TBL sustainability viability assessment was developed by employing the goal model. Employing a goal model implies that the TBL sustainability viability assessment of these corrective actions should be evaluated in terms of the degree to which the TBL goals are achieved. It takes into account some implications as described by Small and Svendsen (1990) such as:

1. Subjectivity: It is impossible to evaluate the TBL sustainability viability performance of a system in a purely objective fashion both in the establishment of the goals and in the way in which differing (and sometimes conflicting) goals are weighted.
2. The criterion of objectives: The TBL sustainability viability objectives should be evaluated in terms of the degree to which the goals are achieved. The viability of the approaches was developed and tested against key sustainability issues that are the goals to be achieved in implementing the approaches.
3. Levels of evaluation: The TBL sustainability viability was assessed based on viability, that is, the degree of goal attainment. The goals were specified in terms of the results achieved (output goals or impact goals).
4. Whose values and goals: The goals were established based on the stakeholders' irrigation values and goals.
5. The purposes of the assessment: The purposes of the TBL sustainability viability assessment is to analyse further what has been obtained from the previous assessment i.e., the existing performance assessment and the TBL sustainability assessment of the case studies irrigation system and to find out the appropriate approaches to improve the TBL sustainability of the irrigation systems in the future.
6. Types of assessment measures: The type of measure was indirect since the parameters used were based on the data obtained from previous performance assessments and stakeholders' opinion on the proposed approach to the improvement of irrigation systems.
7. Standard: The TBL sustainability viability assessment is considered as an external standard since it was derived from a variety of sources. To make comparisons of performance between systems it is necessary to use external or relative standards and to incorporate a time dimension into performance evaluations, since an irrigation system has year-to-year variability in conditions; and there are possibilities for conflicts between short-term performance and the sustainability of the irrigation system over the longer term.

(*See Appendix 6.4* for the key issues, goals/objectives, criteria and statement of sustaianability viability assessment framework).

Based on the above criteria, the viability of the interventions/corrective actions/alternatives are tested against three key sustainability issues i.e., the goals to be achieved in implementing the alternatives. The three key sustainability issues that were used in this study are:

- technical and economic,
- social, institutional and legal issue, and
- environmental, public health and safety.

These key issues were then developed further into several criteria of sustainability/viability that determined whether the goals were achievable. A number of important rules which facilitate an objective approach to achieving the goals for each criterion are: to be independent, non-duplicative, measurable and exhaustive. The flow chart was used in assessing the viability of the proposed interventions:

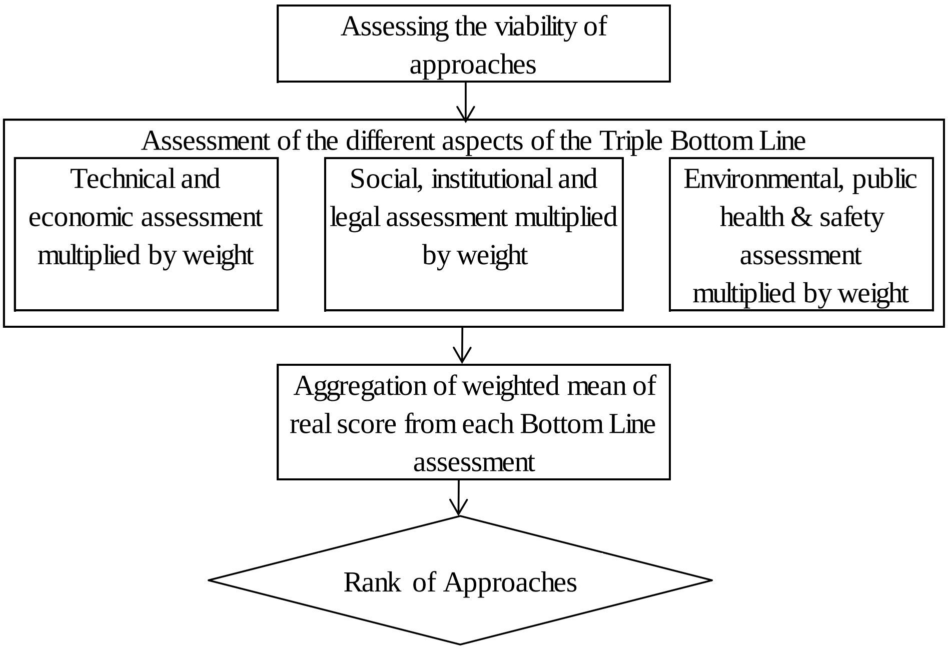


Figure 3.2. The TBL viability assessment of the proposed interventions

Analysing and interpreting the data

Each criterion of the three key sustainability issues was measured through examining statements in which a score was imposed based on the ability to satisfy the statements. The scores were 1 for low, 2 for moderate and 3 for high. Weights were also allocated to each criteria based on the rank of the options obtained from the stakeholders opinion survey analysis using the Pairwise Comparison Matrix and Analysis. The higher the value obtained by an action, the more viable.

Further discussion on the TBL sustainability viability assessment of proposed intervention priorities is presented in the Chapter 5.

3.4 Objective 3: The Improved, Sustainable, and Cost-effective Asset Management Planning (AMP)

Following the Stage 1 and Stage 2 of Research, the findings were assembled in a manner which facilitated integration and analysis within the AMP. The improved, sustainable, and cost-effective AMP that enable farmers to manage asset of tertiary level irrigation system developed in this research are aimed to help the government in providing an appropriate system to match local capability and resources. These can be built on and developed over time, promoting such incentives as effective and viable user association impact training, assigning the roles and responsibilities of different actors in a credible way and extending technical support pertaining to the management of the irrigation system.

The AMP activities were developed based on the priorities of physical interventions generated from the previous stage. The improved, sustainable, and cost-effective AMP was developed based on the guidelines for the preparation of an AMP for irrigation infrastructure provides by the IIS, University of Southampton, UK. The IIS was chosen since it was developed based on a technique derived from the UK water industry and its potential application to irrigation in developing countries was examined in Yogyakarta, Indonesia.

Elements of AMP that relevant for further analysis for the irrigation system are:

3.4.1 Turnover, Management and Physical Upgrades, and Desired Level of Service (LoS)

Turnover has been introduced to enable better water management and water distribution at the farm level. As a consequence, the construction of tertiary networks is, in principle, considered as the responsibility of the farmers together with the responsibility for the operation and management of tertiary networks.

The government has a crucial role to play in the irrigation sector, taking responsibility for the day-to-day management, operation and management of the irrigation system transferred to water users with a view to expediting and improving water management at the farm level. It keeps the administrative and operational requirement as low as possible and the number of control structures in the canal to a minimum.

Future asset rehabilitation, reconstruction, repair, and renewal of irrigation systems were adjusted according to the priorities of managerial and physical interventions generated from Stage 2 research and the availability of O&M funding at tertiary level of irrigation system. The aim of the asset renewal or modernisation strategy is to identify and choose the optimum asset for a particular service. This includes optimising both the technical and financial options suitable to improve the performance of the assets and sustainability of the system. While, managerial interventions focus on the introduction of a set of 'improved' practices in the operation of irrigation system.

Management and physical upgrade and turnover of tertiary level irrigation system are intended to improve the level of service of existing irrigation systems, minimise costs, and maximise benefits.

3.4.2 Needs based Budgeting and Budget Constraints, Sources and Realistic Levels of Fundings (ISF)

The improved, sustainable, and cost-effective AMP provides information on spending activities on the assets in the future that includes:

- capital investment activities: costs associated with the works undertaken to rehabilitate, upgrade, extend, or improve existing system infrastructure,
- system operating costs: typical costs associated with the operation of the system are staff costs, equipment costs, transport, etc.,
- routine maintenance costs: referencing and recording cost operations over time, looking at a particular pattern of capital investments for deteriorating assets and operations enables observation of costs trends which allow preparation of an operating expenditure (OPEX) budget,
- replacement and renewal costs: parts of the irrigation system will eventually need replacement and renewal,
- depreciation: in the economic analysis of a project, depreciation should be considered.

The budget allocated for each type of activities were based on the needs and priority since it has been know in advance that the most of the irrigation system have limited funds and the ISF collected from the farmers is very small and not sufficient to fund the irrigation system

There are various methods of charging irrigation water. According to Sampath (1992), prices are often determined by the amount needed to recover at least the cost of maintenance and operation of irrigation projects. Public irrigation water is usually associated with this approach since the objective is to provide service to the user at a reasonable cost. Consequently, public irrigation should seek a strategy to increase the price to an amount sufficient to cover the project as well as to promote efficient use of scarce irrigation water. However, the application of water charges and collection of water charges for cost recovery and the O&M of public irrigation systems are often complicated by various factors such as a fundamental belief that water should be free, along with the difficulty of measuring use volumetrically.

Sampath (1992) suggested a solution that may resolve the O&M of public irrigation systems problem is to devolve financial autonomy for O&M to user groups (WUAs). The inclusion of WUAs in irrigation management is a mechanism for introducing user incentives and they can play a key role (rights and responsibilities) in the management of a small irrigation system (minor irrigation infrastructures). The implication of this policy is that either the user should pay all O&M costs, and as much as possible of the capital costs.

WUAs also responsible to allocate water amongst its members and to collect the charges. The ISF established at the tertiary level is aimed at generating and allocating sufficient funds to properly operate and maintain transferred irrigation systems as well as for efficiency and sustainability of irrigation land and water resources and the sustainability of irrigation system. A workable ISF rate in the irrigation system is based on a per hectare (area) basis.

Assumptions made for analytical purposes and justification in examining types of O&M of this research is that O&M at tertiary level of irrigation system will be fully funded on channels and drains only, excluding flood control, tubewells, and other structures (small dams, building). The cost components consist of: capital investment activities, system operating costs, routine maintenance costs, replacement and renewal costs, and depreciation.

3.4.3 Cost of Service, Irrigation Service Fee (ISF) and Efficient Operation and Maintenance (O&M) of Tertiary Level Irrigation Systems

The turnover of management of tertiary level irrigation systems to WUAs means that WUAs are now fully responsible for assets and management at this level. In order to successfully manage tertiary irrigation assets, WUAs must use the option that minimises the whole-life cost of providing the required SOS (i.e., the optimum balance between maintenance and replacement costs). This option helps WUAs to ensure, where possible, that available funds are spent on planning, purchasing and installation, O&M, and renewal of tertiary level irrigation assets in a cost-effective way.

As mentioned in Section 2.7.3, there are three alternative asset management approaches suggested by the Australian Asset Management Collaborative group (2008). However the Option C, minimises the whole-life cost of providing the required SOS (i.e., the optimum balance between maintenance and replacement costs), should be taken for WUAs to operate its assets in a cost-effective manner. Effective asset management operation needs clear responsibilities for whole-life costs and sound information systems to support the best asset management decisions based on the whole-life cost. A historical record of past expenditure, coupled with a forecast of expenditure to sustain the SOS, is a solid foundation on which to establish life cycle costs (LCC).

In addition to these, there is a need to review whether the ISF established at the tertiary level is sufficient to properly fund the O&M of transferred irrigation systems.

3.4.4 Cost Model and Presenting the Asset Management Planning (AMP)

Cost model of efficient O&M assets of tertiary level irrigation system was utilised LCC. LCC is the total cost of ownership of over the life of an asset, including its cost of acquisition, operation, maintenance, conversion/upgrade/renewal, and decommission, with consideration given to the time value of money. The objective of LCC analysis is to choose the most cost effective approach to achieve the lowest long-term cost of ownership. A historical record of past expenditure coupled with a forecast of expenditure to sustain the SOS are a solid foundation on which to establish LCC.

Cost model is developed based on the MEA value of the assets. MEA value is the cost, at current prices, of a modern asset of equivalent function. The gross MEAValue is the full amount needed to provide such an asset at the current time. The net MEA value allows for the depreciation of asset value over its life.

The discount rate refers to the meaning of computations of the present value of an asset. The discount rate that was applied was constant discount rate and the rate was based on the Indonesia inflation rate for the last 20 years.

A formal asset management system should provide information on asset condition or performance and the future O&M strategies. The financial modelling process is one of reviewing and refining the provisional investment program presented in the AMP. Financial modelling considers constraints and priority influences in respect of:

1. alternative strategies,
2. capital planning (20 years),
3. budget planning (5 years),
4. budget priorities (investment priorities) (5 years), and
5. sources and realistic levels of funding (ISF, subsidies, etc.)

The discussion of the process of developing an improved, sustainable, and cost-effective AMP is presented in Chapter 6.

3.4.5 Agreed Level of Service, Consultative Process & Trainings

As mentioned in Section 2.7.5, an agreed level of service at tertiary level should be negotiated and established between farmers as service users who have to pay for this service and WUAs as service providers. Since the service level at tertiary level which is provided by WUAs is highly depend on the service level at upper levels which is provided by irrigation authority, a consultative process between WUAs and irrigation authority staffs needs to be established. As well as government support in strengthening the local resources and monitoring to show improvements in irrigation performance over time are needed in order to maintain the sustainability of implementing the improved, sustainable, and cost-effective AMP for O&M irrigation at tertiary level by WUAs,

3.5 Overview of Methodology

In summary, the ultimate objective of this research is to develop an appropriate irrigation asset management model that enables WUAs in rural Indonesia to manage transferred irrigation systems in the best/most cost-effective way. The discussion will only review the basic function of the irrigation system as a supplier of water for irrigation and will emphasize the tertiary channels of the system due to these are being farmer-managed.

Research data will be collected from the study area that was carefully chosen based on several considerations. The study area covers 11 (1 large, 3 medium and 7 small) scale irrigation systems across Way Seputih and Way Sekampung River catchment area on The District of Central Lampung, Sumatra, Indonesia. The systems are purely government-run on primary and secondary levels, and by the farmer water users at the tertiary level. Farmer water user organisations are formed and protected by the government.

Sequences of data collection began with the desk study/preliminary investigation that was aimed to establish relevant information prior to undertaking fieldwork. This was then followed by a preliminary visit that was aimed to obtain a more precise picture of the study area and to meet with the parties that would become sources of data for research. The fieldwork consisted of two opinion survey and field survey. The opinion survey was conducted by distributing questionnaires to a representative sample of farmers to gather the opinions (discourse, perception, satisfaction) of the people who are affected by the 'management transfer policy' and to obtain better insight into the wishes of the most affected people. Subsequent opinion survey to stakeholders also undertook to find out the preference of stakeholders on the physical and managerial intervention needed to improve irrigation performance and sustainability. The field survey consisted of an irrigation asset condition survey carried out to examine the existing conditions of irrigation assets and the RAP and Benchmarking system performance survey aimed to assess irrigation system performance. The data was obtained both on a system level and farm level for use as primary or secondary data.

The stages used to accomplish the research objectives are:

1. Stage 1: assessing the existing system performance (Objective 1)

   To gain a more in-depth understanding of performance and sustainability in existing Indonesian irrigation systems, the assessment incorporated methods of RAP and Benchmarking, an opinion survey, and an asset survey. The performance of existing irrigation and sustainability was analysed using the SPSS for farmer opinion survey and RAP and Benchmarking procedure for the performance of the existing irrigation system (*see Section 3.2*).

2. Stage 2: assessing the existing system performance and sustainability and the viability of interventions needed to improve irrigation performance and sustainability

   Integrating a TBL sustainability assessment to performance assessment results from Stage 1 was aimed to appraise the system performance issues and its causes, quantify the sustainability of the system, and indicate the physical and managerial interventions needed to improve irrigation performance and sustainability. Subsequently, the viability of the proposed interventions was assessed by using a Stakeholders' opinion survey and a TBL sustainability framework. Preferences of stakeholders were assessed by using the Simple Pairwise Comparison Questionnaires and Matrix Analysis. The results were then used to weigh the sustainability framework of the proposed interventions (*see Section 3.3*).

3. Stage 3: developing the improved, sustainable, and cost-effective AMP model that enables WUAs in rural areas to manage the transferred irrigation system in a best-cost effective sustainable way (Objective 3).

   The simplified AMP model for a transferred system was developed according to the guidelines for the preparation of an AMP for irrigation infrastructure provides by the IIS, University of Southampton, UK. Elements of AMP that relevant for further analysis for the irrigation system are: needs based budgeting, ISF, turnover program, and efficient O&M. It also is based on the most robust proposed physical and managerial interventions and by considering the aspects of budget constraints, and sources and realistic levels of funding. The AMP, consisting of budget planning and and short-term planning, was based on the the priorities of improving irrigation performance and sustainability (*see Section 3.4*).

The methodologies described in this Chapter were used to produce the results presented in the Chapter 4 (Stage 1), Chapter 6 (Stage 2) and Chapter 7 (Stage 3).

CHAPTER 4. DATA AND ANALYSIS OF EXISTING IRRIGATION SYSTEM PERFORMANCE

4.1 Introduction to Existing Irrigation System Performance

As mentioned in Section 2.1, Indonesian irrigation systems have issues with performance and sustainability. Water shortages are increasingly evident during the dry season in many parts of Indonesia, and irrigated areas are in decline for various other reasons. These issues are further aggravated by deferred maintenance and rehabilitation along with the ageing of irrigation assets caused by a lack of adequate funding. This lack of funding has created severe constraints on performance which will eventually result in low productive use of water and land for agriculture. Therefore, the performance of Indonesian irrigation systems must improve to respond to the drive for increasingly productive agriculture, whilst continuing to utilise scarce natural resources efficiently, wisely and cost effectively.

Improved irrigation system performance to achieve sustainable irrigation systems can be achieved through better asset management. The AMP for the irrigation system was developed through three stages. Assessing system performance is the first stage and major component of the AMP (Objective 1). This is necessary to determine how productive the use of water and land is for agriculture, to evaluate how to improve existing irrigation system performance, and to assess potential irrigation asset management systems where management can be performed independently by WUAs in rural Indonesia in the most cost-effective and sustainable way.

As mentioned in Section 2.2.3.2, it is important to choose which systems, what irrigation functions, and what kind of irrigation performance to investigate. This research presents eleven irrigation systems; case studies which are scattered throughout the Way Seputih and Way Sekampung river catchment area in the Province of Lampung. The performance assessment reviews focus on the recurring operation and maintenance (O&M) of supplying water for irrigation, and on the supporting activities associated with the basic function of irrigation systems – to supply irrigation water. The measurement of performance emphasises the degree to which the systems attain their established goals. Since the ultimate objective of this research is to develop an appropriate irrigation asset management model to enable

WUAs in rural Indonesia to manage turnover irrigation systems in a cost-effective way, the discussion focusses on tertiary channels of the system as they are farmer-managed. The primary and secondary channels are not excluded as they are the responsibility of the irrigation authority. The number of systems investigated was a compromise between the desired precision of research results and the data available.

Figure 4.1 shows the stages required in order to achieve research Objective 1.

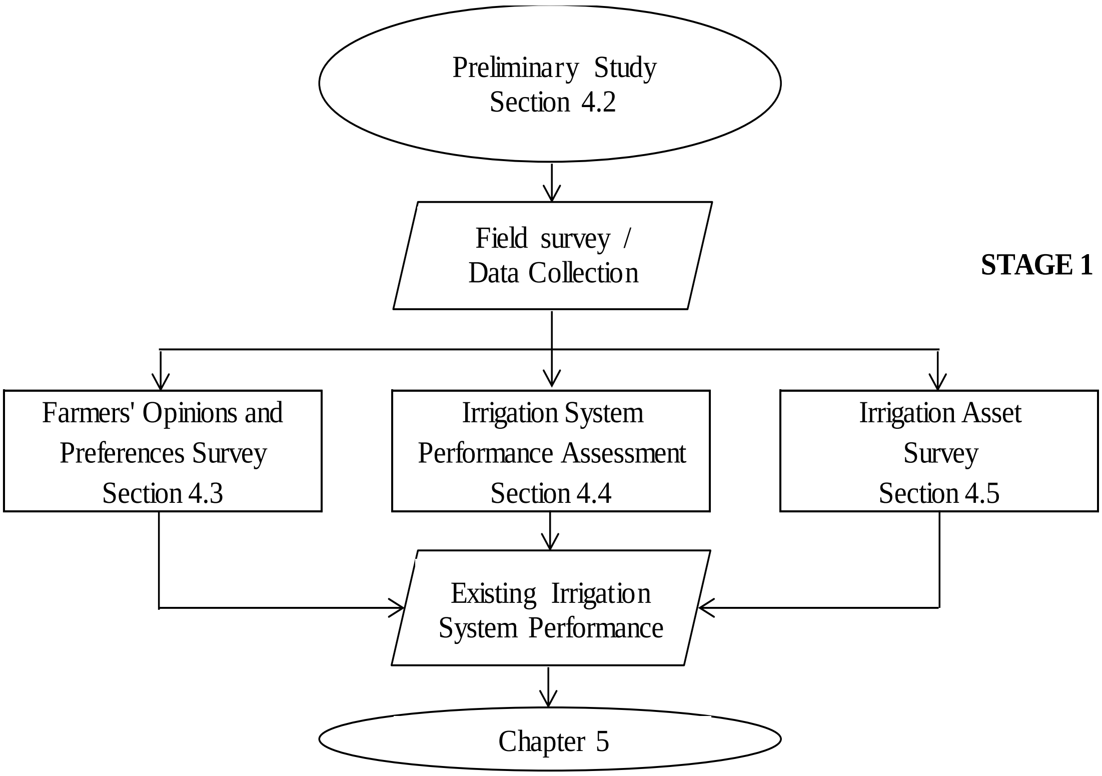


Figure 4.1. The stages of research Objective 1

Section 2.3.5 summarised the four key management areas of irrigation performance, which are: 1) water balance, 2) finance, 3) agricultural productivity, and 4) economic and environmental. To gain a more in-depth understanding about performance issues regarding existing Indonesian irrigation systems, performance was assessed by utilising the following methods: Rapid Appraisal Process (RAP) and Benchmarking, an opinion survey, and an asset condition survey.

This chapter presents the results of the irrigation systems performance assessment. The content of each section is described below: Section 4.2 presents the initial steps prior to data collection. The preliminary study consisted of collecting secondary technical data, reviewing what irrigation functions to investigate and determining what case studies to investigate.

Section 4.3 presents the data and analysis of the opinion survey. The opinion survey was aimed to gather the opinions, discourses, expectations and preferences of water users through a questionnaire. The data was then analysed statistically and the results presented graphically showing the following information: the demographic of respondents, irrigation and drainage service, infrastructure asset condition, management practice, and WUA and farmer income.

Section 4.4 shows the data and analysis of the irrigation asset condition survey. The asset condition survey was carried out by comparing the previously recorded assets condition (i.e., 2009) with the current assets condition. A grading system was used for condition and serviceability.

Section 4.5 illustrates the assessment of irrigation system performance, which aimed to determine the extent, function, condition, value, and performance of the existing irrigation system. System performance is assessed through external and internal indicators and the results are presented in a graph (*see Figure 4.2 to 4.49*).

Section 4.6 and 4.7 summarise the findings and recommends further actions following the findings.

4.2 Preliminary Study

Data was collected sequentially and methodically to ensure validity and reliability. Collection began with a desk study/preliminary investigation. It was aimed to gather secondary technical data available from the appropriate offices and consultants involved in projects associated with the irrigation system. This information was then reviewed and used for primary data collection purposes.

4.2.1 Defining and Identifying System and Function

The main purpose of irrigation system is to supply water for irrigation and to remove water by drainage. In addition to these, irrigation also functions to sustained an increase in agricultural productivity, increased incomes in rural sector, rural economic development, and improved livelihoods of rural people and sustained socio-economic development for the entire economy. Moreover, irrigation infrastructure is also commonly used for several subsidiary purposes such as non-irrigation uses of water, flood protection, etc. All of these purposes of irrigation system might be taken into consideration in evaluating irrigation system performance. The broader the purposes for which irrigation system is being evaluated, the greater is the significance that factors external to the activities of irrigation will have in determining the extent to which those purposes are achieved. Therefore, it is important to isolate functions to investigate, clarify the level of evaluation involved, and the extent to which factors external to irrigation affect the observed results. These are needed to provide clarity in system definition and performance assessment criteria.

Since the ultimate objective of this research is to develop an appropriate irrigation asset management model that enables WUAs in rural Indonesia to manage turnover irrigation systems in the best/most cost-effective way, it was therefore decided that this research would review only the basic function of irrigation systems that is to supply water for irrigation where emphasis was given to the tertiary level of the system as they are farmer-managed.

4.2.2 Selection of Location of Survey (Study Areas)

Previous investigations of Indonesia irrigation system performance were mainly done in Java; for example: Sempor and Wadaslintang irrigation systems, Central Java (Santosa, Susanto and Suparmi, 2010) Johnson and Reiss, 1993), Bondoyudo Mayang irrigation system, East Java (Wicaksono, Prasetyo, and Nobukazu, 2006), Cipanumbangan, Cinangka II, Planditan and Kaliduren irrigation systems, Java (Vermillion et al., 1999). Just by looking at performance reviews of irrigation systems in Java do not represent the performance of the majority of irrigation systems in Indonesia since it is widely known that irrigation systems are well developed in Jawa and Bali. Irrigation systems in Java and Bali account for about 31% of the total area of Indonesia irrigation systems. In addition, traditioned based irrigation organisations in Java and Bali represent mono-ethnics farming organisations involving only natives (ethnic Java in Java and ethnic Bali in Bali) who became farmers. Therefore, the case studies considered should located in provinces where irrigation infrastructure were developed properly since this is the profile of the majority of irrigation systems in Indonesia. As well as it should a multi-ethnics areas such as Lampung since it can represent the diversity of Indonesian tradition based irrigation organisations.

The Province of Lampung was chosen for some reasons. The province is one of the major rice production centres in Indonesia, and is a mainstay of regional food security. The following table shows the rice production in 2011. Based on the data obtained from the Central Bureau of Statistics Indonesia in 2011, the province of Lampung is the seventh largest producer of rice of the 33 provinces in Indonesia.

Table 4.1. Rice producers in Indonesia (2011)

Province	Harvest area (Ha)	Yield (Tonnes)	%
Indonesia	**13,203,643**	**65,756,904**	**100.00**
Jawa Barat	1,964,466	11,633,891	17.69
Jawa Timur	1,926,796	10,576,543	16.08
Jawa Tengah	1,724,246	9,391,959	14.28
Sulawesi Selatan	889,232	4,511,705	6.86
Sumatera Utara	757,547	3,607,403	5.49
Sumatera Selatan	784,820	3,384,670	5.15
Lampung	606,973	2,940,795	4.47
Others	4,549,563	19,709,938	29.97

(Central Bureau of Statistics Indonesia 2011)

The eastern part of the Central Lampung is determined as a centre of irrigated agriculture and is important for the food security of the Province of Lampung. Agriculture has great potential for further development. The main crops are rice, corn, soy and tuber. In 2009, the rice fields in this area took up 112,000 hectares and produced 591,160 tonnes of rice. This counts for 1.04% of Indonesia rice production (Crop agricultural Service, the District of Central Lampung, 2009).

The topography of the province can be grouped into hilly and mountainous, alluvial plain, tidal swamp and river basin region of Way Seputih, and the Way Sekampung river catchment area. In general, central Lampung has a humid tropical climate.

The population of this area is multi-ethnic since the province was a major resettlement destination in the Dutch colonial era and the Green Revolution Era. Thus rice farmer communities in Lampung reflect the culture from which they originate. The ethnic population of East Java, Central Java, West Java and Bali are the majority of communities who came to the Province of Lampung. Whereas, the Lampung indigenous ethnics only account for approximately 12% of the population. The population in 2008 was more than 1,177,967.

The main rivers are Way Seputih and Way Sekampung. The river of Way Seputih and its fourteen tributaries form a basin as wide as 7,550 km^2 and a total length of rivers as long as 965 km. The basin lies on the west of Central Lampung to Metro and East Lampung. The river of Way Sekampung and its twelve tributaries form a basin as wide as 5,675 km^2 and a total length of rivers as long as 623 km. These basins form the major irrigation systems that are the Way Sekampung and the Way Seputih system that serve 9 out of 15 districts/cities in the province. The irrigation systems are purely government-run on primary and secondary levels, and by the farmer water users at the tertiary level. The distribution of water at tertiary levels follows a tradition-based customary governances. Farmer water user organisations are formed and protected by the government.

Irrigation in Lampung is a fascinating mix of old, new, rehabilitated, planned, and abandoned irrigation systems. Modern irrigation structures are still built into the systems which were planned in the 1930s by the colonial government to support colonisation (i.e., to decrease population pressure on Java). The Way Seputih and Sekampung irrigation areas were the first irrigation systems developed in the Province of Lampung by the Dutch Colonial Government. The systems were developed from about 1935 with the construction of the Argoguruh weir on the Sekampung River to serve 20,600 hectares. Subsequently, the Government of Indonesia continues to develop the irrigation system through various projects during *Pelita*. At full development the total irrigated area within the Seputih – Sekampung basin increased to about 120,000 hectares. The potential for further water resources development in the Seputih – Sekampung among other things consists of :

- development/improvement of irrigation network totalling 153,334 hectares,
- development/improvement of swamp network totalling 12,924 hectares,
- development of water resources for electricity totalling 39 MW,
- development of fresh water network as much as 5,000 lt/s,
- development of water resources for tourism, which is Batutegi Reservoir and Way Jepara Reservoir.

The study area covers 13 irrigation systems across the Way Seputih and Way Sekampung River catchment area in the districts of Central Lampung, South Lampung and Tanggamus, however most of the irrigation system is located in Central Lampung. This district lies at the centre of the Province of Lampung with the capital city of Gunung Sugih. It lies between 104°35` and 105°50`E longitude and between 4°30” and 4°15`S latitude. The irrigation systems studied are as follows:

1. Large irrigation system: Way Pengubuan
2. Medium irrigation systems: Way Negara Ratu, Way Padang Ratu, and Way Tipo Balak
3. Small irrigation systems: Way Muara Mas, Way Muara Mas I, Way Muara Mas II, Way Muara Mas III, Way Tipo Lunik, Way Ilihan Balak, and Way Srikaton.

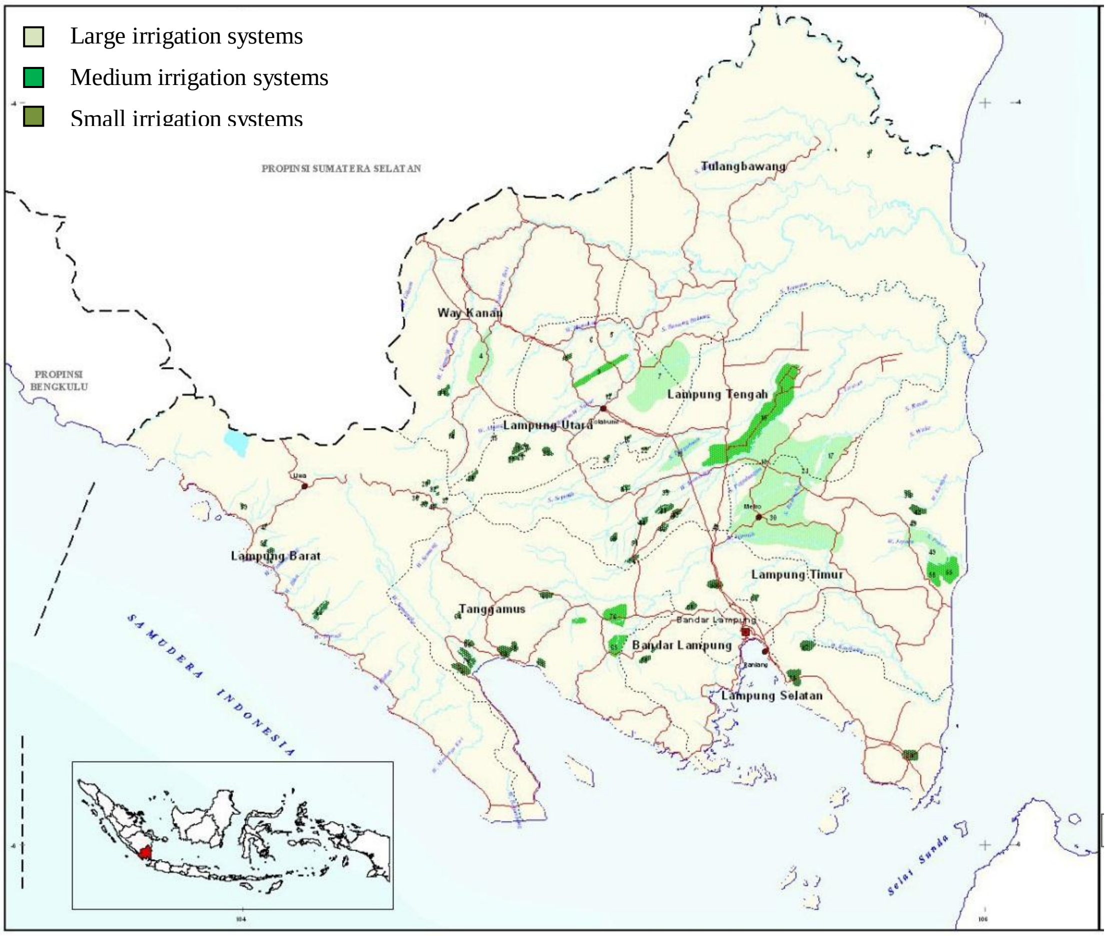


Figure 4.2. Study area location

The number of systems investigated will be a compromise between the desired precision of the research results and the time and resources available.

The case studies were chosen because from 2005 to 2012, they were granted the WISMP (Water Resources and Irrigation Sector Management Project) and PISP (Participatory Irrigation Sector Project). The PISP funded the rehabilitation works of tertiary level of irrigation systems which was designed to ensure that the deferred maintenance cycle is broken and that irrigation systems performance is maintained at or close to the original design level. The projects aims were to: consolidate the successful achievements of irrigation reforms, sustain the decentralisation of the management of irrigation systems, increase the sustainability of investments in the past, increase yield of irrigated crops, increase economic growth and reduce rural poverty. The projects implemented the growing need for the Participatory Irrigation Management approach. It is expected that the involvement of WUAs in project-funded rehabilitation will enable financial independence. This research utilised the latest data obtained from the project.

Because of the reasons above the investigation of Performance of the Existing Irrigation Systems was conducted in locations within this province. The research results from the study area are expected to be generally applicable to other areas in Indonesia and Southeast Asia.

4.2.3 Preliminary Data

Preliminary relevant information is an important part of preparation prior to undertaking field surveys. It establishes the availability of relevant information prior to undertaking fieldwork on each sample system. The Institute of Irrigation Studies - University of Southampton suggested that preliminary data should establish:

- a layout of the system, both as a survey drawing and as a schematic showing the positions of each asset,
- the area served by each offtake and thus, by addition, by each asset,
- the maximum design flows in each channel and at each offtake,
- records of previous surveys of the system,
- reports by operating staff of problems or particular maintenance needs,
- irrigation facility basic data, such as: year constructed, year transferred, command area (hectares), conveyance & distribution network, and type of assets in the systems.

4.2.4 Survey Team

In conducting field work, the researcher was accompanied on site by the staffs of the provincial irrigation authority and local technical implementation unit (unit pelaksana teknis daerah or UPTD) of the irrigation systems, the staffs of the consultants involved in the irrigation project and WUA heads. Since the level of trust and respect of WUAs and farmers as well as UPTD staffs to the provincial irrigation authority staffs are very high, the help from the provincial irrigation authority was needed to open up access to UPTD of the irrigation system and WUAs. Without their influence, it was hard to involve them in this research.

On the other hand, the help from UPTD staffs was needed since they were familiar with the day-to-day operation of the systems. They have direct access to the WUAs and farmers. With their help, the data collection and farmer opinion survey were more easier.

The researcher also enlisted some final year students to help with the field survey. They were known to be technically competent and possessed a basic knowledge of irrigation engineering. The researcher provided them with brief training on how to execute the irrigation asset survey and opinion survey.

4.2.5 Preliminary Visit

The fieldwork was aimed at collecting data to achieve the objectives of the study. Preliminary visits consisted of:

1. Visits to the government bodies and consulting and contracting organisations involved in the Sekampung Irrigation System. The visit aimed to acquire permission to conduct the research in the particular study area and to collect secondary data/documentation about the PISP project implementation in the District of Central Lampung.
2. Visits to the sample villages, before questionnaire surveys were distributed, to explain to the WUA representative and village leaders the purposes of this study and to encourage their active participation in the study.

Overall, preliminary study was useful to set up a plan for data collection so that data collection process goes well.

4.3 Water User Opinions and Preferences

The opinion survey was conducted between December 2008 and February 2009. As discussed in Section 2.4, The aim was to capture farmer opinion and discourse on the current level of service, perception of differences in service levels before and after the project was executed, and expectation of the future level of service and desire for service level or infrastructure upgrades.

This research utilised a quantitative method and simple closed-ended questions, written in the local language (Bahasa), and took into consideration the average education level of farmers. The questionnaires consisted of 12 statements related to irrigation and drainage services, condition of assets, management practice, WUAs, and farmer income (*see Appendix B.2*).

The population surveyed included farmers from 11 case study irrigation systems. A stratified random sampling method was used to ensure farmers from small, medium and large irrigation systems were questioned. The farmers selected were interviewed semi-individual and semi-direct on-farm (in the village). This was done to save the time and expense of the survey. The number of samples accepted for further analysis was 87 (out of 100). The stratified composition of sampling is presented in Table 4.2.

Table 4.2. The stratified composition of sampling

Irrigation system			Small	Medium	Large	Total
Indonesia		(ha)	3,256,004	1,355,971	2,863,361	7,475,336
		(%)	44	18	38	100
Lampung		(ha)	123,075	25,987	273,642	422,704
		(%)	29	6	65	100
Case studies	Project area	(ha)	1,691	2,844	3,501	8,036
		(%)	21	35	44	100
	Service area	(ha)	4,975	3,318	2,514	10,807
		(%)	46	31	23	100
No. of completed questionnaires			22	31	34	87
% of completed questionnaires			25	36	39	100

The table shows that the proportion of each type of irrigation systems varies largely among Indonesia, Lampung, and case studies. It was initially planned to stratify samples based on proportion of each type of irrigation system in the case studies. However, there was a difference between the proportion of the planned and the actual completed questionnaires. Subsequently, it was decided to accept all questionnaires since the figure was close to the planned and also taking into account the large differences in proportion of each type of irrigation system that exist among Indonesia, Lampung and case studies.

The questionnaire data was analysed statistically using descriptive statistics. It was then transformed into graph images to simplify interpretation. Figures 4.3 to 4.8 present the demographics of farmer respondents (*see Appendix C.1. SPSS Demographics*). Figures 4.9 to 4.23 show the results from the farmer water user opinion survey (*see Appendix C.2. SPSS Opinion Survey*).

4.3.1 Farm Characteristics

The farm characteristics are the statistical characteristics of the population in the irrigation system study areas. The farm characteristics surveyed can be seen in Figure 4.3 to 4.8. Detailed calculations on farm characteristics can be seen on *Appendix C.1*.

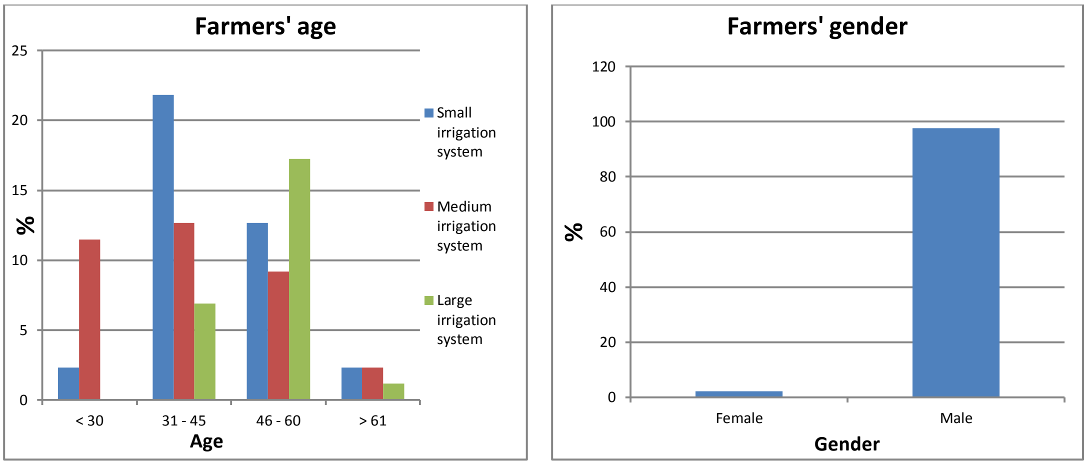


Figure 4.3. (a) Farmers' age and (b) gender

Figure 4.3(a) indicates a majority (94%) of farmers that actively cultivate their land are of child-producing age (between 31 and 60 years). While Figure 4.3(b) shows that the majority were men (98%) who work in the fields. Women also work in the fields helping their husbands, but the primary responsibility lies in the hands of the male population. Women often take on primary responsibility for the plot when their husbands die or move to work as labourers in the city.

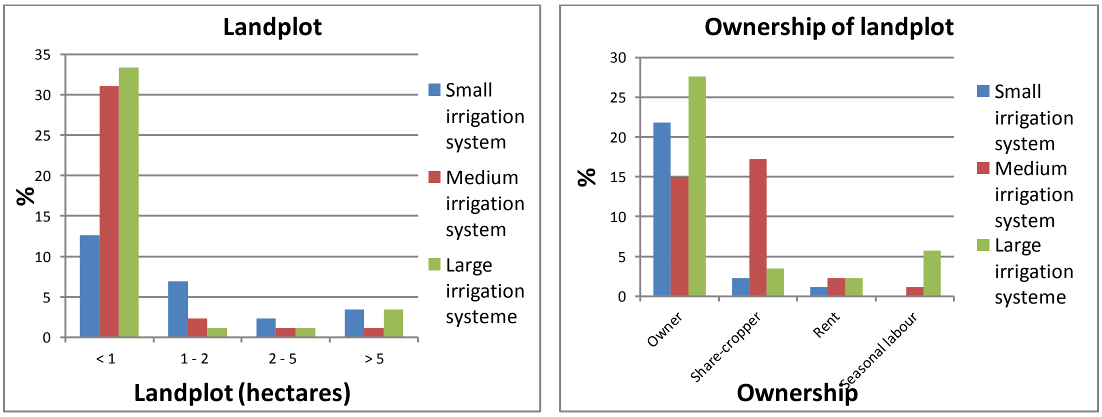
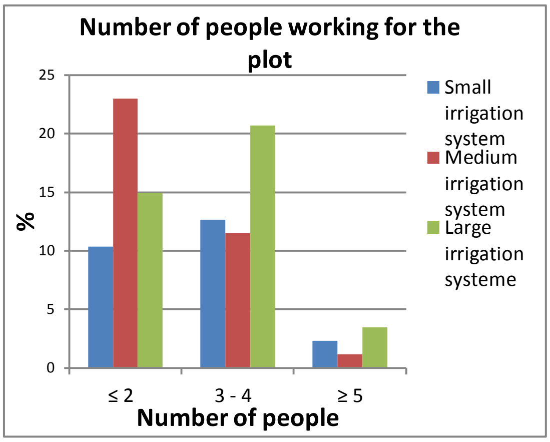


Figure 4.4. (a) Landplot size and (b) ownership of landplot

Figure 4.4(a) shows that regardless of the size of the irrigation system, most farmers (77%) have less than one hectare of agricultural land. This was reinforced by the data obtained from the field survey of RAP performance assessment that showed all the irrigation systems had an average of 0.5 hectares of agricultural land *(see Table 4.6 Section 4.4).* As illustrate in Figure 4.4(b), most farmers (64%) are farmers who own and cultivate the landplot themselves. Others are sharecroppers, tenant farmers and seasonal farm labourers.



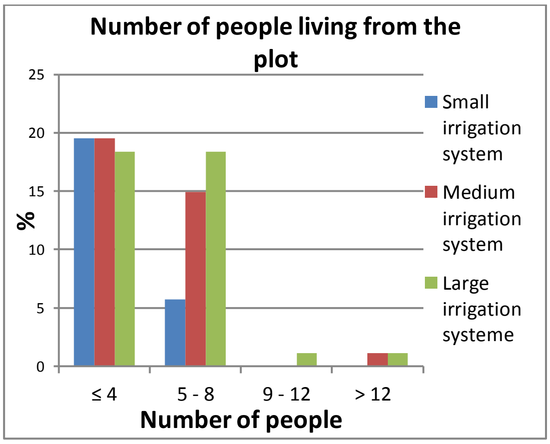


Figure 4.5. (a) The number of people working on and (b) living from the landplot

Figure 4.5(a) illustrates that 39% of respondents said the number of people working for the plot was less than two people and up to four people lived from the landplot. While, 36% said up to four peoples worked for the plot and five to eight people lived on the landplot. The rest was more than 5 peoples worked for the plot and more than 12 peoples lived from the plot. These, suggests that each landplot is commonly tended by one family, which consists of a parent and two children. This family composition is a sign of the success of the family planning program (*keluarga berencana* abbreviated KB) which was implemented by the government of Indonesia in 1970. The program planned to establish healthy and prosperous families by limiting births to two per couple. Currently most families in Indonesia, in urban and rural areas, have two children (Randall, E., 2012). A larger landplot may be tended by a large family consisting of the core family and close relatives such as grandparents, or the owner may hire people who feed their family by working on the landplot.

Figure 4.6(a) indicates that the main source (90%) of irrigation water in the areas comes from rivers that is Way Seputih and Way Sekampung. In addition to water supplied by the river, 9% receive additional irrigation water from a natural reservoir and only 1% gain additional irrigation water from wells. This suggests that the role of rivers is very important for rice farming in Lampung rural areas, so it is important to preserve the rivers in order to sustain irrigation systems and agricultural practice. Since the Province of Lampung experiences heavy rainfall and most of the region experiences a wet season between nine and ten months of the year, the potential for resourcing surface water and groundwater is large. This water resource could potentially support the expansion of an irrigation area or allow an increase in cropping intensity.

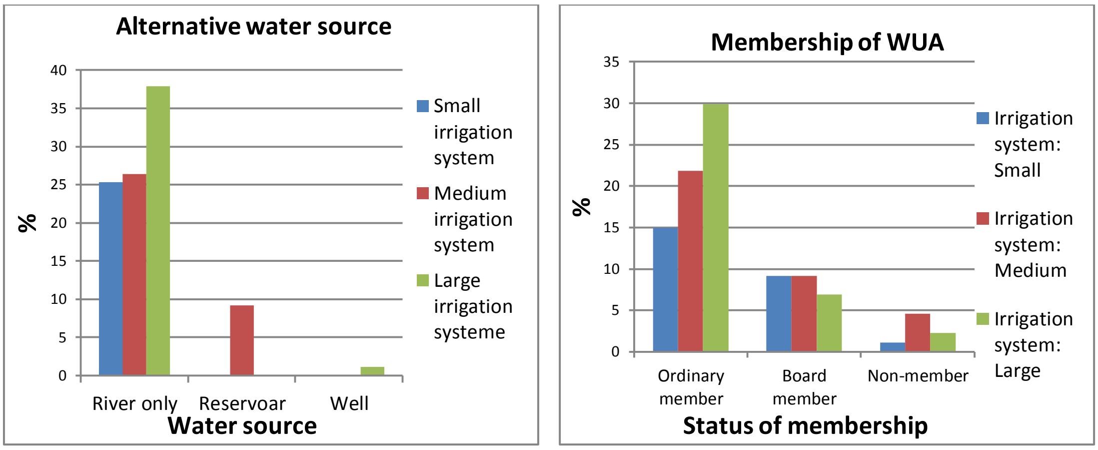


Figure 4.6. (a) Alternative water source and (b) membership of WUA

Figure 4.6(b) shows that almost farmers are involved in the WUA, either as members or board members (92%). Their involvement in WUAs were in voluntarily bases due to the benefits they perceive. The WUA facilitates monthly member meetings; these include social gatherings, meetings with government agencies related to irrigation and agriculture, and meetings with government-extended workers related to village improvement programs. In addition, WUAs facilitate the spread of information, provide promotional events for fertiliser suppliers and seed companies, and allow for the gathering of money for farmers in need.

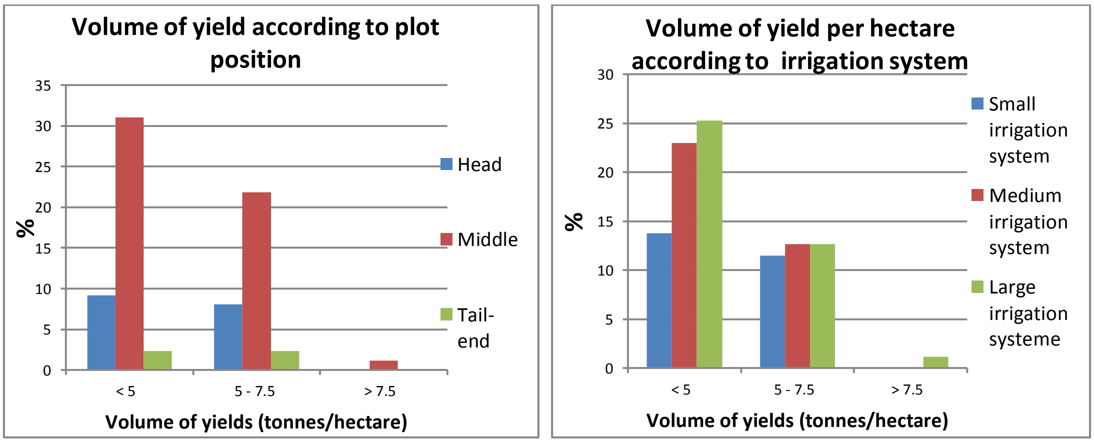


Figure 4.7. Volume of yield per hectare by (a) plot position, and (b) irrigation system

Figure 4.7(a) and (b) show that the volume of yield per hectare is generally between 5 and 7.5 tonnes. In total, 62% of farmers said their yield was under 5 tonnes/hectare, 37% had yields between 5 and 7 tonnes, and 1% of farmers had yields of greater than 7.5 tonnes/hectare. Landplots with a small irrigation system and those with a plot position in the tail-end tend to produce lower yields. This may be due to the fact that the service delivery of large irrigation system is better than medium and small irrigation systems as well as the fact that the position of landplots in the middle means that they tend to receive water more uniformly than landplots at the head and tail-ends (*see Chapter 4.5.2.1*).

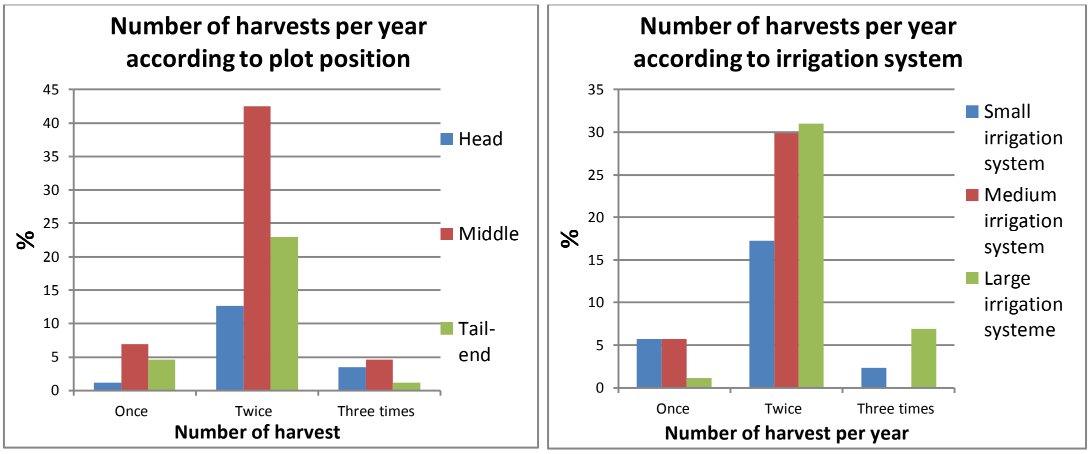


Figure 4.8. Number of harvests per year by (a) plot position, and (b) irrigation system

Table 4.8(a) and (b) show that the number of rice crop harvests is generally two a year (78%). Some areas can be harvested three times a year, but very few obtain a rice harvest three times per year. A common harvesting pattern consists of a rice crop harvest twice a year plus a harvest of *palawija* (crops planted in the dry season). The plot position in small and large irrigation system more likely to harvest three times a year.

Based on the results of the Census of Agriculture 2003, most farmers in rural areas have low economic capacity, and the yields gained from their landplot are just sufficient to meet primary needs. During a poor season with crop failure, farmers often cannot pay the monies owed for seed purchased at the beginning of the growing season, and they often go into debt just to feed their families (BPS, 2004).

4.3.2 Irrigation and Drainage Service

Irrigation management includes aspects of irrigation water utilisation that contribute to O&M, security, rehabilitation, and improvement of irrigation networks.

Operation and maintenance is at the heart of irrigation management and includes the provision, distribution, delivery, use and disposal, and maintenance of the irrigation network.

The daily management and operation of an irrigation system is carried out by a local technical implementation unit area called the UPTD (*Unit Pelaksana Teknis Daerah*). The UPTD is an extension of the government (central, provincial, or district) in the local area. At tertiary and quaternary levels, the operation, maintenance, renewal, finance, and management responsibility of the systems falls on the financially autonomous WUAs.

This section discusses farmer perspectives on the level of service of operation of irrigation systems. As mentioned in *Section 2.4.3.1*, operational performance in this study is concerned with the routine implementation of the agreed (or preset) level of service. As discussed in *Section 3.2.1*, the questionnaire consisted of 12 statements relating to irrigation and drainage services, condition of assets, management practice, WUAs, and farmer income. It aimed to capture the farmer's opinion and discourse on the current level of service, perceived differences in service levels before and after project execution, expectation of future service levels, and willingness to bear the consequences of upgrades to service levels and/or infrastructure. The results of the opinion survey can be found in Figures 4.9 to 4.12. Detailed calculations on irrigation and drainage service can be seen on *Appendix C.2.1*.

Figure 4.8 shows farmer perception about the current level of service in terms of water supply adequacy, water arrival times, flexibility and equity of service, and supply level or flow rate fluctuation. Water supply adequacy is the ability of the irrigation service to meet the water demand for optimum plant growth. With regard to adequacy, 70% of farmers are satisfied with the service provided.

There are patterns regarding the supplying of water to paddy fields; these are in accordance with the discharge conditions of irrigation water. If the discharge is greater than 70% of the discharge plan, the irrigation water from the primary and secondary channels flows continuously to plots through tertiary offtake structures. If discharge is 50-70% of the discharge plan, the irrigation water is supplied to the plots via rotation. The rotation can be set amongst secondary channels. Each rotation generally consists of three days of water delivery and each secondary channel gets three days-worth of water delivered to the plot until the water debt is reduced. When the discharge is less than 50% of the plan, discontinuous (intermittent) water supply is undertaken in order to make efficient use of water. Generally, water flows from the reservoirs for one week and then supply is closed for one week and this continues in an alternate fashion .

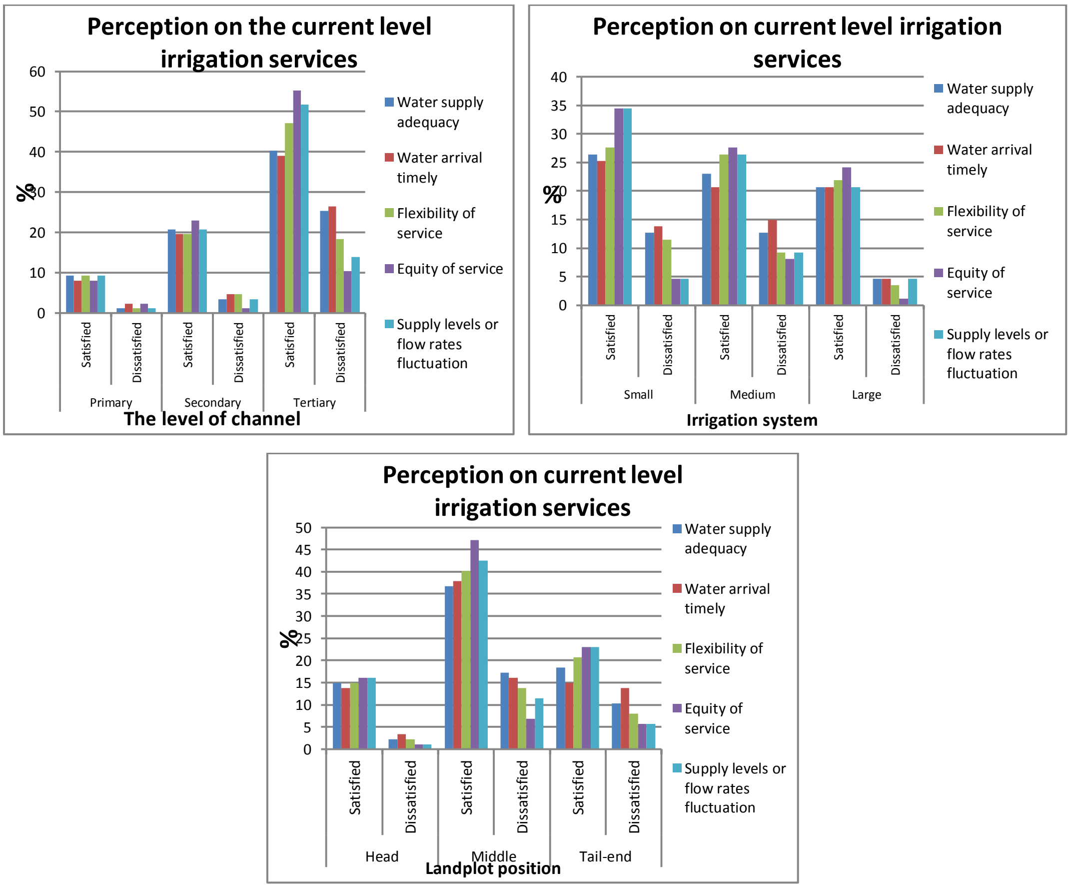


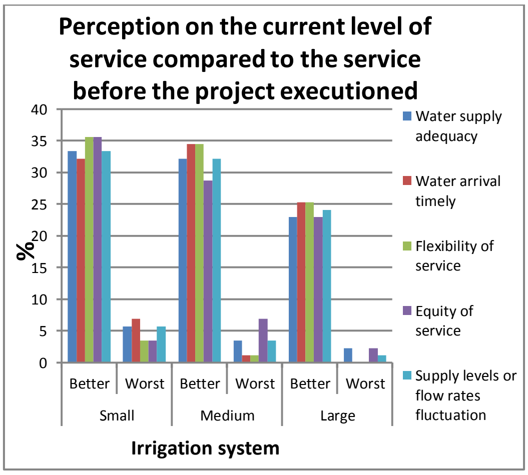
Figure 4.9. Farmer’s perception on the current level of irrigation service by (a) level of channel, (b) irrigation system, and (c) landplot position.

Reliability in an irrigation system requires confidence in the water supply, including a timely and uniform rate of supply. Based on the water arrival time, 67% of farmers were satisfied with the water arrival time. In addition, a majority (82%) of farmers were satisfied with the supply level or flow rate was quite uniform.

Flexibility allows farmers to choose the frequency, rate, and duration of water supplied. Farmers in rural Indonesia have this flexibility to a certain degree. The distribution of water to the landplots is generally carried out by rotation. This is generally arranged at the request of farmers, *Ulu-Ulu* and *Ili-ili* (local traditional institutions for irrigation water management), and WUAs. The water rotation arrangement is documented and must be approved by the local irrigation authority before implementation. Seventy-six percent of farmers were satisfied with the flexibility of the water service they received.

Equity of service is the fair distribution of water during a water shortage. In general, equity is not a problem during the rainy season where water is abundant. However, it becomes a sensitive issue during the dry season. Based on equity, 86% of farmers were satisfied with the service provided.

Based on the five components of service level, an average of 76% of farmers were satisfied with the current level of service.



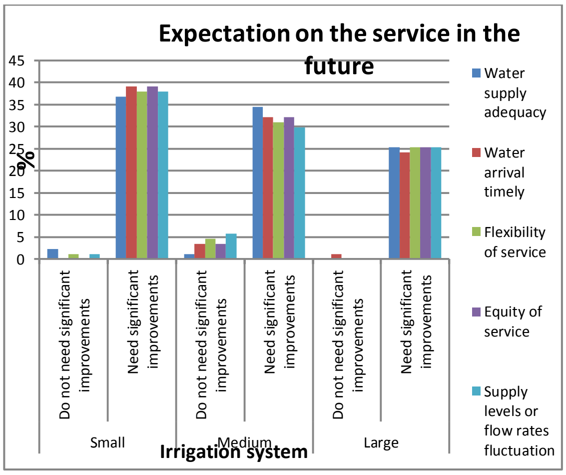


Figure 4.10. Farmers' (a) perception on the current level of service compared to the service before project was executed (b) expectation of the future level of service

Figure 4.10(a) shows the perception of farmers with regard to comparing the current level of service with the level of service before the project was executed. Figure 4.10(b) shows the expectation of service in the foreseeable future.

In all five areas of irrigation service, 91% of farmers felt that the level of service was currently better than before the project was implemented. Farmers were generally satisfied with the current irrigation service and thanked the government for providing an irrigation infrastructure for the improvement of their welfare. However, they still wish that the irrigation infrastructure could be further improved.

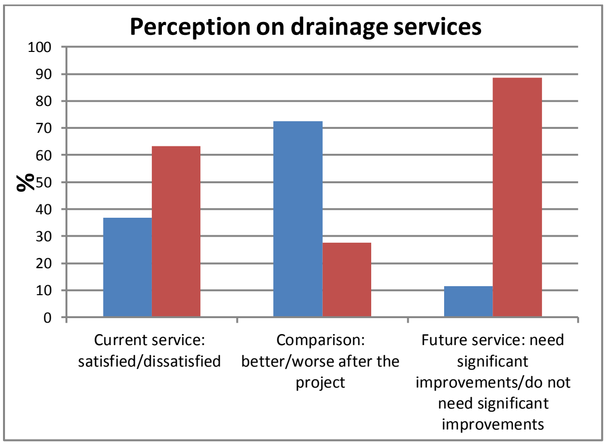


Figure 4.11. Farmers' perception on the current drainage service

Drainage services can be assessed through ability to confidently dispose of excess water in minimal time. This is necessary to prevent damage and to allow fair distribution of inundation risks. It also relates to the ability to choose the time, rate, and duration of disposal.

Figure 4.11 shows that only 37% of farmers were satisfied with the current drainage service. However, 72% said that the current drainage service was better than the service before the project was implemented. At the moment, most irrigation systems in rural areas do not have drainage infrastructure since excess irrigation water can be easily discharged into nearby water bodies, therefore only 11% of farmers said drainage facilities and service should be improved. However, since sustainability of irrigation water become an increasing issue, the irrigation system should start preparing drainage infrastructure to circulate irrigation water in order to improve the efficiency of irrigation water.

Upgrading the level of service means that farmers will get irrigation water in sufficient quantity, there will be greater reliability in terms of water arrival time and supply flow rate uniformity. There will also be a more equitable distribution of water, and farmers will have the flexibility to choose the frequency, rate and duration of irrigation water supply.

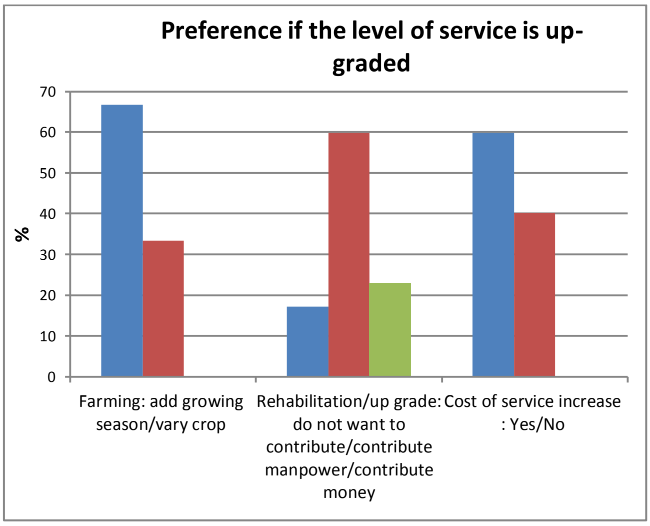


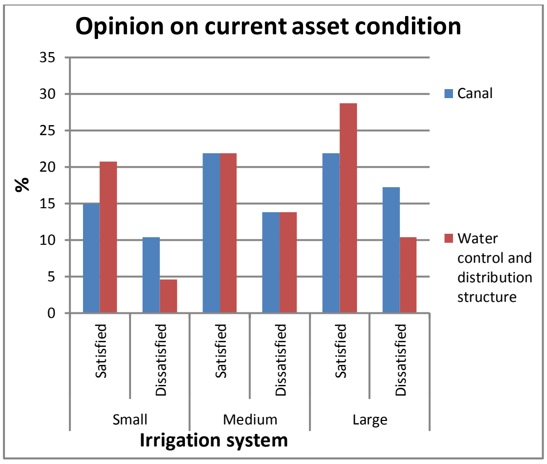
Figure 4.12. Farmers' preference if the level of service is up-graded

It can be seen from Figure 4.12 that if the level of service were to be upgraded, the number of farmers who would want to increase the number of growing seasons and vary their crops was 59% and 41%, respectively. Most farmers (60%) willing to participate by virtue of labour/manpower for upgrading activities and most of them (60%) also willing to pay higher irrigation service fee for better services.

In summary, farmers were generally satisfied with the irrigation and drainage services provided by the current government, even though the standard of service is far below that of irrigation and drainage service in more developed countries. This to the rural farmers being aware that over the years the government has continued to improve the service. However, farmers want further improvement in order to advance their economy and they are willing to support programs run by the government. Therefore, the improvement of irrigation systems based on labour-intensive farmer participation is more appropriate than capital investment.

4.3.3 The Infrastructure Asset Condition

The irrigation and drainage infrastructure consists of a large number of individual assets spread over a wide area including dams, channels and control structures. The opinion survey only focussed on farmer opinion of the conveyance, operation and measurement of assets directly linked to their landplot. This included the functional condition of channels, water control and distribution structures, and tools. Figures 4.13 and 4.14 show the opinions, perceptions, expectations and preferences of farmers regarding: current condition of assets, perception of asset condition before and after the project was implemented, expectation of asset condition in the future, and their preferences should the condition of assets be upgraded. Detailed calculations can be seen on *Appendix C.2.2*.



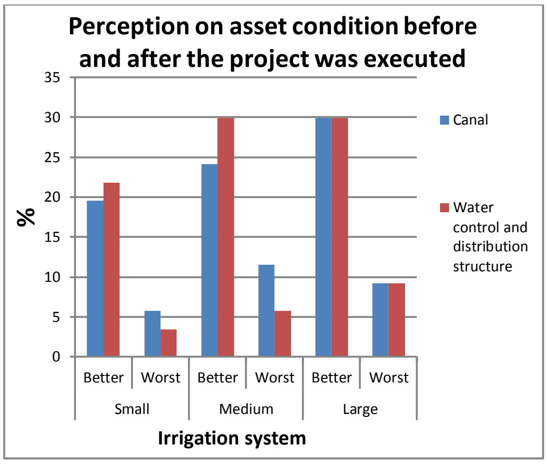


Figure 4.13. Farmers' (a) opinion on the current asset condition directly linked to landplot, and (b) perception of asset condition before and after the project was executed

It can be seen from Figure 4.13 that 59% of farmers were satisfied with the condition of the channels and 71% were satisfied with the water control and the distribution structure conditions regarding their landplot. They also said that the current conditions of assets are better compared with their condition before the PISP was implemented. On average 78% said that asset condition had improved subsequent to project implementation.

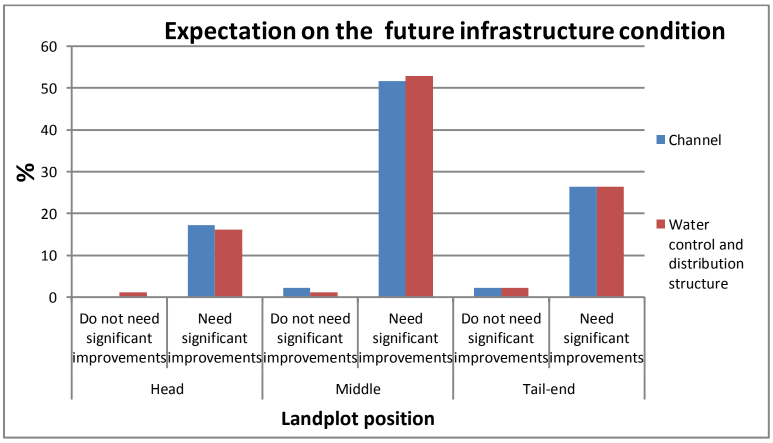


Figure 4.14. Farmers' expectations of future condition

To maintain the condition of an irrigation network, activities such as enforcement, rehabilitation and improvement of networks is required. Irrigation network enforcement is an attempt to prevent and control the occurrence of irrigation network damage caused by the destructive force of water, animals, or people. Rehabilitation of the irrigation system includes repairing the irrigation network and ensuring effective irrigation function and service. Irrigation network improvement/upgrading includes activities to repair irrigation networks which take into account changes in environmental conditions of irrigation areas. Although most farmers were satisfied with the condition of the existing infrastructure, Figure 4.14 shows that 95% felt that the infrastructure could be upgraded further to improve crop yields. The need to upgrade the channel was as great as the need for upgrade the distribution and control facilities.

The irrigation infrastructure in rural areas of Indonesia is still far below the condition of the irrigation infrastructures in developed countries. At the moment, to maintain the condition of the irrigation network, each irrigation system receives routine O&M funding from the authority responsible for the system; this funding differs in amounts depending on each class of irrigation system. A decentralisation policy in Indonesia led to the central government handing over full responsibility for irrigation systems financing to the local government. Areas involved in major rice production receive priority for development assistance from foreign aid; one of these areas is the Province of Lampung. From 2005 to 2012, some of the irrigation systems in the Province of Lampung received assistance through Participatory Irrigation Sector Project and Water Resources and irrigation Sector Management Project (PISP and WISMP) (National Development Planning Agency, The Government of Indonesia, 2007). Thus, the condition of irrigation infrastructure in this area continues to be maintained and developed through these projects. The impact is that farmers are satisfied with the condition of the current infrastructure condition; they feel that current conditions are better than those prior to project implementation, and they hope that future conditions will be even better.

The ability of the irrigation systems to maintain sustainability conditions is still in question. Based on past experiences, conditions often deteriorate rapidly after a project is completed and local irrigation management quickly revert to their previous pattern of maintenance. Therefore, the sustainability of irrigation systems relies on a policy framework that is focussed on improving and sustaining participation in the key tasks of equitable water distribution and maintaining the irrigation infrastructure.

4.3.4 Management Practice and Local Staff

Irrigation management institutions consist of government, local government, WUAs (P3A), and several other parties whose activities are related to irrigation management either directly or indirectly. The principal agencies which implement this are: the Directorate General of Water Resources Development, the Provincial Departments of Public Works, and the District Department of Public Works, along with the supporting implementing agencies - the Provincial and District Department of Agriculture. The division of authority, responsibility, and the working mechanisms of inter-agency irrigation management are implemented in accordance with existing regulations.

Basically, the authority of an irrigation system falls into three categories; central government, provincial, and district (*kabupaten*) authority. The central government administers irrigation systems of more than 3,000 hectares, or those which lie across two or more province borders. The provincial government authorises irrigation systems of between 1,000 and 3,000 hectares, or those which lie across two or more district borders. The district government authorises irrigation systems that are less than 1,000 hectares in size. To establish effective coordination between agencies in areas irrigated with a multipurpose network, a regional coordination forum can be implemented.

The principal implementing agencies are responsible for the operation, maintenance, renewal, finance, and management of irrigation at primary and secondary levels. These agencies are financially dependent on annual budget allocations from the central government, provincial government, or district government.

The day-to-day operation and management of an irrigation system is executed by the *Unit Pengelola Teknis Daerah* (the Local Technical Management Unit) or UPTD which is the extension of the government (central, provincial, or district) in the local area. At tertiary and quaternary levels, the operation, maintenance, renewal, finance, and management responsibility of the system falls on the financially autonomous WUAs. In strengthening the community of farmer water users, the activities of planning, decision making and implementation of proposed activities in the network operations requires involvement from the WUAs.

The opinion survey was aimed at establishing the opinion of farmers regarding the day-to-day operation and management of the irrigation systems which were overseen by the UPTD. The results can be seen in Figures 4.15 to 4.20. Detailed calculations of farmers’ opinion on management practice can be seen on *Appendix C.2.3*.

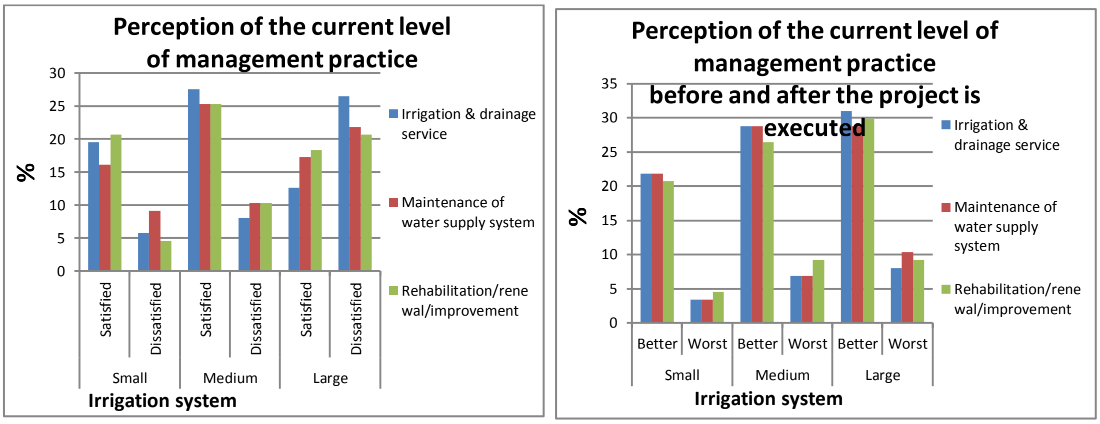


Figure 4.15. Farmers' perception on (a) the current level of management practice, and (b) the current level of management practice before and after the project was executed

Based on the survey, as shown in Figure 4.15(a), 62% of farmers were satisfied with the standard of irrigation and drainage service, maintenance of the water supply system, and rehabilitation, renewal and improvement of the system. Figure 4.15(b) shows that most farmers (78%) felt that the current level of management practice was better than before the project was implemented. Nevertheless, as shown in Figure 4.16, farmers still expect improvements in management in the future.

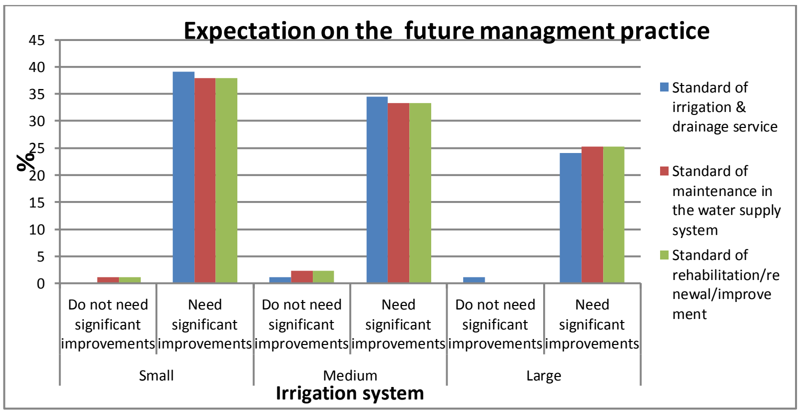


Figure 4.16. Farmers' expectation on future management practice

As mentioned previously, the day-to-day operation and management of irrigation systems in rural Indonesia is executed by the UPTD. Figures 4.17(a) and (b), and 4.17 show the opinions, perceptions and expectations of farmers regarding the staff of the UPTD. These are weighed against the degree of agency staff efforts to arrange water delivery, the degree of responsiveness of UPTD staff, the ease of communication between user and UPTD staff, and the degree of responsiveness of government with regard to the improvement of knowledge/agricultural practice/ irrigation practice for farmers.

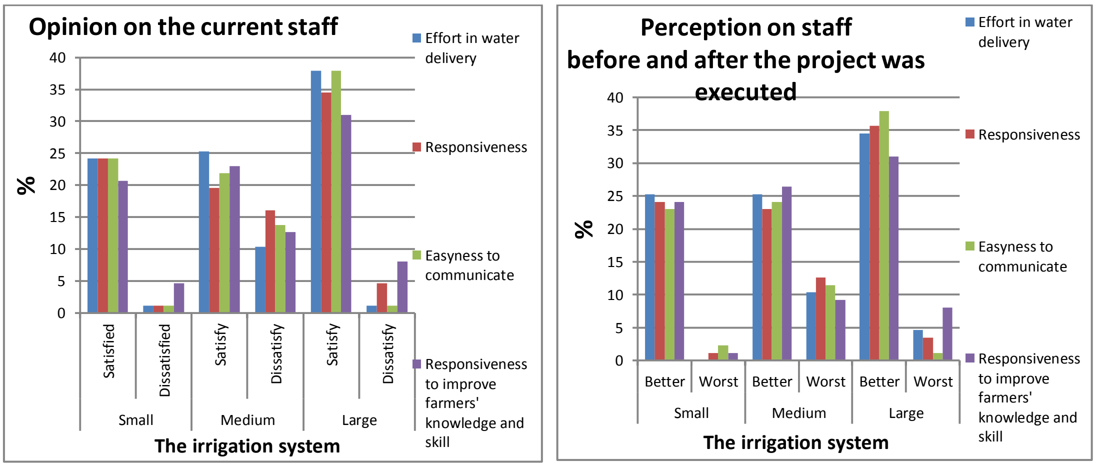


Figure 4.17. Farmers' opinion on (a) the current staff and (b) the staff before and after the project was executed

Figure 4.17(a) shows that an average of 79% of farmers are satisfied with staff performance. Figure 4.17(b) shows that on average, 83% of farmers feel that current staff are now better informed and perform better than they did prior to project implementation.

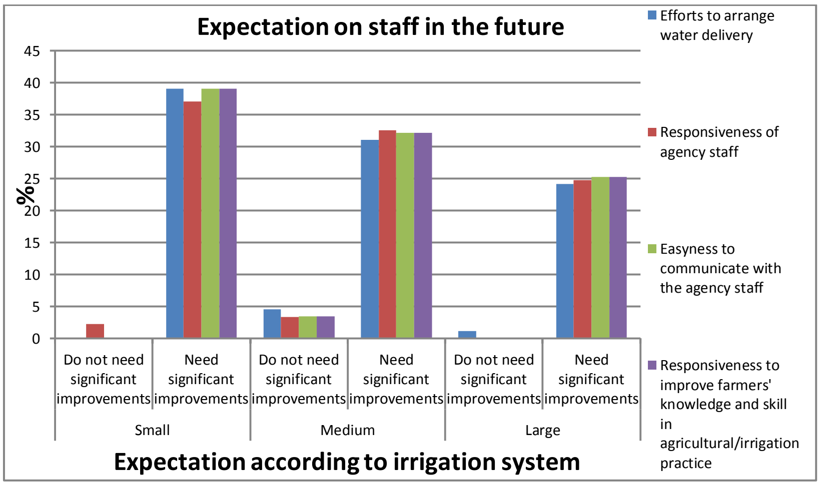


Figure 4.18. Farmers' expectation on staff in the future

Figure 4.18 shows that an average 97% of farmers expect the performance of staff to improve in the future. To support the staff, the government implements several national programs related to rural community and rural development, and provides extension workers/facilitators/village consultants to ensure the success of programs.

To improve tertiary canal systems, the government provides irrigation assistance at the farm level through activities such as physical rehabilitation of the tertiary canal system and establishment of institutional responsibility for the O&M of channels thereafter. An institutional solution that is being tried out with relative success is the establishment of WUAs for each tertiary canal. There are two main approaches for the establishment of these associations; the participatory approach and the public sector approach. The PISP project utilises a participatory approach that tries to motivate farmers into full participation in the planning and execution of improvements and for them to take subsequent responsibility for the O&M of tertiary channels.

To stimulate and accelerate the participation of village communities in the development of rural areas, the government provides extension workers/village consultants/facilitators to assist in implementation. A facilitator can help the village community with socialising, planning, implementing, and sustaining the participatory activities. He/she plays an important role in awakening a desire for change, persuading the community that they can achieve a dramatic improvement in the productivity of their village lands by their own efforts, and generating and guiding cadres of the village. A facilitator sustains the self-confidence of farmers by giving advice, by obtaining help where necessary from skilled technicians and craftsmen, and by assisting villagers to plan and implement desired improvements to the tertiary irrigation system. During the construction period, the facilitator is on-hand to provide any advice or supervision needed. In addition, if necessary, farmers/WUAs can contact the public agencies concerned and ask them to provide training in: organisation and management, technical quality of the irrigation system, O&M, financial management and the level of investment, and crop husbandry.

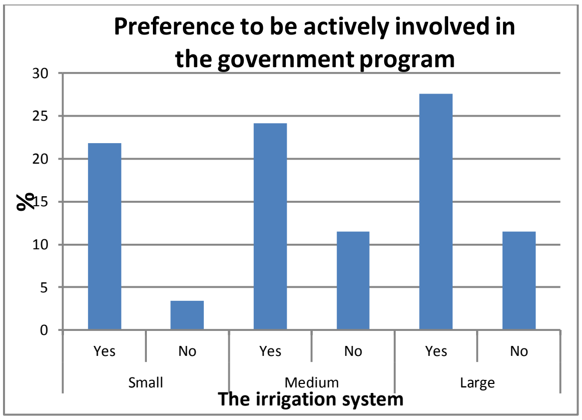
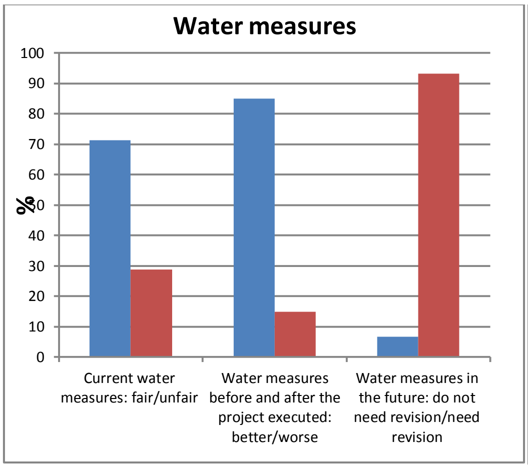


Figure 4.19. Farmers' preference to be actively involved in the government program

The preference of farmers to be actively involved in government programs is shown in Figure 4.19 Farmers are generally (74%) willing to engage in government programs. With the PISP project and its facilitators being deployed in villages, farmers have been encouraged to become more empowered.

As mentioned previously, there are three common methods for supplying water to landplots according to the discharge conditions of irrigation water; 1) continuous, 2) rotational, and 3) intermittent flow. The flow-rate is generally governed by the magnitude of the discharge that is regulated through the discharge opening of an off-take or division gate. It is still common practice in rural Indonesia to measure the water flow rate rather than the volume of water used. The trouble with this practice is that the volume of water is unknown and it is difficult to measure the efficiency of water usage.

Based on the opinion survey as illustrated in Figure 4.19 (a), most farmers (71%) feel that the current measurement of the water supply flow rate is fair. Farmers also feel that the current system of measurement is better than that used before the project was initiated. Nevertheless, most farmers (93%) think that the measurement system could be upgraded to a more sophisticated system.



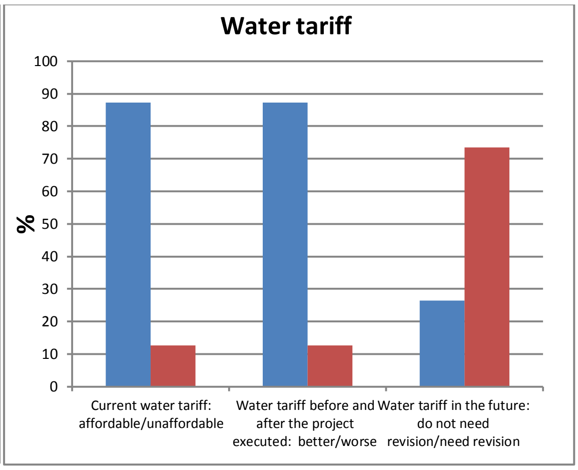


Figure 4.20. Farmers' opinion on (a) water measurement and (b) water tariff by current condition, comparison before and after the project, and future expectation

Since there is no volumetric measurement of water, the irrigation water tariff is calculated according to the landplot area receiving the irrigation water (50-60 kg per hectare per harvesting season). Based on the opinion survey, as shown in Figure 4.18(b), 83% of farmers felt that the current irrigation water tariff was affordable. Table 4.3 illustrates the number of farmers who have to pay the irrigation water tariff per harvesting season, based on the 2009 unhulled rice selling price and 2009 value of the US dollar. The results show that farmers pay water rates that are between 0.80% and 0.96% of their income.

Figure 4.20(b) also suggests that the majority of farmers (91%) feel that the current tariff is better than before the implementation of the project, and most of them (89%) feel content with the current tariff and think the tariff is affordable. (Water tariff in 2009 can be seen in *Table 4.3*).

The government has improved the standard of irrigation management in rural areas. In the management of an irrigation system, the government has accommodated the interests of all parties, including the existence of traditional institutions of community irrigation. Through various programs, the government seeks to increase the capability of staff that handles the day-to-day operations of irrigation systems and seeks to accelerate community participation in the management of irrigation systems and rural development. As a result, farmers are mostly satisfied with the current management of irrigation systems, satisfied with the current measurement of water supply and water tariff, are eager to be involved in the government program for rural development, and expect management can continue to improve in the future.

4.3.5 Water User Associations (WUAs)

Water User Associations/Water User Association Federations (WUAs/WUAFs) or in Indonesia known as *Perkumpulan Petani Pengguna Air/Gabungan Perkumpulan Petani Pengguna Air/Induk Perkumpulan Petani Pengguna Air* (P3A/GP3A/IP3A) are private, non-profitable, and collectively owned organisations responsible for the O&M of irrigation infrastructure above the tertiary turnouts on large- and medium-scale irrigation systems, and the management authority of small-scale irrigation systems smaller than 500 ha. WUAs are also responsible for the administration of water tariffs/ISFs to raise revenue from the water users to provide funds for the O&M of irrigation infrastructure under their authority.

WUA membership consists of all farmer water users of an irrigation system. A Board of Directors is then elected to administer financial resources and implement WUA agreements and dispositions. In general, WUAs face several challenges such as increased pressure on water resources due to competing demands, deteriorating irrigation infrastructure, lack of financial sustainability, and lack of technical capacity to manage irrigation. There are more than 50,000 WUAs in Indonesia with an estimated growth rate of 2.1% per year.

Irrigation management turnover policy was implemented to prioritise the interests of farmers and the government places more responsibility on farmers to care for the supply system. Through this policy, the government handed over O&M responsibility of small-scale irrigation systems to WUAs and introduced WUAs as the decision makers and major stakeholders for irrigation management responsibility. Censequently, it is necessary to empower WUAs, and the government has issued several laws and rules regarding the participation of WUAs in the O&M of irrigation networks. An example is the Decision of the Minister of Public Works KepMen PU No. 498/KPTS/M/2009 on strengthening the farmer water user community in the O&M of irrigation networks.

Delivery of irrigation management devolution was carried out by delegating the rights, authorities, and responsibilities of the local government to WUAs, so that it became their responsibility to manage and finance irrigation. Devolution of irrigation management from the local authority to a legally established WUAs was carried out in a democratic manner and complies with the principle of "one irrigation system, one unified management".

For irrigation systems with a multipurpose irrigation network, devolution of authority is carried out by mutual agreement between the local government, WUAs, and users of irrigation water for other purposes. If the audit of irrigation management shows a failure in management, then the local government will re-establish control and management responsibility.

Empowerment of the WUAs is conducted by the local government through the strengthening and capacity-building of the WUAs. The local government or other parties can provide assistance and facilities to the WUAs, as outlined in the written agreement. In the event of problems in the management structure of the WUAs, the government can facilitate resolution. Local governments might establish a local policy, based on the National Policy, in the form of advance regulations regarding empowerment WUAs.

At tertiary levels, financially autonomous WUAs are responsible for the operation, maintenance, renewal, finance, and management of irrigation. Tertiary irrigation network is an infrastructure network from secondary canal offtakes that serves as irrigation water service in tertiary level irrigation system that flowing water directly to the paddy fields. It consists of tertiary, quaternary and drainage channel networks and its associated infrastructure attached to the networks.

Since the WUAs are responsible for tertiary O&M services, these services are directly and completely financed by the WUAs. Without specific guidelines from the government regarding the arrangement of decentralised and autonomous nature of these associations, each local water-users' group is able to decide on the charge to be levied on its members. In the province of Lampung, fees charged by WUAs for tertiary O&M are established on a seasonal basis according to the area irrigated, with no distinction between cropping seasons. The rates vary between 50kg and 60 kg per hectare. In the financing of irrigation at tertiary levels, WUAs might propose financial assistance from the District Department of Agriculture since WUAs are under the establishment of the Department of Agriculture, along with the Department of Public Works. This is according to the Presidential Instruction of the Republic of Indonesia No. 2 Year 1984 regarding Water User Association Implementation Guidelines.

The government regulates the uniformity of WUAs. However, elements of the institutional tradition of irrigation water arrangement in many places still need to be facilitated. The traditional rice farming practices and tradition-based water arrangements are still preserved in many places in Indonesia. Some of tradition-based water arrangements are the *Subak* System in Bali, *Ulu-ulu Desa* and *Ili-ili* in East Java. Since rice farming in the province of Lampung is developed through the transmigration program from Central Java and East Java, the tradition of rice farming and water arrangements in the Province of Lampung follow the tradition of rice farming in Central Java and East Java, where the *Ulu-ulu* and *Ili-ili* are authorised to arrange water for irrigation. Currently, the *Ulu-ulu* and *Ili-ili* are included in the board membership of WUAs and they play an important role in regulating the day-to-day distribution of irrigation water to landplots.

Ulu-ulu, or the controllers of water distribution, manage the off-take gates in the tertiary channels that deliver water to landplots owned by farmers, whilst *Ili-ili*, or the chairman of the tertiary block, regulates water flow to each landplot. Sociologically, the authority of an *Ulu-ulu* is very strategic; they hold the "power" over the distribution of irrigation water. However, there is no uniformity related to the *Ulu-ulu* position in government bureaucracy. Similarly, farmer perception of the tasks and role of *Ulu-ulu* are often different. Some *Ulu-ulu* becomes village officials, but there are others that have authority on an informal basis only. Villages may give the title *Ulu-ulu* for a lifetime, but some villages impose a time limit on the title. In many cases, an *Ulu-ulu* is a person appointed by the authorities, but in some places - including Lampung – the *Ulu-ulu* is selected and appointed by the members of the community and this is approved by village officials. In the irrigation system, based on the field survey of RAP & Benchmarking, it is known that for the task entrusted to him, *Ulu-ulu* and *Ili-ili* are entitled to about 30% of the water user fees collected by the P3A from farmers every harvest season.

Currently, the position of an *Ulu-Ulu* is complex in nature; there are problems of natural degradation (nature), human behaviour (culture), the management policies of Water Resource Authorities (state) and the commercialisation of water (market / liberalisation) that directly influence the role of *Ulu-ulu*. When the government positioned the *Ulu-ulu* as a technical operator of irrigation and did not attach a more strategic role (spearheading the rescuer and manager of the fair Water Resources), the *Ulu-ulu* were easily tempted by financial bids from parties with strong capital to provide a greater share of water for their own interests rather than the farmers.

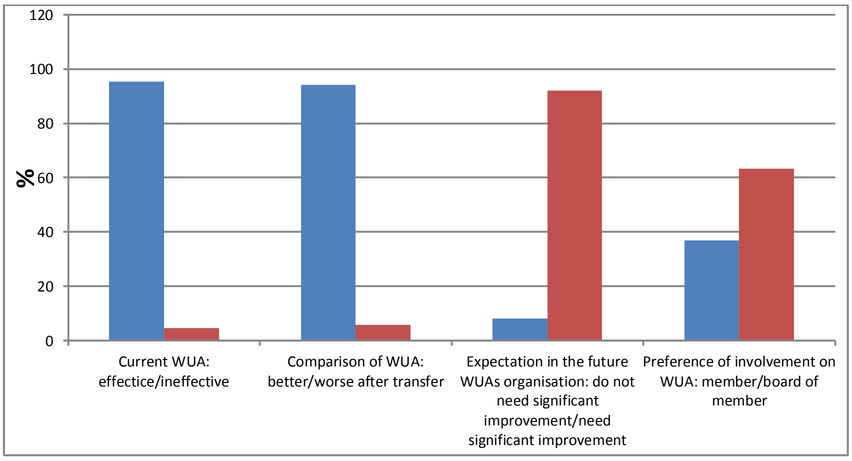


Figure 4.21. Farmers' opinion, perception and preference of WUAs

Figure 4.21 illustrates the opinions, perceptions, expectations and preferences of farmers regarding WUAs. Detailed calculations of farmers' opinion on WUAs can be seen on *Appendix C.2.4*.

The fifure shows that most farmers (95%) think that WUAs are effective in accommodating their needs. Most (94%) also think that WUA performance is better than before the project was implemented. However, 92% said that WUAs still need to improve their performance in the future. Since farmers are aware that WUA board members obtain additional benefits as board members, many farmers (63%) are interested in becoming board members themselves.

In general, since WUAs can convey farmers' interests to the government and vice versa, WUAs have become an extension of government officials in that they can disseminate information to farmers more effectively. In addition, the presence of traditional institutions in water management such as the *Ulu - Ulu* and *Ili-ili* can be further explored and developed to improve the efficiency of irrigation water use and management of irrigation assets.

The sustainability of irrigation systems relies on a focussed policy framework. It must be directed at improving and sustaining participation in the key tasks of equitable water distribution and maintaining irrigation infrastructure. In addition, the government must organise WUAs to carry out government instructions and it must establish mechanisms to assist WUAs to complete various tasks.

4.3.6 Farmer Income

Several years ago, the Indonesian government launched various programs to boost national food security. However, farmers continue to live in poverty and are uncertain of their future. The main cause of farmer poverty is the inadequate size and yield of their landholdings which are too small to produce enough sustenance and income. The average tenure of a farmer is 0.5 hectares, and many have less than 0.25 hectares.

The ownership of small farms means that farmers cannot meet their basic living needs. With only 0.5 hectares of land and with the cost of planting at half the crop yield, the monthly income of a farmer is only Rp1.270,000.00 or US$280 (*see Table 4.4*). A maximum of 50% of their needs can be met from the farm. Revenues are so low that the agricultural sector is of little interest. Some farmers have become workers, relying on wages as farm labourers or from working odd jobs. There is expected to be a decline in the number of people choosing farming as a profession. The calculation of farmer income is depicted in Table 4.3.

Table 4.3. Farmer income

Irrigated Crop Name	Typical yield (tons/ha)	Farmgate selling price (Million Rp/ton)	Typical Farmers' Gross Income (Million Rp/ha)	Irrigation service fee (ha/harvest)			Production cost	Typical Farmers' Net/ha/harvest	
				(kg)	(Million Rp)	(% income)	(%/harvest)	(Million Rp/yr)	(Thousand $US/yr)
Paddy Rice #1 (Wet season - Rendeng)	6.2	4.00	24.80	50 to 60	0.20 to 0.24	0.81 to 0.97	50.00	12.30 to 12.28	1.37 to 1.36
Paddy Rice #2 (Semi dry season - Gadu)	5.8	4.00	23.20	50 to 60	0.20 to 0.24	0.86 to 1.03	50.00	11.48 to 11.48	1.28 to 1.28
Corn #3 (Dry season - Gadu)	7.5	1.80	13.50	50 to 60	0.09 to 0.11	0.67 to 0.80	50.00	6.70 to 6.70	0.74 to 0.74
Total annual value (Rp/$US)			**61.50**		**0.49 to 0.59**	**0.80 to 0.96**		**30.48 to 30.46**	**3.39 to 3.38**
Average income/month/ha								**2.54 to 2.54**	**0.28 to 0.28**
Average farmers' income/month (0.5 ha)								**1.27 to 1.27**	**0.14 to 0.14**

(*Summarised from Appendix C: Table C.6.51*)

Within the next 20 years, Indonesia will lose an estimated 2.5 million paddy fields without an equivalent replacement due to conversion of paddy fields into housing, industry, roads, or plantations. Each year, there are 110 thousand hectares of paddy fields converted to other industries. A total of 59% of paddy fields in Java have been turned into housing, whilst 49% of paddy fields outside the Island of Java have been shifted to other crops such as palm oil (Widjanarko, 2006)

The high value of land becomes one of the drivers that compel low-income farmers to sell their agricultural land to other parties. In fact, national rice security is influenced by the availability of land and human resources. So far there has been no comprehensive policy related to spatial planning, and there is no incentive for farmers who want to keep their paddy fields. These are the causes of the increased rate of conversion of agricultural land which results in a permanent threat to rice production (Irawan, 2005).

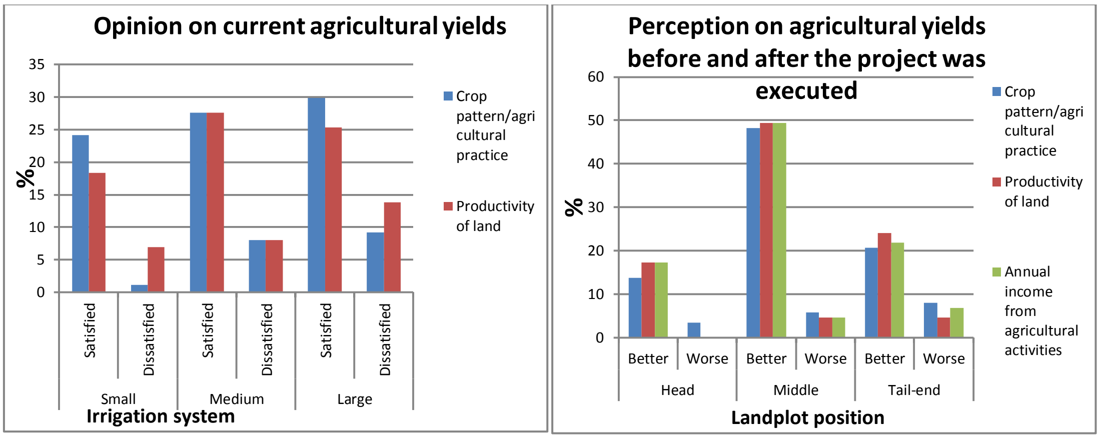


Figure 4.22. Farmers' opinion on (a) current agricultural yields and (b) comparison of yields before and after the project was executed

Based on the opinion survey, Figure 4.22 (a) shows that most farmers (82%) are satisfied with the current crop pattern and 71% are satisfied with the productivity of their land. Figure 4.22(b) shows that on average, 90% of farmers said that the current crop pattern, productivity of land, and annual income from agricultural activities have all improved since the project was implemented.

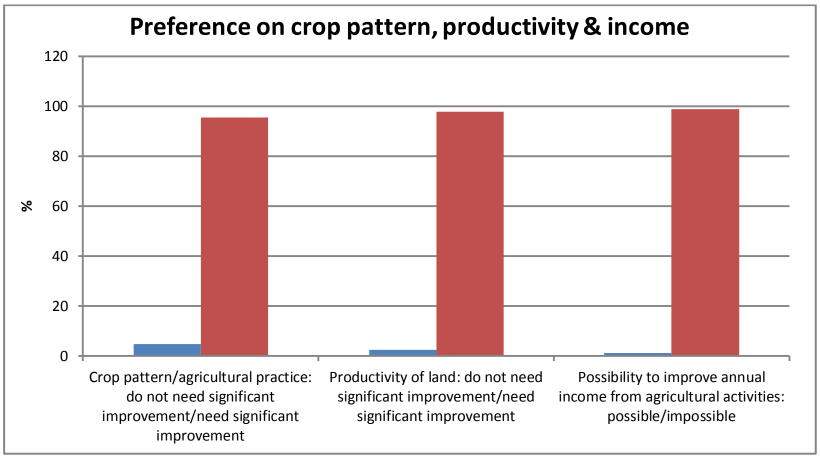


Figure 4.23. Farmers' preference on agricultural yields in the future

Figure 4.23 illustrates that most farmers (95%) expect to be able to increase the cropping pattern and agricultural practice in the future. They also expect to increase the productivity of their lands and believe that there is a chance to increase their annual income from agricultural activities.

Detailed calculations of farmers' opinion on water measure and tariff and farmers' income can be seen on Appendix C.2.5 and C.2.6.

Although farmers believe that current conditions are better than before the PISP project was implemented, the sustainability of these conditions needs to be assessed after the project ends. There is a need to implement a 'pro-poor' intervention strategy and policy to facilitate farmer access to wider landplots and a need to show farmers that their profession is sustainable.

4.4 The Condition of Irrigation Assets

The irrigation and drainage infrastructure in the Province of Lampung are a mix of old and new structures. In general, rural irrigation and drainage systems in this area are characterised by a weak performance and are maintained on a contingency response basis. The following tables show the condition of irrigation infrastructure in Indonesia by region and the condition of irrigation infrastructure in the Province of Lampung.

Table 4.4. Irrigation infrastructure condition by region

Condition		Region: Sumatra	Java	Kalimantan	Sulawesi	Bali, NT, Maluku, Papua	Total
Hectares	Severely damaged	56,149	51,949	0	17,487	542	126,127
	Minor damage	497,752	492,081	158,628	199,776	42,511	1,390,748
	Good	1,283,359	2,727,978	301,337	576,967	365,310	5,254,951
	Total	1,837,260	3,272,008	459,965	794,230	408,363	6,771,826
% of the province	Severely damaged	3.06	1.59	0.00	2.20	0.13	1.86
	Minor damage	27.09	15.04	34.49	25.15	10.41	20.54
	Good	69.85	83.37	65.51	72.64	89.46	77.60
	Total	100.00	100.00	100.00	100.00	100.00	100.00
% of Indonesia	Severely damaged	0.83	0.77	0.00	0.26	0.01	1.86
	Minor damage	7.35	7.27	2.34	2.95	0.63	20.54
	Good	18.95	40.28	4.45	8.52	5.39	77.60
	Total	27.13	48.32	6.79	11.73	6.03	100.00

Data compiled from source: (The Directorate of Water Resource and Irrigation, The State Ministry of National Development Planning et al., 2010)

Table 4.5. Irrigation infrastructure condition in Lampung

Type of irrigation system	Technical irrigation		Swamp irrigation		Total
Condition	Minor damage	Severely damaged	Minor damage	Severely damaged	
Hectares	9,042	18,040	7,506	12,033	46,621
Total		27,082		19,539	
% of the category	33	67	38	62	
% of the total	19	39	16	26	100

While 78% of the irrigation systems in Indonesia are in good condition (Table 4.4.), the technical irrigation systems in the Province of Lampung are severely damaged (Table 4.5). Therefore, in order to obtain the up-to-date information about the condition of case study of irrigation systems, it is necessary to re-examine the condition of the irrigation system. The condition of irrigation system was assessed by following the Institute of Irrigation Studies (IIS) guidelines. As explained in Section 2.3.3, 2.6.1 and 3.2.2, this study utilised four condition grades: good, fair, poor and bad. In addition, four levels of serviceability grade were assigned: fully functional, minor functional shortcoming, seriously reduced functionality, and ceased to function. The assets themselves were divided into four types: water capture/headworks, conveyance, operation/control facilities, and management and general facilities. The asset condition survey was only based on water capture, channels, the division/offtake structure and its gates, because these types of assets are the most conducive to irrigation and drainage performance. The results of the asset condition survey for each study area are presented in Table 4.6. (*See Appendix C.3.1 to C.3.11 for the irrigation system' map of location, layout and network and Appendix C.4.1. to C.4.11 for the irrigation system' asset type and condition*).

Table 4.6. General information about irrigation system case studies

					Irrigation System										
					Large	Medium			Small						
					Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton
Asset Group	Water Capture		Dam's Name		Way Pengubuan Dam	Way Padang Ratu Dam	Way Negara Ratu Dam	Tipo Balak Dam	Muara Mas Dam	Muara Mas I Dam	Muara Mas II Dam	Muara Mas III Dam	Tipo Lunik Dam	Ilihan Balak Dam	Way Waya Dam
			Size	(m)				22					12	175	35
	Conveyance	Channel (m)	Primary	(m)	11,144.00	3,150.00	1,648.00	11,471.00						1,850.00	11,985.00
			Secondary	(m)	65,010.00	7,670.00	9,320.00	575.00	157.00	2,053.00	197.00	499.00	7,050.00	5,750.00	25,830.00
			Tertiary	(m)	102,450.00				3,000.00	500.00	1,050.00	2,445.00		1,770.00	26,550.00
			Quartenary	(m)	168,497.00										
			Drainage	(m)	4,000.00	4,000.00									
		Hydraulic Structure	Division structure	(unit)	5		14		8	11	6	2			13
			Off-take structure	(unit)	46	16	2	20	1	6	3	1	10	1	14
			Division structure w/ OT	(unit)		1	1	1						12	
		Supplementary	Inspection road	(m)		750									
			Bridge	(unit)											
	Operation & Controlling Facilities		Regulators	(unit)	51	17	17	21	9	17	9	3	10	13	27
			Mesuring structures	(unit)											
	Management & General														
Irrigation System			Status		Major	Technical	Technical	Technical	Semi-technical	Semi-technical	Semi-technical	Semi-technical	Semi-technical	Technical	Technical
			First operated		1975	1935	1972	1982	1975	1978	1992	1975	1972	1985/1986	1975
			Authority		Central Governmer	Provincial	Provincial	Provincial	District	District	District	District	District	District	District
			Water capture		Weir	Weir	Free-intake	Weir	Weir	Weir	Weir	Weir	Weir	Weir	Weir
			Potential coverage	(ha)	4,975.00	1,032.00	1,153.00	1,133.00	225.00	500.00	126.00	78.00	396.00	711.00	478.00
			Service Area (2008)	(ha)	3,501.00	750.00	1,153.00	941.00	157.00	343.00	96.00	60.00	356.00	685.00	325.00
			River		Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas	Way Muara Mas	Way Muara Mas	Way Tipo Lunik	Way Ilihan Balak	Way Srimulyo
			Basin		Way Seputih	Way Sekampung	Way Sekampung	Way Seputih	Way Seputih	Way Seputih	Way Seputih	Way Seputih	Way Seputih	Way Seputih	Way Seputih
			No. of WUA		20	5	4	3	1	2	1	1	1	1	4
			WUA Legality		Public notary	Public notary	Public notary	Public notary	Public notary	Public notary	Public notary	Public notary	Public notary	Public notary	Public notary
			WUAF		1	1	1	1	0	0	0	0	0	0	1
			Average land holder	(ha)	0.5	0.5	0.5	0.5	0.25	0.75	0.25	0.25	0.62	0.58	0.5

(*Source: the irrigation and settlement services, the Province of Lampung*)

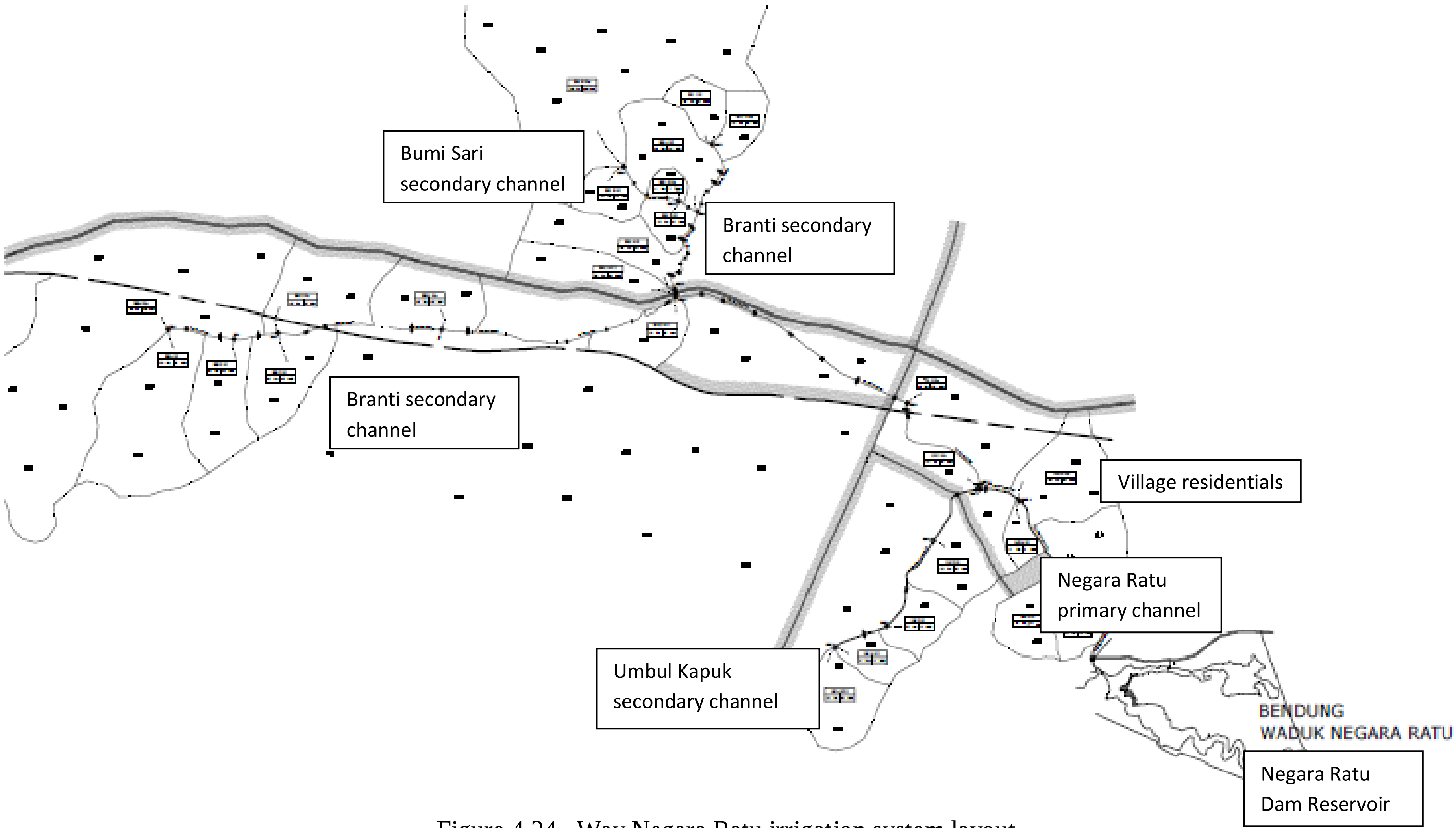


Figure 4.24. Way Negara Ratu irrigation system layout
(*Source: the irrigation and settlement services, the Province of Lampung*)

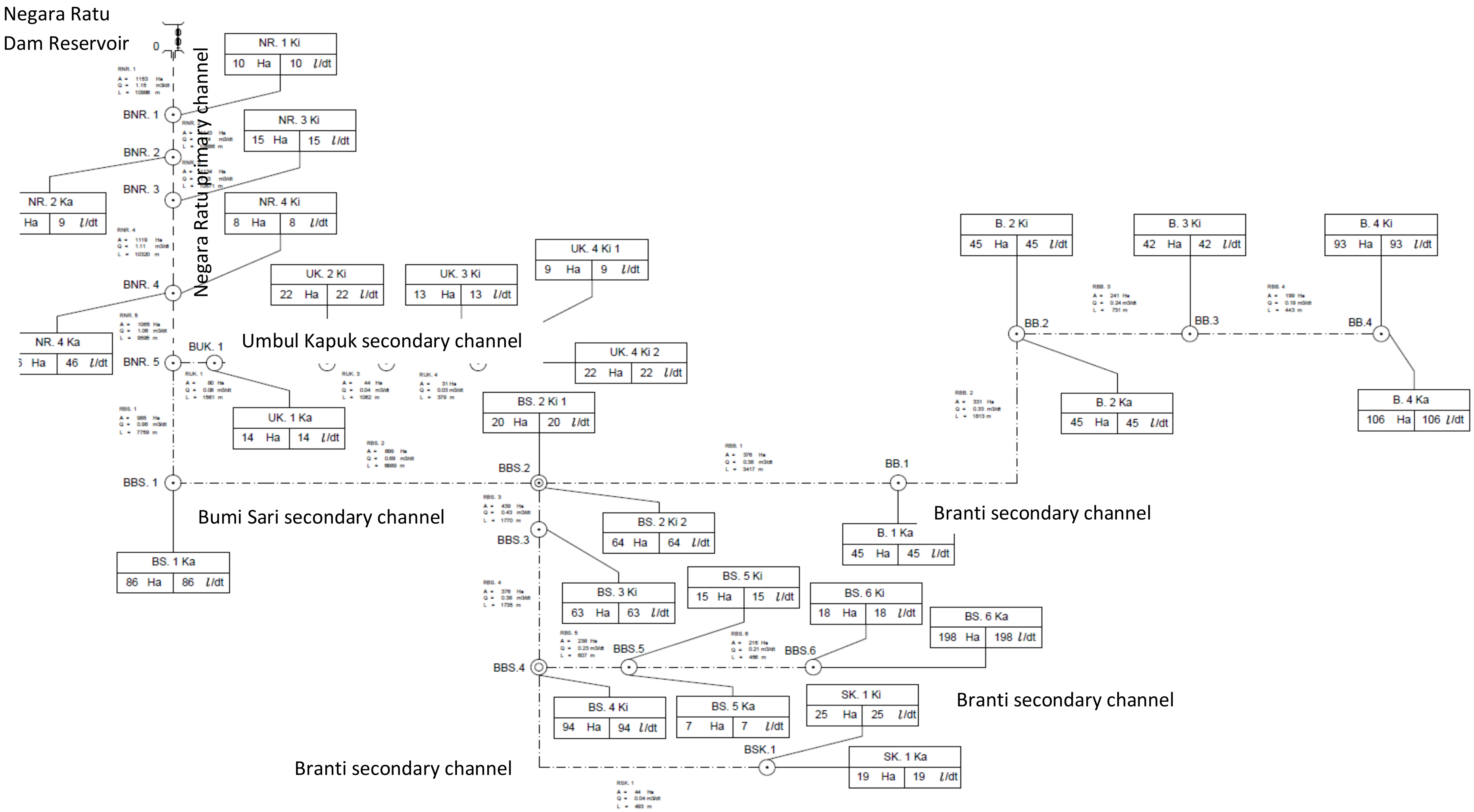


Figure 4.25. Way Negara Ratu irrigation system network
(*Source: the irrigation and settlement services, the Province of Lampung*)

Table 4.7. General condition of assets in the study areas

ASSET GROUP					
Water Capture/Headworks	Conveyance			Operations/Control Facilities	Management & General
	Channels	Hydraulic Structures			
In general, dam main structures in large and medium irrigation schemes were in good condition (1) and fully functional (1), and in small irrigation schemes were in fair condition (2) and minor functional shortcoming (2).	Primary channels were concrete lining. Leaking and damage occurs in several spot along the concrete lining. In general, concrete lining were in good condition (1) and fully functional (1).	In general, the hydraulic structures were in fair condition (2) and minor functional shortcoming (2), however in some of small irrigation schemes, hydraulic structures were in poor condition (3) and seriously reduce its functionality (3).	Large irrigation schemes were equipped with sufficient supplementary structures, medium irrigation schemes were equipped with a very standard supplementary structures, and small irrigation schemes were lack of supplementary structures.	Operation and control facilities in these irrigatio schemes were manually operated gates. These gates mostly were in poor (3) and bad condition (4), even many of the gates were disappeared. It seriously reduce its functionality (3) and ceased to function (4). Its need to be repaired and installed immediately.	Large irrigation schemes were equipped with a standard management and general facilities, medium irrigation schemes were lack of management and general facilities, and small irrigation schemes had limited management and general facilities.
However its components, especially gates were in poor condition (3) and seriously reduced its functionality (3) (for large and medium irrigation schemes), and in bad condition (4) and ceased to function (4) (in small irrigation schemes).	Secondary channels in large and medium irrigation schemes were concrete lining, and in small irrigation scemes were mostly concrete lining with parts of its were earth lining. Leaking and damage occurs in several spot along the concrete lining. In general, concrete lining in large and medium irrigation schemes were in fair condition (2) and minor function shortcoming (2), and in some of small irrigation schemes were in poor condition (3) and seriously reduced its functionality (3). Earth lining were generally in poor condition (3) and seriously reduce the functionality (3), and in some of small irrigation schemes, earth lining were in bad condition (4) and ceased to function (4).	All small irrigation schemes require additional hydraulic structures to improve its level of service.	In general, the supplementary structures were in fair condition (2) and minor functional shortcoming (2) in large and medium irrigation schemes, however in some of small irrigation schemes, supplementary structures were in poor (3) and bad condition(4) and seriously reduce its functionality (30 to ceased to function (4).		Management and general facilities commonly were in fair condition (2), quite feasible to support the activities of the staffs of the irrigation schemes.
Heavy sedimentation occurs on some dams until it reach to the crow's weir. The condition is fair (2) however the functionality is seriously reduced (3).	Tertiary and quartenary channels were earth lining. In general in large and medium irrigation schemes, channels are in fair conditions(2) with parts of the channels were in poor condition (4). However in small irrigation schemes, the channels were mostly in poor conditions (3) and parts of it were in bad condition (4) and ceased to function (4).				
	Only few of irrigation schemes have drainage channels. In general the irrigation water were outflown to the natural water ways. Drainage channels were in fair condition (2), however in the future there is imperative to provide drainage channels in all irrigation systems to make efficient-use or circulate the irrigation water.				

(*Source: summarised from Appendix C: Table C.4*)

Table 4.7 shows the general condition of assets including water capture, channels, division/offtake structure and its gates for each irrigation system, and other basic information about the irrigation systems. Subsequently, Figures 4.24 and 4.25 illustrate a typical layout of an irrigation system in Indonesia. The layout provided here is a medium irrigation system of Way Padang Ratu.

As shown in Table 4.7, the asset condition of irrigation systems under central government authority is very reasonable, the systems under the jurisdiction of the provincial government are in good condition, and the systems under the authority of local governments (district/*kabupaten*) are in poor condition. This is due to differences in the amount of routine maintenance and operational funding received from each authority. In Lampung, the systems under authority of the central government receive routine O&M funds of Rp.135,000.00 (US$15.00) per hectare per year. Meanwhile the systems under the authority of the provincial government receive about Rp.80,000.00 (US$8.89), and the systems under the authority of local governments receive about Rp.40,000.00 (US$4.44). There are also small differences in the routine O&M funds for irrigation systems in each province of Indonesia. The level of funding is chosen by the government authority for an irrigation system, but generally the amount of funding from year to year does not vary greatly.

The decline in asset condition of irrigation systems in Indonesia, especially in irrigation systems under the authority of local governments, is often caused by deferred maintenance needs. Deferred maintenance occurs largely due to under-funding of maintenance. Since 1990, it has become obvious that the cost of O&M is inadequate and this results in decreased irrigation network performance. A report by ICID (in 2001) stated that the real cost of O&M in 1998 is about Rp60,000.00($7.68)[2] per hectare, but the availability of the budget from the central government is only Rp30,000.00 ($3.84) per hectare. The remainder is expected to come from the local (provincial) government. Unfortunately, local government can meet little more than half of the operational needs (Abernethy *et al*., 2001). In 2000, the Japan International Cooperation Agency (JICA) calculated the real O&M

[2] It was not easy to convert IDR values to US$ values in 1998 due to the Indonesian monetary crisis which made the IDR value fall 35% against the US$ value. By December of 1997 the highest IDR exchange rate to US$ was 5,800. However, in June 1998, US$1 was equivalent to IDR16,000 and in 1999, US$1 was equivalent to IDR 7,810. The researcher tends to apply the IDR value in 1999 on the above US$ value since it better represents the real value of IDR against US$.

requirements to be US$15-20/ha/year (Rp125,940.00-167,920.00/ha/year). However, the State and local budgets in 1999 and 2000 were only Rp71.000/ha/year (US$8,46/ha/year). For that reason, delivery of small irrigation systems less than 500 ha to the WUA was carried out.

Vermillion (2002) estimated that the average budgetary requirement for maintenance of Indonesia's public irrigation system was US$18-$28/ha, compared with the actual expenditure of US$5-$13/ha. As a comparison, the estimated O&M requirement in Pakistan is about US$5.70/ha compared with the average actual expenditure of US$2.70/ha (and in India the government allocated approximately US$4-$8/ha in 1992 compared to the estimated US$10-$17/ha). Common maintenance expenses typically represent only about 20% of the total O&M budget, therefore, maintenance is given low priority (Tardieu and Préfol, 2002). A further comparison of the cost of irrigation in several countries is shown in Table 4.8.

Table 4.8. The costs of irrigation in several countries

Country	Costs (US$)		Income (US$)					
	Capital costs/ha	O&M costs/ha	Irrigation service fee, % of O&M costs	Collection rates, %	Supplement income, % of O&M costs	Tax to government (land tax)	Amount received by public agencies	Benefit recovery ratio,%
Indonesia	3,000.00	10.00 - 35.00	Varying rates to cover the full O&M cost of the tertiary facilities	n.a.		Very limited		8.00 - 21.00
Nepal	3,000.00	10.00 - 35.00	60.00	20.00		Very limited		5.00
Philippines	3,000.00	10.00 - 35.00	121.00	62.00				10.00
Thailand	3,000.00	10.00 - 35.00	Not levied			10.00/ha/year		8.00
Korea	8,000.00 – 11,000.00	145.00 - 230.00	93.00	98.00	28.00			26.00 - 33.00

(Small et al., 1986)

The current O&M fund of US$15/ha/year for large irrigation systems provided by the central government is close to the required O&M funds calculated by experts. However, the O&M funds of US$8.89/ha/year and US$4.44/ha/year for medium and small irrigation systems respectively, are far from adequate. The condition of assets in a large irrigation system is better than those in medium and small irrigation systems. This is due to the limited ability of provincial and district governments to fund O&M under their authority.

Other than O&M funds, an irrigation system also receives funds for rehabilitation and improvement or upgrading of the system, but these funds are not routinely available. In general, rehabilitation, improvement and upgrade activities are carried out within the framework of a project.

Between 2005 and 2012 the irrigation system received assistance to rehabilitate their tertiary level of irrigation system from PISP. The assistance was designed to ensure that the deferred maintenance cycle is broken and that the case studies irrigation systems performance is maintained at or close to the original design level. Table 4.9 shows the amount spent on rehabilitating the irrigation system.

Table 4.9. Rehabilitation costs of case study irrigation systems

Irrigation System	Type rehabilition works	Source of funds (Million Rp)			Total		% of type of works
		Loan ADB	GOI Fund	Tax	Rp (Million)	US$ (Thousand)	
Way Pengubuan	Tertiary work	2,948.16	0.00	0.00	2,948.16	327.57	81.39
	Secondary work	0.00	612.98	61.30	674.28	74.92	18.61
	Total	2,948.16	612.98	61.30	3,622.44	402.49	
	Percentage	81.39	16.92	1.69	100.00		
	Rehab cost/ha	1.03				0.11	
Way Padang Ratu	Dam	199.56	118.87	31.84	350.27	38.92	10.61
	Primary network	650.21	387.31	103.75	1,141.27	126.81	34.58
	Secondary network	1,030.40	613.77	164.42	1,808.58	200.95	54.80
	Total	1,880.17	1,119.94	300.01	3,300.12	366.68	100.00
	Percentage	56.97	33.94	9.09	100.00		
	Rehab cost/ha	4.40				0.49	
Way Negara Ratu	Total	1,162.03	0.00	0.00	1,162.03	129.11	100% Tertiary
	Percentage	100.00	0.00	0.00	100.00		
	Rehab cost/ha	1.01				0.11	
Way Tipo Balak	Tertiary work	658.70	0.00	0.00	658.70	73.19	29.02
	Secondary work	0.00	1,464.67	146.47	1,611.14	179.02	70.98
	Total	509.85	1,600.00	160.00	2,269.84	252.20	
	Percentage	22.46	70.49	7.05	100.00		
	Rehab cost/ha	2.41				0.27	
Way Muara Mas	Dam	0.00	0.00	0.00	0.00	0.00	0.00
	Secondary network	152.71	0.00	0.00	152.71	16.97	27.04
	Tertiary network	325.86	78.28	7.83	411.97	45.77	72.96
	Total	478.58	78.28	7.83	564.68	62.74	100.00
	Percentage	84.75	13.86	1.39	100.00		
	Rehab cost/ha	3.60				0.40	
Way Muara Mas I	Dam	572.97	0.00	0.00	572.97	63.66	43.37
	Secondary network	69.76	191.72	19.17	280.65	31.18	21.25
	Tertiary network	467.39	0.00	0.00	467.39	51.93	35.38
	Total	1,110.12	191.72	19.17	1,321.01	146.78	100.00
	Percentage	84.04	14.51	1.45	100.00		
	Rehab cost/ha	3.85				0.43	
Way Muara Mas II	Dam	0.00	0.00	0.00	0.00	0.00	0.00
	Secondary network	0.00	90.41	9.04	99.45	11.05	49.37
	Tertiary network	102.00	0.00	0.00	102.00	11.33	50.63
	Total	102.00	90.41	9.04	201.45	22.38	100.00
	Percentage	50.63	44.88	4.49	100.00		
	Rehab cost/ha	2.10				0.23	
Way Muara Mas III	Dam	0.00	0.00	0.00	0.00	0.00	0.00
	Secondary network	0.00	151.85	15.19	167.04	18.56	50.19
	Tertiary network	165.75	0.00	0.00	165.75	18.42	49.81
	Total	165.75	151.85	15.19	332.79	36.98	100.00
	Percentage	49.81	45.63	4.56	100.00		
	Rehab cost/ha	5.55				0.62	
Way Tipo Lunik	Dam	1,668.95	0.00	0.00	1,668.95	185.44	63.73
	Secondary network	833.00	106.31	10.63	949.94	105.55	36.27
	Tertiary network	0.00	0.00	0.00	0.00	0.00	0.00
	Total	2,501.95	106.31	10.63	2,618.89	290.99	100.00
	Percentage	95.53	4.06	0.41	100.00		
	Rehab cost/ha	7.36				0.82	
Way Ilihan Balak	Dam	0.00	0.00	0.00	0.00	0.00	0.00
	Secondary network	429.28	0.00	0.00	429.28	47.70	22.22
	Tertiary network	1,230.91	247.27	24.73	1,502.91	166.99	77.78
	Total	1,660.19	247.27	24.73	1,932.20	214.69	100.00
	Percentage	85.92	12.80	1.28	100.00		
	Rehab cost/ha	5.03				0.56	
Way Srikaton	Dam	0.00	0.00	0.00	0.00	0.00	0.00
	Secondary network	2,362.02	0.00	0.00	2,362.02	262.45	90.19
	Tertiary network	120.70	123.79	12.38	256.87	28.54	9.81
	Total	2,482.72	123.79	12.38	2,618.89	290.99	100.00
	Percentage	94.80	4.73	0.47	100.00		
	Rehab cost/ha	8.06				0.90	
Percentage	Dam						10.70
	Primary & Secondary network						43.23
	Tertiary network						46.07
	Total						100.00
Rehabilitation cost/ha (average)		**4.04**				**0.45**	

Table 4.9 shows that an irrigation system receives Rp1 to Rp8 million per hectare for rehabilitation. On average, the systems spent Rp4 million or US$450 per hectare on rehabilitation activities. Based on this information, these districts may have become targets for irrigation system rehabilitation by the WISM and PISP projects.

4.5 Irrigation Performance

As explained in Section 2.3, performance assessment is an essential component enabling the management process to function effectively and efficiently. A performance assessment is necessary since resources (land and water) in irrigation systems are not being managed appropriately. The performance of a system is represented by its measured levels of achievement by one or several parameters that are considered indicators of a system's goals. Performance indicators are basically a quantitative measure of an aspect of irrigation standards which help to evaluate and monitor irrigation efficiency. Performance indicators can be used in a number of distinct ways by different users which include farmers, water managers, policy makers, researchers, and the general public.

The availability of water and land for agriculture is shrinking rapidly with the growth of cities and industries, particularly in developing countries. Therefore irrigated agriculture must improve its way of utilising these increasingly scarce resources. Moreover, the performance of irrigation system will decrease due to deterioration in the system, and lack of O&M due to very limited government finance. Table 4.4 shows that in 2010, about 1.5 million hectares (22%) of 6.77 million hectares of irrigated rice fields were in poor condition (75% of which were located in Java and Sumatra). It is important to assess the performance of irrigation systems in Indonesia to see how productive the use of water and land for irrigation is and to assess how to improve the existing irrigation system performance and evaluate the prospects of potential irrigation asset management systems performed independently by WUAs in rural Indonesia in the most cost-effective and sustainable way.

This section presents the results of the field survey on irrigation system performance. The survey aimed to assess the extent, function, condition, value, and performance of existing irrigation systems. The results were then used to explicitly describe the condition and performance of the assets as a baseline against which to measure future condition and performance. System performance is assessed through irrigation efficiency and crop yields (external indicators) along with canal condition, labour employment, social harmony, and environment (internal indicators). The procedure used to assess irrigation performance was RAP and Benchmarking. The field work itself was conducted between December and February 2009 at 11 case study irrigation sites. The detailed calculations on the RAP and Benchmarking of each irrigation system case study can be seen in *Appendix C.6.1 to C.6.7.12*.

4.5.1 External Indicators

External indicators are expressions of various forms of indicators that relate to water balance, financial, agricultural productivity and economics, environmental and other. They examine the inputs and outputs of an irrigation system and therefore establish key information about the system. Table 4.10 presents the summary of performance indicators of case study irrigation systems. A more detailed results of the external indicators assessment can be seen in *Appendix C.6.3 and C.6.4* and detailed assessment of external indicators can be seen in *Appendix C.6.7*. Further discussions on the value of the indicators contained in Table 4.10 for each group of indicators mentioned above is described in Section 4.5.1.1 to 4.5.1.6. Some graphics presented in these sections were derived from the *Appendix C.6.3*.

In general, water balance indicators show that the current supply of irrigation water is still adequate and secure, but the efficiency of water delivery and water use efficiency is still very low. Agricultural productivity (land and water productivity) is quiet low, but possible to be improved. Revenue collection is very good, but revenue collected only enough to maintain tertiary level of the systems. No revenue is remitted to government, instead MOM costs of primary and secondary level still rely on government subsidies. There is no available data on environmental monitoring. It can be concluded that environmental aspects have not been a concern in the irrigation systems.

Table 4.10. Summary of irrigation systems' performance indicators

	Indicators	Unit	Value	
			Range	Average
WATER BALANCE INDICATORS				
1	Total annual volume of irrigation water available at the user level	MCM	1.14 - 51.28	-
2	Total annual volume of irrigation supply into the 3-D boundaries of the command area	MCM	1.08 - 78.89	-
3	Total annual volume of irrigation water managed by authorities (including internal well and recirculation pumps operated by authorities) (can include recirculated water; but does not include any drainage or groundwater that is pumped by farmers)	MCM	1.08 - 78.89	-
4	Total annual volume of water supply	MCM	1.63 - 118.69	-
5	Total annual volume of irrigation water delivered to users by project authorities	MCM	0.70 - 51.28	-
6	Total annual volume of ground water pumped within/to command area	MCM	0.00	-
7	Total annual volume of field ET in irrigated fields	MCM	0.55 - 34.67	-
8	Total annual volume of (ET - effective precipitation)	MCM	0.33 - 20.39	-
9	Peak net irrigation water requirement	MCM	0.03 - 1.55	
10	Total command area of the system	ha	48.00 - 3,501.00	-
11	Irrigated area, including multiple cropping	ha	99.00 - 6,280.00	-
12	Annual irrigation supply per unit command area	m3/ha	14,583.33 - 31,827.99	23,255.28

	Indicators	Unit	Value	
			Range	Average
13	Annual irrigation supply per unit irrigated area	m3/ha	7,225.81 - 16,248.20	11,438.57
14	Conveyance efficiency of project-delivered water (weighted for internal and external, using values stated by project authorities)	%	65.00	65.00
15	Estimated conveyance efficiency for project groundwater	%	0.00	0.00
16	Annual Relative Water Supply (RWS)	none	2.64 - 5.37	-
17	Annual Relative Irrigation Supply (RIS)	none	2.97 - 32 - 22	-
18	Water delivery capacity	none	2.19 - 13.94	-
19	Security of entitlement supply	%	33.37 - 100	93.94
20	Average Field Irrigation Efficiency	%	16.13 - 72.98	47.76
21	Command area Irrigation Efficiency	%	10.48 - 47.44	31.05
FINANCIAL INDICATORS				
22	Cost recovery ratio	none	0.45 - 1.23	0.75
23	Maintenance cost to revenue ratio	none	0.34 - 0.48	0.38
24	Total MOM cost per unit area	US$/ha	51.26 - 133.20	96.42
25	Total cost per staff person employed	US$/person	90.14 - 510.26	324.93
26	Revenue collection performance	none	1.00	1.00
27	Staff persons per unit irrigated area	Persons/ha	0.02 - 0.12	0.04
28	Number of turnouts per field operator	None	0.41 - 1.79	1.17
29	Average revenue per cubic meter of irrigation water delivered to water users by the project authorities	US$/m3	0.00220 - 0.00657	0.00431
30	Total MOM cost per cubic meter of irrigation water delivered to water users by the project authorities	US$/m3	0.00148 - 0.00594	0.00282

	Indicators	Unit	Value	
			Range	Average
AGRICULTURAL PRODUCTIVITY AND ECONOMIC INDICATORS				
31	Total annual value of agricultural production	US$	260,500.00 - 5,548,711.11	
32	Output per unit command area	US$/ha	4,476.59 - 7,710.19	5,366.51
33	Output per unit irrigated area, including multiple cropping	US$/ha	2,238.30 - 2,676.66	2,611.00
34	Output per unit irrigation supply	US$/m3	0.16 - 0.37	0.24
35	Output per unit water supply	US$/m3	0.12 - 0.24	0.16
36	Output per unit of field ET	US$/m3	0.48 - 0.68	0.62
ENVIRONMENTAL INDICATORS				0.00
37	Water quality: Average salinity of the irrigation supply	dS/m	1.00	1.00
38	Water quality: Average salinity of the drainage water	dS/m	n.a.	n.a.
39	Water quality, Biological: Average BOD of the irrigation supply	mgm/liter	n.a.	n.a.
40	Water quality, Biological: Average BOD of the drainage water	mgm/liter	n.a.	n.a.
41	Water quality, Chemical: Average COD of the irrigation supply	mgm/liter	n.a.	n.a.
42	Water quality, Chemical: Average COD of the drainage water	mgm/liter	n.a.	n.a.
43	Average depth to the shallow water table	m	n.a.	n.a.
44	Change in shallow water table depth over last 5 years (+ is up)	m	n.a.	n.a.
OTHER				
45	Percent of O&M expenses that are used for pumping	%	0.00	0.00

4.5.1.1 Rainfall versus Evapotranspiration (ETo)

The water requirements of a crop must be satisfied in order to achieve potential yields. Potential evapotranspiration (Eto) is used to calculate crop water requirements (consumptive use). Figure 4.26 presents the annual rainfall versus ETo in the irrigation system. The ETo of the irrigation system was calculated using the Penmann Modified Method and the climatic data was gathered from the weather stations nearest the irrigation systems. The data indicates that the annual reference Eto, of the irrigation systems analysed, exceeds annual precipitation. Therefore, an irrigation system is required in this area to achieve the potential crop yields.

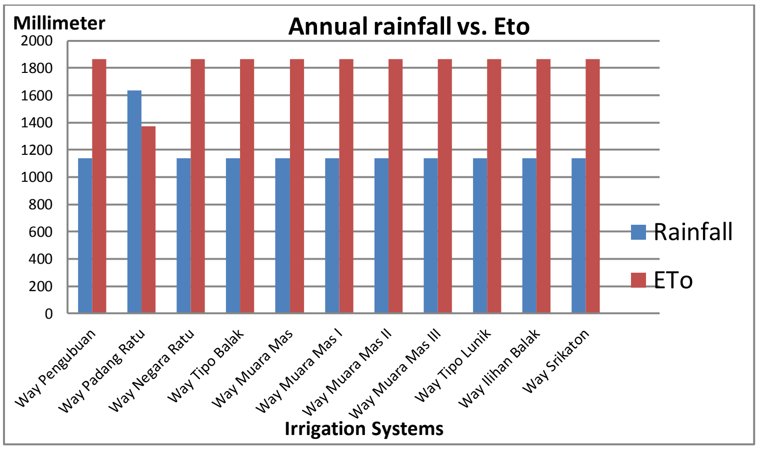


Figure 4.26. Annual rainfall vs. annual ETo

Rainfall in the province of Lampung is generally quite high, and most of the region experiences a wet season for nine to ten months of the year. Based on rainfall data between 2001 to 2009, rain fell almost every month at varying rates. However, ~60% of the average annual rainfall occured between December and March. The months with rainfall below 100 mm were those of June, July, and August (BPS Lampung Province, 2009).

Figure 4.27 illustrates that irrigation water is required between the months of April and November. During the wet season of December to March, the first cropping season of rice occurs since rain water is sufficient to meet the needs of the rice plant. The second cropping season occurs between March and June, which requires the support of irrigation water to achieve an optimal harvest. In some areas, where irrigation water is adequate, a third cropping season can be undertaken by growing a different crop (*palawija*) during the dry season.

As with high rainfall, the potential for surface water and groundwater resources in Lampung is great. There are five major river basins in the province of Lampung and the study areas are located in the Way Seputih and Way Sekampung river basins. In total, the Way Seputih – Sekampung river basin has an area coverage of 14,650 km^2 and a potential 11,851 million m^3 of water per year. The basin area is used for an irrigated area of nearly 295,544 ha.

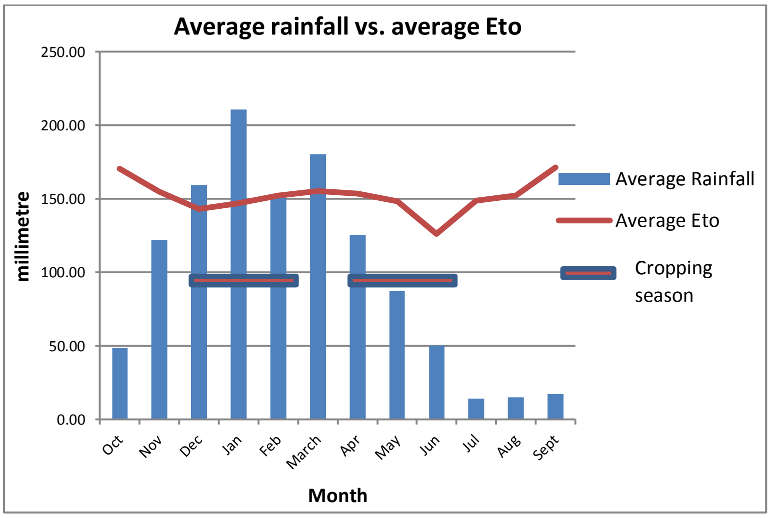


Figure 4.27. Average monthly rainfall vs. average monthly ETo

4.5.1.2 Water Balance

Water balance accounts for all water volumes that enter and leave a three-dimensional (3-D) boundary over a specific period of time. In this study, irrigation water generally comes from river runoff and surface water supplies rice fields by furrow irrigation. The system consists of an open canal network, generally underlined with rudimentary water intakes and distribution systems, supplying small plots devoted mostly to subsistence agriculture. Water is rarely metered and fees are mostly based on a hectare of land basis rather than on the volume of water used. Preliminary calculations show that the average conveyance efficiency in this study area is 65%. Irrigation water is lost due to the reliance on inefficient irrigation systems; including leaky distribution systems and the failure to maintain/improve gravity and flooding irrigation methods. Inefficient irrigation systems together with inadequate irrigation management lead to pervasive irrigation practices, with farmers utilising water in excess of crop requirements and availability.

One of the greatest challenges for irrigation systems is the fact that many have a deficit in irrigation water. Surface irrigation systems in Lampung face a major problem due to surface water differences between the rainy and dry seasons. The debit ratio of the rainy to dry season of almost the entire river basin is high (records show that fluctuations in water flow rate are between 61% and 43%, except for Way Semangka (7%) and Way Way Rarem (23%). Consequently, there is a shortage of water in the dry season and an excess in the rainy season.

Based on the data from the Central Bureau of Statistics of the Province of Lampung (BPS, 2009), the shortage of water during the dry season is worsened by the destruction of the hydrological functions of protected areas and the relatively porous local soil. The destruction of hydrological function is generated by deforestation of protected forest areas in the upper region and agricultural cultivation practices without conservation. More than 60% of protected forests have been destructed which makes up the critical areas of approximately 647,747.05 hectares throughout Lampung. Especially in the river basins, this condition increases the level of water turbidity due to soil erosion and affects the availability of water resources for downstream irrigation. From the Way Seputih River alone, around 10.5 million tonnes of sediment reach the sea every year.

In addition to these problems, irrigation system in Lampung has higher water demands compare to Java. This is due to the relatively porous nature of the local soil resulting in excessive infiltration. This phenomenon was recognised in the 1930s, in a study by Wehlburg, who stated that the normal water requirement during the stable condition was 1.26 L/s/hectare. A later report defined capacities of 1.65 L/s/hectare (in the wet season) and 1.89 L/s/hectare (in the dry season) (Ertsen and Pradhan, 2004).

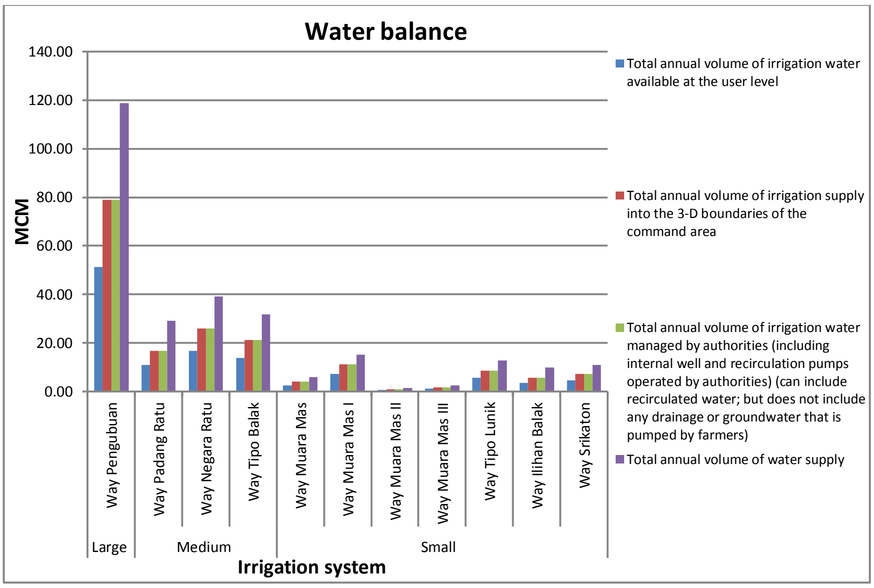


Figure 4.28. Water balance

Higher water demand and considerable differences in the discharge of river water in the rainy and dry season have an impact on water availability for irrigation, especially during the dry season. Therefore, there is a need to prepare a water management system that enables optimal utilisation of rainfall water during the dry season. Systems that can be pursued include the construction of reservoirs or ponds, recirculation of irrigation water, and utilisation of groundwater. Condition and performance assessment of the irrigation system is required to decide the best solution for an irrigation system.

Of the 11 case study irrigation systems, only Negara Ratu takes water from the river through free-intake; the others obtain water via weirs. Figure 4.28 shows, for all the irrigation system, that the total annual volume of irrigation water available at the user level was below the total annual volume of irrigation supply into the 3D-boundaries of the command area. All irrigation water supplies into the 3D-boundaries of the command area are managed by the authority. Therefore, the volume is equal to the total annual volume of irrigation water managed by authorities. Taking into account a 65% stated conveyance efficiency of imported canal water, the potential availability of water is still more than adequate, as shown by the total annual volume of water supply, being the surface irrigation water inflow from outside the command area (gross at diversion and entry points). This is still well above the current volume managed by the authority today.

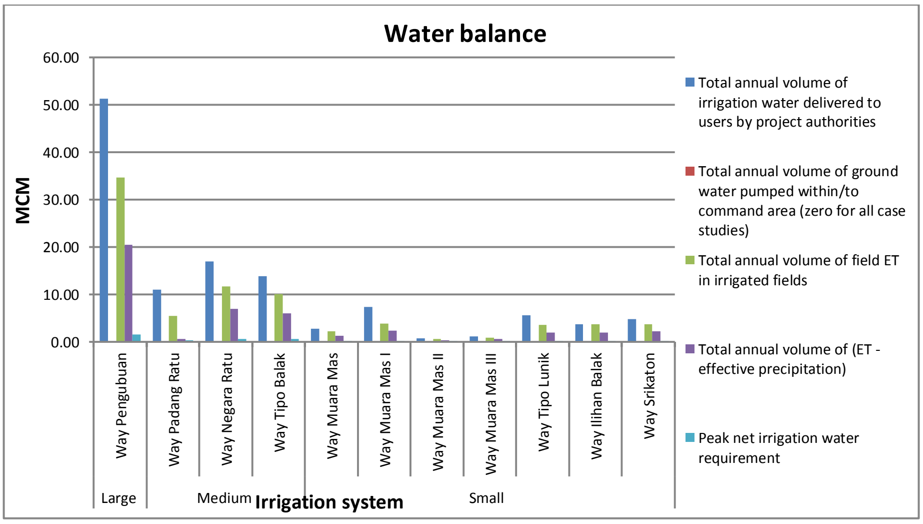


Figure 4.29. Water balance

Figure 4.29 shows that all of the water supplied by the authorities in the irrigation system is from surface water and the utilisation of ground water is zero (shown by red column). The total annual volume of irrigation water delivered to users by project authorities is well above the total annual volume of field ETo in irrigated fields.

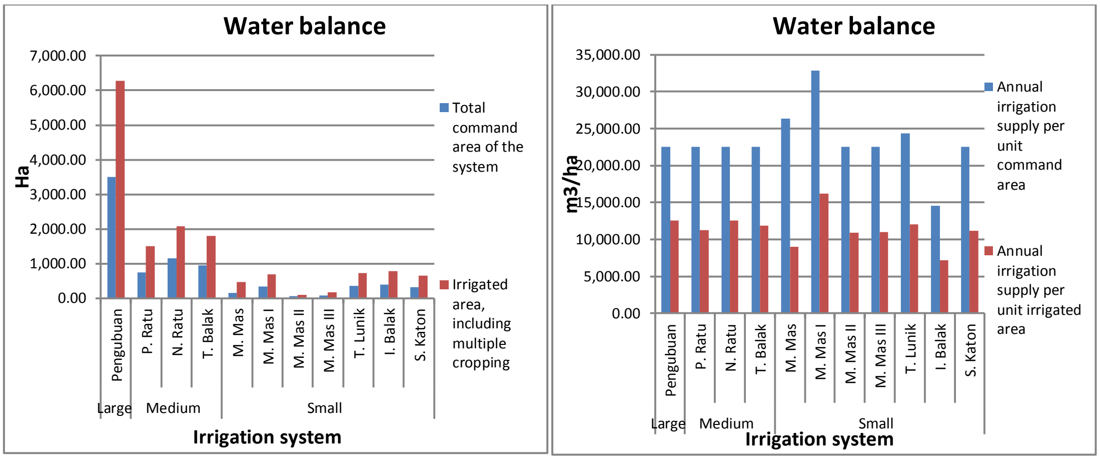


Figure 4.30. Water balance

Figure 4.30(a) presents the total command area of the system and irrigated areas, including multiple cropping. Based on this data, it can be calculated that the average command area to irrigated area ratio of the irrigation system was 0.73, and the average cropping intensity was 2.03 (*see Figure 4.34 (a) and (b)*). Based on the previous data presented in Figures 4.28, it is possible to increase the ratio and the cropping intensity of the irrigation system.

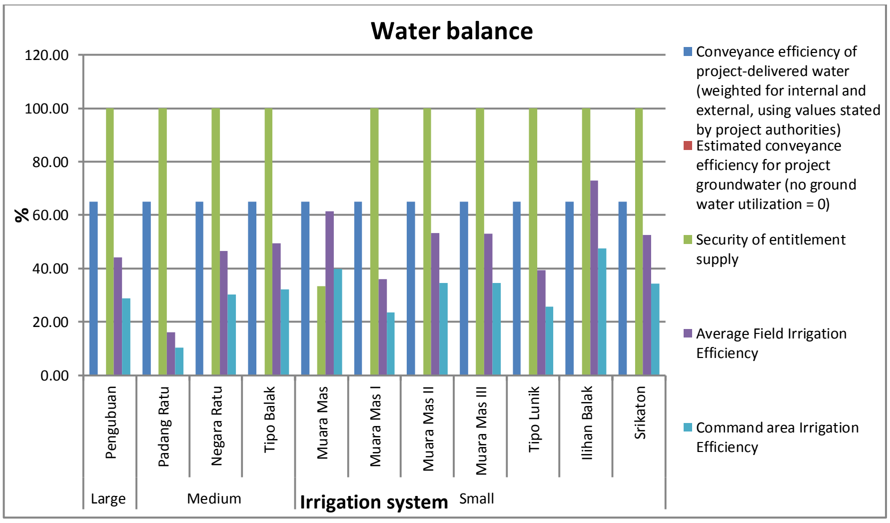


Figure 4.31. Water balance

Figure 4.31 show that the conveyance efficiency of project-delivered water in all case study irrigation systems was 65%, which is quite low. This value is uniform for all case study irrigation systems due to each UPTD staff following an established standards, they have the same educational background and training, and years of service. In all case study irrigation systems, field irrigation efficiency also are higher than the values of command area irrigation efficiency due to improved water settings at the water user level by the WUAs.

As seen in Figure 4.31, there is no groundwater utilisation in any of the irrigation system, so the value of the estimated conveyance efficiency of project groundwater is zero. The current water supply is still able to satisfy user demand for all case study irrigation systems, shown by the value of the security entitlement supply being 100%. Since there is no current obvious water problem, farmers still do not appreciate the value of water. This is evident from the very low field irrigation efficiency value of between 16% for the Padang Ratu irrigation system and 73% for the Ilihan Balak irrigation system. On average, the field irrigation efficiency of the irrigation system was only 48%. The very low field irrigation efficiency of the Padang Ratu irrigation system can be understood because this area has abundant water potential, which is high in the wet and dry seasons. Increased efficiency at the project/system level is more complex than improving efficiency in the field. Efficiency at the system level requires the improvement of irrigation system management arrangements in terms of infrastructure, staffing and standards. On the other hand, efficiency in the field is easier. This is due to the growing awareness of the value of water by farmers, and the increasing knowledge of *Ulu-ulu* and *Ili-ili* of more efficient regulation of water distribution operations and the embracing of their role as the vanguard in the efficient use of field irrigation water.

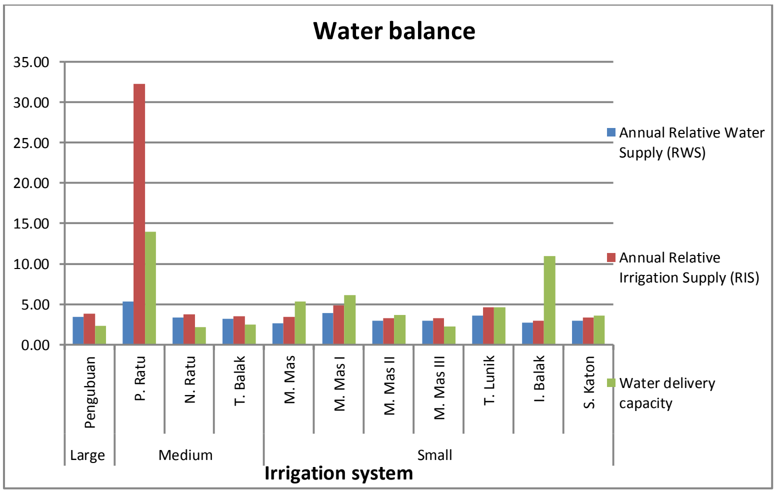


Figure 4.32. Water balance

It can be seen in Figure 4.32 that half of the irrigation systems have the value of water delivery capacity higher than the annual relative water supply (RWS) and annual relative irrigation supply (RIS). It indicates that the channel capacities are still below the potential of irrigation water available and that distributed to the systems. However, the other half need the channel capacities to be enlarged to accommodate the delivery capacity of the systems. With an exception for the Way Padang Ratu irrigation system where irrigation water is highly abundant, water delivery capacity actualy had exceeded the requirement.

4.5.1.3 Agricultural Productivity and Economics

As mentioned in *Section 2.3.3.3*, irrigation provides direct and indirect benefits, an overall benefit, and an added value benefit. Since it is not easy to assess all of these benefits, performance assessment generally focusses on the direct benefits of irrigation i.e., agricultural productivity.

Agricultural productivity is measured as the ratio of agricultural outputs to agricultural inputs. An increase in agricultural productivity leads to agricultural growth and this can help alleviate poverty in poor and developing countries, particularly with regard to farmers in poor rural areas. Agricultural productivity is becoming increasingly important as the world population continues to grow and this productivity is often linked with sustainable development. As irrigation systems implement measures to increase the productivity of their irrigated land, they must also find ways to ensure that future generations will also have the resources they need to live and thrive.

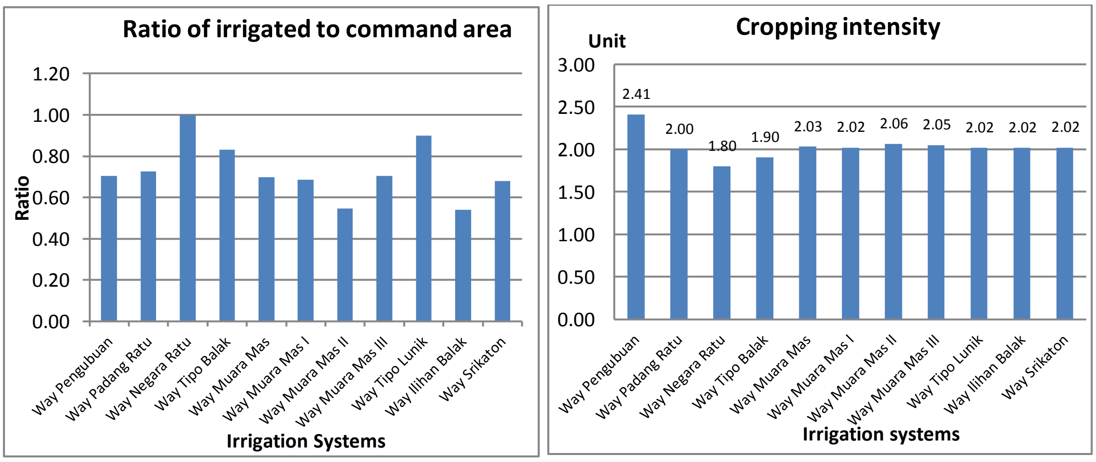


Figure 4.33. (a) Ratio of irrigated to command area and (b) Cropping intensity

Figure 4.33(a) shows that the irrigation system had an irrigated to command area ratio that varied from 0.5 for the Ilihan Balak system to 1.0 for the Negara Ratu system. The Negara Ratu system is a medium irrigation system, located near a suburban area and airport. This accessibility attracted farmers to the land where they bought plots and thus agricultural land developed rapidly with the irrigation system being first introduced in 1975. Currently, the system has reached its maximum capacity, indicated by an irrigated to command area ratio of 1.0. On the other hand, the Ilihan Balak system is a small irrigation system which is located in a remote area of central Lampung. Its remoteness makes it less desirable, and only half of the system has been developed into an irrigated area since it was first operated in 1985.

On average, the irrigation systems surveyed had cropping intensities of 2.0, apart from the Way Pengubuan system (Figure 4.33(b)). The Way Pengubuan system is a large system that is authorised and managed by the central government. It has a more sophisticated infrastructure than the other systems surveyed, and therefore most of the irrigated land can be used three times a year.

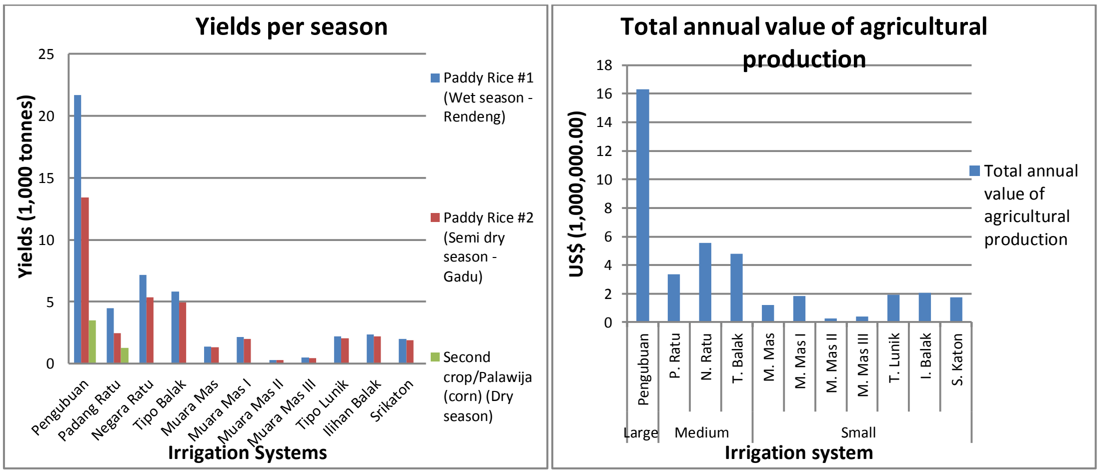


Figure 4.34. (a) Yields per season and (b) agricultural production

The yield and value of agricultural production varies according to the scale of irrigation systems. In all irrigation systems, the yield for a paddy in the wet season is 5 – 6.2 tonnes/ha and in the dry season 4 – 5.8 tonnes/ha. Figure 4.34(a) shows that the Way Pengubuan system had the highest yield, since it possessed the most extensive irrigation area and greatest cropping intensity. The highest yields were obtained in the first planting season (rainy season/*rendeng*), followed by the harvest in the second growing season (semi-dry/*gadu*). The lowest yield was during the third growing season (dry season). The total annual value of agricultural production of the Way Pengubuan system was the highest at US$16,307,522.22, as shown in Figure 4.34(b). In this case study, the output value was measured as the market value of final output at the farm-gate (farm-gate selling price).

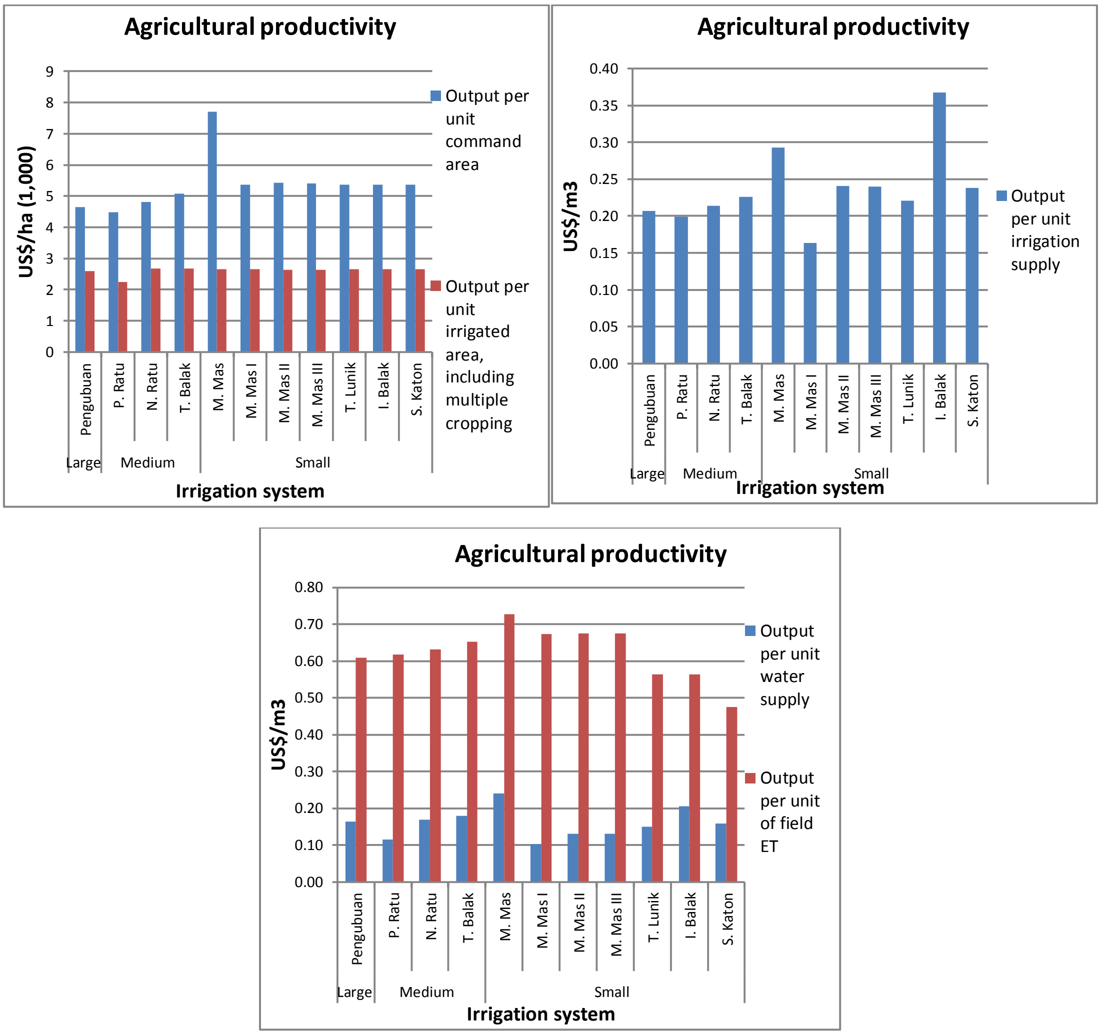


Figure 4.35. Agricultural productivity

Figure 4.35(a) shows the output per unit command area and the output per unit irrigated area, including multiple cropping of the irrigation system. Output per unit command area is the result of the division of the total annual value of agricultural production against the total command area of the system, whilst output per unit irrigated area is the result of the total annual value of agricultural production divided by the total annual irrigated crop area. On average, the output per unit command area was US$5,366.51/ha and the output per unit irrigated area, including multiple cropping, was US$2,611.00/ha. The Way Muara Mas system had the highest value of output per unit command area at US$7,710.19/ha and the Way Padang Ratu system had the lowest value at US$4,476.59/ha. The Negara Ratu system had the highest value of output per unit irrigated area at US$2,676.66/ha and the Way Padang Ratu had the lowest value at US$2,238/ha.

Figure 4.35(b) shows the output per unit irrigation supply, which is the division of the total annual value of agricultural production by the total annual volume of irrigation supply into the 3-D boundary of the command area. On average, the irrigation system had a value of output per unit irrigation supply of US$0.24/m^3, with the Way Ilihan Balak system having the highest value at US$0.37/m^3 and the Way Muara Mas I system the lowest value at US$0.20/m^3.

Figure 4.35(c) presents the value of output per unit water supply and the value of output per unit of field ETo. The output per unit water supply is the division of the total annual value of agricultural production by the total annual volume of water supply; and the value of output per unit of field ETo is the total annual value of agricultural production divided by the total annual volume of field ETo. On average, the value of output per unit water supply and the value of output per unit of field ETo were US$0.16/m^3 and US$0.62/m^3, respectively. The Way Muara Mas system had the highest value of output per unit water supply and output per unit of field ETo at US$0.24/ m^3 and US$0.73/m^3, respectively. The Way Muara Mas system had the lowest value of output per unit water supply at US$0.10/ m^3 and the Way Sri Katon system had the lowest value of output per unit of field ETo at US$0.48/ m^3.

4.5.1.4 Financial

The financial accounting of agricultural productivity is presented in Figures 4.36.

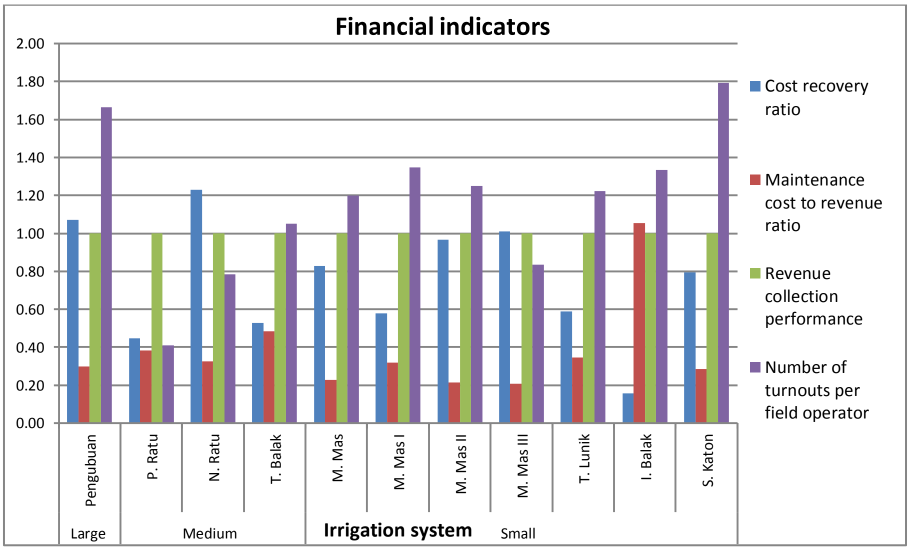


Figure 4.36. Financial indicators

Figure 4.36 displays the cost recovery ratio, maintenance cost to revenue ratio, revenue collection performance, and the number of turnouts per field operator of the irrigation system. These indicators are calculated based on the level of management by the WUA, which starts from the third canal level of an irrigation system.

The cost recovery ratio indicates a ratio of total revenues collected from payment of services by water users divided by total MOM (management, operation, and maintenance) costs of irrigation and drainage services, excluding capital expenditure and depreciation/renewals. The average cost recovery ratio of case study irrigation systems was 0.75, where the Way Negara Ratu system had the highest value of 1.23 and the Way Ilihan Balak system had the lowest at 0.16. The Way Negara Ratu is a medium irrigation system authorised by the provincial government, whereas the Way Ilihan Balak is a small system authorised by the district/*kabupaten* government. Since MOM funds from the provincial government are higher than those from the district government, the infrastructure condition of a medium irrigation system is generally superior to that of a small irrigation system. A better maintained system generally has a lower MOM cost, therefore, the ratio of the Way Negara Ratu system is better than that of the Ilihan Balak system. The cost recovery ratio of the Negara Ratu system is superior to the ratio of a large system authorised by the central government, since it is not influenced by sedimentation due to erosion from higher land.

The maintenance cost to revenue ratio is the division of the total expenditure on system maintenance by the total revenue collected from payment of services by water users. On average, the irrigation system had a ratio of 0.38. The best system was the Muara Mas II and Muara Mas III with a ratio of 0.21 and the worst was the Ilihan Balak system with a ratio of 1.05. This means that all available funds collected from water users on the Ilihan Balak system are used only for emergency maintenance purposes.

Revenue collection performance shows the total revenue collected from payment of services by water users divided by the total revenue due for collection from water users for provision of irrigation and drainage services. All of the irrigation system had a ratio of 1.0, meaning that all farmers were paying for the service they received. This cooperation was not simply because the WUAs imposed administrative and harsh social sanctions for members who violate it, but also because the farmers felt that the fees were affordable and the services received met their expectations.

The number of turnouts per field operator shows the total number of turnouts/offtakes divided by the total number of personnel engaged in field irrigation and drainage services. The value shown in Figure 4.36 is misleadingly high (on average 1.17), as almost every operator handles only one turnout. In reality, the number of offtakes is not adequate and the addition of offtakes is required for more equitable water distribution.

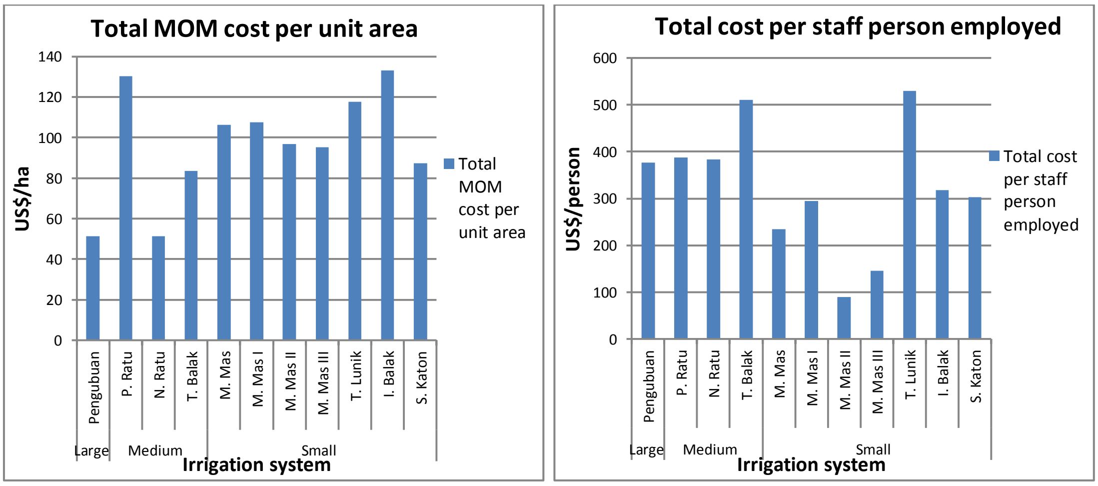


Figure 4.37. Financial indicators: (a) total MOM cost per unit area, and (b) total cost per staff person employed

The total MOM cost per unit area is the value obtained from the total MOM cost of providing the irrigation and drainage service, excluding capital expenditure and depreciation/renewals, divided by the total command area serviced by the system. The total cost per staff member employed is the division of the total cost of personnel by the total number of personnel. The total MOM cost per unit area of the irrigation system varied between US$51.47/ha/year and US$133.20/ha/year (on average US$96.42/ha/year), as shown in Figure 4.37(a).

Figure 4.37(b) shows that the total cost per staff member employed, varied from US$90.14/person to US$529.74/person (on average US$324.93/person. This variation was due to the different project budgets received by each irrigation system for works. These works included improvement of structures, modernisation, maintenance, rehabilitation and other operations carried out over the previous five years.

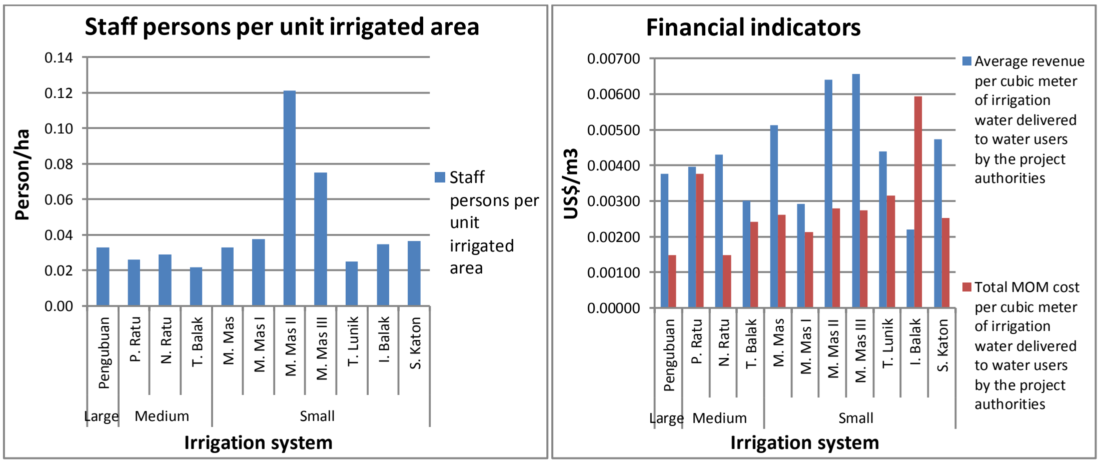


Figure 4.38. Financial indicators : (a) staff person per unit irrigated and (b) revenue and cost per cubic meter of irrigation water

The number of staff per unit of irrigated area is the total number of personnel engaged in irrigation and drainage services divided by the total irrigated area serviced by the system. Figure 4.38(a) shows that this varied from 0.02 to 0.12 persons/ha (0.04 persons/ha on average). A local technical implementation unit called the UPTD (*Unit Pelaksana Teknis Daerah*) carries out the daily management and operation of an irrigation system. Generally, a UPTD is in charge of 5,000 to 7,500 hectares of irrigated area. Therefore, a UPTD can control more than one irrigation system. The UPTD staff in an irrigation area consists of one head, approximately five administrative staff, and a few technical staff. The technical staff includes water clerks, weir operation officers, and sluice officers. A water clerk is responsible for about 750 to 1,500 hectares of irrigated area, a weir operations officer is responsible for one weir (or there may be several if the weir is large), and a sluice officer is responsible for three to five division/offtake structures (2km to 3 km of channel or 150 to 500 hectares of irrigated area).

The average revenue per cubic meter of irrigation water delivered to water users by the project authorities is the gross revenue collected divided by the total annual volume of project irrigation water delivered. This varies from US$0.00220 to US$0.00657/m^3 (US$0.00431/m^3 on average), as shown in Figure 4.38(b). All revenue collected by WUAs is used for the management, O&M of irrigation assets at the tertiary level, and is under the responsibility of WUAs. No portion of the revenue is sent to the government.

The total MOM cost per cubic meter of irrigation water delivered to water users by the project authorities is a division of the total MOM cost by the total annual volume of irrigation delivered by project authorities. Figure 4.38(b) shows that it varies between US$0.00148/ m^3 and US$0.00594/ m^3 (US$0.00282/$m^3$ on average). This variation is again due to the different project budgets received by each irrigation system for works in the previous five years.

4.5.1.5 Environmental

In general, the environmental aspect of irrigation systems in Indonesia has not received proper attention, as the focus remains on improving the water balance and agricultural productivity, along with financial and economic performance. Currently the government regularly checks the pollution levels of river water, but does not yet have to monitor agricultural land or irrigation system pollution. River water pollutant parameters that are checked include; dissolved oxygen, biochemical oxygen demand, and chemical oxygen demand (DO, BOD, and COD). The three are the physico-chemical properties that directly or indirectly depend on the amount of oxygen in the river water. The assessment of three major rivers in the catchment area of the irrigation system (Way Pengubuan, Way Sekampung and Way Seputih rivers) showed that the average monthly DO, BOD, and COD was 4.1, 11.0, and 32.2 mg/L, respectively (the Government of the Province of Lampung, 2009). In 1992, the UNESCO, WHO and UNEP published a BOD threshold of 3-6 mg/L and COD threshold of < 20 mg/L for river water used in agricultural water supplies and for fisheries (UNESCO, WHO and UNEP, 1992). From this information, it can be concluded that the above rivers are in a critical condition and do not meet the requirements for irrigation water .

Unfortunately, no data is available on the salinity assessment of river water for irrigation, especially average irrigation water salinity (ECw) and total dissolved solids (TDS), which are important parameters of quality. The FAO provides guidelines regarding the usual range of ECw (0 – 3.0 dS/m) and TDS (0 – 2,000 mg/L) (UNESCO, WHO and UNEP, 1992). This research assumes that average irrigation water salinity is 1.0 dS/m.

Other environmental aspects in the RAP assessment and Benchmarking are average depth to the shallow water table (m) and change in shallow water table depth over the last five years (+ representing an increase) (m). These are environmental aspects that have not yet been recorded in the case study areas.

4.5.1.6 Other

An additional indicator used in the RAP assessment and Benchmarking is the percentage of O&M expenses used for pumping. Rural irrigation systems in the Province of Lampung and in Indonesia generally use surface irrigation, and water pumping is not required. Therefore, there are currently no additional O&M costs. However, since groundwater is used as an alternative where there is a lack of irrigation water in the dry season, a calculation of additional O&M costs for groundwater pumping needs to be considered.

4.5.2 Internal Indicators

According to Burt (2001), the broad goals of modernisation are to achieve improved irrigation efficiency and better crop yields (external indicators), less canal damage from uncontrolled water levels, more efficient labour, improved social harmony, and an improved environment which would be accomplished by less diversions or better quality return flows. These goals can only be achieved by paying attention to internal details (Burt, 2001). RAP and Benchmarking addressed these issues by assessing the service and social order; main, second level and third level canals; budgets, employees and WUAs; and some special indicators.

Table 4.11 presents the summary of performance internal indicators of case study irrigation systems. A more detailed results of the internal indicators assessment can be seen in *Appendix C.6.5 and C.6.6* and detailed assessment of internal indicators can be seen in *Appendix C.6.7*. Further discussions on the value of the indicators contained in Table 4.11 for each group of indicators mentioned above is described in Section 4.5.2.1 to 4.5.2.4. Some graphics presented in these sections were derived from the *Appendix C.6.5*.

In general, water delivery service throughout the irrigation systems were in moderate quality.

Table 4.11. Summary of Internal indicators

Indicator Label	Primary Indicator Name	Value (0-4)		Rating
		Range	Average	
SERVICE and SOCIAL ORDER				
I-1	Actual Water Delivery Service to Individual Ownership Units (e.g., field or farm)	2.18 - 2.64	2.31	Fair
I-2	Stated Water Delivery Service to Individual Ownership Units (e.g., field or farm)	2.18 - 2.64	2.53	Good
I-3	Actual Water Delivery Service at the most downstream point in the system operated by a paid employee	2.12 - 2.82	2.45	Fair
I-4	Stated Water Delivery Service at the most downstream point in the system operated by a paid employee	1.76 - 2.24	2.19	Fair
I-5	Actual Water Delivery Service by the Main Canals to the Second Level Canals	2.56 - 3.00	2.93	Good
	Stated Water Delivery Service by the Main Canals to the Second Level Canals	1.89 - 2.79	2.54	Good
I-7	Social "Order" in the Canal System operated by paid employees	3.25 - 4.00	3.61	Good
MAIN CANAL				
I-8	Cross regulator hardware (Main Canal)	1.71 - 2.86	2.45	Poor
I-9	Turnouts from the Main Canal	2.33 - 3.00	2.44	Poor
I-l0	Regulating Reservoirs in the Main Canal (Note: No regulating reservoir in these systems)	n.a	n.a	n.a
I-11	Communications for the Main Canal	2.18 - 2.27	2.26	Fair
I-12	General Conditions for the Main Canal	1.20 - 2.40	1.85	Poor
I-13	Operation of the Main Canal	2.14 - 2.66	2.40	Fair

Indicator Label	Primary Indicator Name	Value (0-4)		Rating
		Range	Average	
SECOND LEVEL CANALS				
I-14	Cross regulator hardware (Second Level Canals)	1.43 - 3.57	2.22	Fair
I-15	Turnouts from the Second Level Canals	2.33 - 3.00	2.45	Fair
I-16	Regulating Reservoirs in the Second Level Canals (Note: No regulating reservoir in these systems)		n.a	n.a
I-17	Communications for the Second Level Canals	2.09 - 2.55	2.25	Fair
I-18	General Conditions for the Second Level Canals	1.20 - 2.20	1.67	Fair
I-19	Operation of the Second Level Canals	1.78 - 2.40	2.31	Fair
THIRD LEVEL CANALS				
I-20	Cross regulator hardware (Third Level Canals)	0.86 - 2.00	1.44	Poor
I-21	Turnouts from the Third Level Canals	2.67 - 3.00	2.24	Fair
I-22	Regulating Reservoirs in the Third Level Canals (Note: No regulating reservoir in these systems)	n.a	n.a	n.a
I-23	Communications for the Third Level Canals	2.09 - 2.28	2.12	Fair
I-24	General Conditions for the Third Level Canals	1.40 - 2.80	1.64	Fair
I-25	Operation of the Third Level Canals	2.34 - 2.88	2.45	Fair

Indicator Label	Primary Indicator Name	Value (0-4)		Rating
		Range	Average	
BUDGETS, EMPLOYEES, AND WUAs				
I-26	Budgets	0.40 - 1.20	0.47	Bad
I-27	Employees	1.35 - 1.93	1.42	Fair
I-28	Water User Associations	2.92 - 3.23	3.16	Good
I-29	Mobility and Size of Operations Staff	0.00	0.00	Bad
I-30	Computers for billing and record management	0.00	0.00	Bad
I-31	Computers for canal control	1.00	0.73	Poor
INDICATORS THAT WERE NOT PREVIOUSLY COMPUTED				
I-32	Ability of the present water delivery service to individual fields, to support pressurized irrigation methods	1.83 - 3.17	2.41	Fair
I-33	Changes required to be able to support pressurized irrigation methods	2.50	2.59	Fair
I-34	Sophistication in receiving and using feedback information. This does not need to be automatic.	1.00 - 2.00	1.64	Fair
SPECIAL INDICATORS THAT DO NOT HAVE A 0-4 RATING SCALE				
I-35	Turnout density	125 -2,800	718.45	Poor
I-36	Turnouts/Operator	0.41 - 1.79	1.01	Excellent
I-37	Main Canal Chaos	1.08 - 1.59	0.66	Overstated
I-38	Second Level Chaos	0.95 - 1.60	1.13	Slightly understated
I-39	Field Level Chaos	0.83 - 1.21	0.92	Slightly overstated

4.5.2.1 Service and Social Order

Up to the secondary level of a system, the day-to-day operation and management of an irrigation system is executed by the UPTD (Local Technical Management Unit) which is an extension of the government (central, provincial, or district) in the local area. At tertiary and quaternary levels, the operation, maintenance, renewal, finance, and management responsibility of the system falls on the financially autonomous WUAs.

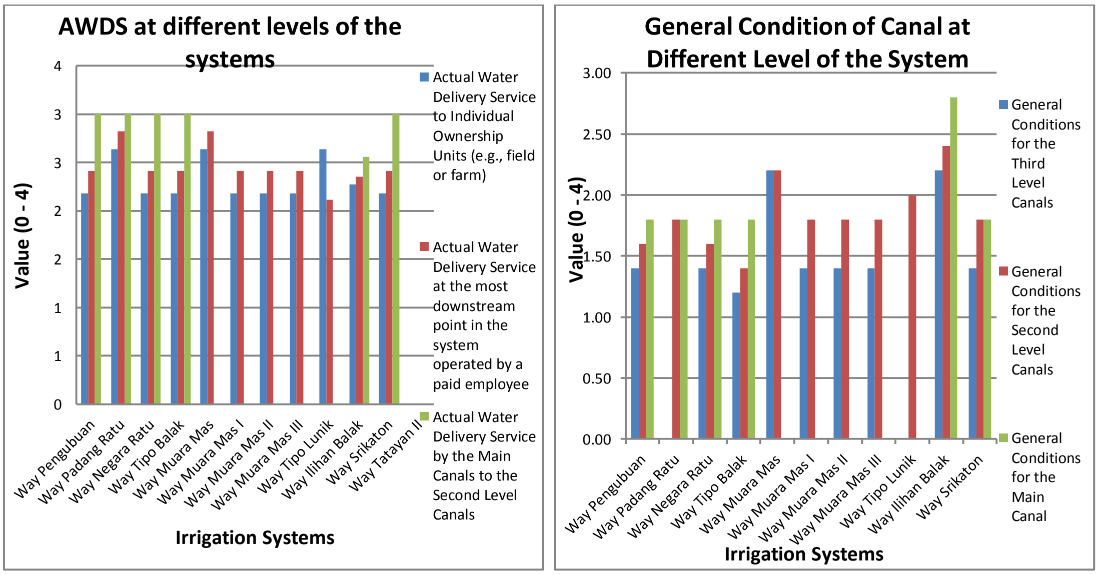


Figure 4.39. (a) AWDS at different levels of the system and
(b) general condition of channel at different levels of the system

There was discontinuity between the actual water delivery service (AWDS) at different levels of the irrigation system (*see Figure 4.39(a)*). The AWDS gradually decreased (except for Way Tipo Lunik) below the main channels (or second level for Way Muara Mas 0, 1, 2, 3 and Way Tipo Lunik since they do not have main channels; shown by no green column) and continued to the channels of individual ownership. It can be seen from Table 4.11, the average AWDS at the main channels to the second level channels and at the most downstream point operated by a paid employees are 2.93 and 2.45 out of 4 respectively. While average AWDS to the individual ownership units which is administered by WUAs is 2.31 out of 4.0.

This condition is in line with the infrastructure condition which also declines gradually from the main channels to the channels of individual plots as shown in Figure 4.39(b) (note that Way Tipo Lunik also do not have third level channel).

Table 4.11 also shows that the average condition for main, second level, and third channels were 1.85, 1.67 and 1.64 out of 4.

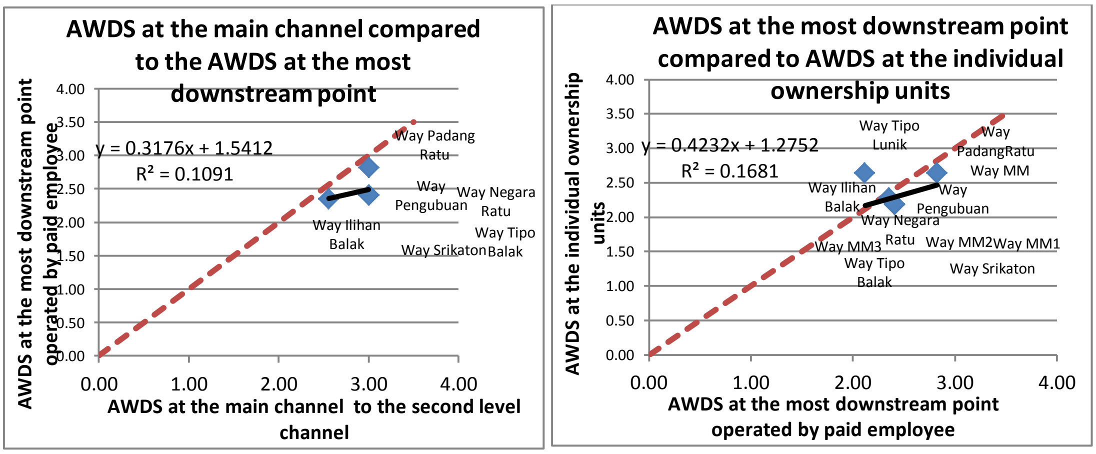


Figure 4.40. (a) AWDS at the main channels compared to the AWDS at the most downstream point, and (b) AWDS at the most downstream point compared to AWDS at the individual ownership units

Figure 4.40(a) and (b) show a comparison of the AWDS at different levels of the system. The red dashed line represents a situation where the AWDS at both levels is the same and the management of the different levels of a system is consistent, and therefore the quality of AWDS is expected to be the same.

Figure 4.40(a) shows that all the irrigation systems are below the red line. It means that they all have the AWDS from the main channels to its offtakes (second level channels) better than at the most downstream point. Both were operated by a paid employee. It can also bee seen from Table 4.11 that the average AWDS at main channel to the second level channel and the average AWDS at the most downstream point were 2.93 and 2.45 out of 4 respectively. It can be calculated that the performance levels dropping an average 14%.

Figure 4.40(b) and Table 4.11 also show that in general the AWDS at the most downstream point in the system operated by a paid employee (2.5) was better than the AWDS at the individual ownership unit (2.31). It can be calculated that the performance levels dropping an average 8%. The overall decline in the performance level from the main channels to the individual plots managed by WUAs was 215%.

These may be due to the condition of the infrastructure and operating systems at a higher level being better than at lower levels, as shown in Table 4.11 and Figure 4.39(b).

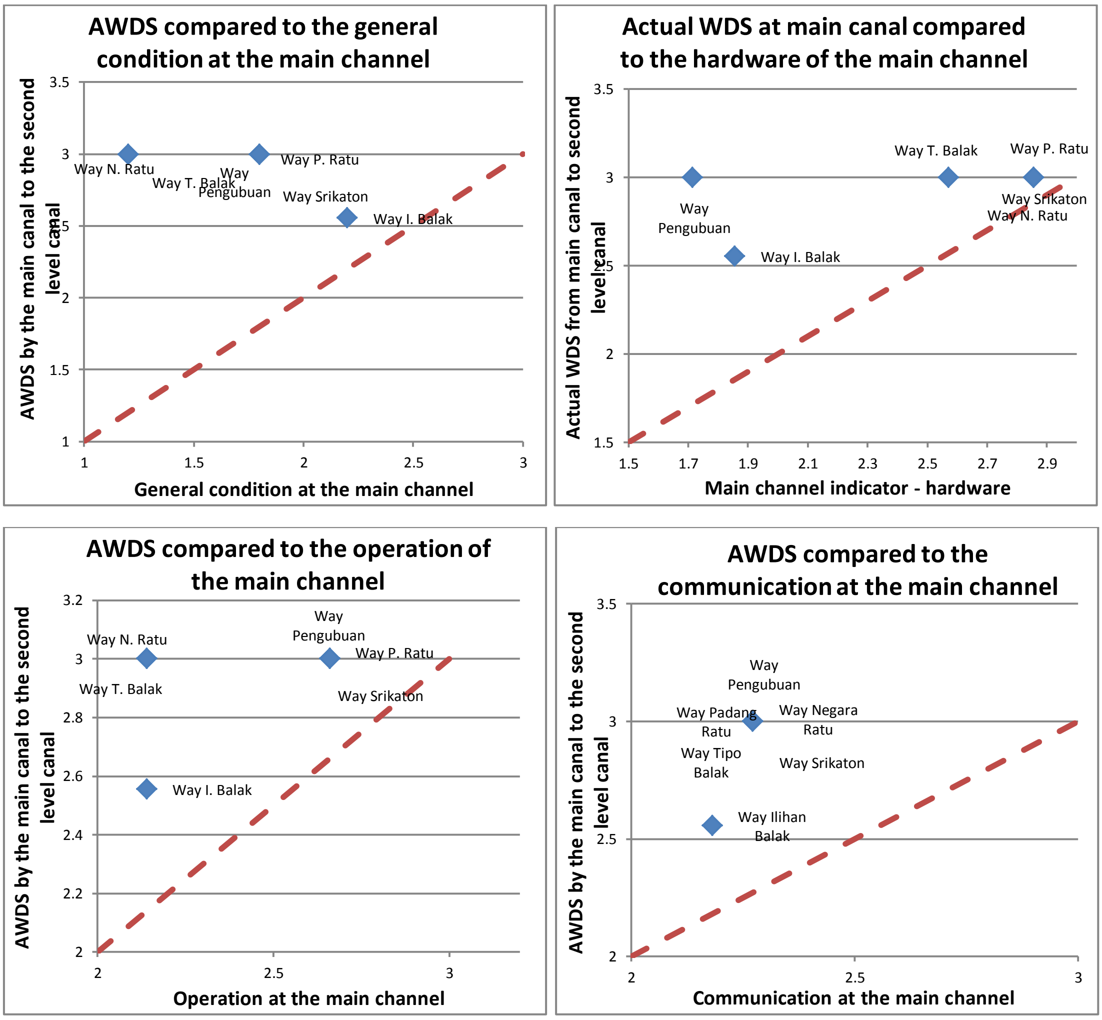
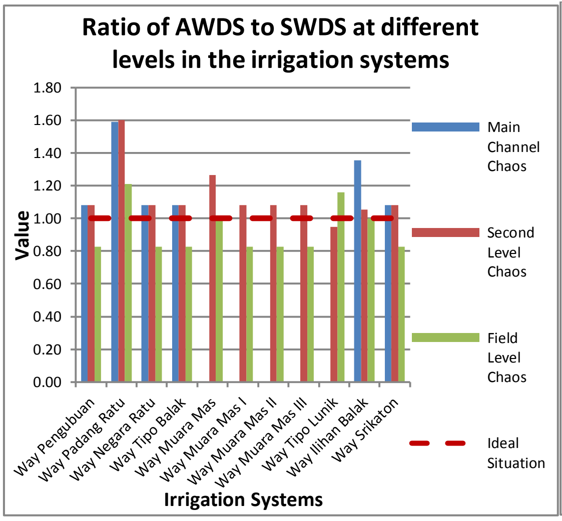


Figure 4.41. AWDS compared to (a) condition, (b) hardware, (c) operation and (d) communication at the main channels

For an irrigation system to be functioning at its best, it requires adequate infrastructure and appropriate operation and communication to provide a good quality water delivery service to its farmer users. The red dashed line represent a situation where the quality of AWDS at main channels are texpected to be the sam with the condition, hardware, operation and communication and the management of the main channels. Table 4.11 shows that the average indicator value of AWDS in the main channel was 2.93 out of 4.0, whilst the average indicator values of general conditions, hardware, operations and communication were 1.85, 2.45, 2.40 and 2.26 (respectively) out of 4.0.

It can be postulated from Figure 4.41 (a), (b), (c) and (d) that the performance of AWDS at main channel of all irrigation systems are above the red lines. Therefore, it can be postulated that the staff responsible for the daily operation of irrigation systems have tried to provide the best water delivery service possible, given the condition of the existing infrastructure and hardware, and the level of operations and communication.



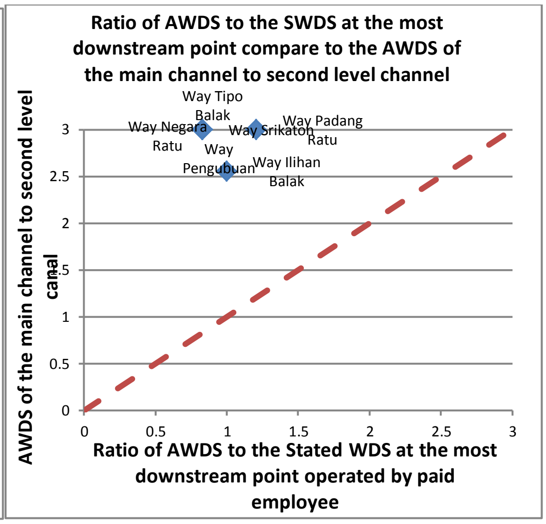


Figure 4.42. Ratio of AWDS to SWDS (a) at different levels in the system (b) at the most downstream point compared to the AWDS at the main channels

The ratio of AWDS to stated water delivery service (SWDS) is called chaos. The main channel chaos is the division of AWDS by SWDS at the main channel to the second level channel. Second level chaos is the division of AWDS by SWDS at the most downstream point operated by a paid employee. While, the field level chaos is the division of AWDS and SWDS at the individual ownership units. The RAP an Benchmarking explains that the ratio of AWDS to SWDS reveals the extent of knowledge of irrigation engineers about the actual field situation in their system. The closer the value is to 1.0, the more aware a manager is of the problems, constraints and possible achievements of their irrigation system. It is shown by the red dashed line in Figure 4.42(a) which represents the most desirable situation where AWDS is the same as SWDS.

Figure 4.42(a) presents the ratio of AWDS to SWDS at different levels in the irrigation system. The graph shows that managers generally overstated the quality of the water delivery service (WDS) at the individual landplot units since most of the green columns are below the red dashed line. On the other hand, the managers tends to understated the quality of their service at the main and second level channels, and at the most downstream point operated by a paid employee. It can be seen that the blue and red columns are upright above the red dashed line in Figure 4.42(a) and the irrigation systems are above the red dashed line in Figure 4.42(b). The figure also shows that most of the irrigation system had an AWDS at the main channel approaching the value of 3.0.

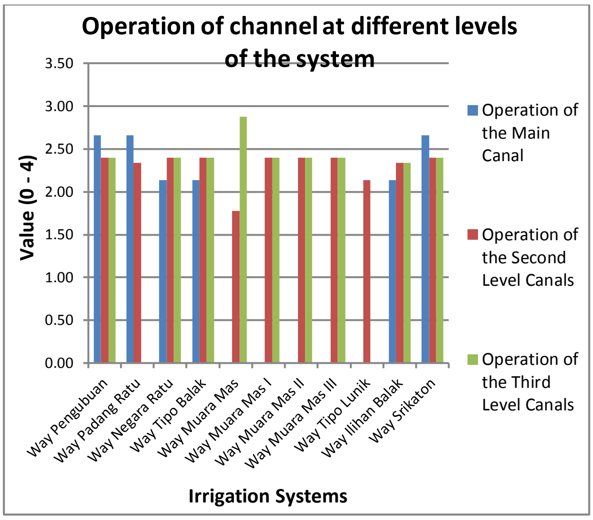


Figure 4.43. Operation of channel at different levels of the system

The operating performance of an irrigation system, as shown in Figure 4.43, was approximately the same across all case study irrigation systems and at all levels in the system, with a value of about 2.4 out of 4.0. This is due to the fact that all the irrigation systems are simply following the standard procedure for operation of irrigation networks issued by the Ministry of Public Works.

4.5.2.2 Budgets, Employees, and Water User Associations (WUAs)

Since several institutions are involved in the management and finance of an irrigation system and the division of responsibility/authority of an irrigation system, it is not easy to trace the source of funding even in a single financial year. Furthermore, there is no direct financing mechanism to cover the cost of irrigation services provided by the government. That is why management transfer programs impact on the financial viability of an irrigation system is assessed at a tertiary level (WUA level) since the tertiary O&M services are directly and completely financed by WUAs.

The turnover policy guides the arrangement of decentralised management and autonomous nature of these associations. It allows each local water user group to levied charges on its members. In the province of Lampung, fees charged by WUAs for tertiary O&M are established on a seasonal basis according to the area irrigated, with no distinction between cropping seasons. The rates vary between 50 kg and 60 kg of crops/ha.

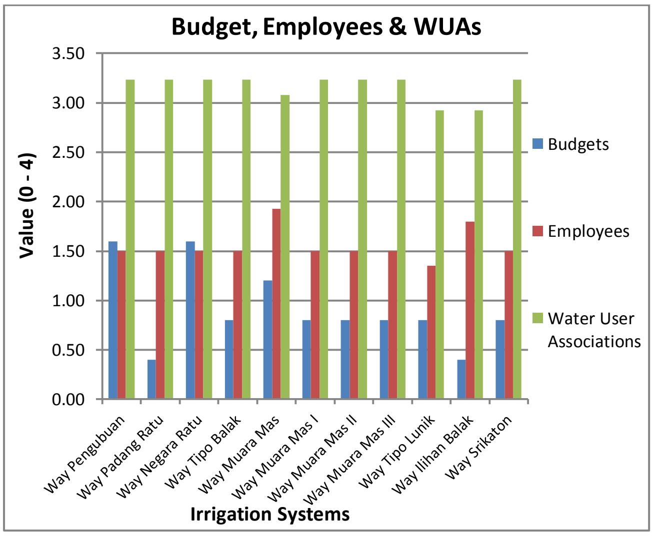


Figure 4.44. Budget, employees and WUAs

Figure 4.44 shows that budget and employee performance levels are low, being on average only 0.01 and 1.42 (respectively) out of 4.0. However, WUA performance is good at an average of 3.1 out of 4.0. Even though the performance indicator value of WUAs is good, however the organisation and management of WUAs is actually relatively weak. WUAs have enough power to make irrigation water sharing arrangements run harmoniously, and irrigation water charges run smoothly, from the tertiary level to individual landplots. The rare event of breaches are often due to social sanctions that make offenders uncomfortable in the neighbourhood.

In general, WUAs are formed when an irrigation system is first operated. Table 4.6 in Section 4.4 shows that the irrigation system were built between 1972 and 1992, except Way Padang Ratu and Way Negara Ratu which existed in the colonial era. The Way Padang Ratu irrigation system was built in 1935 and the Way Negara Ratu was established in 1916 and revitalised in 1972. The organisation of WUAs in the irrigation system was therefore initiated between 1972 and 1992, but many were formed informally without any legal documentation (*see Appendix C.5.1. The lists of WUAs in the irrigation system, and Appendix C.5.2. The typical organisation of a WUA*).

Participation in irrigation management (PIM) has been considered necessary since 1980. Since 2007, through WISMP and PISP, the government has helped WUAs to improve their organisation and complete their legal requirements with five administrative documents including: constitution and bylaws of the organisation, number and date of organisation registration in the district court, the regent's letter of approval, public notary attestation certificate, and a tax file number and bank account. By having these documents, a WUA may act as a business and can establish contracts with other parties for agreed services.

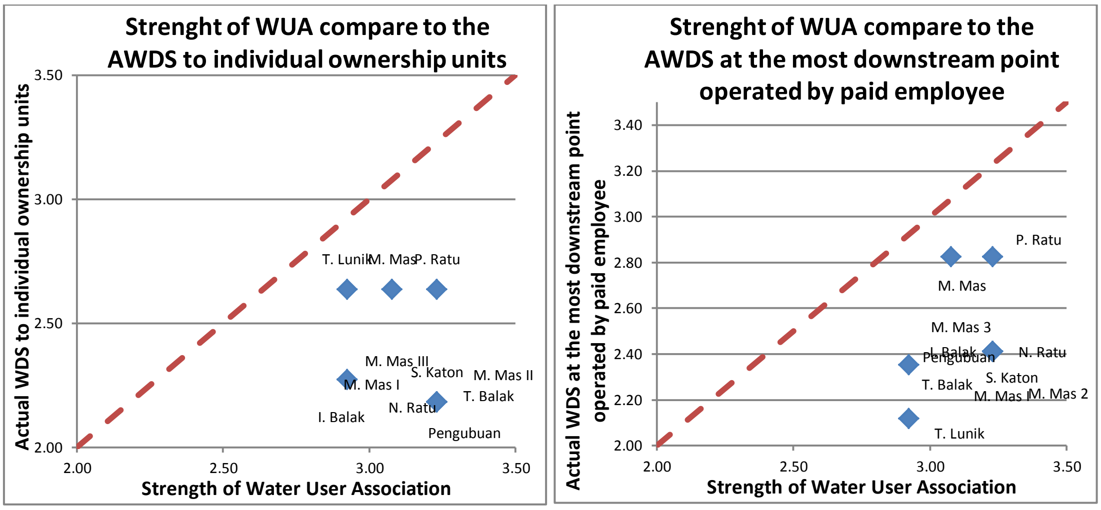


Figure 4.45. Strength of WUAs compared to the AWDS (a) to the individual ownership units and (b) at the most downstream point operated by a paid employee

Figure 4.45 (a) and (b) display the performance indicator values of WUAs compared to AWDS to individual landplots units (2.3 out of 4.0 on average) and AWDS to the most downstream point operated by paid employees (2.5 out of 4.0 on average). From these values, it can be concluded that the AWDS provided by paid employees is better than the AWDS provided by WUAs.

4.5.2.3 Output

It is expected that a better WDS to individual ownership units would result in better outputs per unit irrigated area and per unit water supply.

It can be seen from Table 4.10 that irrigation systems have output per unit irrigated area between US$2,238.30/ha to US$2,676.66/ha (most of the irrigation system, except the Way Padang Ratu System, have a relatively similar output per unit irrigated area). Table 4.10 also shows that the irrigation systems have output per unit water supply between US$0.12/ha to US$0.24/ha (*see also Appendix C6.3, C.4 and C6.7*).

On the other hand, the AWDS to the individual ownership units are vary from 2.18 to 2.64 as can be seen in Table 4.11 (*see Appendix C6.5, C.6 and C6.7*).

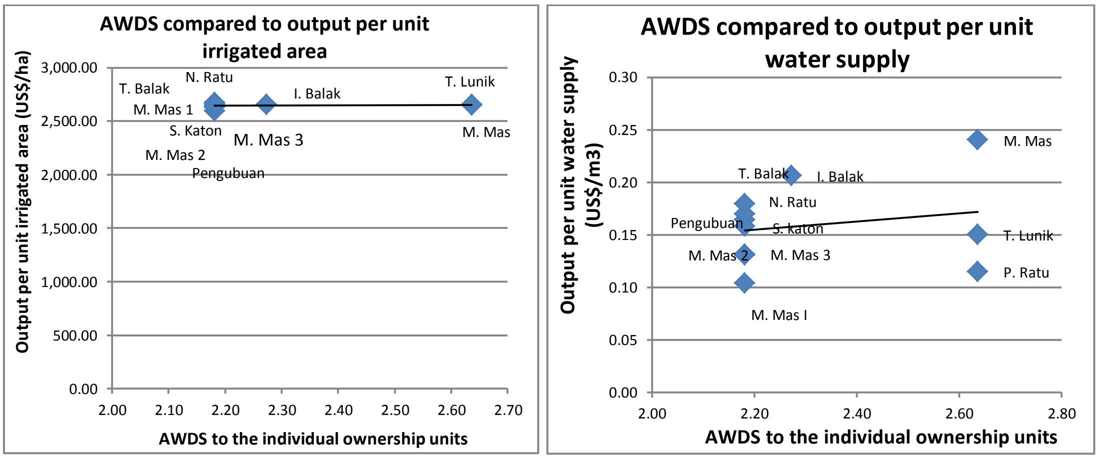


Figure 4.46. AWDS to the individual ownership units compared to out put per unit (a) irrigated area and (b) water supply

The black line in Figure 4.46 shows relationship between the AWDS to the individual ownership units with (a) the output per unit irrigated area and (b) output per unit water supply. It can be seen that the line is slightly ascending which shows that the greater the value of AWD the higher the output per unit irrigated area and output per unit water supply. It can be conclude that the better the quality of the WDS, the better the output per unit irrigated area and output per unit water supply. In other word, a higher output per unit irrigated area and per unit water supply are the result of a higher quality of AWDS.

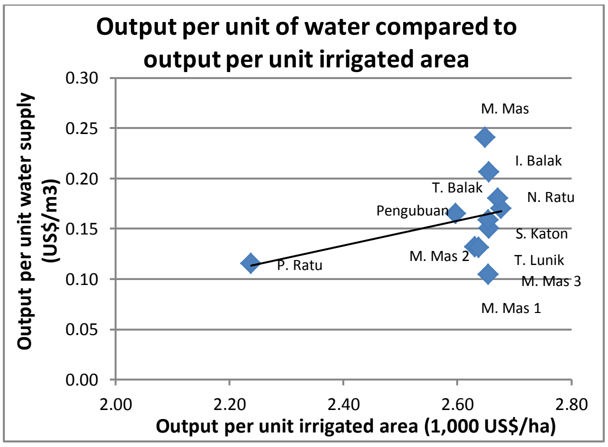


Figure 4.47. Output per unit of water compared to output per unit irrigated area

Figure 4.47 illustrate the relationship between the output per unit water supply and output per unit irrigated area. The black line shows that the better the output per unit water supply the better the output per unit irrigated area.

4.5.2.4 Other Indicators

Other indicators considered here include applying pressurised irrigation to irrigation systems in rural Indonesia. The factors that need to be examined include the ability of the current WDS to support pressurised irrigation methods and the changes required. The ability of the present WDS to support pressurised irrigation methods requires measurement and control of volumes to the field, and flexibility and reliability of the field aspects. Introducing pressurised irrigation methods also requires changes to support procedures, management, and hardware.

Figure 4.48 shows that in general, the ability of WDS to support pressurised irrigation to individual fields in the irrigation system is relatively low and the changes required are major changes in water ordering, staff, training and mobility, and larger capital expenditure. The graph also shows that the ability of the irrigation systems to receive and use feedback information is low.

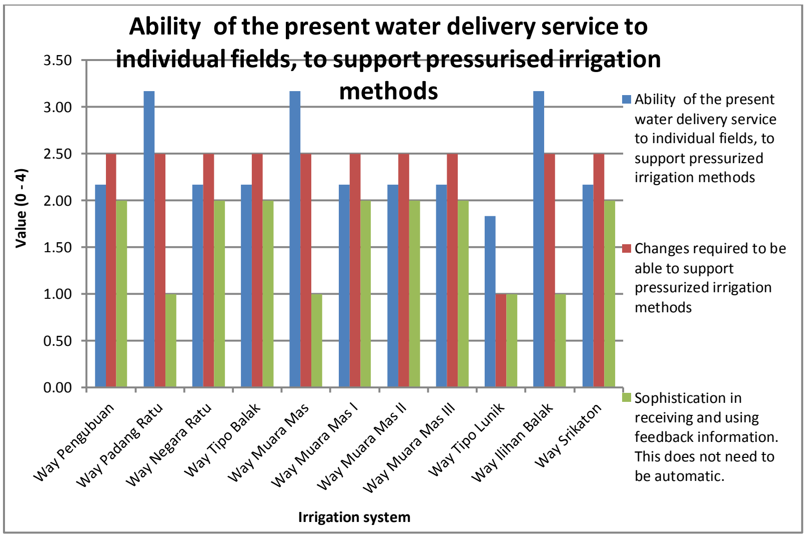


Figure 4.48. Ability of the present WDS to individual fields to support pressurised irrigation methods

4.6 Summary of Irrigation Performance Assessment

The conclusions from the results of farmer opinions and preferences (Section 4.3), the irrigation system asset condition survey analysis (Section 4.4), and the RAP and Benchmarking assessment (Section 4.5) are summarised in *Appendix C.7*. The results can be briefly summarised as follows:

1. *Water resources*

   Almost all of the irrigation system divert water from the river through a dam's off-take gate and distribute it further by open channel gravity irrigation methods.

All of the irrigation system are surface water irrigation systems. (*See Section 4.3.1, Section 4.5.1.1 and Section 4.5.1.2*).

2. *Management*

   The irrigation system' management at the tertiary level has been transferred to WUAs. The O&M of irrigation systems up to the secondary channel is executed by the *UPTD*. WUAs are responsible for the operation, maintenance, renewal, finance, and management at the tertiary level from the off-take gate at the tertiary channel to a single landplot unit. The *Ulu-ulu* (the controller of water) of the WUA is responsible for the equal distribution of water along the tertiary and quaternary channels, whilst the *Ili-ili* (chairman of the tertiary block) is responsible for regulating equal water flow to each landplot. (*See Section 4.2.1, Section 4.3.1, Section 4.3.2, Section 4.3.4, Section 4.5.2.1 and Section 4.5.2.2*).

3. *Infrastructure condition*

   The infrastructure condition of the irrigation system, before the PISP, was sufficient for large irrigation systems, fair for medium irrigation systems, and poor for small irrigation systems, since maintenance was inadequate. These conditions were improved by the PISP. (*See Section 4.3.2 and Section 4.4*).

4. *Environment*

   The upper parts of the irrigation system are located on higher land with a gradual slope towards the tail-end (surface-gravity flow irrigation method). Only the large irrigation system (Way Pengubuan) has a drainage channel in the system and even then it is of very limited length, and the excess irrigation water flows to the river. Irrigation water quality in all of the irrigation system is critical and fails to meet the requirements of UNESCO/WHO/UNEP threshold values of BOD and COD in river water for agricultural water supply and fisheries. (*See Section 4.5.1.5*).

5. *Irrigation performance*

   Water availability in the irrigation system is in general adequate and water supply equity along the system is reasonable. However, in the dry season the water becomes a problem since irrigation efficiency is weak. In the past, water losses along the system were quite high due to leakage in the secondary channel and seepage in the tertiary channel which was in general due to the earth lining at the small irrigation systems. The conditions have been improving since the introduction of the PISP. The irrigation performance incorporating service delivery performance, production efficiency performance, financial performance, and environmental impact performance, is in general sufficient for large irrigation systems, fair for medium irrigation systems, and poor for small irrigation systems. (*See Section 4.3.4 and Section 4.5*).

6. *Agriculture and financial*

   The planting pattern and plan are determined by the Irrigation Committee and instituted by the head of the provincial/district government. The planting pattern applied is usually rice-rice-subsistence crops. The subsistence crops grown in the dry season are generally corn, soybean, and peanut. The production rate in the system ranges between 5.8 tonnes/ha and 6.2 tonnes/ha for rice crops and is around 7.5 tonnes/ha for corn crops. The farmers' economy is poor since the average landholder possesses only 0.5 hectares. (*See Section 4.3.1, Section 4.3.6 and Section 4.5.1.3*).

4.7 Overview and Recommendations

To gain a more in-depth understanding of the problems of performance and sustainability of the existing Indonesian irrigation system, this research utilises the following methods; RAP and Benchmarking, farmer opinion surveys, and asset condition assessments. In summary, the performance assessment results show that the irrigation system have low performance and fail to achieve the current service targets. This is alarming since irrigation systems should run according to a certain operating standard to maintain the current levels of agricultural production. The issues that need to be addressed to improve irrigation performance are:

1. Financial performance

   The asset MOM costs are low compared to the MOM cost of similar assets in other countries. The current ISF is also inadequate to cover the MOM costs at a tertiary level. Renewal of tertiary level assets still relies on government subsidies. (*See Section 4.3.1, Section 4.3.6 and Section 4.5.1.3*).

2. Asset performance

   a. Function

      The current assets are suitable for the activities and functions they support. However, the asset condition and capacity need to improve to provide a better service for users.

b. Utilisation

   Assets are utilised intensively during the semi-dry season (second crop planting season) and not so intensively in the wet season (first crop planting season) or dry season (third crop planting season). By improving their condition and capacity, the utilisation of assets can help to extend the service area (improve the command area to irrigated area ratio), and increase the crop intensity and productivity of water and land.

c. Physical condition

   The assets are inadequately maintained. Asset MOM costs are low compared to MOM costs of similar assets in other countries which have resulted in assets being inadequately maintained.

(*See Section 4.3.2 and Section 4.4*).

3. Management
   a. Farmer water users: farmers have a low appreciation of the value of water.
   b. WUAs: lack of capability of WUAs to carry out government instructions.
   c. Irrigation authority: there were several constraints that limits the ability of irrigation offices to provide a good service and no mechanisms are in place to assist WUAs in sustaining and enhancing the condition of the irrigation infrastructure.

   (*See Section 4.2.1, Section 4.3.1, Section 4.3.2, Section 4.3.4, Section 4.5.2.1 and Section 4.5.2.2*).

   There is a need to empower the farmer water users and to strengthen the WUAs and local irrigation authority (UPTD) organisations, in addition to modernising the irrigation system to improve water use efficiency.

Since there is an obvious problem in the performance of the irrigation systems, it is important to assess system sustainability. The next chapter will discuss the assessment of irrigation system sustainability using aspects of the Triple Bottom Line. The performance and sustainability assessment is then used to appraise system performance issues and causes of issues. The physical and management interventions/corrective actions can then be identified to improve irrigation performance and sustainability.

CHAPTER 5. INVESTIGATION OF METHODS USED TO MANAGE AND MAINTAIN IRRIGATION PROJECTS

5.1 Introduction to the Sustainability of Irrigation

The performance assessments in Chapter 4 show that in general the irrigation system cases studied have low performance in achieving the current service targets (*see Section 4.6*). Whereas, the Section 2.5 has demonstrated the close relationship between an irrigation system's sustainability and the various aspects of their performance. Therefore, a sustainability assessment needs to be integrated into performance assessment results to provide a balanced view of how the system meets service targets with socio-economic benefits and environmental consequences demonstrated. Hence, the second stage of this research was undertaken to assess the sustainability of irrigation systems. It also assesses the feasibility of the corrective actions needed to improve irrigation performance and sustainability.

The work reported in this chapter is presented in sequence in Figure 5.1:

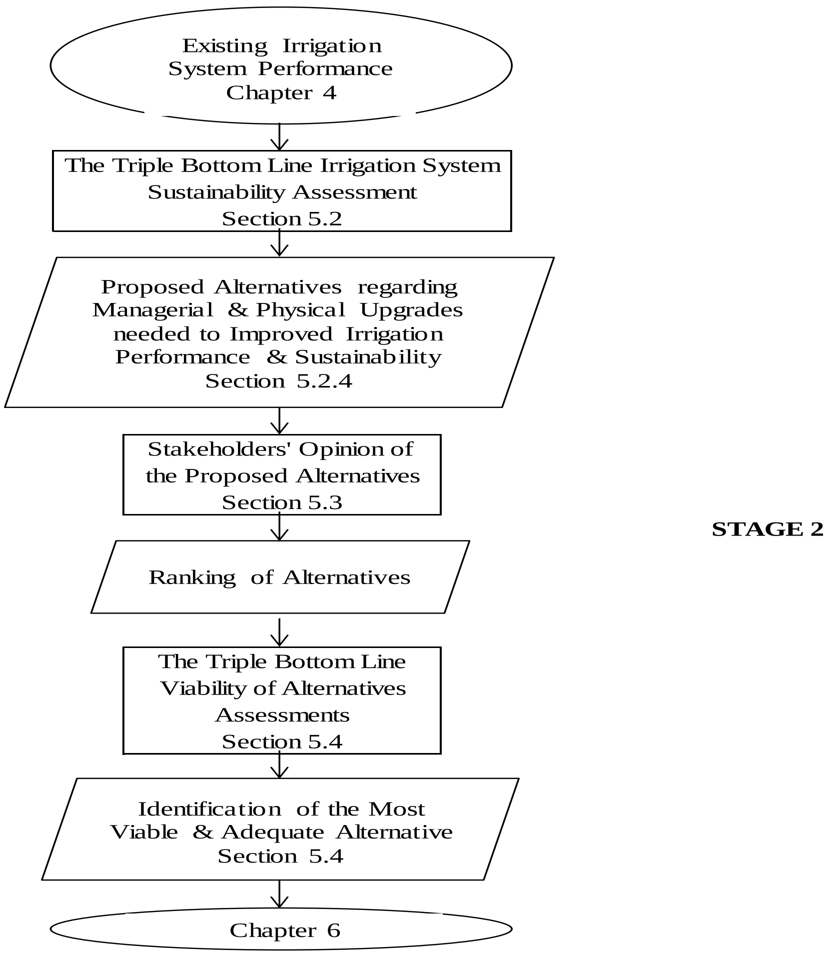


Figure 5.1. Steps in the second stages of the research

As the first step, Section 5.2 presents the data and analysis of existing irrigation system performance against a TBL sustainability framework, performance and sustainability issues and its causes, and the corrective actions needed to improve irrigation performance and sustainability. The sustainability of existing irrigation systems was assessed by using a framework developed from an adaptive framework and methodology for improved Triple Bottom Line (TBL) reporting by the irrigation organisations developed by the Sustainability Challenge Project (Shepheard et al., 2006) and the three dimensions of corporate TBL sustainability by Stapledon (Stapledon, 2012) (*see Section 2.5.2.1*).

Section 5.3 presents the data and analysis of the opinion survey of stakeholders about their preferences on the corrective actions (technical and organisational adjustments) priorities, pairwise comparison matrix and rank and weight of the alternatives. The opinion survey was analysed using the pairwise comparison matrix method to determine the rank and the weight of the proposed approaches. These methods and the reasons for their adoption were discussed in Section 2.6.2.

Section 5.4 presents the data and analysis used to assess the proposed alternatives regarding managerial and physical upgrade needed to improve irrigation performance and sustainability. The key sustainability objectives of the alternatives were weighted with the values obtained from the previous step (Section 5.3). By quantifying the viability of the alternatives, it is possible to determine the most viable options that also preferred by the stakeholders.

5.2 The Triple Bottom Line (TBL) Sustainability Performance of the Existing Case Study Irrigation Systems

Section 2.5 discussed the definition of sustainable irrigation system (ASCE/UNESCO, 1998), sustainable aspects that an organisation must take into account (Elkington, 1995), three dimensions of corporate TBL sustainability (Stapledon, 2012), major resources that must be assembled and maintained (Abernethy, 1994), the issues that need to be addressed (Abernethy, 1994), limitation of existing TBL framework to be used in irrigation (GRI, 1999), four tiers of ISAF and adaptive sustainability assessment framework and methodology for irrigation (Christen et al., 2006) and associated RAP and Benchmarking performance indicators. Taking into account those opinions, a set of sustainability issue indicators was addressed as can be seen in 2.5.2.2 and *Appendix A.8*.

Section 5.2.1 presents the data and analysis of existing irrigation system performance results against a TBL sustainability framework. Section 5.2.2 discusses the 'profit' aspect of the TBL sustainability assessment results. Section 5.2.3 analyses the 'planet' aspect of the TBL sustainability assessment results. Section 5.2.4 reviews the 'people' aspect of the TBL sustainability assessment results.

5.2.1 The Triple Bottom Line (TBL) Sustainability Assessment

Since there is a close relationship between the performance and sustainability, the sustainability assessment was carried out based on the results inferred from the performance assessment of the irrigation systems (Section 4.6). By doing this, correlations between the sustainability indicators associated with the performance issues and its causes can be identified. The sustainability assessment used the ratings: below compliance, compliance and beyond compliance/best practice. Also given are the performance issues and its causes, and the action required to improve the existing irrigation performance and sustainability.

The following Table 5.1 shows the summary of the TBL sustainability assessment results. (*Appendix D.1 gives the complete TBL sustainability assessment: the sustainability objectives and the value related to its achievement to the objectives, the sustainability issues and its causes, and the action (physical and management interventions/corrective actions) needed to improve the irrigation performance and sustainability*).

Further discussions on the TBL assessment of profit, planet and people aspects are in Section 5.2.2, 5.2.3 and 5.2.4. Section 5.2.5 summarised the assessment results and related physical and managerial interventions needed to improve irrigation performance and sustainability.

Table 5.1. Summary of the TBL sustainability assessment

Sustainability objective	TBL Rating of the existing performance
PROFIT	
a. Water balance, productivity and efficiency	
Maintain stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability: crop occupancy, irrigated area, groundwater rise/fall, and mapping the problematic areas (matching complex demands for water with constraints in supply and delivery).	√
Increase the agricultural productivity.	√
Maintain efficiency of irrigation water: application, distribution and conveyance (reducing the losses of the irrigation system).	√
Measure the water delivered accurately (pricing water).	√
b. Financial sustainability	
Achieved financial and economic efficiency/profitability of irrigated agriculture (yields vs. water cost ratio, yields vs. water supply ratio, relative water cost).	√
Achieved financial viability (financial self-sufficiency, O&M fraction, fee collection performance).	√
Enhance the financial sustainability of existing water supply system.	√
Increase the value of the irrigation system through targeted investment in existing and new irrigation facilities (development/renewal/modernisation).	√
Enlightened government burden on O&M costs.	√
c. Economic sustainability	
Achieved high level of good quality production.	√√
Achieved financial and economic efficiency (standardise gross value of output per hectare, standardise gross value of output per unit of water diverted).	√
d. Asset sustainability	
Ensure continuing asset serviceability.	√
Ensure asset integrity is safeguard.	√√
e. Business management (irrigation system management)	
Achieved managerial ability to supply the required water to meet the crop water requirements (technical knowledge of the staffs).	√√
Adapt to new technology to improve system performance by modernising irrigation system.	√
Adapt to new management approaches to improve system performance and sustainability.	
Ensure compliance with legislative requirements.	√√
PLANET	
a. Water uses efficiency	
Enhance appreciation of farmers to the value of water.	√
Increase distribution system efficiencies.	√
Increase output of water uses (output per unit water supply)/litres of water used per dollar value of item produced.	√√

Note: TBL ratings,

Below compliance	√
Compliance	√√
Beyond compliance/Best practice	√√√

Sustainability objective	TBL Rating of the existing performance
PROFIT	
a. Water balance, productivity and efficiency	
b. Achieve high level of environmental performance in systems	
Minimise negative environmental impacts of irrigation, especially the	
In the irrigation project: waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna.	√
Downstream of the project: reduced surface water availability, increased groundwater inflow, water logging, and polluted incoming water.	√
Consider the net effects of the system to environment as follow:	
Quality and quantity of drainage water discharge into natural water course (or otherwise disposed of).	√
Health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury).	√
Direct effects of management practices (e.g. de-silting).	√
Impact of irrigation on groundwater quality and level.	√
Impact of irrigation on groundwater quality and level.	√
Impact of irrigation on river health.	√
c. Social aspect of environmental:	
The environmental effects often impoverish tail-end farmers.	√
PEOPLE	
a. Staffs	
Have a motivated, empowered and well-skilled workforce with an achievement-oriented culture.	√√
b. Customer/farmers	
Improve the level of customer satisfaction with government/ UPTD (local technical implementation unit) services.	√√
Build improved customer/ farmers relationships.	√√
c. WUAs	
a. Strengthen WUAs and WUAF technically, financially and legally (handover more responsibility on the farmers to care for the supply system and hand over of responsibility for the O&M irrigation infrastructure above the tertiary turnouts on large and medium scale irrigation system, or the management authority of small scale irrigation system smaller than 500 ha from the government to the WUAs). WUAs also responsible to the administration of water tariffs/irrigation service fee (ISF) to raise revenue from the water users to provide funds for operation and maintenance of irrigation infrastructure under its authority.	
Legal:	
Availability of appropriate policy/legislation/regulation and guidelines for planning and operating the system under WUAs.	√√
Institutional:	
WUAs organisational and institutional capacity to operate the system.	√
Improve WUAs as a business organisation.	√
Trust/confidence in WUAs.	√√
c. Customer/farmers	
b. Achieved social capacity (users stake in irrigation system):	
Water user rights and participation in basin management.	√
c. Poor communities in the upper region who do not receive the benefits of irrigation are often deforest the mountains to feed their families.	
There should be a benefits sharing given to them to prevent them from deforesting the upper region by implementing a dividend reinvestment projects that benefit local communities and the environment (to stop sedimentation and flood in lower region).	√

5.2.2 Economic Aspects (Profit) of the Triple Bottom Line (TBL)

When considering sustainability, TBL is different to the traditional accounting approach that only considers financial gain, i.e., the difference between the amount earned and the amount spent on all inputs. With TBL, profit is the real economic impact the project has on the economic environment plus the real economic benefit enjoyed by the host society. For a public irrigation system such as those being examined here TBL economic (profit) aspects are: water balance, productivity and efficiency (Section 5.2.2.1), and financial economic sustainability (Section 5.2.2.6), asset sustainability (Section 5.2.2.2), and business management (irrigation system management) (Section 5.2.2.5).

5.2.2.1 Water Balance, Productivity and Efficiency

Understanding the water balance is essential for sustainability. It is highly dependent on system operation. Water balance should include all water that enters and leaves the irrigation system, the source of irrigation water, and where it is destined. A TBL irrigation system objectives on operation are:

- to maintain stability of water supply for satisfying 100% of crop irrigation requirements that is crucial for productive sustainability. These are: cropping occupancy, irrigated area, groundwater rise/fall, and mapping of the problematic areas (matching complex demands for water with constraints in supply and delivery),
- to increase output of water use (output per unit water supply) /litres of water used per dollar value of items produced and to increase agricultural productivity,
- to increase distribution system efficiency and maintain the efficiency of irrigation water and its application, distribution and conveyance (reducing the losses of the irrigation system), and
- to measure the water delivered accurately (pricing water).

It can be seen on the Table 5.1 and *Appendix D.1 (Table D.1.1)* that the current water supply is still able to satisfy user demand, as shown by the value of the security entitlement supply of 100% and there is no obvious water problem. However, the TBL rating in this aspect of the existing irrigation system is considered below compliance since there is evidence of a shortage of water in the dry season. The stated conveyance efficiency of imported canal water provided by irrigation authority is 65%, and farmers are still unable to recognise the value of water, as is shown by the field irrigation efficiency values of 16% to 73%. Furthermore, the performance values of field irrigation efficiency, command area irrigation efficiency, and irrigated to command area ratios are low.

Considerable differences in the discharge of river water in the rainy and dry season have an impact on the water available for irrigation. However, the availability of water is still reasonable since the total annual volume of water supply (surface irrigation water inflow from outside the command area) is still well above the current volume managed by the authority today (*see Figure 4.28 of Section 4.5.1.2*). The total annual volume of irrigation water delivered to users by project authorities is well above the total annual volume of field ET in irrigated fields (*see Figure 4.29 of Section 4.5.1.2*), and there is no evidence of groundwater utilisation.

The data related to agricultural productivity among other things is: the average command area to irrigated area ratio is 0.7, the average cropping intensity is 2 (*see Figure 4.34 of Section 4.5.1.3*), yields for paddy are 5 – 6.2 tonnes/ha in the wet season and 4 – 5.8 tonnes/ha inthe dry season. The average output per unit command area is US$5,366.51/ha and the output per unit irrigated area, including multiple cropping, is US$2,611.00/ha (*see Figure 4.35(a) of Section 4.5.1.3*). The output per unit irrigation supply is US$0.24/m^3 (*see Figure 4.35(b) of Section 4.5.1.3*), and the output per unit water supply and the values of output per unit of field ET of case study irrigation systems are US$0.16/m^3 and US$0.62/m^3 respectively *(see Figure 4.35(c) of Section 4.5.1.3*).

As mentioned in Section 4.3.1, irrigation water in the study areas generally relies on supplies from run-of-river and is devoted mostly to subsistence agriculture. This surface water flows into rice fields by gravity through an open channel network that is generally unlined and rudimentary. Leaky and under-maintained distribution systems together with inadequate irrigation management leads to pervasive irrigation practice with farmers applying water in excess of crop requirements and water availability. This can be seen in the Section 4.5.1.2 and 4.5.1.3 where Figures 4.31 and 4.33(a) show that the performance values of field irrigation efficiency, command area irrigation efficiency, and irrigated to command area ratio are low. The performance values of field irrigation efficiency vary from 16.13% to 72.98% (47.76% on average) and the performance values of command area irrigation efficiency are in general 30% lower than field irrigation efficiency, whereas the ratios of irrigated to command area vary from 0.54 to 1.00 (0.73 on average).

By taking into account these considerations the performance assessment results related to these aspects of the TBL assessment were in general poor and the value of these TBL aspects was below compliance.

There is a possibility of increasing irrigated area by 33%, cropping intensity by 33% and yields by 50% per season with better irrigation and rice farming methods. Basically, irrigation is needed only for a second cropping season (in the semi-wet-dry season) and the third cropping season in some areas where irrigation water is adequate (in the dry season).

Increased efficiency in project/system levels is more complex than improving efficiency in the field. Efficiency at the system level requires the improvement of irrigation system management arrangements in terms of infrastructure, staffing and standards. Modernisation of irrigation systems such as pressurised irrigation and recirculation of irrigation water provide excellent opportunities to improve water use efficiency in terms of application, distribution and conveyance (reducing the losses of the irrigation system), but this takes a substantial investment to implement.

Efficiency in the fields can be effected by building the awareness of farmers with regard to the value of water (the principles of the water footprint and virtual water). Other enhancements include utilising volume measurement devices in order to measure and determine water prices accurately and improving the knowledge of *Ulu-ulu* and *Ili-ili* so that they can perform a more efficient regulation of water distribution operations. The government benefits from their existence and becomes the vanguard in improving the efficiency of field irrigation water.

5.2.2.2 Financial and Economic Sustainability

In order to be financially sustainable, an irrigation system should demonstrate value for money, design and operate the asset for a longer economic life (for example using life cycle costing and life cycle analysis), and contribute to the strength of the local economy. Therefore, the objectives of financial sustainability are:

- to increase the value of the irrigation system through targeted investment in existing and new irrigation facilities (development/renewal/modernisation),

- to lighten the government burden on O&M costs (review cost difference of option between WUAs and government managed organisations, provide savings to government to lighten the government burden on O&M costs),
- to achieve financial and economic efficiency/profitability of irrigated agriculture (yields vs. water cost ratio, yields vs. water supply ratio, relative water cost, standardise gross value of output per hectare, standardise gross value of output per unit of water diverted),
- to achieve financial viability (financial self-sufficiency, O&M fraction, fee collection performance),
- to achieve a high level of good quality production, and
- to promote financially legally independent WUA organisations.

It can be seen on the *Appendix D.1 (Table D.1.2)*, the TBL rating for financial sustainability is considered below compliance since the irrigation are characterised by weak performance. From Figure 4.33, 4.34 and 4.35 in Section 4.5.1.3 it is known that irrigated area to command area ratio varies from 0.5 to 1.00, shows a cropping intensity of 2, and in general the yields for paddy in the wet season are 5 – 6.2 tonnes/ha and in the dry season 4 – 5.8 tonnes/ha. Further calculations show that the output per unit command area is from US$4,477/ha to US$7,710/ha (5,367/ha on average), the output per unit irrigated area, including multiple cropping is from US$2,238/ha to US$2,677/ha (2,611/ha on average), the output per unit irrigation supply is from US$0.2/m3 to US$0.4/m3 ($0.2/m3 on average), the value of output per unit water supply is from US$0.1/m3 to US$0.2/m3 (0.2/m3 on average), and the value of output per unit of field ET is from US$0.5/m3 to US$0.7/m3 (0.6/m3 on average). These figures show that the efficiency with regard to irrigation water and land utilisation is still low.

In addition to these problems, funding for both routine operation and maintenance (O&M) as well as for rehabilitation and improvement of irrigation still relies heavily on government subsidies. At the moment, financially autonomous WUAs have not yet been able to lighten the government burden on irrigation. Figure 4.38(b) shows that the revenue per cubic metre of irrigation water delivered to water users by the project authorities varies from US$0.00220 to 0.00657/m^3 (US$0.00431/m^3 on average); and Figure 4.36 shows that collection performance demonstrates the value of 1, which means that WUAs could effectively carry out the task of collecting irrigation service fees (ISF) from farmers. However, no portion of the revenue is sent to the government to be used for refunding irrigation. These revenues are used for management, operation, maintenance and renewal of irrigation assets at tertiary level which are the responsibility of WUAs.

Figure 4.37(a) in the Section 4.5.1.4 shows that the total MOM cost per unit area of case study irrigation systems varies from US$51 – 133/ha/year (US$96/ha/year on average) and Figure 4.38(b) shows that the total MOM cost per cubic metre of irrigation water delivered to water users by the project authorities varies from US$0.00148 to 0.00594/ m^3 (US$0.00282/$m^3$ on average). On the other hand, Figure 4.36 shows that the average cost recovery ratio of case study irrigation systems was 0.75 (varying from 0.2 to 1.2) and the average maintenance cost to revenue ratio was 0.4 (varying from 0.2 to 1). These ratios suggest that the irrigation system have not yet been able to meet funding needs. It cannot be denied that many function on a contingency response basis – if something goes wrong it will get fixed, but until there is a crisis, no action is taken.

There were a number of actions to be taken to ensure continued financial and economic sustainability of irrigation systems such as: improving channel condition to provide better irrigation water distribution, implementing pressurised irrigation and recirculate irrigation water to improve irrigation efficiency, expanding the scope of the ISF, specifying water delivery services and installing volumetric measuring structures within the systems to improve irrigation water efficiency, diversifying agriculture to open up opportunities for farmers to earn higher income from horticulture, turnover and expand the participatory in irrigation, and contracting the O&M of irrigation to third parties. However, all of these options need to be assessed in advance to know whether these options are feasible or not to be implemented.

5.2.2.3 Asset Sustainability

Stapledon (2012) stated that infrastructure needs to deliver its service over its lifetime efficiently and reliably. To do so, it needs to be adaptable and resilient to change. This suggests obtaining/maintaining assets with a long useful life, with minimum reliance on non-renewable resources, with maximum benefit to society and the environment and which contribute to, rather than endanger, national prosperity in the long term. Therefore the main objectives of asset sustainability are:

- to ensure continuing asset serviceability to fulfil community expectation over its entire life,
- to ensure resiliency and adaptability to changing external circumstances, and
- to ensure asset integrity and consistency as part of the wider irrigation infrastructure system is safeguarded.

It can be seen on the the Table 5.1 and *Appendix D.1 (Table D.1.3)* that the TBL rating in this aspect of the existing irrigation system is considered below compliance since various performance indicators that refer to this aspect are generally low. At the tertiary level, the performance indicators are as follow:

Table 5.2. Average performance indicator values at tertiary level

Indicator	Unit	Value		Reference
		Range	Average	
Cost recovery ratio	none	0.45 - 1.23	0.75	Figure 4.36 of Section 4.5.1.4
Maintenance cost to revenue ratio	none	0.34 - 0.48	0.38	
Total MOM cost per unit area	US$/ha		96.42	Figure 4.37(a) of Section 4.5.1.4
Average revenue per cubic meter of irrigation water delivered to water users by the project authorities	US$/m3	0.00220 - 0.00657	0.00431	Figure 4.38(b) of Section 4.5.1.4
Total MOM cost per cubic meter of irrigation water delivered to water users by the project authorities	US$/m3	0.00148 - 0.00594	0.00282	

All revenues are collected by WUAs and no portion is sent to the government. WUAs use the revenue for management and the O&M of irrigation assets at tertiary level. However, most of the revenue is only sufficient for emergency maintenance purposes to keep assets operational. The government still subsidises irrigation systems up to secondary level, including routine MOM costs and upgrades, improvements and/or rehabilitation costs.

Action to be taken to ensure continued asset serviceability and sustainability is to increase MOM cost revenue by expanding the scope of the ISF, specifying water delivery services and installing volumetric measuring structures within the systems.

5.2.2.4 The Business Management of Irrigation Systems

At the moment many organisations seek opportunities to improve and enhance their value and that of irrigation systems, as interpreted by the stakeholders, through good environmental, social and governance performance while avoiding environmental and social harm that may damage their value. According to Stapledon (2012), in order to be sustainable, management should strengthen the image and reputation, enhance employee engagement, improve cost savings, improve revenue from service enhancements or new revenue sources, and strengthen social license to operate to environmentally responsible way. Therefore, the TBL objectives of business management of the irrigation system are:

- to achieve managerial ability to supply the required water to meet crop water requirements,
- to enhance employee engagement with organisational goals, create loyalty, a sense of belonging and to make a commitment to achieve and work beyond usual expectations,
- to adapt to new technology to improve system performance and improve cost savings, introduce new rice varieties and new methods of rice cultivation to increase yields, and
- to encourage participation of water users in the operation, maintenance and management of certain parts of the irrigation system, and
- to ensure compliance with legislative requirements.

The Table 5.1 and *Appendix D.1 (Table D.1.4)* shows that *the* UPTD is responsible for the day-to-day management and operation of an irrigation system. All UPTDs follows standard procedures in operating the irrigation system established by the Directorate General of Water Resources Development. There is only a slight variation of management from one irrigation system to another. The TBL rating of business management of irrigation system aspects is considered to be at compliance, as most of the irrigation systems can perform their main task of supplying irrigation water quite well according to the five components of serviceability of irrigation (adequacy, water arrival time, the uniformity of flow rate, flexibility and equity) and most farmers are satisfied with their current service (*see Figure 4.9 in Section 4.3.2*).

The actions proposed to improve business management aspects of irrigation system among other things are: improved procedure, management and communication, modernising irrigation system, and diversifying agriculture and expanding the role of WUAs. However, the irrigation system's adaptability to new technology, new rice varieties, and new methods of rice cultivation is questionable, since all the policies on irrigation modernisation, introduction of new varieties or new methods of farming are commonly dictated by the central government and the irrigation system only implements what is decided by the central government. Generally, the implementation of a policy will be supported and accompanied by other activities such as dissemination and training to ensure the policy is successfully implemented. It is uncommon for an irrigation system to initiate changes in management particularly with regard to running their organisation as a business organisation.

5.2.3 Environmental Aspects (Planet) of the Triple Bottom Line (TBL)

Irrigation projects can have large benefits, but the negative side effects are often overlooked. Irrigation systems draw water from the river and distribute it over the irrigated area. The installation and operation of the system has a negative impact on the environment since it changes hydrological conditions both directly, indirectly and with regard to complexity, the intricate subsequent impact of which is mentioned in the Section 2.5.2.2.

Planet refers to sustainable environmental practices. Therefore, a TBL irrigation system endeavours to benefit the natural order as much as possible or at the least do no harm. It should also minimise the environmental impact by carefully managing consumption of resources and non-renewable resources in an efficient and effective manner including the use of water, land, energy, and construction materials. It should be able to maintain ecosystems and biodiversity by rendering drainage less toxic, managing emissions, pollution and waste before disposing of these in a safe and legal manner with regard to land, air and water, and the reduction of water and carbon footprints. An environmentally sustainable irrigation system is more profitable in the long run.

Currently, the cost of disposing of non-degradable or toxic waste from irrigation is borne financially and environmentally by the residents along the rivers. Ecologically destructive practices, such as excessive consumption of water, use of chemical fertilisers and pesticides, and endangering the depletion of resources are avoided by a competent TBL irrigation system.

By looking at those consideration, for a public irrigation system such as those being examined here TBL environment (profit) aspects considered are: efficient and effective use of resources (Section 5.2.3.1), maintenance of hydrological functions, ecosystem and biodiversity (Section 5.2.3.2), as well as manage social aspects of environmental impact (Section 5.2.3.3).

5.2.3.1 Managing Consumption of Resources in an Efficient and Effective Manner (Irrigation Efficiency and Water Use Efficiency)

A TBL compliant irrigation system should be able to carefully manage its consumption of resources and non-renewables in an efficient and effective manner including its use of water (the relationship between water (input) and agriculture product (output)(Perry *et. al*., 2009), land, energy, and construction materials. It also should be able to increase irrigation efficiency by increasing conveyance efficiency to reduce water losses (the effectiveness of irrigation water delivery and use). By doing so, hydrological functions can be maintained and the negative environmental impact (direct and indirect) of irrigation on hydrological functions can be minimised along with subsequent impact. The results of increased irrigation efficiency are:

- in the irrigation system: reducing water losses (reduce evaporation in the system, reduce groundwater recharge, maintain the water table level, and reduce the drainage flow), reducing waterlogging, soil salination, and pollution of drainage water (increasing the quality of land and water), and reducing the loss of natural habitats of flora and fauna.
- downstream of the system: increasing downstream surface water availability (downstream river discharge) and quality, increasing downstream drainage, reducing groundwater inflow and increasing groundwater quality, and reducing water logging and polluted incoming water.

Appendix D.1.6 presents the value of TBL assessment related to the water use efficiency of the irrigation systems and the system's performance assessment results associated with it. The table also presents the sustainability issues and the actions needed to solve the problems.

There were several actions proposed to improve the irrigation efficiency namely: improving channel condition, increasing the number of turnouts/offtakes, implementing pressurised irrigation and recirculate irrigation water, imposing higher ISF rate, and maximise the role of *Ulu-ulu* and *Ili-ili* in regulating irrigation water to the fields. When irrigation involves the use of groundwater, the direct hydrological result is the lowering of the water level. The indirect effects may be water mining and land/soil subsidence, and saltwater intrusion along the coast.

On the other hand, water use efficiency can be increased by planting water-save rice plant varieties, implementing proper irrigation application to prevent excessive field evaporation to save water, diversifying agriculture with water-efficient plants and with a higher market price, as well as implementing water pricing as a means for enhancing water use efficiency in irrigation.

The existing system operations of irrigation systems are considered below compliance since there is evidence of inefficient use of water and land where farmers have not yet accounted for the value of water (water footprint). This is particularly so during the wet season as evidenced by low field irrigation efficiency values and inefficient conveyance that results in 35% of irrigation water being lost on the way to landplots, low output, low performance values of the command area irrigation efficiency, and low irrigated to command area ratios (*see the Section 5.2.2.1*).

5.2.3.2 Maintenance of Hydrological Functions, Ecosystem and Biodiversity in Systems and Basin Level

A TBL compliant irrigation system should be able to manage the net indirect impact of the system on natural and ecological conditions at the tail-end area of the river basin and downstream of an irrigation system. The irrigation system should be able to:

- increase the quality and quantity of surface water available (river discharge) at basin level,
- reduce polluted incoming water and quantity of drainage water discharged into the natural water course (or otherwise disposed of),
- reduce water logging and
- minimise the impact on groundwater quality and level.

Appendix D.1.7 shows the value of TBL assessment related to the environmental performance in irrigation system and basin level. From the table, it is evident that the irrigation system have not given enough attention to sustainability of the environment. None of the above aspects have been checked or recorded (*see Section 4.5.1.5*). Therefore, the TBL rating for this aspect is considered under compliance.

It is known also from Section 4.5.1.5 that in general, the environmental aspect of irrigation systems in Indonesia has not received proper attention, because the focus is still on how to improve performance in water balance, along with the financial, agricultural productivity and economic aspects. At the moment, the government simply checks the pollution of river water regularly, but does not check the impact of irrigation systems on the environment. River water pollutant parameters that are checked are: dissolved oxygen, biochemical oxygen demand and chemical oxygen demand (DO, BOD, and COD). The assessment results of 3 major rivers in the catchment area of irrigation systems shows that the rivers are in a critical condition and do not meet the requirements set by the UNESCO/WHO/UNEP in 1992 for the use of irrigation water. Therefore, the TBL rating for this aspect is set at under compliance.

There are several actions which can be take to improve environment in the irrigation system and basin level. WUAs can provide a structure for participation in basin water resource management, dealing with problems such as reallocation (clearer water use rights to irrigation system) and water quality. There should also be a benefits sharing given to the people in the upper region to prevent them from deforesting the upper region. Even though the government has regulated the use of water with regard to the river basin by issuing legislation and policies, its implementation results have not yet shown a concrete improvement in the quality of the environment at the basin level. The implementation should incorporate a discretionary standard (best practice) reflecting local concerns to make it workable. On the other hand, the Government involvement also need to prevent irrigation systems from becoming overwhelmed by larger resource problems such as deforestation, soil erosion, and unsustainable land use practice and water pollution.

5.2.3.3 Social Aspects of Environmental Impact

A TBL compliant irrigation system should be able to manage the intricate subsequent impact on the socio-economic conditions of water users in the tail-end area (downstream and in the river basin) since the environmental effects of an irrigation system often impoverish tail-end farmers. A TBL irrigation system should be able to:

- minimise the health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury),
- minimise the direct effects of management practices (e.g. de-silting),
- minimise the impact of irrigation on river health, and

- minimise lost land use opportunities.

Appendix D.1.8 shows the value of TBL assessment related to the social aspect of environment. The table also presents the sustainability issues and the actions needed to solve the problems. The TBL rating for this aspect is below compliance since there is no evidence that the benefits sharing given to the people in the upper region to prevent them from deforesting the upper region has been addressed by the irrigation system.

5.2.4 Social Aspects (People) of the Triple Bottom Line (TBL)

A TBL compliant irrigation system should enhance constructive engagement with all internal and external stakeholders. It is expected that those people concerned with irrigation practices would wish them to be fair and beneficial with regard to employers/labourers, customers/farmers, and the community. An effective TBL irrigation system conceives of a reciprocal social structure in which the well-being of organisations, labour and other stakeholder interests are interdependent. An ethical TBL irrigation system seeks to benefit all stakeholders, and not to exploit or endanger any particular group of them.

Labour of irrigation systems are mainly government employee and some government casual employees. Government employees have clear salary structure and class rank. In addition to salary, government employee receives allowances for family, health, and several other benefits from the government. In general, the welfare of government employees is sufficient. Beside the salary they receive from government, farmers usually set aside a portion of their harvest to these employees as a reward for helping them to achieve a good harvest. There are also people who are paid by the WUA such as:WUAs boards, ISF collector, *Ulu-ulu* and *Ili-ili*. However, the people aspects of irrigation were focussed on the well-being of community in general. Therefore, the people discussed here are: staffs (Section 5.2.4.1), WUAs (Section 5.2.4.2), farmers (Section 5.2.4.3), and community in the upstream and downstream of irrigation system (Section 5.2.4.4).

5.2.4.1 The Staff

Employee engagement is critical to serviceability. The TBL main objectives with regard to staff are:

- to have a motivated staff (who support the organisational goals, have a sense of belonging to the organisation, and intend to stay with the organisation),
- to have an empowered and well-skilled workforce with an achievement-oriented culture (a commitment to work beyond usual expectations),
- to maintain the safety, health and well-being of the workforce,
- to build capacity through training and development and through capturing and sharing knowledge about sustainability, and
- to promote equity, including equal opportunity and local employment.

The *Appendix D.1.8* shows the value of TBL assessment related to the staffs of the irrigation system and the system's performance assessment results associated with it. The table also presents the sustainability issues and the actions needed to solve the problems.

At the moment TBL rating for staff is considered to be at complianc**e** since staff weaknesses and strengths are considered balanced. Staff performance is weak as can be seen on the Figure 4.44 in Section 4.5.2.2; that it is 1.42 out of 4. There is inconsistency in AWDS at different levels of irrigation systems as shown by Figure 4.40(a) and (b). The irrigation managers (UPTD's chiefs) generally overstate their perception of the quality of WDS they provide at the individual landplot units, and understate the quality of their service at the main and second level channels and at the most downstream point operated by paid employees (as can be seen in the Figure 4.42(a) in Section 4.5.2.1). On the other hand, Figures 4.17(a) and 4.18 in Section 4.3.4 show that two-thirds are satisfied with staff performance and most of them expect improvements to staff performance in the future. Moreover, based on the available infrastructure, hardware, and operation and communication as shown by Figures 4.41 in Section 4.5.2.1, the staff responsible for the daily operation of irrigation systems have tried their best to give the best water delivery service possible.

The main target TBL sustainability of staff is staff at UPTD level since they carry out the day-to-day management and operation of an irrigation system. Generally, a UPTD is in charge of 5,000 to 7,500 hectares of irrigated area, therefore a UPTD may control more than one irrigation system. A UPTD office commonly employs staffs that consist of one chief, 5 administrative staff, and some technical staff. Technical staff consists of water clerks, weir operation officers, and sluice officers. Staffs are employed based on nationally established qualifications. Current staff is quite competent to perform their job, although they may be less motivated to achieve the best where existing management does not show appreciation of their achievements. There may also be a lack of innovation where existing management has outlined all standard operating procedures specified nationwide.

5.2.4.2 The Customers/Farmers: Participation of Farmers

A TBL compliant irrigation system should also enhance constructive engagement with farmers to increase their participation in improving the efficiency of irrigation water use. To be sustainable, the irrigation system should be able:

- to improve the level of customer satisfaction with government/ UPTD (local technical implementation unit) services and to build improved customer/farmer relationships with the irrigation authority,
- to provide for the farmer and broader community's safety, health and well-being along with establishing active stakeholder participation in decision-making, and
- to address natural and cultural heritage issues.

Appendix D.1.9 presents the value of TBL assessment related to the customers i.e. farmers of the irrigation system and the system's performance assessment results associated with it. The TBL rating in this aspect of the existing irrigation system is considered to be at compliance based on most farmers are satisfied with the current service (*see Figures 4.9 to 4.11 in Section 4.3.2*) on the five components of serviceability of irrigation (adequacy, water arrival time, the uniformity of flow rate, flexibility and equity) mentioned above. In addition to this, in all of these five areas of irrigation service, 91% of farmers feel that the current level of service is better than the service before the PISP was implemented and 72% of farmers said the current drainage service is better than the service before the PISP was implemented. However, 92% of farmers still expect improvement on the level of irrigation service and only 11% of farmers said drainage facilities and service should be improved due to the fact that they can easily discharge the excess of irrigation water into nearby water bodies. If the level of service were to be upgraded, the number of farmers who want to increase the number of growing seasons and who want to vary crops is almost equal in number to those who are willing and not willing to pay higher prices for better service.

Irrigation systems must be upgraded in order to achieve efficient utilisation of water resources and irrigated land. Better yields mean improved satisfaction. In the long-term, efficiency in the utilisation of irrigation water and land will guarantee the sustainability of the irrigation system.

Efficient utilisation of irrigation water and land is also achieved through farmer participation. It is the responsibility of the irrigation authority to educate farmers on the concepts of the water footprint and virtual water along with building awareness of the value of water. Once the farmers have internalised this information, they should voluntarily and consciously implement these strategies. This leads to the building of good relationships between irrigation service providers and farmers/customers as both ultimately have the same goals of sustainability.

5.2.4.3 The Partners (Water User Associations/Federations): Strengthen WUAs/WUAFs

A TBL compliant irrigation system should enhance constructive engagement with internal stakeholders such as the water user associations and the water user association federations (WUAs and WUAF) to increase their participation in irrigation management (PIM).

Currently, technically, financially, legally autonomous WUAs are responsible for the operation, maintenance, renewal, finance, and management of irrigation above the tertiary turnouts of large and medium-scale irrigation systems, or irrigation system less than 500ha. WUAs are also responsible for the administration of the water tariff/ISF to raise revenue from the water users to provide funds for the O&M of irrigation infrastructures under their authority.

To increase WUAs engagement in irrigation system management it is necessary to expand the current WUA organisations into business organisations that could organise members to respond to the specific business opportunities such as fisheries, joint purchase of agricultural inputs, marketing crops, and electric power generation that are present in the system.

Appendix D.1.10 illustrates the value of TBL assessment related to the WUAs. The table also presents the sustainability issues and the actions needed to solve the problems. As can be seen in Figure 4.21 in Section 4.3.5, most farmers are satisfied with the WUAs organisation and think that WUAs are effective in accommodating their needs. Therefore, it is considered that the TBL rating for this aspect is one of compliance.

It is necessary to provide WUAs with legal support that is the availability of appropriate policy/legislation/regulation and guidelines for planning and operating the systems under WUAs as business organisations. Along with this institutional support is required, such as improving WUAs organisational and institutional capacity to operate the system and strengthen farmer trust and confidence in WUAs.

5.2.4.4 Community (Downstream and Upstream of the Irrigation System): Water Rights and Benefit Sharing

A TBL compliant irrigation system must be able to prevent the negative effects of irrigation on downstream water users as well as extending a portion of benefits from irrigation activities to the communities upstream. *Appendix D.1.11* illustrates the value of TBL assessment related to community at downstream and upstream of irrigation system. The table also presents the sustainability issues and the actions needed to solve the problems.

Downstream water users may fall victim to the negative developmental aspects of irrigation. They may find their land and water resources blocked by new irrigation developments, or they may have a flood/recession where cropping is seriously affected by the upstream interception of river water for irrigation purposes. This can often happen without users having legal water rights and legal recourse. On the other hand, poor communities in the upper region who do not receive the benefits of irrigation are often deforesting the mountains to feed their families. There should be benefit sharing for downstream and upstream communities in the irrigation system. This could be in the form of a dividend reinvestment project that benefits local communities and the environment (for example, to stop sedimentation and flooding in the lower region). At the moment, there is no benefit sharing enjoyed by these communities, therefore the TBL rating for this aspect is below compliance.

In addition to this, since there is evidence that shortage of water during dry season and it often detriments tail-end farmers, a clearer allocation of water rights could help reduce conflict and facilitate trading and compensation arrangement for reallocation and efficient water resource utilisation.

5.2.5 Proposed Approaches to Improve Sustainability

From the discussion above, it can be concluded that the irrigation system cannot be categorised as sustainable organisations since many aspects of the TBL are under compliance. To be sustainable, the Indonesian irrigation authorities must apply the principles of the TBL to maintain and enhance the sustainability of irrigation systems, since TBL reporting provides a means of showing the public that irrigated agriculture can be sustainable.

Improved irrigation performance and sustainability can be achieved through physical and managerial interventions. Physical interventions such as modernisation and rehabilitation are aimed at achieving improved irrigation performance. In considering physical interventions, management and operational adjustments are necessary as a parallel activity to modernisation. The interventions are also termed as remedial works, corrective actions, interventions, and approaches by experts. From this point it will termed as proposed approaches. The following is a selected set of approaches necessary to improve irrigation system performance and sustainability; these have previously been proposed by Bruns and Helmi (1996) and (Burt, 2001) and discussed in Section 2.7.1:

1. Modernising of irrigation systems can be effected by:
   1. Applying pressurised irrigation methods and recirculating the irrigation water to improve irrigation efficiency,
   2. Improving channel conditions and increasing the number of turnouts/offtakes to improve irrigation service and water distribution,
   3. Installing volumetric measuring devices and expand the scope of the ISF by specifying water delivery services to implement ISF based on the volume of water used and to raise the ISF to improve water use efficiency and to increase management, maintenance and operation (MOM) cost recovery.
2. Improving irrigation system management, procedures, and communication by improving PIM:
   a. Diversifying agriculture and developing agricultural business

   It is difficult to obtain sufficient income from rice farming on small landplots (on average below 0.5 hectares). Moreover, rice production offers lower and declining returns to farmers. Higher income is more likely to be gained from horticultural crops, therefore there is an increasing demand to diversify agriculture and develop agricultural business (note: Government policy allows farmers to choose their own crops freely, even though this is constrained by continuing concerns with maintaining self-sufficiency in rice production).

b. WUAs as business organisation/enterprises

   PIM projects have always aimed to improve farmers' income, but they have not been directly aimed at income generation. One approach in strengthening WUAs and increasing benefits to farmers may be through the development of WUAs as business organisations.

c. Turnover Secondary Level/Larger System to WUAs

   While the turnover of smaller/tertiary level systems has been fairly successful, there is a reluctance to proceed in the turnover of larger/secondary/main level systems. In fact, staff shortages, lack of vehicles and communication equipment, and operational budget constraints minimise the ability of irrigation offices to provide services. In addition to this, farmers are being asked to assist with the maintenance and operations of larger systems although it is not within their capacity. These obvious deficits require official follow-up (Note: Even if larger systems are turned over, the government must retain the authority to supervise water allocation to maintain upstream systems and not deprive downstream areas during periods of shortage. Re-engineering of irrigation management should focus on how to best accomplish the key process of equitably distributing irrigation water to farmers).

There are several aspects to be considered to improve existing irrigation system sustainability. For example, upgrading the open-channel-gravity-irrigation method to a closed-channel-pressurised-irrigation method. This method requires measurement and control of volumes devices in the field (hardware), and reliable procedures and management that enable flexibility. Therefore, to implement this method requires consideration on aspects such as the ability of the present WDS in individual fields to support pressurised irrigation methods (*see Figure 4.48 in Section 4.5.2.4*), and overcome the challenges and make the changes required (*see Appendix D.2*).

As can be seen in Figure 4.48 in Section 4.5.2.4, the ability of WDS in individual fields to support pressurised irrigation methods in the irrigation system is low (2.4 out of 4). I was assessed from three 3 aspects namely: measurement and control of volumes to the field, flexibility to the field, and reliability to the field. At the moment, the irrigation system have not implemented volumetric metering. They are able to measure flow rates reasonably well, but not volume. Flow is also well controlled. Water usually arrives as promised, but it cannot be varied upon request. Delay occasionally occurs, but water is still very reliable in rate and duration.

To support pressurised irrigation method, changes are required in the aspects of procedures and management and hardware. It required major changes in water ordering, staff training, mobility and communications. As well as need to repair some of the existing structures and to add new structures for water recirculation. To be sustained in the future, irrigation systems should operate in a more effective and efficient manner and pressurised irrigation methods are an appropriate and reliable method.

A complete assessment on applying the proposed physical and managerial improvements approaches to TBL sustainability and the obstacles that must be overcome can be seen in a table in *Appendix D.2*. The table was developed from the opinions of Bruns and Helmi (1996) and Burt (2001), and also some of the ideas developed by the author.

In making choices as to which corrective actions should be implemented, a stakeholders' opinion survey was conducted to establish weightings or priorities for evaluation criteria. Evaluation criteria utilised was a TBL sustainability viability framework for irrigation. This survey and its results are discussed in section 5.3.

5.3 The Stakeholder Opinion Survey

The opinion survey of stakeholder preferences on the proposed approaches to improve existing irrigation system sustainability was aimed at obtaining the most suitable and appropriate approaches by first ranking stakeholder preferences on proposed approaches. The ranking process which was used is set out in Section 5.3.1. Subsequently, based on these rankings, the weight of each proposed approach was determined. The viability of each proposed approached was then assessed against the different aspects of the TBL, (technical, economic, social, institutional and legal, environmental). The higher the value obtained by an approach, the more viable; therefore it can be regarded as the most suitable and appropriate approach to be implemented. The viability assessment process is discussed in Section 5.4.

5.3.1 The Simple Pairwise Comparison

To determine the rank of the most preferred approaches to be implemented in order to achieve improved irrigation performance and sustainability, the principal stakeholders of irrigation systems were surveyed. The stakeholder groups participated in the survey were irrigation authorities from both provincial, districts and local technical implementation unit staff of UPTD, local (both from provincial and district) planning boards (*Bapeda*), consultants and WUAs (*see Table 3.3 in Section 3.3.2*). The respondents interviewed were individually based at their places of work.

In making choices, it is important to establish weightings or priorities for the managerial and physical improvements approaches as mentioned in Section 5.2.5. The subsequent opinion survey was conducted to determine stakeholder preferences or to rank the approaches most likely to be implemented. There are methods used to evaluate prioritisation of asset maintenance/renewal. However, for these irrigation systems, the method used to weight the proposed activities was a Simple Pairwise Comparison Questionnaires and Matrix.

Pairwise comparison questionnaires was chosen because it is easy (select one of the two), reliable and economical. The questionnaires consisted of three statements related to managerial interventions and three statements related to physical interventions. It was developed further into 15 questions that simply asked the decision makers to compare two alternatives at the same time. The questionnaires were in Local Language that is Bahasa Indonesia. The following are an example of question; Choose (a) or (b) of the following physical intervention options that are more likely to be implemented in Indonesia irrigation systems:

a.	Applying pressurised irrigation method and recirculate the irrigation water	b.	Improving channels condition and increasing the number of turnouts/offtakes

(*The complete questionnaires form can be seen in Appendix B.5*).

The results of the opinion survey regarding the approach desired by stakeholders are shown in the *Appendix D.3.1 and D3.2*. The rank of approaches was indicated by how many times an approach was chosen and the most-chosen approach is the most desirable approach. Based on these ranks, the weight of each approach was determined. The preferences on the proposed approaches vary between irrigation authorities, consultants and farmers. In total, the most to the least desired approaches are to:

Table. 5.3. The rank of preferences on the proposed approaches

Alternatives	Rank
Improve channel condition	I
WUAs as bussiness organisation	II
Install volumetric measuring devices & expand the scope of ISF	III
Diversifying agriculture	IV
Pressurized irrigation + recirculation	V
Expand the scope of WUAs authority	VI

5.4 The Viability Assessment of Options on the Aspects of the Triple Bottom Line

Managerial and physical irrigation system improvements that require balancing conflicting objectives of people, planet and profit are among today's most challenging decisions to be made by the irrigation authorities. Although many techniques exist for helping decision makers to select among project alternatives, it is not easy to identify the TBL aspects based on clearly articulated stakeholder values and then to use this information to create policy alternatives.

It was decided to utilise the goal model to assess the TBL sustainability viability of the three managerial and the three physical irrigation improvement approaches. Utilising the goal model means that the viability of these proposed approaches would be tested in term of the degree to which the TBL sustainability goals are achieved. The three key sustainability issues which are the goals to be achieved in implementing the approaches are: technical and economic, social, institutional and legal issues, and environmental, public health and safety. These three key issues were then developed further into several criteria of sustainability/viability that determined whether the goals were achieved in implementing the approaches (*see Appendix B.6.1 and Appendix B.6.2*).

The ability to satisfy the criteria statements was measured through a score. In this thesis, the score were 1 for low, 2 for moderate and 3 for high. Weights were also allocated to each criteria based on the rank of the options obtained from the stakeholder opinion survey (*see Table 5.3*). Since the parameters used were based on the data obtained from previous performance assessments and stakeholder opinion of the proposed approach to the improvement of irrigation systems, this assessment is considered as an indirect measure. Further more, it is also considered as an external standard since it was derived from a variety of sources. The weight of each proposed approach are as follow:

Table 5.4. Weight of approaches

Alternatives		Rank				Overall weight
		Irrigation Authority/ UPTD/ Bapeda	Consultant	WUAs	Overall	
1.	Pressurized irrigation + recirculation	4	6	5	5	1.2
2.	Improve channel condition	2	1	1	1	4.8
3.	Install volumetric measuring devices & expand the scope of ISF	5	2	4	3	1.7
4.	Diversifying agriculture	3	5	3	4	1.6
5.	WUAs as bussiness organisation	1	4	2	2	2.7
6.	Expand the scope of WUAs authority	6	3	6	6	1.1

The final scores were obtained from a combination of scores and weights. The approach with the highest final score was the option that was not only viable but also preferred by the stakeholders (*see Appendix D.4*).

An illustrative example is given of how the viability of approaches was formulated. It can in the following Table 5.5:

Table 5.5. Example of viability assessment calculation

Pressurised irrigation method, recirculate the irrigation water and install volumetric measurement devices to improve irrigation efficiency						
Goal		**Criteria**	**Statement**	**Score**	**Weight**	**Real score = score * weight**
Technical and economic aspects	**Technical viability**	Suply reliability/ serviceability	Stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability	3.0	1.2	3.6
		Efficiency	Efficiency of irrigation water: application, distribution and conveyance, and reducing the losses of the irrigation system	3.0	1.2	3.6

For example, for pressurised irrigation and recirculate irrigation water approaches, the key issue of technical and economic aspect has technical viability goal. The technical viability goal consists of supply reliability/serviceability and efficiency criteria. The statements for supply reliability are to satisfy 100% of crop irrigation requirements that crucial for productive sustainability. By implementing this option, this goal is high likely to be achieved. Therefore, the score for this statement is 3.

However, based on the opinion survey, the weight for these approaches was 1.2. Therefore, the real score for these criteria was 3.6. This was done until all the criteria were scored and weighted and the total real score for this approach was obtained.

Table 5.6 shows the summary of assessment results of the viability of modernising irrigation system approaches (*see Appendix D.4.1.1 to D.4.2.3 for detailed assessment*) and Table 5.7 presents the summary of assessment results of the viability of improving irrigation system management, procedures, and communication by improving PIM (*see Appendix D.4.2.1 to D.4.2.3 for detailed assessment*).

Table 5.6. Summary of assessing the viability of modernising irrigation systems

Key Issue	Goal/objective	Criteria	Pressurised irrigation method, recirculate the irrigation water and install volumetric measurement devices to improve irrigation efficiency			Improving channel condition and increasing the number of turnouts/offtakes to improve irrigation service and water distribution			Install volumetric measuring devices and expand the scope of the irrigation service fee (ISF) & raise the ISF to increase management, maintenance and operation (MOM) costs		
			Score	Weight	Real score = score * weight	Score	Weight	Real score = score * weight	Score	Weight	Real score = score * weight
Technical and economic aspects	Technical viability	Suply reliability/serviceability	3	1.2	3.6	3	4.8	14.4	2	1.7	3.4
		Efficiency	3	1.2	3.6	2	4.8	9.6	3	1.7	5.1
		Operation and maintenance	3	1.2	3.6	3	4.8	14.4	3	1.7	5.1
		Utilise existing infrastructure	2	1.2	2.4	3	4.8	14.4	3	1.7	5.1
		Upgradeability	3	1.2	3.6	2	4.8	9.6	3	1.7	5.1
	Technical sustainability	Future demand	3	1.2	3.6	2	4.8	9.6	2	1.7	3.4
		Flexibility	3	1.2	3.6	2	4.8	9.6	2	1.7	3.4
		Long-term operation and maintenance	3	1.2	3.6	2	4.8	9.6	3	1.7	5.1
	Economical viability	Investment cost	1	1.2	1.2	2	4.8	9.6	1	1.7	1.7
		O&M cost efficiency	2	1.2	2.4	2	4.8	9.6	1	1.7	1.7
		Pricing irrigation water accurately	3	1.2	3.6	2	4.8	9.6	3	1.7	5.1
		Agricultural productivity	3	1.2	3.6	2	4.8	9.6	3	1.7	5.1
	Economical sustainability	Financial sustainability	3	1.2	3.6	2	4.8	9.6	1	1.7	1.7
Social, institutional, and legal aspects	Social viability	Complain/dissatisfaction*)	2	1.2	2.4	2	4.8	9.6	2	1.7	3.4
		Acceptance	2	1.2	2.4	3	4.8	14.4	2	1.7	3.4
		Trust/confidence	2	1.2	2.4	3	4.8	14.4	2	1.7	3.4
	Institutional viability	Local capacity	2	1.2	2.4	3	4.8	14.4	3	1.7	5.1
		Acceptance	2	1.2	2.4	3	4.8	14.4	1	1.7	1.7
	Legal viability	Legislation/regulation	2	1.2	2.4	3	1.4	4.2	2	1.7	3.4
Environmental, and public health and safety aspects	Environmental viability	In the irrigation project	3	1.2	3.6	1	4.8	4.8	1	1.7	1.7
		Downstream of the project	3	1.2	3.6	1	4.8	4.8	1	1.7	1.7
		Irrigation water efficiency	3	1.2	3.6	2	4.8	9.6	3	1.7	5.1
	Public health and safety	Health and safety	3	1.2	3.6	1	4.8	4.8	1	1.7	1.7
		Quantity & quality od drainage	3	1.2	3.6	1	4.8	4.8	1	1.7	1.7
		Effect on tail-enders	3	1.2	3.6	1	4.8	4.8	2	1.7	3.4
		Education/awareness	3	1.2	3.6	2	4.8	9.6	2	1.7	3.4
Total score					82			254			91

Score : 1 = low, 2 = moderate, 3 = high
1 = high, 2 = moderate, 3 = low*)

Table 5.7. Summary of assessing the viability of improving management of irrigation systems

Key Issue	Goal/objective	Criteria	Diversifying agriculture and developing agricultural business			WUAs as business organisation/enterprises			Turnover Secondary Level/Larger System to WUAs		
			Score	Weight	Real score = score * weight	Score	Weight	Real score = score * weight	Score	Weight	Real score = score * weight
Technical and economic aspects	Technical viability	Suply reliability/serviceability	1	1.6	1.6	2	2.7	5.3	2	1.1	2.3
		Efficiency	3	1.6	4.8	2	2.7	5.3	2	1.1	2.3
		Operation and maintenance	1	1.6	1.6	2	2.7	5.3	2	1.1	2.3
		Utilise existing infrastructure	2	1.6	3.2	3	2.7	8.0	3	1.1	3.4
		Upgradeability/adaptability	2	1.6	3.2	3	2.7	8.0	2	1.1	2.3
	Technical sustainability	Future demand	1	1.6	1.6	3	2.7	8.0	3	1.1	3.4
		Flexibility	3	1.6	4.8	3	2.7	8.0	3	1.1	3.4
		Long-term operation and maintenance	3	1.6	4.8	3	2.7	8.0	3	1.1	3.4
	Economical viability	Implementation cost	2	1.6	3.2	2	2.7	5.3	2	1.1	2.3
		O&M cost efficiency	2	1.6	3.2	2	2.7	5.3	2	1.1	2.3
		Pricing irrigation water accurately	3	1.6	4.8	3	2.7	8.0	3	1.1	3.4
		Agricultural productivity	3	1.6	4.8	3	2.7	8.0	3	1.1	3.4
	Economical sustainability	Financial sustainability	3	1.6	4.8	3	2.7	8.0	3	1.1	3.4
Social, institutional, and legal aspects	Social viability	Complain/dissatisfaction*)	2	1.6	3.2	2	2.7	5.3	2	1.1	2.3
		Acceptance	2	1.6	3.2	2	2.7	5.3	2	1.1	2.3
		Trust/confidence	2	1.6	3.2	2	2.7	5.3	2	1.1	2.3
	Institutional viability	Local capacity	2	1.6	3.2	2	2.7	5.3	2	1.1	2.3
		Acceptance	2	1.6	3.2	2	2.7	5.3	2	1.1	2.3
	Legal viability	Legislation/regulation	2	1.6	3.2	3	2.7	8.0	2	1.1	2.3
Environmental, and public health and safety aspects	Environmental viability	In the irrigation project	3	1.6	4.8	3	2.7	8.0	3	1.1	3.4
		Downstream of the project	3	1.6	4.8	3	2.7	8.0	3	1.1	3.4
		Irrigation water efficiency	3	1.6	4.8	3	2.7	8.0	3	1.1	3.4
	Public health and safety	Health and safety	3	1.6	4.8	2	2.7	5.3	2	1.1	2.3
		Quantity & quality od drainage	3	1.6	4.8	2	2.7	5.3	2	1.1	2.3
		Effect on tail-enders	3	1.6	4.8	2	2.7	5.3	2	1.1	2.3
		Education/awareness	3	1.6	4.8	2	2.7	5.3	2	1.1	2.3
Total score					99			171			71

Score : 1 = low, 2 = moderate, 3 = high
1 = high, 2 = moderate, 3 = low*)

Based on Table 5.6 and Table 5.7, the weighted score and the rank of the approaches is as follows:

Table 5.8. Summary of assessing the TBL viability of the approaches

Alternatives		Weighted score	Ranking
1.	Pressurized irrigation + recirculation	82	**V**
2.	Improve channel condition	254	**I**
3.	Install volumetric measuring devices & expand the scope of ISF	91	**IV**
4.	Diversifying agriculture	99	**III**
5.	WUAs as bussiness organisation	171	**II**
6.	Expand the scope of WUAs authority	71	**VI**

It can be concluded that the preferred approaches to improve the TBL sustainability of the Indonesian irrigation system in the future are a moderate improvement in the management or moderate improvement in infrastructure that do not require high investment costs. Modernisation of irrigation system such as pressurised irrigation will improve efficiency and sustainability in terms of resources usage, management and operations and maintenance. However, modernisation is undesirable in that it requires heavy investment and requires a restructuring of the management, O&M of irrigation systems.

There is little difference in the ranking obtained from the results of the stakeholder opinion survey only and the TBL sustainability viability assessment of the proposed approaches result, as can be seen in the Table 5.26. However, the score obtained from the viability assessment is more effective in showing the feasibility of an approach to proceed to the next stage.

Table 5.9. Comparison between pairwise and TBL viability

Alternatives		Pair wise score	Ranking	TBL weighted score	Ranking
1.	Pressurized irrigation + recirculation	75	**V**	82	**V**
2.	Improve channel condition	161	**I**	254	**I**
3.	Install volumetric measuring devices & expand the scope of ISF	91	**III**	91	**IV**
4.	Diversifying agriculture	88	**IV**	99	**III**
5.	WUAs as bussiness organisation	145	**II**	171	**II**
6.	Expand the scope of WUAs authority	70	**VI**	71	**VI**

It can be concluded that the simple pairwise comparison is a reliable method to obtain priority of approaches. Whereas, the TBL sustainability viability framework is very useful to determine the strength of a proposed approach to be implemented.

The process used in this research to assess the viability against the different aspects of the TBL is depicted in Figure 3.2 of Section 3.3.3.

5.5 Summary of Analysis

Based on the TBL sustainability assessment of existing irrigation systems as shown in the table above, it can be summarised that:

- Globally, the major issues of the sustainability of irrigation systems rest on the sustainability of irrigation water availability and agricultural land available (within the framework of the quantity and quality) (*see Section 5.2.2.1*), and
- Locally, the issue of sustainability of the irrigation system in Indonesia is linked to the low performance of irrigation systems (low water and land productivity, ageing, poor and diminishing capacity due to sedimentation irrigation infrastructure, increased Management, Operation and Maintenance (MOM) *costs*

and low MOM cost recovery, lack of government financing in irrigation, and lack of attention to the environmental impact caused by the irrigation activity) (*see Section 5.2.2.1, 5.2.2.2 and 5.2.3.1*).

- Based on the TBL sustainability performance assessment, the irrigation system operations are considered to be below-compliant since there is evidence of an inefficient and ineffective manner of system operation and management, and the use of resources. In order to achieve long-term sustainability, irrigation systems must be able to transform their organisations into TBL organisations that address the issue of ecological (environment) and social (people/community) performance in addition to financial (profit) performance (*see Section 5.2.2.3, 5.2.2.4, 5.2.4.1, 5.2.4.2, 5.2.4.3 and 5.2.4.4*).
- There are several approaches promoted with regard to improving the sustainability of irrigation systems, as proposed by the experts, that consist of physical and management interventions/corrective actions/remedial works. This research tested the six most appropriate approaches to be implemented into the Indonesian irrigation systems through the stakeholder opinion survey and the TBL sustainability viability assessment (*see Section 5.2.5*).
- The stakeholder opinion surveys were conducted by distributing questionnaires to six major irrigation stakeholders in Indonesia, namely local planning boards (*Bapeda*) and irrigation authorities from provinces, other districts and local technical implementation unit staff of UPTD, consultants and WUAs). The questionnaires obtained preferences on the proposed approaches to improving the TBL sustainability of Indonesian irrigation systems in the future. The analyses were performed quantitatively by involving the simple pairwise comparison matrix method. The results obtained are in the form of ranking the proposed approaches from the most to the least desirable approaches to be implemented further (*see Section 5.3*).
- The analysis then continued further over the TBL sustainability viability assessment in which the proposals were scored based on the TBL sustainability viability framework for irrigation systems. The results were also weighted based on the stakeholder opinion survey results, to find out the most popular approaches. In the form of the rank of the proposed approaches, the results obtained were similar to opinion surveys. However, the scores from the proposed approach

demonstrated the differences between the most effective and least effective approaches (*see Section 5.4*).

- The results of the analysis indicate that the physical upgrades required will incur large capital costs and these, along with the required costly management upgrades to broaden the WUAs authority are less desirable for all stakeholders (*see Section 5.4*).

5.6 Overview and Recommendations

This chapter has discussed the need for irrigation systems to assess their performance and sustainability to determine their actual condition. Based on the performance and sustainability assessment of irrigation systems, to be sustained, it is required to apply the TBL principle in their O&M of irrigation systems.

There are some intervention approaches both physical and management that can be implemented to achieved improved irrigation performance and sustainability. Our finding suggests that the irrigation system stakeholders voted on the proposed approaches were based on the cost of physical intervention approaches and the capability of WUAs to carry out responsibility consideration.

Taking into account the simplicity and reliability, the simple pairwise comparison method is best used when it is desired to obtain the priority of proposed approaches quickly and accurately. Modifying the simple pairwise with a TBL sustainability viability framework is found to successfully link the priority with viability of a set of proposed approaches.

There is a need for a procedure that will allow the development of the most appropriate AMP for an irrigation system. This would enable WUAs in rural Indonesia to cost-effectively manage the assets of turnover irrigation systems and achieve sustainability goals. The AMP would help to focus the attention of WUAs/WUAFs on sustaining and enhancing the condition of tertiary level irrigation infrastructure. The assets covered by the AMP are the assets required for irrigation systems to perform their basic function of supplying water to farmers. Chapter 6 will discuss the procedure for developing the improved, sustainable, and cost-effective AMP. The improved AMP will be developed by considering the approaches obtained in this chapter.

CHAPTER 6. DATA AND ANALYSIS OF THE IMPROVED ASSET MANAGEMENT PLANNING

6.1 Introduction to Asset Management Planning (AMP)

Stage One research results (Chapter 4, Section 4.7) identifies deficiencies in the operation of the irrigation systems studied. They were performing below their potential and the current net benefit of irrigation was heavily weighted towards producing outcomes at the expense of the environment. Constraints on performance were caused by delays in irrigation system maintenance due to inadequate funding. This situation resulted in low productive use of water and land, which in turn threatened the sustainability of irrigation systems.

Stage two research (Chapter 5) demonstrated that the irrigation system did not comply with Triple Bottom Line (TBL) sustainability objectives (Section 5.2.5). Stage two research also examined the six intervention options, which consisted of three physical changes to modernise irrigation, and three managerial changes to improve irrigation system performance and sustainability (Section 5.2.5). The results indicated (*Section 5.4*) that a physical upgrade would require substantial capital cost, and a management upgrade to broaden the authority of Water User Associations/Water User Association federations (WUAs/WUAFs) were not desired by stakeholders

As mentioned in Section 5.6 there is a need for a procedure that will allow the development of the most appropriate asset management planning (AMP) for irrigation systems to perform their basic function of supplying water to farmers. Since the O&M of tertiary level of Indonesia irrigation system has been transferred to WUAs, then the AMP developed should be appropriate for a system that is transferred. This AMP would enable WUAs in rural Indonesia to cost-effectively manage the assets of transferred irrigation systems and achieve sustainability goals. The AMP also would help WUAs/WUAFs to focus their attention on sustaining and enhancing the condition of tertiary level irrigation infrastructure.

The improved, sustainable, and cost-effective AMP model for a transferred irrigation system was developed according to guidelines provided by the Institute of Irrigation Studies (IIS), University of Southampton, UK (1995). The AMP cost model developed for this research project was developed by considering the efficient operation and maintenance (O&M) of assets, needs-based budgeting, irrigation service fees (ISF), and turnover. In addition to the IIS guidelines, the AMP also considers the most robust proposed physical and managerial interventions achieved in the previous analysis. Budget constraints and the sources of and required levels of funding were also taken into account in the analysis, where the data comes from the latest project implementation (PISP and WISM).

The IIS guidelines suggested that the timeframe for an AMP should be divided into: budget priorities, budget planning (5 years) and capital planning (20 years). The improved, sustainable, and cost-effective AMP model developed proposes to divide the timeframe into: budget priorities (routine MOM costs, 5 years), budget planning (rehabilitation of irrigation system, in year 16), short-term planning (investment priorities, 10 years: channel condition and network improvements, and increasing the number of turnouts/offtakes to improve irrigation services and water distribution), medium-term planning (capital planning, 20 years: installing volumetric measuring devices), long-term planning (capital planning; 25 years: implementing pressurised irrigation methods and recirculating the irrigation water). Since the goals of the budget priorities, budget planning and short-term planning timeframes are quite simple, it is expected that WUAs can carry it out independently. Meanwhile for medium-term capital planning (20 years: installing volumetric measuring devices) and long-term capital planning (25 years: implementing pressurised irrigation methods and recirculating the irrigation water), the government's assistance in funding is required. The steps involved in developing the AMP model are illustrated in Figure 6.1.

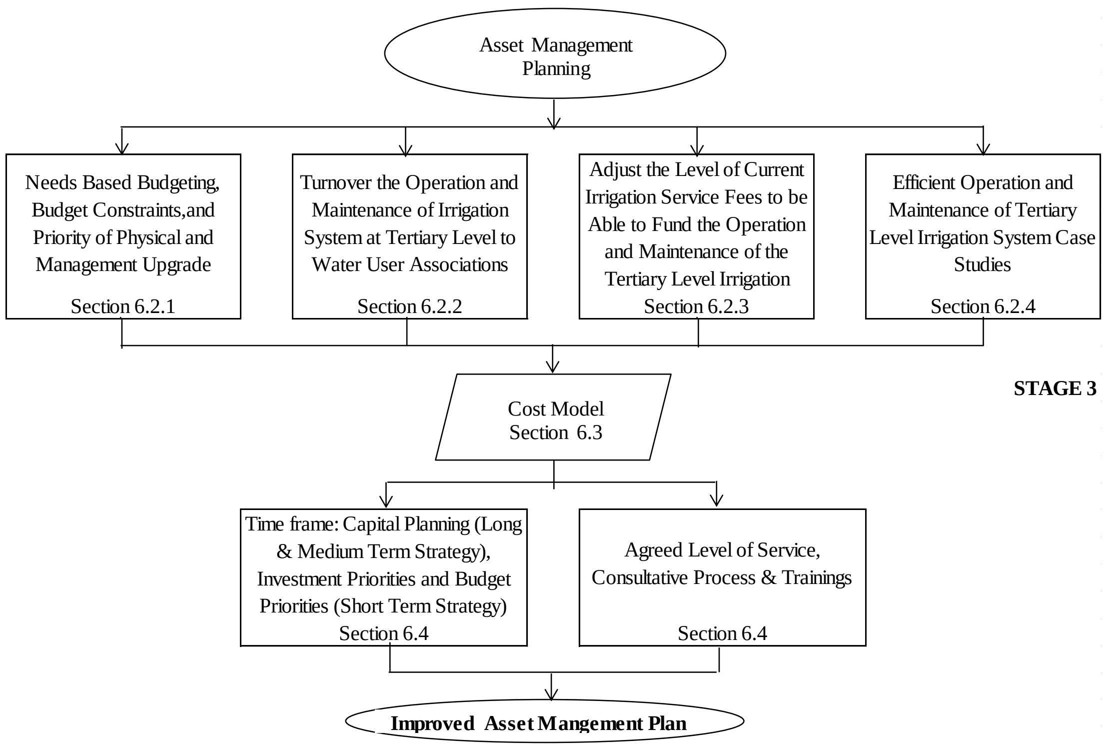


Figure 6.1. The steps involved in developing the AMP model (Stage three research)

This chapter addresses the final research objective, which is to develop a simple, sustainable, and cost-effective AMP to enable water user associations (WUAs) in rural Indonesia to manage the assets of a turnover irrigation system.

Section 6.2 presents and explains the elements of the improved, sustainable, and cost-effective AMP, including needs-based budget allocation and budget constraints, turnover tertiary irrigation system to WUAs, ISF, and efficient O&M of tertiary level irrigation systems.

Elements of the cost model of the proposed management and physical upgrades for each case study irrigation system are reviewed in Section 6.3. This section includes the level of service and the cost of service, asset maintenance planning, asset useful life, depreciation and salvage value, asset valuation (including discount rate), and a life cycle cost (LCC) analysis.

In Section 6.4 the improved, sustainable, and cost-effective AMP for the irrigation system is presented in short, medium and long-term timeframes and the role of WUAs are reviewed.

6.2 The Elements of an Improved Asset Management Planning (AMP)

As mentioned in Section 2.2.4, in the Indonesia context, the IIS suggested the AMP should include the elements of needs-based budgeting, turnover programs, ISF, and efficient O&M. In addition to these, the improved, sustainable, and cost-effective AMP should also consider aspects of the priority of management and physical upgrade, source and realistic level of funding, needs-based budget allocation and budget constraints. Moreover, Section 5.4 had indicated the priority of the six proposed approaches to be implemented. Subsequently, how these elements incorporated is discussed in the following sections; 6.2.1, 6.2.2 and 6.2.3.

6.2.1 Needs based Budgeting, Budget Constraints and Priority of Physical and Management Upgrades

Various assets (or components of assets) have different useful lives and different maintenance requirements. Timely attention to maintenance requirements slows the overall deterioration of assets, restores the condition of short-life components, and allows the end of an asset's 'useful life' to be reached.

Section 4.7 summarised that financial constraints were evident in the irrigation system. The asset MOM costs were low compared to the MOM cost of similar assets in other countries. The current ISF was also inadequate to cover the MOM costs at the tertiary level. Renewal of tertiary level assets still relies on government subsidies. As shown in Table 4.9 39% of the technical irrigation systems in the Province of Lampung are severely damaged.

With limited funds, the irrigation system should budget the need for maintenance and physical upgrades according to priority.

6.2.1.1 Needs based Budgeting

Deterioration is regularly associated with maintenance expenditure. At less frequent intervals maintenance expenditure, more extensive refurbishment and upgrading can occur to replace assets and change asset functionality to accommodate service change requirements. In addition to this, the restored condition is of possibility lesser quality than that of new assets. A typical deterioration in the condition of channel networks and related assets, over time, in tertiary level irrigation systems, is discussed below.

As suggested by the Australian Asset Management Collaborative Group (AAMCoG) (2008), general performance trends are established for the asset group by plotting asset condition information (obtained from historical and current condition surveys) on the vertical axis and the age of assets at the time of survey (or since the last major rehabilitation was performed) on the horizontal axis. However, since, there were no past records of maintenance and renewal activities of assets at the tertiary level available to enable observation of trends in maintenance and renewal expenditure, the typical deterioration curve for channels and hydraulic structure asset groups was assumed based on Figure 6.2.

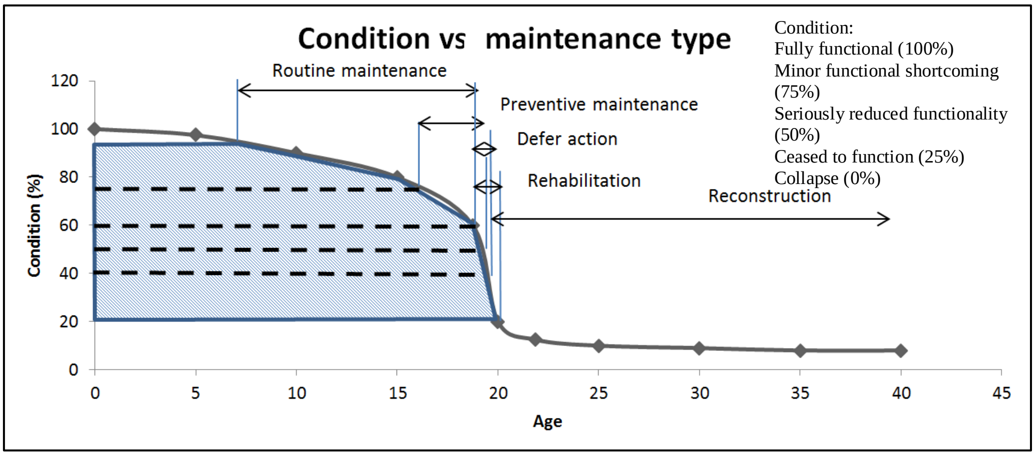


Figure 6.2. Typical deterioration curve for channels and hydraulic structure asset groups (adjusted from Stapelberg, 2004)

Figure 6.2 indicates that there is roughly a 40% drop in asset condition within 75% of useful life (assuming a useful life of 25 years). There is a further 40% drop in condition (i.e., an 80% drop) within 80% of its useful life (20 years). The required maintenance required in relation to the change in asset condition is:

1. Routine maintenance (when asset condition falls to 60% - 90% of original). Ongoing services performed by the assets require day-to-day maintenance to maintain optimum condition. Routine maintenance is not planned in detail.
2. Preventative maintenance (when asset condition falls to 50% – 75% of original). Planned cost-effective maintenance strategy of existing assets aims to preserve the assets, delay future deterioration, and maintain or improve the functional condition of assets without increasing the asset's capacity.
3. Rehabilitation (when asset condition falls to 25% – 60% of original). This entails the restoration of an asset according to its original design, condition, and geometry so that it will function until the expiration of its useful period. It is

important to determine whether the asset has reached its cost-effective usage (i.e., performance).

4. Reconstruction (when asset condition falls to less than 40% of original). The re-establishment of an asset to a different design, capacity, material or geometry.

Based on this figure, the asset maintenance strategic plan for the improved, sustainable, and cost-effective AMP model for the irrigation system over the first five years is based on preventative routine maintenance.

6.2.1.2 Budget Constraints

Previous results indicate that the irrigation system are experiencing a deferred maintenance of assets due to government's budget constraints. To break the deferred maintenance cycle and to keep irrigation system performance running either at or close to the original design level, the government rehabilitates the irrigation system through PISP. Rehabilitation works carried out were at a low level of periodic replacement/rehabilitation. Since the PISP was only completed in 2011, it can be assumed that the current condition of assets in tertiary level irrigation systems is high (90 – 100%).

Table 6.1 shows the amount spent by the government on the rehabilitation of the irrigation system through PISP. The amount spent on tertiary rehabilitation works were 39% of total rehabilitation works of irrigation systems.

Table 6.1. The amount spent by the PISP on tertiary level irrigation systems

Irrigation system		Rehabilitation works minus tertiary works (5 year PISP		Tertiary works (5 year PISP implementation)		Total rehabilitation works (5 year PISP implementation)	
		Billion Rp	Million US$	Billion Rp	Million US$	Billion Rp	Million US$
Large	Way Pengubuan	0.67	0.07	2.95	0.33	3.62	0.40
Medium	Way Padang Ratu	3.30	0.37	0.00	0.00	3.30	0.37
	Way Negara Ratu	0.00	0.00	1.16	0.13	1.16	0.13
	Way Tipo Balak	1.61	0.18	0.66	0.07	2.27	0.25
Small	Way Muara Mas	0.15	0.02	0.41	0.05	0.56	0.06
	Way Muara Mas I	0.85	0.09	0.47	0.05	1.32	0.15
	Way Muara Mas II	0.10	0.01	0.10	0.01	0.20	0.02
	Way Muara Mas III	0.17	0.02	0.17	0.02	0.33	0.04
	Way Tipo Lunik	2.62	0.29	0.00	0.00	2.62	0.29
	Way Ilihan Balak	0.43	0.05	1.50	0.17	1.93	0.21
	Way Sri Katon	2.36	0.26	0.26	0.03	2.62	0.29
TOTAL		**12.27**	**1.36**	**7.68**	**0.85**	**19.94**	**2.22**

(Source: The Government of the Province of Lampung, the Public Works Unit, PISP Implementation Unit, 2012)

Table 6.2 illustrates the average amount spent on rehabilitating the systems and Table 6.3 presents the average amount spent on rehabilitating the tertiary level irrigation systems. The average amount spent on the systems was Rp4.11 Million (US$460)/hectare and the average amount spent on the tertiary level was Rp960 Thousands (US$110)/hectare. The amount spent to rehabilitate per hectare basis of tertiary level works was approximately 70% of the amount spent per hectare basis of the irrigation systems.

Table 6.2. Rehabilitation costs for each irrigation system

Irrigation System	Rehabilitation cost/hectares	
	Million Rp.	Thousand US$
Way Pengubuan	1.03	0.11
Way Padang Ratu	4.40	0.49
Way Negara Ratu	1.01	0.11
Way Tipo Balak	2.41	0.27
Way Muara Mas	3.60	0.40
Way Muara Mas I	3.85	0.43
Way Muara Mas II	4.20	0.47
Way Muara Mas III	4.27	0.47
Way Tipo Lunik	7.36	0.82
Way Ilihan Balak	5.03	0.56
Way Srikaton	8.06	0.90
Rehabilitation cost/ha (average)	**4.11**	**0.46**
Type Rehabilition Works (%)	Dam	6.02
	Primary& secondary	24.46
	Tertiary network	69.52
	Total	100.00

(Source: The Government of the Province of Lampung, the Public Works Unit, PISP Implementation Unit, 2012)

Table 6.3. Rehabilitation costs per hectare basis spent on tertiary level

Irrigation system		Tertiary works		
		Cost		Year
		Million Rp.	Thousand US$	
Large	Way Pengubuan	1,171.33	130.15	2010
		1,776.83	197.43	2011
		2,948.16	**327.57**	Total
Medium	Way Padang Ratu	0.00	0.00	2009
	Way Negara Ratu	675.58	75.06	2010
		486.45	54.05	2011
		1,162.03	**129.11**	
	Way Tipo Balak	285.03	31.67	2009
		373.68	41.52	2010
		658.70	**73.19**	Total
Small	Way Muara Mas	411.97	45.77	2008
	Way Muara Mas I	467.39	51.93	2008
	Way Muara Mas II	102.00	11.33	2008
	Way Muara Mas III	165.75	18.42	2008
	Way Tipo Lunik	0.00	0.00	2008
	Way Ilihan Balak	384.96	42.77	2008
		1,117.96	124.22	2009
		1,502.91	**166.99**	Total
	Way Sri Katon	256.87	28.54	2008
TOTAL		**7,675.79**	**852.87**	
Average/ha		**0.96**	**0.11**	

(Source: The Government of the Province of Lampung, the Public Works Unit, PISP Implementation Unit, 2012)

As mentioned in Section 4.3.4, 4.3.5 and Section 4.5.2.2, the government enables WUAs to decide the ISF to be levied on its members for the services they receive. The ISF are established on a seasonal basis according to the area irrigated, with no distinction between cropping seasons. The rates vary between 50 kg and 60 kg of crops/ha. WUAs are also free to decide the part of ISF collected to finance the organizations' activities. Most of irrigation systems utilised 20% of the ISFs collected to fund maintenance costs at the tertiary level (varies across irrigation systems, between 20% and 40% of the collected ISFs). The majority (60%) of the ISF were used to pay the salary and wages of WUAs board members and seasonal labours (controllers of water distribution (*Ulu-Ulu* and *Ili-ili*), collectors of the ISF, and administrative costs). The remaining 20% was retained to cover unexpected cost events and WUAs' office overhead costs.

Table 6.4 was developed based on the provision of 20% of ISF for maintenance activities. The table shows that the ISF collected over 5 years was US$1.75 Million. On the other hand, Table 6.1 shows that the amount spent by PISP for tertiary rehabilitation works for the irrigation systems in 5 years was US$0.85 Million. Based on these figures, ISF collected should be able to fund maintenance of irrigation systems. However, since WUAs only allocates 20% of ISF collected for maintenance (US$0.35 Million), it is only half of what is needed to take care of the system.

Table 6.4. ISF versus provision of ISF for maintenance

Irrigation system		**Irrigation service fee**				**20% Provision of ISF for maintenance**	
		(Billion Rp/yr)	**(Million $US/yr)**	**(Billion Rp/5-yr)**	**(Million $US/5-yr)**	**(Billion Rp/5-yr)**	**(Million$ US/5-yr)**
Large	Way Pengubuan	1.40	0.16	6.99	0.78	1.40	0.16
Medium	Way Padang Ratu	0.27	0.03	1.36	0.15	0.27	0.03
	Way Negara Ratu	0.41	0.05	2.07	0.23	0.41	0.05
	Way Tipo Balak	0.36	0.04	1.79	0.20	0.36	0.04
Small	Way Muara Mas	0.06	0.01	0.32	0.04	0.06	0.01
	Way Muara Mas I	0.14	0.02	0.69	0.08	0.14	0.02
	Way Muara Mas II	0.02	0.00	0.10	0.01	0.02	0.00
	Way Muara Mas III	0.03	0.00	0.16	0.02	0.03	0.00
	Way Tipo Lunik	0.17	0.02	0.86	0.10	0.17	0.02
	Way Ilihan Balak	0.15	0.02	0.77	0.09	0.15	0.02
	Way Sri Katon	0.13	0.01	0.65	0.07	0.13	0.01
TOTAL		**3.15**	**0.35**	**15.76**	**1.75**	**3.15**	**0.35**

On the other hand, based on ISF rate of 50 kg of crops per hectare per harvest, the following Table 6.5 shows that the average ISF/hectare/year was US$44. The

20% provision of ISF for routine maintenance cost accounted for US$9/hectares/year and 60% of provision of ISF for operation was US$26. Therefore, the amount used for O&M costs were US$35/hectare/year.

Table 6.5. The value of agricultural production and ISF

Irrigation system		Irrigated crop name	Typical yield (tons/ha)	Farmgate price (Million Rp/ton)	Service area (hectares)	Gross tonnage (tonnes/yr)	Value of agricultural production		Irrigation service fee			
							(Million Rp/yr)	(Thousand US$/yr)	Fee/ha (kg)	(Million Rp/yr)	(Thousand $US/yr)	% income
Large	Way Pengubuan	Paddy Rice #1 (Wet season - Rendeng)	6.2	4.00	3,501	21,706.20	86,824.80	9,647.20	50.00	700.20	77.80	
		Paddy Rice #2 (Semi dry season - Gadu)	5.8	4.00	2,312	13,409.60	53,638.40	5,959.82	50.00	462.40	51.38	
		Corn #3 (Dry season - Gadu)	7.5	1.80	2,625	3,502.50	6,304.50	700.50	50.00	236.25	26.25	
		Total annual value ($US)					**146,767.70**	**16,307.52**		**1,398.85**	**155.43**	**0.95**
Medium	Way Padang Ratu	Paddy Rice #1 (Wet season - Rendeng)	6	4.00	750	4,500.00	18,000.00	2,000.00	50.00	150.00	16.67	
		Paddy Rice #2 (Semi dry season - Gadu)	5	4.00	497	2,485.00	9,940.00	1,104.44	50.00	99.40	11.04	
		Corn #3 (Dry season - Gadu)	5	1.80	253	1,265.00	2,277.00	253.00	50.00	22.77	2.53	
		Total annual value ($US)					**30,217.00**	**3,357.44**		**272.17**	**30.24**	**0.90**
	Way Negara Ratu	Paddy Rice #1 (Wet season - Rendeng)	6.2	4.00	1,153	7,148.60	28,594.40	3,177.16	50.00	230.60	25.62	
		Paddy Rice #2 (Semi dry season - Gadu)	5.8	4.00	920	5,336.00	21,344.00	2,371.56	50.00	184.00	20.44	
		Corn #3 (Dry season - Gadu)	7.5	1.80	0	0.00	0.00	0.00	50.00	0.00	0.00	
		Total annual value ($US)					**49,938.40**	**5,548.71**		**414.60**	**46.07**	**0.83**
	Way Tipo Balak	Paddy Rice #1 (Wet season - Rendeng)	6.2	4.00	941	5,834.20	23,336.80	2,592.98	50.00	188.20	20.91	
		Paddy Rice #2 (Semi dry season - Gadu)	5.8	4.00	850	4,930.00	19,720.00	2,191.11	50.00	170.00	18.89	
		Corn #3 (Dry season - Gadu)	7.5	1.80	0	0.00	0.00	0.00	50.00	0.00	0.00	
		Total annual value ($US)					**43,056.80**	**4,784.09**		**358.20**	**39.80**	**0.83**
Small	Way Muara Mas	Paddy Rice #1 (Wet season - Rendeng)	6.2	4.00	157	1,395.00	5,580.00	620.00	50.00	31.40	3.49	
		Paddy Rice #2 (Semi dry season - Gadu)	5.8	4.00	157	1,305.00	5,220.00	580.00	50.00	31.40	3.49	
		Corn #3 (Dry season - Gadu)	7.5	1.80	7	52.50	94.50	10.50	50.00	0.63	0.07	
		Total annual value ($US)					**10,894.50**	**1,210.50**		**63.43**	**7.05**	**0.58**
	Way Muara Mas I	Paddy Rice #1 (Wet season - Rendeng)	6.2	4.00	343	2,126.60	8,506.40	945.16	50.00	68.60	7.62	
		Paddy Rice #2 (Semi dry season - Gadu)	5.8	4.00	343	1,989.40	7,957.60	884.18	50.00	68.60	7.62	
		Corn #3 (Dry season - Gadu)	7.5	1.80	7	52.50	94.50	10.50	50.00	0.63	0.07	
		Total annual value ($US)					**16,558.50**	**1,839.83**		**137.83**	**15.31**	**0.83**
	Way Muara Mas II	Paddy Rice #1 (Wet season - Rendeng)	6.2	4.00	48	297.60	1,190.40	132.27	50.00	9.60	1.07	
		Paddy Rice #2 (Semi dry season - Gadu)	5.8	4.00	48	278.40	1,113.60	123.73	50.00	9.60	1.07	
		Corn #3 (Dry season - Gadu)	7.5	1.80	3	22.50	40.50	4.50	50.00	0.27	0.03	
		Total annual value ($US)					**2,344.50**	**260.50**		**19.47**	**2.16**	**0.83**
	Way Muara Mas III	Paddy Rice #1 (Wet season - Rendeng)	6.2	4.00	78	483.60	1,934.40	214.93	50.00	15.60	1.73	
		Paddy Rice #2 (Semi dry season - Gadu)	5.8	4.00	78	452.40	1,809.60	201.07	50.00	15.60	1.73	
		Corn #3 (Dry season - Gadu)	7.5	1.80	4	30.00	54.00	6.00	50.00	0.36	0.04	
		Total annual value ($US)					**3,798.00**	**422.00**		**31.56**	**3.51**	**0.83**
	Way Tipo Lunik	Paddy Rice #1 (Wet season - Rendeng)	6.2	4.00	356	2,207.20	8,828.80	980.98	60.00	85.44	9.49	
		Paddy Rice #2 (Semi dry season - Gadu)	5.8	4.00	356	2,064.80	8,259.20	917.69	60.00	85.44	9.49	
		Corn #3 (Dry season - Gadu)	7.5	1.80	7	52.50	94.50	10.50	60.00	0.76	0.08	
		Total annual value ($US)					**17,182.50**	**1,909.17**		**171.64**	**19.07**	**1.00**
	Way Ilihan Balak	Paddy Rice #1 (Wet season - Rendeng)	6.2	4.00	384	2,380.80	9,523.20	1,058.13	50.00	76.80	8.53	
		Paddy Rice #2 (Semi dry season - Gadu)	5.8	4.00	384	2,227.20	8,908.80	989.87	50.00	76.80	8.53	
		Corn #3 (Dry season - Gadu)	7.5	1.80	7	52.50	94.50	10.50	50.00	0.63	0.07	
		Total annual value ($US)					**18,526.50**	**2,058.50**		**154.23**	**17.14**	**0.83**
	Way Sri Katon	Paddy Rice #1 (Wet season - Rendeng)	6.2	4.00	325	2,015.00	8,060.00	895.56	50.00	65.00	7.22	
		Paddy Rice #2 (Semi dry season - Gadu)	5.8	4.00	325	1,885.00	7,540.00	837.78	50.00	65.00	7.22	
		Corn #3 (Dry season - Gadu)	7.5	1.80	7	52.50	94.50	10.50	50.00	0.63	0.07	
		Total annual value ($US)					**15,694.50**	**1,743.83**		**130.63**	**14.51**	**0.83**
							Average irrigation service fee as % of income					0.84
							Average irrigation service fee/hectare/year (US$/yr)					43.59

As mentioned in Section 2.7.4, Shivakoti et al. (2005) mentioned the average budgetary requirement for maintenance of Indonesia's public irrigation systems in 1998 was $18-28/ha. Based on the inflation rate (see Figure 6.4), and the value of the US dollar in 2011, this would be equivalent to US$62 to 97/hectare/year. Therefore the current maintenance fund of US$9/hectare/year is insufficient to meet routine maintenance requirements and needs to be increased to US$62/hectare/year (assuming this lowest amount is for maintenance requirements for tertiary level irrigation systems). By adding the operation cost of US$26, it makes the total requirement for O&M become US$88/hectare/year.

Based on this review, budget constraints were experienced by all irrigation systems. The current ISF allocation of US$35/hectare/year was not sufficient to cover the O&M of irrigation systems. There is needed to overview whether the ISF should be raised as well as the provision of ISF for maintenance should be raised in order for WUAs to be able to independently fund the maintenance and rehabilitation of tertiary level irrigation systems. The results of this review will have consequences for the asset strategic plan for the improved, sustainable, and cost-effective AMP model for the irrigation system. This will determine whether the AMP over the first five years only could cover the preventative routine maintenance or also could cover the physical upgrading activities.

6.2.1.3 Management and Physical Upgrade Priority

Section 4.7 concluded that there are financial, asset, and management related issues that influence the irrigation performance and sustainability. To address these issues, Chapter 5 concluded (in Section 5.4) the order of priority of physical and management interventions to improve irrigation system performance and sustainability. The order of the priority of physical upgrade from the best to the least are:

1. Improving channel conditions and increasing the number of turnouts/offtakes,
2. Installing volumetric measuring devices, and
3. Applying pressurised irrigation methods and recirculating the irrigation water.

By looking at the previous review on budget constraints that WUAs only allocates 20% of ISF collected for maintenance which is only half of what is needed to take care of the system and rehabilitation of the systems still relies on government funding, it is more likely that irrigation system upgrades could not be achieved in short-term planning of AMP. Therefore, it would make more sense to serve the investment priorities to improve channel condition and network and increase the number of turnouts/offtakes to improve irrigation services and water distribution as a medium-term investment planning which to be achieved in 10 years from now. Consequently, the plan to install volumetric measuring devices and to implement pressurised irrigation and measuring devices also is delayed.

6.2.2 Turnover the Operation and Maintenance (O&M) of Irrigation System at Tertiary Level to Water User Associations (WUAs)

In the 1980s, there was an increasing drive to improve participation in irrigation management (PIM) in Indonesia. Subsequently, various regulations and projects were launched to support this strategy. PIM means that the government turnover the responsibility for the operation, maintenance, renewal, finances and management of tertiary level irrigation systems to WUAs. Tertiary irrigation network is the that convey water from the secondary canal offtakes to the paddy fields.

Subsequently, since 2008, the government has implemented the Participatory Irrigation Sector Project (PISP) and Water Resource and Irrigation Sector Management Project (WISMP) which facilitates WUAs to act as business organisations to stimulate rural economies through PISP and WISMP, the government has assisted WUAs in obtaining legal status so the WUAs can act as business organisations and make service contracts with other parties.

Tradition-based water arrangements such as using *Ulu-ulu* and *Ili-ili* (water controllers and chairman of tertiary block) are accommodated in the WUAs which aim to improve the efficiency of irrigation water usage at the farm-level. Based on the farmer opinion survey (*see Section 4.2*), most farmers believe that WUAs are effective in accommodating their needs, and performance of WUAs has improved following project implementation. They also recognise the effectiveness of WUAs in conveying the interests of farmers to the government, and vice versa. WUAs have become an extension of the government and they disseminate information to farmers more effectively than other means. Table 6.6 presents the general information about each irrigation system case study.

Table 6.6. Information detailing each case study irrigation system

System summary	Irrigation system	Large	Medium			Small						
		Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton
First developed		1975	1916	1916	1982	1975	1978	1992	1975	1972	1985	1975
First operated		1978	1935	1935	1986	1975	1978	1992	1975	1975	1986	1975
Project Area		4,975.00	1,032.00	1,153.00	1,113.00	225.00	500.00	88.00	110.50	396.00	711.00	478.00
Command Area (in 2008)		3,501.00	750.00	1,153.00	941.00	225.00	343.00	48.00	78.00	356.00	384.00	325.00
Status		Major	Technical	Technical	Technical	Semi-technical	Technical	Semi-technical	Semi-technical	Technical	Technical	Technical
Authority		Central	Provincial	Provincial	Provincial	District	District	District	District	District	District	District
		UPTD Way Pengubuan	UPTD Padang Ratu	UPTD Negara Ratu	UPTD Bangun Rejo	UPTD Kali Rejo	UPTD Kali Rejo	UPTD Kali Rejo	UPTD Kali Rejo	UPTD Bangun Rejo	UPTD Bangun Rejo	UPTD Bangun Rejo
		Dinas PSDA Lampung Utara	Dinas PSDA Pesawaran	Dinas PSDA Lampung Selatan	Dinas PSDA Lampung Tengah	Dinas PSDA Lampung Tengah	Dinas PSDA Lampung Selatan	Dinas PSDA Lampung Selatan	Dinas PSDA Lampung Selatan	Dinas PSDA Lampung Selatan	Dinas PSDA Lampung Selatan	Dinas PSDA Lampung Selatan
Water capture		Weir	Weir	Free-intake	Weir	Weir	Weir	Weir	Weir	Weir	Weir	Weir
River		Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas	Way Muara Mas	Way Muara Mas	Way Tipo Lunik	Way Ilihan Balak	Way Srimulyo
Basin		Way Seputih	Way Sekampung	Way Sekampung	Way Seputih	Way Seputih	Way Seputih	Way Seputih	Way Seputih	Way Seputih	Way Seputih	Way Seputih
No. village coverage		20	5	4	3	1	2	1	1	1	1	4
No. of WUA		20	5	4	3	1	2	1	1	1	1	4
WUA Legality	: 2008 (before PISP)	Public notary	Public notary	Public notary	Public notary	Public notary	Public notary	Public notary	Public notary	Public notary	Public notary	Public notary
	: 2010 (after PISP)	Complete documents	Complete documents	Complete documents	Complete documents	Complete documents	Complete documents	Complete documents	Complete documents	Complete documents	Complete documents	Complete documents
WUAF		1	1	1	1	0	0	0	0	0	0	1
Average farm size (ha)		0.5	0.5	0.5	0.5	0.25	0.75	0.25	0.25	0.62	0.58	0.5
Annual rainfall (mm)		573.40	1,636.00	573.40	573.40	573.40	1,867.20	1,867.20	1,867.20	1,867.20	1,867.20	1,867.20
Annual Eto (mm)		1,136.80	1,375.00	1,136.80	1,136.80	1,137.00	1,136.80	1,136.80	1,136.80	1,137.10	1,136.80	1,136.80
Irrigation water available at user level (MCM)		51.28	10.99	16.89	13.78	2.69	7.32	0.70	1.14	5.63	3.64	4.76
Major crop - cropping pattern		R-R-C	R-R-C	R-R	R-R	R-R-C	R-R-C	R-R-C	R-R-C	R-R-C	R-R-C	R-R-C
Water balance	Field irrigation efficiency (%)	45.06	16.13	43.41	44.42	59.20	6.68	9.15	9.31	37.47	72.98	52.67
	Irrigation efficiency (%)	29.29	10.48	28.22	28.87	38.48	4.34	5.95	6.05	24.35	47.44	34.24
Financial indicators	Cost recovery ratio	0.48	0.43	0.46	0.15	0.84	0.14	0.25	0.26	0.20	0.14	0.21
	Maintenance cost to revenue ratio	0.20	0.46	0.28	0.43	0.23	0.32	0.21	0.21	0.34	1.05	0.29
	Revenue of irrigation water (US$/m3)	0.00376	0.00397	0.00431	0.00301	0.00513	0.00291	0.00640	0.00657	0.00439	0.00220	0.00473
	MOM cost of irrigation water (US$/m3)	0.00148	0.00375	0.00148	0.00241	0.00262	0.00213	0.00280	0.00275	0.00315	0.00594	0.00252
Agricultural productivity	Output per unit irrigation supply (US$/m3)	247,746.44	198,665.35	213,568.58	225,623.42	292,744.86	163,395.50	240,846.89	240,100.14	220,458.04	367,589.29	238,120.16
	Output per unit water supply (US$/m3)	0.20	0.12	0.17	0.18	0.24	0.10	0.13	0.13	0.15	0.21	0.16

Table 6.6 shows that each WUA is in charge of one village. Table 6.7 shows that on average, a single WUA organisation manages an average of 200 hectares of paddy fields. There are often multiple WUAs in large irrigation systems which federate into WUAFs. WUAs/WUAFs obtain legal status through five administrative documents. The PISP and WISMP provided assistance for WUAs/WUAFs to process these five administrative documents. The projects also provided help for WUAs/WUAFs to understand their rights and responsibilities under new policies.

Table 6.7. Average area handled by a WUA in the irrigation system

Irrigation System		Command Area (ha)	No. of WUA	No. WUAF	Average land holder (ha)	Average area handled by the WUA (ha)
Large	Way Pengubuan	3,501	20	1	0.50	175
Medium	Way Padang Ratu	750	5	1	0.50	150
	Way Negara Ratu	1,153	4	1	0.50	288
	Way Tipo Balak	941	3	1	0.50	314
Small	Way Muara Mas	157	1	0	0.25	157
	Way Muara Mas I	343	2	0	0.75	172
	Way Muara Mas II	48	1	0	0.25	48
	Way Muara Mas III	78	1	0	0.25	78
	Way Tipo Lunik	356	1	0	0.62	356
	Way Ilihan Balak	384	1	0	0.58	384
	Way Srikaton	325	4	1	0.50	81
		Average land holder (ha)			**0.47**	
		Average area handled by the WUA (ha)				**200**

In addition to these, the PISP has assisted WUAs/WUAFs in utilising their legal status to obtain contracts with third parties connected to irrigation management. The PISP engaged WUAs/WUAFs in the rehabilitation of tertiary level irrigation systems. Civil works contract packages of up to US$25,000 were available and awarded to qualifying WUAs/WUAFs. The first contract awarded did not exceed US$10,000. It was stated that upon satisfactory completion, subsequent contracts might increase to US$25,000. The intention was to give WUAs/WUAFs financial independence (DGWR, 2005). Tables 6.1 and 6.3 show the amount spent for tertiary irrigation system work packages which were carried out by WUAs/WUAFs.

These activities were aimed to strengthen the WUAs organisation and to drive them to respond to specific business opportunities to generate income. As a business organisation, it is expected that these financially autonomous WUAs are capable of funding the O&M of irrigation systems at the tertiary level independently. This is particularly important since over the next five years the irrigation systems will not receive any project funding from the Government, as it is the nature of the project cycle in Indonesia. The amount spent by the project could be used as a guideline to estimate the amount needed to rehabilitate the tertiary level over the next five years.

Furthermore, WUAs need to find a way to remove their dependence on government subsidies by increasing the ISF, increasing the proportion of ISF for maintenance or by generating income from sideline activities. Unfortunately, it is not easy to impose a higher ISF upon farmers. Most of the farmers only cultivate landplots of 0.5 hectares on average, which only generates a monthly income of US$95.40. This amount only meets about half the needs of the average farmer, if there is no disruption to the harvest. Raising the ISF is not an option for them (*see Table 4.4 in Section 4.3.6*).

Based on these constraints, it is more likely that the WUAs are not ready to accept the responsibility for routine O&M funding. Therefore, the asset maintenance strategic plan for the improved, sustainable, and cost-effective AMP model for the irrigation system over the first five years is based on only preventative routine maintenance.

6.2.3 The Level of Current Irrigation Service Fees (ISF) to Fund the Operation and Maintenance (O&M) the Tertiary Level Irrigation System Case Studies

The price of water plays a critical part in encouraging equitable and productive (efficient) use of water by farmers, funding of O&M, and determining the levels of demand and supply and amount of invested resources. The ISFs applied in various countries differ considerably. In Australia, water utilities are required to recover the full cost of service provision. Unfortunately, in Asian countries, such as India and the Philippines, ISFs are low (less than 2% of farmer income), as are recovered costs (less than 50% of O&M costs), and collection rates (less than 70%) (*see Section 2.9.2.2*).

Figure 4.26 in Section 4.5.1.1 shows that irrigation water is plentiful during the wet season (cropping season 1), and become an issue in the semi-dry season (cropping season 2) and the dry season (cropping season 3). During the second and third cropping season, water availability is an important factor affecting the level of service provided to farmers. Unfortunately, the actual volume of water supplied to landplots is unknown, and it is difficult to measure the efficiency of water since existing methods measure water flow rate instead of volume.

In Indonesia, the ISF is established at a tertiary level, and is aimed at generating sufficient funds for WUAs to support tertiary O&M activities. The ISF rate is low and only accounts for less than 1% of average farmer income, based on the 2009 income for unhulled rice (*See Table 4.4. Section 4.3.6 and Table 6.5 Section 6.2.1.2*). However, the ISF collection rate is high at almost 100%.

Based on the results of the opinion survey (*see Section 4.2*), farmers generally felt that the current measurement of irrigation water supply flow rate was fair and better than before the PISP was implemented, but expected it to be upgraded to a more sophisticated system. They also thought that the current irrigation water tariff was affordable, they were content with the current tariff, and they hoped that this tariff would remain in place.

Unfortunately, as discussed in Section 6.2.1.2, the current ISF is not enough to cover O&M of irrigation at tertiary level (O&M at primary and secondary level are fully subsidised by the government) since the WUAs currently only allocate 20% of ISF collected for maintenance. To finance the O&M irrigation system at tertiary level independently, one of which is to raise the ISF. Unfortunately, it is more likely that farmers would object this decision. Based on these constraints, the AMP model for the irrigation system over the first five years is based on only preventative routine maintenance.

6.2.4 Efficient Operation and Maintenance (O&M) of Tertiary Level Irrigation System Case Studies

Section 2.7.3 reviewed the three alternative asset management approaches suggested by the Australian Asset Management Collaborative Group (AAMCoG) (2008). The AAMCoG is a collaboration of several of Australia's peak bodies interested in work programmes in asset management including industries, universities, and government. It was formed in 2006 by the Cooperative Research Centre for Integrated Engineering Asset Management (CIEAM) to promote and enhance asset management for Australia. The AAMCoG provides best practice in integrated engineering asset management and public sector asset performance and reporting which can be applied to any asset anywhere.

The three alternative asset management approaches are: (A) the annual maintenance costs are low, but the annual capital costs are relatively high, (B) the annual maintenance costs are high in order to prevent the deterioration of assets, but the annual capital cost of sustaining the standard of service (SOS) is low, and (C) minimises the whole-life cost of providing the required SOS (i.e., the optimum balance between maintenance and replacement costs).

The turnover of management of tertiary level irrigation systems to WUAs means that WUAs are now fully responsible for assets and management at this level. The Option C should be chosen if WUAs want to run efficient operations and maintenance since it is aimed to achieve the lowest whole-life cost in providing the required standard of service (SOS). Option C helps WUAs to ensure, where possible, that available funds are spent on planning, purchasing and installation, O&M, and renewal of tertiary level irrigation assets in a cost-effective way. Unfortunately, up until now, WUAs have been following Option A.

Moreover, in establishing LCC of the best asset management decisions, historical records of past expenditure is required to forecast of expenditure to sustain the SOS. Unfortunately, as mentioned in Section 6.2.1.1, records have not been kept of past expenditure and asset condition over time. Therefore, the LCC developed was assumed based on the typical deterioration curve Figure 6.2.

6.2.5 Summary of the Elements of the Improved Asset Management Planning (AMP)

It can be summarised that, the improved, sustainable, and cost-effective AMP has been developed by WUAs in rural irrigation systems needs to consider elements of needs-based budgeting, turnover programs, ISF, and efficient O&M.

The PISP provided essential information to forecast expenditure to sustain the SOS in the future. The project also rehabilitated the current asset's conditions to close to the original design level which make asset valuation easier.

WUAs are entitled to decide the amount of ISF to be levied on its members, to collect the ISF, and to decide the provision of ISF collected used to finance the O&M of tertiary level irrigation systems. Unfortunately, besides the ISF rate being too low, the proportion of the ISF used to maintain the tertiary level irrigation system was also too low. The budgetary requirement to keep the irrigation system in good condition at the moment is US$62/hectare/year.

Based on these constraints, it is more likely that the WUAs are not able to accept the responsibility for routine O&M funding. Therefore, the asset maintenance strategic plan for the improved, sustainable, and cost-effective AMP model for the irrigation system over the first five years is based on only preventative routine maintenance. With limited funds, the investment priority to improve channel condition and network and increase the number of turnouts/offtakes could not be achieved in the short-term. Therefore, it would make more sense to use this priority as a medium-term investment goal to be achieved in 10 years from now. Consequently, the plan to install volumetric measuring devices and to implement pressurised irrigation and measuring devices also is delayed.

The option C helps WUAs fund the maintenance and renewal of tertiary level irrigation assets in a cost-effective way. Since, there were no records of past maintenance and renewal activities of assets at the tertiary level available, the trends in maintenance expenditure of the LCC developed follows the curve of typical deterioration in the condition of channel networks and related assets over time as shown in Figure 6.2.

6.3 The Cost Model Developed for the Improved Asset Management Planning

The cost model developed for the improved, sustainable, and cost-effective AMP was utilised the LCC. The LCC is an approach used to make decisions regarding operation, maintenance, refurbishment and replacement of assets. LCC analysis is also referred to as total cost of ownership (TCO).

In Section 2.2.1, the steps required to produce an AMP were illustrated in accordance with the guidelines of the Institute of Irrigation Studies (IIS), University of Southampton, UK (1995). The final step in the process is the building of a cost model.

The cost model enables monitoring of asset creation, usage and disposal costs throughout the asset's lifetime, which will enable timely decisions on how to minimise costs. It is essential that all costs that accumulate during the lifetime of an asset are accounted for. This essentially involves an analysis of the historical capital expenditure (CAPEX) and operational expenditure (OPEX) to determine future projections. Whole-of-life costing should account for all costs and benefits associated with the planning, design, construction, use, deterioration, maintenance and rehabilitation of assets over their useful life prior to reconstruction.

Elements of the cost model include: the demand projection, the level of service, cost of service, asset maintenance planning, useful life, depreciation and salvage value, discount rate, asset value, and life cycle analysis. These cost elements have dependency with the elements that should be considered in the AMP as discussed in section 6.2. For example, the level of service is closely linked to the availability of the budget, WUAs readiness in providing services and the asset physical condition and capacity to provide the service. The cost of service depends on the level of service provided. Asset maintenance planning is closely associated with the efficient O&M of asset and asset investment priority.

A more detailed discussion of the elements of the costs model is discussed in the following section:

Section 6.3.1 discusses the demand projection for the irrigation system in the future and its impact on services.

Section 6.3.2 discusses the level of service of the irrigation system at current performance and target performance in the future as well as the process to measure the performance.

Section 6.3.3 discusses the cost of providing the services.

Section 6.3.4 discusses the asset maintenance planning for the irrigation system. Asset maintenance planning should consider aspects of useful life, depreciation and asset valuation and discount rate.

Section 6.3.5 discusses the summary of cost model developed for the improved, sustainable, and cost-effective AMP.

6.3.1 Demand Projection for the Irrigation System Case Studies

The LCC encompasses the average costs required to sustain the service level over the longest life of an asset. Proper manner in operating an asset and timely maintenance causing asset can achieve its longest life span.

For public infrastructure assets, the level of service indicates the capacity per unit demand for an asset. Increasing demand for water in the future requires ongoing reviews of the ability of irrigation systems (UPTD at system level and WUAs at tertiary level) to meet such demand. However the demand projection for the irrigation systems only based on the available project area.

Based on the performance assessments results (Section 4.5.1.2) and the sustainability assessment results (Section 5.2.5), it can be concluded that the possible future demand for the irrigation system is as shown by the following table 6.8.

Table 6.8. Future demand on the irrigation systems (projections)

Demand factor	Present position	Projection	Impact on services
Projection on service delivery			
Command area	8,066.00	10,807.00	Greater demand
Cropping intensity	2.03	3.00	Greater demand
Supply of water	No water restriction (water distribution rotation only), no volume measurements	Decreasing availability of water resource and increased costs of service (there is imperative to metering volume of water)	Greater irrigation water efficiency and require the review of water charges to cover the MOM costs (increase ISF)
Farmers' need	Monoculture of rice and second crops in the dry season	Diversifying agriculture	Greater flexibility in water supply services to satisfy and match complex demands for irrigation water as a result of crop diversity
Projection on physical asset			
Greater flexibility in water supply services requires irrigation water metered accurately	Reasonable water measurement and control devices	Install volumetric measurement device	Greater irrigation efficiency
Improving channel conditions and increasing the number of turnouts/offtakes	Only part of tertiary channels are concrete	Increase the length of concrete lining	Increase conveyance efficiency, improve irrigation service and water distribution
	Insufficient number of turnouts/offtakes	Increase the number of turnouts/offtakes	
Increase the length of drainage channels	Only 2 of the irrigation system case studies have drainage channels	All irrigation systems have drainage channels	Minimize impact on the river/environment
			Greater efficiency by circulating irrigation water in the fields to conserve water
Effluent reuse/recirculate irrigation water	Currently all the irrigation system case studies are discharging its drainage water to the natural water bodies/rivers	Circulate irrigation water is meant to prevent fresh water as much as possible discharged into the river and preventing the flow of fresh water into the sea/saltwater	Greater efficiency to conserve water

The table illustrates the demand projection on service deliveries and physical assets. Demand projection on service deliveries are caused by an increase in demand for water supply due to the expansion of command area, increasing cropping intensity and diversifying agriculture. The table shows that the irrigation system need to expand their service to an area 34% larger than current command area and to increase current cropping by 33%. The irrigation systems also should be able to answer the challenges of farmers who want to diversifying to horticulture since it gives better income than rice plant. However, crop diversity requires greater flexibility in water supply services to satisfy and match complex demands for irrigation water. On the other hand, it is projected that climate change will cause the water supply in the future increasingly fewer and indeterminate. But, horticulture offers a more water-efficient crop than rice planting.

In addition to these, there are also some changing aspects that affect the demand in the future as shown in Table 6.9.

Table 6.9. Changes in technology and the effect on service delivery

Changing aspect	Effect on service delivery
Irrigation methods / techniques	Improved efficiency
Information technology	Automated service delivery
New plant or paddy varieties / diversity	Sustainable plantings
Climatic conditions	Global warming / changing weather patterns

Irrigation techniques such as pressurised irrigation enable irrigation system to improve water efficiency. Information technology such as computerized service delivery enables irrigation system to improve its efficiency. However, for the irrigation system, investing in such technologies are still beyond the capability of government. It is more impossible to be funded by WUAs to be applied at tertiary level.

The increasing demand in service deliveries consequently results on the demand to improve physical assets. Physical assets that projected to be improved to meet the challenges of increased demand for service deliveries are: increase the length of channels with concrete lining, increase the number of turnouts/offtakes, install volumetric measurement device, provide all irrigation systems with drainage channels, implement pressurised irrigation and circulating irrigation water. The investment planning for an increase in physical assets will affect LCC. As mentioned in Section 6.2.5, with limited funds, over the first five years, the investment priority can only be focus on improving channel condition and network and increasing the number of turnouts/offtakes.

6.3.2 Level of Service (LoS) of the Irrigation Systems

To address the various problems and issues of irrigation management, the Indonesian government has issued policies, legislation, regulation presidential decrees, presidential instructions, government regulations, and the minister's decision (*see Appendix E.1*). The obligations placed on an irrigation service by national and regional legislation must be taken into account when setting and reviewing the level of service (LoS) as well as the investment plans.

There are aspects of institutional framework and social development that affect the setting of the LoS. Indonesia's constitutional framework establishes sole ownership and managerial responsibility of water resources. The government allows water use under special conditions and appropriate payment of a water tariff, whilst maintaining ownership and ultimate control. In carrying out its obligations to supply irrigation water to farmers, WUAs are supported by legislations. However, WUAs also must be able to meet the legislative requirements. In general, WUAs face several challenges such as increased pressure on water resources due to competing demands, deteriorating irrigation infrastructure, lack of financial sustainability, and lack of technical capacity to manage irrigation.

For the irrigation system, the targeted LoS at tertiary level should be negotiated between farmers, WUAs and irrigation authority/UPTD with regards to the needs of farmers, WUA capability and legislative requirements relating to irrigation and drainage and environmental protection. The targeted LoS was also determined after reviewing the performance assessments results and the opportunity to increase the LoS in the future. It is expected that the targeted LoS can be achieved with the improved physical condition and management prioritised to be implemented in the irrigation system.

With a clear statement of the LoS that must be provided by the WUAs, they can force the irrigation authority/UPTD to establish adequate irrigation service to up to secondary level. This will provide a basis for WUA to establish a good services at the tertiary level. In addition, WUAs/WUAFs can lobby industries and the government to ensure that river water from industrial waste is of sufficient quality for irrigation requirements.

For social development aspects, there are two issue that affect the setting of LoS:

1. The changing perceptions and demands of water users as 'customers'. This requires effective liaison with WUAs to establish perceptions on what constitutes good service. It also helps with changing farming practices which lead to altered technical requirements of the irrigation system.
2. The movement of populations from a rural, agricultural base towards an urban, industrial one.

   Urbanisation and industrialisation affect the planning of an irrigation system in several ways:

   - in the construction of buildings on land which has been irrigated,
   - in making conflicting demands on the available water supplies,
   - by polluting irrigation water, and
   - by their secondary effects on the rural population (e.g. greater affluence and reduced dependency on agricultural income) leading to a change in their demands on the irrigation system.

The LoS to meet farmers' needs for access to irrigation water is divided into the LoS of supplying irrigation water and drainage (*see Appendix E.2*), and technical capability of physical tertiary level assets to fulfilled supplying irrigation and draining excess water (*see Appendix E.3*). The level of service also can be differentiated into the LoS to satisfy farmers' need and the technical capability to achieve the LoS in order to satisfy the farmers' needs. This targeted LoS is reasonably accurate since it was determined by reviewing the performance assessment results regarding the aspects of water balance.

6.3.2.1 Level of Service (LoS): Irrigation and Drainage

The LoS at the tertiary level needed to supply irrigation water and excess drainage is highly dependent on the level of service of irrigation at levels above this (at the primary and secondary levels). Basically, the LoS of irrigation at a tertiary level provided by WUAs/WUAFs requires a supply of irrigation that satisfy the quality and quantity (equitable, is of sufficient quantity, frequency, flow-rate, time and duration). While, the LoS of drainage at the tertiary level requires efficient collection and disposal of excess water without causing harm to the health and safety of the people as well as the environment.

The technical aspects to achive the LoS of irrigation were cost effectiveness, quality of MOM, condition of asset, and health and safety. While the technical aspects to achieve the LoS of drainage were cost effectiveness, function and condition of asset, accessibility and safety.

6.3.2.2 Level of Service: Physical Asset

The physical assets contribute to meeting farmers' needs for access to irrigation water which are interconnected channel networks including hydraulic structures and operation/control facilities attached to it. These assets can be separately maintained, renewed, or replaced. In general, these assets, if properly maintained, have 25 years of useful life (*see Table 2.10 in Section 2.7.4.1*).

The LoS of tertiary level irrigation assets were basically about the quantity (adequacy of asset and accessibility), quality and function (condition of asset), and safety.

6.3.3 Cost of Providing Service

The improved, sustainable, and cost-effective AMP includes allowance for the provision of the basic function of supplying water from tertiary level irrigation systems to individual landplots. Table 6.10 shows that assets at the tertiary level of irrigation systems consist mainly of conveyance facilities (channels and hydraulic assets), and operation and controlling facilities (regulators) that are attached to the channel networks (*See Appendix C.4 for summary of asset type and condition of Way Pengubuan irrigation system*).

Table 6.10. Assets covered by the improved, sustainable, and cost-effective AMP

					Irrigation System										
					Large	Medium			Small						
					Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton
Asset Group	Conveyance	Channel	Tertiary	(m)	102,450				3,000	500	1,050	2,445		1,770	4,000
			Quartenary	(m)	168,497	7,670	9,320	575					1,770		
			Drainage	(m)	4,000	4,000									
		Hydraulic	Off-take structure	(unit)	46	16	2	20	1	6	3	1	10	1	14
			Division structure with off-takes	(unit)		1	1	1						12	
		Supplementary	Inspection road	(m)		750									
	Operation & Controlling Facilities		Regulators	(unit)	51	17	17	21	9	17	9	3	10	13	27
	Management & General		Guard post	(unit)	9	3	3	2	2	1	1	2	1	1	1

(Source: The Province of Lampung, the Public Works Unit, PISP Implementation Unit)

Asset service costs at least cover the cost of operating and maintaining assets. However, as mentioned in Section 2.7.4, economic efficiency and fiscal sustainability demand that the capital costs of irrigation infrastructure should eventually be recovered from water users. Therefore, the improved, sustainable, and cost-effective AMP developed reviews all the costs associated with providing irrigation service at tertiary level. The following are the cost components of the irrigation system as set out in Section 2.7.4:

1. Capital investment activities

   The capital investment costs are the costs associated with the works undertaken to rehabilitate, upgrade, extend, or improve existing system infrastructure. To date, irrigation system investment activities have been highly dependent on the program disbursed by the central government. However, the Decentralisation Policy has reduced investment funding from the central government, with reliance on local government to fund infrastructure investments. WUAs have not yet been able to utilise the ISF to fund capital investment. To improve irrigation performance and sustainability in the future, WUAs need to establish capital to fund activities to improve channel conditions and to increase the number of turnouts/offtakes to improve irrigation service and water distribution efficiency. According to Small, Adriano and Martin (1986) (*Table 2.7 in Section 2.7.4*), the capital cost for small irrigation systems was US$8,000/hectare (where US$1 = Rp1,110), and for medium and large systems US$1,500/hectare and US$3,000/hectare, respectively. Based on the inflation rate (*see Figure 6.3 of Section 6.3.4.3*), and value of the US dollar in 2011, this corresponds to between US$2,000/hectare and US$4,000/hectare today. Assuming the capital cost for investments at tertiary level irrigation system are about the same as the capital cost of small irrigation systems, therefore US$2,000/hectare are needed to reconstruct the irrigation system in the future (25 years from now). This amount deploys into an annual cost over 25 years of US$80/hectare/year to secure future capital investments.

2. System operating costs

   The aim of mapping the cost of operation is to gather as many elements of cost as possible that go into the operation of a system, to identify the possible gains with the current operational setup and service, and to know the cost of improved service implementation. Therefore, this step focusses on mapping the cost for current operation techniques and services, breaking down the elements contributing to costs, and determining cost options for various levels of service using current and improved techniques.

The operational cost of assets should be integrated with other costs of service delivery (personnel, equipment and IT, transport, and other overheads) to determine the aggregate cost per service. The operating costs of the irrigation system include:

a. Staff costs: 60% of ISF collected: mainly the salaries of WUA board members, controllers of water distribution, and collectors of ISF.
b. Equipment costs: all assets are operated manually; therefore, equipment operating costs do not apply (to note that irrigation gates and pipes replacement is included to maintenance costs).
c. Transport of personnel: a single WUA usually manages a local irrigation system; therefore, transport costs do not apply.

Based on previous results (*Section 6.2.1.2*), the current provision of ISF used to fund the cost of operation has been calculated at US$26/hectare/year. It is assumed that this amount is quite satisfactory for WUAs and their personnel's since the current involvement at WUAs are on voluntary basis.

3. Maintenance costs

This refers to the recorded costs of irrigation system operations over time, with a particular pattern of capital investment apparent when looking at deteriorating assets. Past maintenance records enable observation of trends in operating expenditure (OPEX). Unfortunately, historical data on routine maintenance, replacement and renewal activities of assets especially those older than five years are difficult to access (are not available). Moreover, it is common that the government is more likely to fund the reconstruction of physical assets rather than finance the routine maintenance of assets since it is easy to monitor in order to avoid misuse of funds (corruption). Therefore, the maintenance costs of tertiary level are assumed based on the 20% of the collected ISF or US$9/hectare/year as discussed in Section 6.2.1.2. This amount is still far below the provisions required to maintain irrigation system in good working condition of US$62/hectare/year. This maintenance costs when combined with the operating costs at point (2) amount to US$88/hectare/year.

It is clear that there is an O&M deficit and revenue rates (ISF) are insufficient to finance current O&M, therefore liabilities should be increased in order to finance the O&M.

4. Replacement and renewal costs

   As mentioned in point (3) the historical data on past expenditure activities of assets especially those older than five years are not available. Therefore, replacement and renewal activities of tertiary assets are assumed to be required when the condition of assets deteriorates to between 25% and 60% of their original condition, and this usually occurs when assets reach 75-80% of their useful life (*see Figure 6.2 in Section 6.2.1.1*). This means that rehabilitation works are needed when the age of assets reaches 16 to 20 years. Table 6.5 shows that the rehabilitation costs for tertiary assets were US$106/hectare. Assuming that rehabilitation costs are deployed over 20 years to raise fund for future rehabilitation activities, then the rehabilitation cost required annually would be US$7/hectare/year.

5. Depreciation

   In the economic analysis of a project, depreciation should be considered. The simplest way to calculate depreciation is to utilise a straight-line method, in which an asset's condition depreciates uniformly over time. Since the useful life of an asset is considered to be 25 years, then assets will depreciate at a rate of 4% per year (*see Section 6.3.4.2*). Therefore, the amount should be allocated to depreciation is 4% of US$80/hectare/year = US$3/hectare/year.

As set out in *Section 2.8.1*, the broad goals of irrigation system modernisation are to achieve improved irrigation performance (Burt, 2001). Any increase in service performance will result in increased costs. The Table 6.11 summarises the cost components of irrigation systems. If the capital cost of an asset is to be recovered by the end of its useful life, the cost of service (ISF) should increase to US$175/hectare/year from previously US$44/hectare/year (*see Table 6.3*). This amount account for about 3% of farmers' income which is a decent amount to be charged to farmers.

Table 6.11. The costs of service

Cost of service in 2011/hectare/year	US$
Capital cost	80
Routine O&M	88
Replacement	7
Cost of service	175
Depreciation	3
Total cost of service/hectar/year	**353**

6.3.4 Asset Maintenance Planning

Assets should exist to support service delivery. Before deciding to acquire new assets, all relevant factors including non-asset solutions, full LCC, risk analysis, and improving the use of existing assets must be considered.

Asset maintenance planning plays a key role in the strategic management of an asset over its useful lifespan. The aim is to ensure that assets remain productive but that maintenance costs are kept to a minimum. Asset maintenance planning outlines three possible courses of action: maintenance, renewal, and disposal. Maintenance is aimed at meeting the ongoing service role of an asset. Renewal or adaptation is aimed at changing the service need using capital expenditure, while disposal of an asset is executed when it is no longer required for service delivery. Maintenance and rehabilitation must be initiated before the condition of an asset deteriorates beyond a specified condition.

The asset maintenance strategic plan must: focus on ensuring that assets continue to support planned delivery services, identify deferred maintenance requirements, and establish funding plans. WUAs are required to determine the most effective combination of asset maintenance and rehabilitation activities to achieve those goals, to enhance performance of tertiary level irrigation assets, and to ensure irrigation sustainability. In order to successfully implement maintenance planning, WUAs need to establish target for asset maintenance and performance.

The asset maintenance planning should consider the useful life of assets, depreciation and asset value, and depreciation.

6.3.4.1 Useful Life, and Depreciation and Asset Value

The useful life of a project includes its physical and economic life. Economic life is the period of time (years) that produces a minimum equivalent uniform annual cost (EUAC) for ownership and operation of an asset. An asset's economic life may cease or become shorter due to economic changes, for example, changes in the market and technical obsolescence (renewal of technology and processes). On the other hand, useful life can generally be extended indefinitely with proper maintenance and other measures.

A useful life period of 25 years is set for the tertiary irrigation assets under evaluation (*see Table 2.12 in Section 2.9.1.1*) since the assets are mainly conveyance structures for channels, hydraulic structures, measuring structures, along with regulator and measuring devices. The time span of analysis is therefore between 2011 (when rehabilitation of tertiary channel of irrigation systems completed) to 2036.

Depreciation can be defined as a measure of reduction in the value of an asset, which is monitored with the intention of saving sufficient funds for replacement. The depreciation method used in this analysis is the straight-line depreciation method, in which an asset has a fixed reduction in condition throughout its lifespan. If the useful lifespan of an asset is 25 years, then its condition will depreciate at a rate of 4% per year. At the end of their useful life, tertiary level irrigation assets have zero value since they require total rehabilitation (of channels, hydraulics, and measuring structures) or modernisation (upgrading of regulator and measuring devices).

The values of assets depreciate over time as a natural function of ageing, usage, and obsolescence. The asset's depreciated value is also a monetary reflection of its condition. All public sector organisations are required to record and update this information on a regular basis to satisfy financial reporting requirements. Unfortunately, this has not received proper attention in rural irrigation systems in Indonesia.

The replacement value of an asset should be identified. The replacement value is the current cost of replacing an existing asset with the most appropriate and up-to-date replacement of the same size and standard. The gap between an asset's depreciated value and the asset's replacement value greatly assists in making decisions about asset investment planning and current asset expense such as O&M costs.

There were no historical records in Indonesia that detail asset condition over time. However since the PISP was only completed in 2011 and the current condition of assets in the tertiary level irrigation systems were assumed to be 90 - 100%, the gap between an asset's depreciated value and the asset's replacement for the irrigation system can be considered zero (the condition of asset is in line with its current value). Also, since the tertiary assets of the irrigation systems are mainly of channels, hydraulics, and measuring structures which are considered to have useful life of 25 year, therefore the assets' value is considered to decrease according to depreciation rate of 4% of their initial value per year over its useful life.

6.3.4.2 Discount Rate

As mentioned in Section 2.7.4.2, in whole-of-life costing, costs are calculated using net present worth (NPW) in order to quantify the time impact on future costs. The LCC are converted to an equivalent present value by imposing an appropriate discount rate. Discounting compensates for the fact that more significant estimates are placed on costs in the near future compared to estimates looking at the long-term.

Basically the discount rate is justified based on interest rate. Based on data obtained from the Bank of Indonesia, the inflation rate has fallen since 1990 (*see Figure 6.3*). This is due to sound economic growth and the current stable political condition in Indonesia. The latest records from the Bank of Indonesia show an inflation rate of 4.9%. However, it is not easy to estimate future inflation rates since in the past Indonesia has experienced economic distress and very high inflation rates occurred during the global economic crisis in 1998. By taking into account the increase in cost and selling price of agriculture product, the rate of inflation of 10% is appropriate to be used in the LCC developed, even though the trend line in Figure 6.3 suggests a lower rate.

Figure 6.3 illustrates the rate of inflation in Indonesia within the last 25 years.

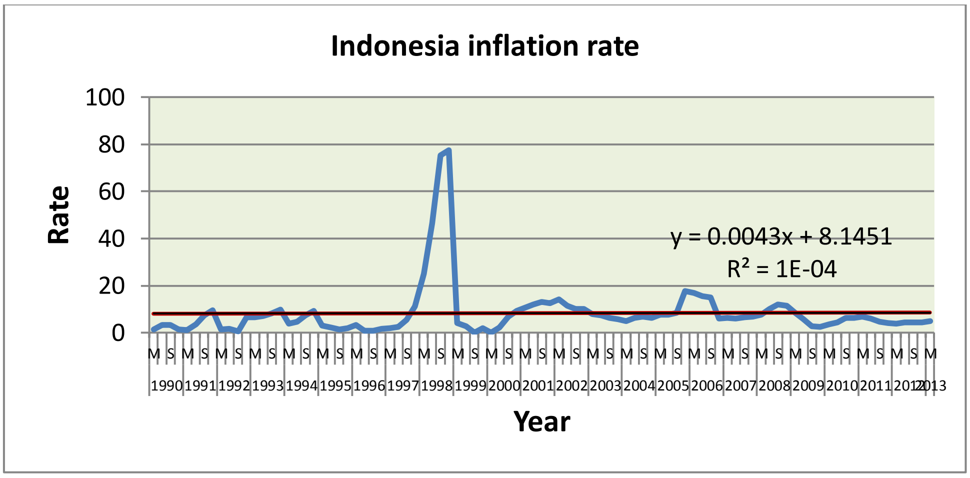


Figure 6.3. Indonesian inflation rate changes between 1990 and 2013

(Source: Bank of Indonesia website http://www.bi.go.id)

The rate of discount is the desired return on investment, and this depends on the risks and uncertainties of a project. This means that the discount rate may be slightly higher than the costs that were incurred. Based on some considerations such as changes to the Indonesian inflation rate over the last 22 years (*see Figure 6.3*), the agricultural business sector is one of the biggest in Indonesia, the risk of crop production that is dependent on global climate change, and the discount rates that apply in other countries (15% in the Philippines, 10% -12% in India and Pakistan, and 10% - 12% at the World Bank and Asian Development Bank (*see Table 2.11 in Section 2.7.4.2*)), a 15% discount rate was applied in this study.

6.3.5 Overview of the Cost Model Developed for the Irrigation System Case Studies

Based on the discussion in Section 6.3.1 to 6.3.4, the following are the LCC of the irrigation systems:

1. Maintenance cost

   According to Figure 6.2, the assets may receive only routine maintenance up to the point where they reach 75% of their useful life. As discussed in Section 6.2.1.2, the irrigation systems just underwent rehabilitation works. Therefore, over the next 5 years, the irrigation systems only required routine maintenance. As suggested, the current maintenance costs of US$9/hectares/year should be increased to US$62/hectare/year. Table 6.12 illustrates the assets at tertiary level maintenance costs estimates for irrigation systems to keep them in good condition.

   Table 6.12. Tertiary maintenance cost estimates

Irrigation System		Potential coverage (ha)	Tertiary maintenance costs estimates US$ (000)
Large	Way Pengubuan	4,975	308
Medium	Way Padang Ratu	1,032	64
	Way Negara Ratu	1,153	71
	Way Tipo Balak	1,133	70
Small	Way Muara Mas	225	14
	Way Muara Mas I	500	31
	Way Muara Mas II	126	8
	Way Muara Mas III	78	5
	Way Tipo Lunik	396	25
	Way Ilihan Balak	711	44
	Way Srikaton	478	30

Basically, LCC varies each year. The provision for a rise and fall in LCC is based on seasonal variations of maintenance activities in a single year. The accuracy of unit cost data for maintenance activities depends on the inflation increase and provision for a rise and fall in LCC. However, for the irrigation systems, the routine maintenance costs were assumed to be the same each year. Table 6.13 shows the projection of routine maintenance costs and the rise expected from an inflation rate of 10%.

Table 6.13. Tertiary routine maintenance costs projection

Irrigation System		**Tertiary maintenance costs projections US$ (000)**					
		Year					
		2011	**2012**	**2013**	**2014**	**2015**	**2016**
Large	Way Pengubuan	308	339	373	411	452	497
Medium	Way Padang Ratu	64	70	77	85	94	103
	Way Negara Ratu	71	79	86	95	105	115
	Way Tipo Balak	70	77	85	93	103	113
Small	Way Muara Mas	14	15	17	19	20	22
	Way Muara Mas I	31	34	38	41	45	50
	Way Muara Mas II	8	9	9	10	11	13
	Way Muara Mas III	5	5	6	6	7	8
	Way Tipo Lunik	25	27	30	33	36	40
	Way Ilihan Balak	44	48	53	59	65	71
	Way Srikaton	30	33	36	39	43	48

2. Rehabilitation costs

Whole-of-life costing evaluation considers alternative rehabilitation treatment types within forecast budget constraints, and estimated costs are priority-based. Figure 6.2 shows that rehabilitation works of tertiary assets are needed when the asset condition is 25% - 60% of its original, which occurs at 75% - 80% of an asset's useful life (at 16 to 20 years). Based on the rehabilitation costs spent by PISP on the tertiary level irrigation systems, the estimated rehabilitation costs of tertiary assets were calculated using the US dollar at net present value.

Table 6.14. Tertiary rehabilitation costs: estimation for 2011 and projection for 2026

Irrigation System		Potential coverage (ha)	Tertiary rehabilitation costs US$ (000)	
			2011 estimate	2026 projection
Large	Way Pengubuan	4,975	527	1,288
Medium	Way Padang Ratu	1,032	109	267
	Way Negara Ratu	1,153	122	299
	Way Tipo Balak	1,133	120	293
Small	Way Muara Mas	225	24	58
	Way Muara Mas I	500	53	129
	Way Muara Mas II	126	13	33
	Way Muara Mas III	78	8	20
	Way Tipo Lunik	396	42	103
	Way Ilihan Balak	711	75	184
	Way Srikaton	478	51	124

3. Improvements and reconstruction

   Previous review on budget constraints and irrigation system improvement priority (*Section 6.2.1.2 and 6.2.1.3*) suggested that the investment priorities to improve channel condition and network and increase the number of turnouts/offtakes to be achieved in medium-term investment planning (10 years). Further plans to install volumetric measurement devices can be set to long-term investment planning (20). Eventually, the plan to modernise irrigation systems by pressurised irrigation method and recirculate irrigation water can be set at the end of asset life of 25 years.

   By increasing the ISF to US$175/hectares/year as mentioned in Section 6.3.3, it has been structured to cover the funds needed to reconstruct irrigation at the end of its useful life. Whereas, with adequate maintenance, properly operated and rehabilitated at year 16, it can be ascertained at the end of its service life, the irrigation assets are still in good condition. This means, the ISF provision for reconstructing the irrigation system can be used for upgrading the irrigation system.

   The provision of ISF deposited to fund reconstruction in the future is US$80/hectare/year. Therefore, the funds collected during the first 10 years can be allocated to improve channel condition and network and increase the number of turnouts/offtakes (Year 2021). Subsequently, the funds collected at the second 10 years can be invested in installing volumetric measurement devices (2031). Eventually, for modernising the irrigation system, WUAs can use the funds collected from the Year 2031 to 2036 to reconstruct/modernise the irrigation systems. Table 6.15 presents the projections of ISF collected to fund the improvements.

Table 6.15. Tertiary improvement cost projections

Irrigation System		Potential coverage (ha)	ISF provision for improvements US$ (000)		
			Year		
			2021	2031	2036
Large	Way Pengubuan	4,975	7,244	18,098	17,981
Medium	Way Padang Ratu	1,032	1,503	3,754	3,730
	Way Negara Ratu	1,153	1,679	4,194	4,167
	Way Tipo Balak	1,133	1,650	4,122	4,095
Small	Way Muara Mas	225	328	818	813
	Way Muara Mas I	500	728	1,819	1,807
	Way Muara Mas II	126	183	458	455
	Way Muara Mas III	78	114	284	282
	Way Tipo Lunik	396	577	1,441	1,431
	Way Ilihan Balak	711	1,035	2,586	2,570
	Way Srikaton	478	696	1,739	1,728

It was assumed that the funds needed to modernise the irrigation system is similar to the funds needed to reconstruct the irrigation system. The funds required were as mentioned in the following table. It is clear that WUAs should look for other funding opportunities to support this plan.

Table 6.20. Modernising irrigation costs projection

Irrigation System		Potential coverage (ha)	Tertiary reconstruction costs estimates US$ (000) (2011)	Tertiary reconstruction costs estimates US$ (000) (2036)
Large	Way Pengubuan	4,975	9,950	107,805
Medium	Way Padang Ratu	1,032	2,064	22,363
	Way Negara Ratu	1,153	2,306	24,985
	Way Tipo Balak	1,133	2,266	24,551
Small	Way Muara Mas	225	450	4,876
	Way Muara Mas I	500	1,000	10,835
	Way Muara Mas II	126	252	2,730
	Way Muara Mas III	78	156	1,690
	Way Tipo Lunik	396	792	8,581
	Way Ilihan Balak	711	1,422	15,407
	Way Srikaton	478	956	10,358

Figure 6.4 shows cost projection for Way Padang Ratu irrigation system.

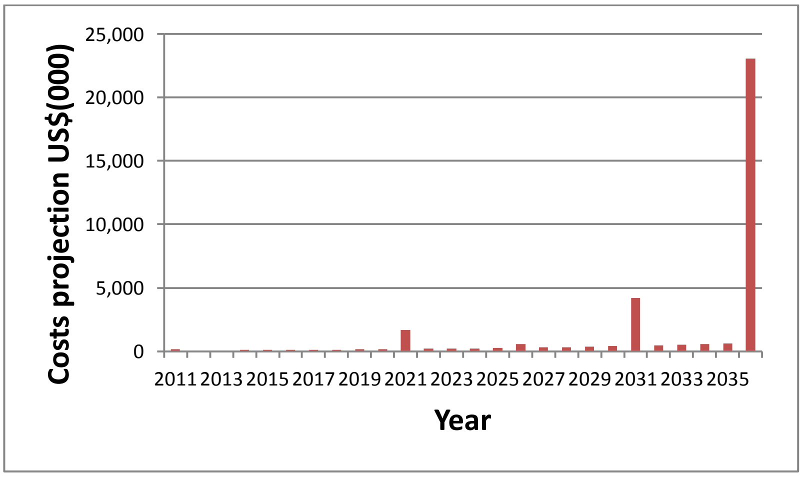


Figure 6.4. Costs projection for Way Padang Ratu Irrigation System

6.4 Asset Management Planning (AMP) Time-frame for Implementation

The AMP is primarily used to communicate information about assets and the actions required to provide a defined level of service. Actions should be implemented gradually and can be divided into short-term, medium-term and long-term planning.

The stakeholder opinion survey implied that all stakeholders, including farmers, are still reluctant to turn over the maintenance and operation of larger systems to the farmers themselves, based on the belief that farmers do not yet have the capacity to manage this. This warrants further investigation. The improved, sustainable, and cost-effective AMP enables WUAs in rural Indonesia to manage the assets of a transferred irrigation system in the most cost-effective way in order to achieve sustainability goals.

Until capacity-building is improved and the ISF is raised, WUAs' authority should be limited to the carrying out of budget priorities (5 years): routine MOM costs for tertiary level irrigation systems, and budget planning (rehabilitation of irrigation systems, in year16). Figure 6.4 illustrates the example of short-term maintenance planning of the Way Padang Ratu irrigation system and Figure 6.5 shows the rehabilitation costs projection for the Way Padang Ratu Irrigation System in 2026.

In the next five years, it is expected that WUAs able to consolidate its organisation and funding capabilities. They must increase the ISF before they can proceed with the following investment plans:

1. Short-term planning (investment priorities at the tertiary level; 10 years): Improves channel condition and networks, and increases the number of turnouts/offtakes to improve irrigation service and water distribution.
2. Long-term planning (capital planning; 20 years): Install suitable measuring devices to implement ISFs based on the volume of water used. Raise the ISF to recover fully all the costs of providing irrigation services. It is expected that this ISF could improve water use efficiency and to increase cost recovery.
3. Long-term planning (capital planning; 25 years): Implement pressurised irrigation methods and recirculate irrigation water to improve irrigation efficiency. Since it requires massive capital costs, the WUAs should look for government assistance or other funding opportunities to support this plan.

A planning process for long-term asset maintenance and rehabilitation works, as planned in the AMP, requires annual works program (AWP), clear determination on worst allowable condition (WAC) and target asset condition profiles (ACPs). Budgets also have to be adjusted over the useful life of assets for projected whole-of-life costs. The bottom-up budget is refined until the expected asset condition for budgeted treatment is achieved, as well as until the planned budget results in an AWP meet the WAC and target ACPs.

Preparing ACPs over the useful life of an asset need two types of performance measurement:

1. Regular day-to-day surveillance of the asset to ensure that WUAs are complying with specified maintenance intervention parameters (MIPs) for both short-term and long-term maintenance and rehabilitation works.
2. Asset condition surveys to measure the nominated attributes for each asset element. This allows for the determination of calculated ACPs; the asset is maintained according to these, and prediction of the condition of the asset in future years. These measurements are undertaken annually during the initial years of the outcome-based contract; however the frequency may be increased or decreased during the term of the contract.

The results are linked to key performance indicators (KPI) which are an incentive for the WUAs to achieve or exceed the minimum specified conditions of the asset. These performance measures are primarily undertaken to provide an objective assessment for audit and surveillance.

6.5 Overview and Commentary on the Proposed Improved Asset Management Planning (AMP)

The improved AMP for sustainable future irrigation system was developed by integrating various methods proposed by organisations such as: the Institute of Irrigation Studies – the University of Southampton, U. K., the Australian Asset Management Collaborative Group (AAMCoG) and the Cooperative Research Centre for Integrated Engineering Asset Management (CIEAM) as well as various methods and aspects proposed by experts such as: irrigation performance assessment methods, irrigation system sustainability assessment methods, assessment to prioritise management and physical upgrades, ISF, needs based budgeting, and turnover. Al the methods integrated in this procedure were selected carefully based on its reliability, appropriateness, and ease of implementation. Figure 6.5 illustrates the basic stages of developing the improved, sustainable, and cost-effective AMP for the irrigation system:

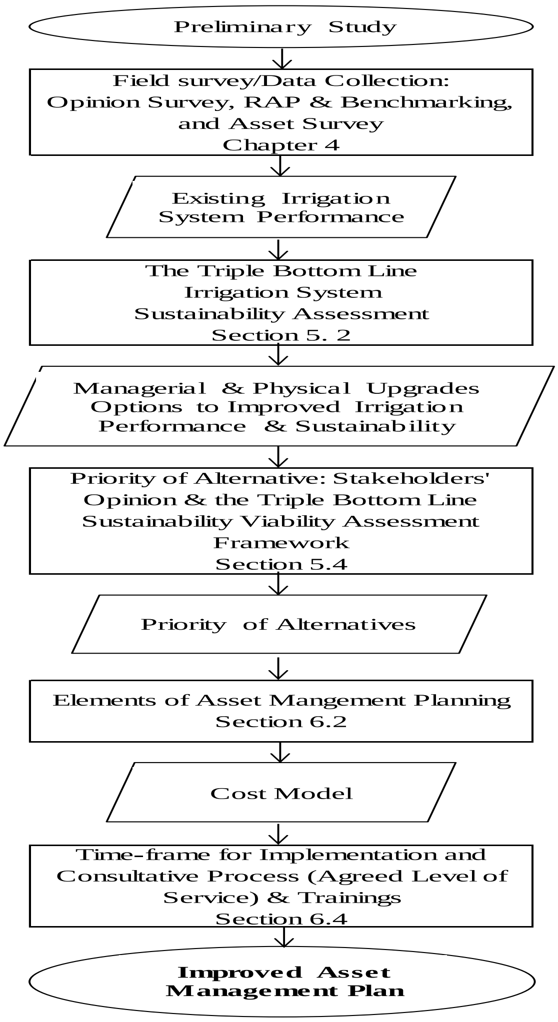


Figure 6.7. The Basic Stages of developing the AMP

The improved, sustainable, and cost-effective AMP has been developed to help the irrigation systems provide WUAs with a tool to meet the required level of service in the most cost-effective manner and in accordance with all legislative requirements, standards, and codes for present and future demands (sustainability).

The key features of the proposed improved, sustainable, and cost-effective AMP are:

1. Through performance measurements, provide a means to assess the suitability, functionality, affordability, and service levels of tertiary level irrigation systems to meet farmer expectations and to recognise the full potential of assets.
2. Through LCC, ensure, where possible, that funds are available for the planning, purchase and installation, management, operation and maintenance (MOM), and renewal of tertiary level irrigation assets.
3. Raise and promote the ability of WUAs and farmers to take on their responsibilities to manage the assets the tertiary level irrigation systems for which they have been given responsibility.

The transfer policy is designed to move responsibility for MOM of irrigation systems at the tertiary level (typically third level irrigation channels and associate assets) to users/farmers (through Water User Associations (WUAs)). However, management, operations and maintenance of irrigation systems involves use of expertise such as finance, engineering and technical operations. It is acknowledged that the experience of WUAs, especially financial, is often weak, and WUAs often do not have professional financial and technical staff with expertise to properly manage the irrigation system (Vermillion, 1997).

Also, until now there has been no established asset management system used by government that could have been passed to WUAs. The AMP developed in this study helps WUAs to take on their new obligation to accept responsibility to manage, operate and maintain irrigation systems. The improved AMP provides an appropriate way of running irrigation systems in an efficient, cost-effective and sustainable way and can be used by any organisations such WUAs who do not any previous experience in running MOM of asset of irrigation system.

To ensure that the improved AMP is successfully executed by the WUA, it is needed impetus forces such as legal enforcement, government legislation and regulation. It requires government assistance to provide technical support pertaining to the management of tertiary level irrigation systems, and to assign detailed roles and responsibilities of WUAs in the management of tertiary level irrigation systems. In addition, the government needs to provide training and promote effective and viable user associations.

6.6 Future Use of the Improved Asset Management Planning (AMP)

The procedure that has been developed and demonstrated in this chapter can be used for any irrigation systems in Indonesia or regions with similar irrigation systems. It has the advantages over other systems already in use for asset management that the implementation is carried out in stages following the timeframe as follows:

a. budget priorities (sets routine MOM costs, 5 years),
b. budget planning (sets rehabilitation of irrigation system, in year 16),
c. short-term planning (sets investment priorities at the tertiary level, 10 years: channel condition and network improvements, and increasing the number of turnouts/offtakes to improve irrigation services and water distribution),
d. medium-term planning (sets capital planning, 20 years: installing volumetric measuring devices), and
e. long-term planning (sets capital planning; 25 years: implementing pressurised irrigation methods and recirculating the irrigation water).

If WUAs demonstrate the ability to successfully apply short-term planning, greater responsibility can be allocated to them in the future. It is expected that by implementing and demonstrating proficiency in using the improved, sustainable, and cost-effective APM that WUAs could eventually develop the capacity to independently fund the management, operation and maintain irrigation infrastructure. Successful application of this process will improve irrigation productivity while maintaining and enhancing the sustainability of irrigation land and water resources.

CHAPTER 7. SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 Overview

Irrigation plays a fundamental role in safeguarding the food security and the economy of rural communities. However, many irrigation systems in Indonesia suffer from water shortages, compounded by increasing competition amongst agricultural users and industry. Current irrigation issues in Indonesia include: poor system performance, low productivity of land and water, ageing irrigation systems, increased operation and maintenance (O&M) costs, low O&M cost recovery, lack of government financing, and diminishing reservoir capacities due to sedimentation. These problems will eventually adversely affect the sustainability of irrigation systems.

This chapter summarises the results of this study, including the overall conclusions and recommendations for future research.

7.2 Review of Research and Objectives

There is increasing pressure in Indonesia to develop and implement a better management strategy to improve irrigation performance. Unfortunately, there is a lack of relevant, adequate, reliable, and timely irrigation data. Few irrigation systems have their performance accurately evaluated and none of the Water User Associations (WUAs) in Indonesia have an asset management planning (AMP) for tertiary level irrigation systems. Therefore, there is a need to assess existing irrigation systems in rural areas and to develop an improved AMP.

The Indonesian government implemented a policy in 1988, which turnover irrigation management to WUAs. The latest policy (2008) states that WUAs will operate as separate business organisations. This policy aims to ensure that WUAs are capable of independently financing tertiary level irrigation assets. In the future, it is expected that all irrigation systems (upstream and downstream), will be independently funded by WUAs.

To address these problems and developments the objectives of this research were to:

1. assess the existing irrigation system performance since it is the first stage and major component of the AMP;
2. (a) assess the performance of the case study irrigation systems in the framework of sustainability since there is a very close relationship between an irrigation system's sustainability and the various aspects of its performance; and

   (b) further assess the managerial and physical changes required to improve irrigation performance and sustainability; and
3. develop an appropriate AMP that would enable WUAs in rural Indonesia to manage the assets of a turnover irrigation system in the best/most cost-effective and sustainable way in order to achieve sustainability goals.

The asset management model developed in this study is an improved, sustainable, cost-effective AMP that enables WUAs to improve irrigation performance and sustainability under irrigation management turnover. It is a valuable mechanism for focussing the attention of WUAs/WUAFs on sustaining and enhancing the condition of irrigation infrastructure in Indonesia.

7.3 Review of Methods of Analysis

The research focus is on the recurring O&M of supplying water for irrigation. It focussed on tertiary channels as they are farmer-managed, although primary and secondary channels were not excluded as they come under the responsibility of the irrigation authority.

The ultimate objective of this research was achieved through three research stages:

Stage one: Assessing existing irrigation system performance

Assessing existing irrigation system performance is the first and most fundamental stage of AMP. The aim was to evaluate the productivity of water and land for agriculture, as well as gaining a more in-depth understanding of the current performance of Indonesian irrigation systems. This was achieved using RAP and Benchmarking, an opinion survey, and an asset condition survey.

The RAP and Benchmarking method is an international tool for irrigation performance assessment. It was used to systematically diagnose problems with the existing internal management process. The procedure took approximately two weeks and required the collection and analysis of relevant information from irrigation authority staff, WUAs, and farmers. The information was analysed by addressing 46 external indicators and identifying key factors relating to internal indicators.

The farmer opinion survey was carried out in questionnaire format. Responses were selected from farmers across 11 case study irrigation systems via a stratified random sampling technique to give a representative sample from large, medium, and small irrigation systems. The questionnaire was carefully designed using expert advice; it was as short as possible, used simple closed-ended questions, and was written in the local language (Bahasa Indonesian). The questionnaire consisted of 12 statements relating to irrigation and drainage services, asset condition, management practice, WUAs, and farmer income. It aimed to capture average farmer opinion and discourse on the current level of service, farmer perceptions about service levels before and after project execution, their expectation of future service levels, and their willingness to cooperate with service level changes and/or infrastructure upgrades. The data was analysed using descriptive statistics (cross tabulation and frequency distribution) with Statistical Package for Social Science (SPSS) software.

The asset condition survey was conducted using secondary data on the pre-existing condition of assets, which was matched to the current condition of assets. It was carried out in accordance with the Institute of Irrigation Studies (IIS) guidelines (University of Southampton, UK, (1995), which differentiates between the general condition of an asset and the ability of an asset to perform its function (serviceability). The ratings used for condition assessment were: good, fair, poor, and bad. The ratings used to assess the serviceability of assets were: fully functional, minor functional shortcomings, seriously reduced functionality, and ceased to function.

Stage two: Assessing existing irrigation system sustainability, issues (including their causes), and the proposed physical and managerial interventions required to improve irrigation performance and sustainability.

Agricultural production is often boosted at the expense of environmental resources. A triple bottom line (TBL) sustainability assessment was incorporated into this section, as the RAP and Benchmarking approach only considered the net benefit from irrigation in relation to production outcomes. The TBL sustainability frameworks developed in this study balanced the competing demands of agriculture and ecosystems. It also addressed the current challenges of water scarcity or over-supply, salinity, modernisation, efficiency, and environmental water management. It consisted of 20 profit indicators, 12 planet indicators, and 7 people indicators. The TBL assessment provided a means of showing the levels of sustainability and the sustainability issues of existing irrigation systems.

A performance and sustainability assessment of the irrigation system showed that performance was inadequate and sustainability was below compliance. As a result, six physical and management interventions were selected, and a stakeholder opinion survey and TBL sustainability assessment were carried out. The purpose of integrating both methods was to find an alternative and robust solution that would be welcomed by stakeholders.

Stakeholder preference was assessed using a simple pairwise comparison questionnaire and matrix analysis. This was the easiest way to determine the order of priorities, as decision makers had to consider two alternative strategies at the same time. The interventions were ranked according to how many times they were selected by stakeholders.

The opinion survey questions were carefully developed, taking into account ease of choice, reliability, and the local language (Bahasa Indonesia). Questionnaires consisted of 15 questions that asked respondents to compare two different management intervention scenarios and three physical intervention scenarios.

Respondents were carefully selected based on their level of importance in the irrigation system. Each case study irrigation system was represented by a WUA leader and a delegate from the local irrigation authority (UPTD) head office. In addition, representatives were selected from the irrigation authority, provincial and district/Kabupaten authorities, and consultants and contracting organisations involved in the development of irrigation systems. Respondents were interviewed on an individual basis in their offices.

The results were used to weigh the proposed interventions against the key issues of the TBL including the technical and economic aspects, social, institutional and legal aspects and environmental aspects. The higher the score of an intervention, the more viable. The conclusion was that physical changes requiring major financial capital and managerial changes giving WUAs greater authority were not considered viable options.

Stage three: developing an improved, sustainable, cost-effective AMP that enables WUAs to manage irrigation infrastructure at a tertiary level

The improved, sustainable, cost-effective AMP was based on the priority of interventions from Stage two. The AMP was developed in accordance with guidelines published by the IIS, University of Southampton, UK (1995), the asset management approaches suggested by the Australian Asset Management Collaborative Group (2008), and elements considered relevant to the case studies as suggested by experts. The elements included needs-based budgeting, irrigation service fees (ISF), turnover programs, efficient O&M, aspects of budget constraints, funding sources and realistic levels of funding. Eventually, the AMP was presented in terms of a budget plan, short-term, medium term and long term plan.

By completing these three stages the objectives of the project have been achieved and a more practical and effective method of analysing the performance and sustainability of existing irrigation systems has been specified. This systematic approach can by applied to similar irrigation projects throughout Indonesia and SE Asia

7.4 Conclusions Related to the Studies Undertaken

The following conclusions can be drawn from the results of this study.

The performance and sustainability of irrigation systems are linked to global and local issues. The report also considers indicators of performance in the assessment of the case study irrigation systems. Performance and sustainability assessment of the case study irrigation system shows that in general, performance is inadequate and sustainability is below the required compliance (*see Section 4.6 and Section 5.2.5*).

To overcome issues with performance and sustainability, physical and management interventions can be implemented. However, physical changes require major financial capital, and managerial changes that give WUAs greater authority are not popular (*see Section 5.3 and Section 5.4*).

Water availability in general, is adequate, and water shortages that occur in the dry season can be solved by implementing improved asset management. WUA involvement in asset management at the tertiary level is aimed at immediate improvement of land and water productivity and stabilising deteriorating irrigation systems. In summary, the main issues with O&M are:

1. Financial performance

   Asset management, operation and maintenance (MOM) costs are low compared to MOM costs of similar assets in other countries. The current ISF does not cover MOM costs at the tertiary level. Renewal of tertiary level assets still relies on subsidies from the government. Farmers cannot afford higher ISFs due to their small landplot areas of 0.5 hectares or less and thus they have low productivity. (*See Section 4.3.1, Section 4.3.6 and Section 4.5.1.3*). The approach to developing WUAs as business enterprises, so that they can respond to specific business opportunities, was favoured by stakeholders, and should improve farmer welfare (*see Section 5.4*).

2. Function

   The current assets suit the activities and functions they are required to support. At the tertiary level, the asset types managed by WUAs are mainly conveyance structures of channels, and hydraulic structures attached to channels. However, the assets are inadequately maintained and no historical data exists regarding the maintenance of assets. Therefore the deterioration curve typical for channel and hydraulic structure assets was established using other infrastructure information. (*See Section 4.3.2 and Section 4.4*). The cost models for asset maintenance planning were based on this curve, and on the asset conditions required to provide a better service to irrigation users (see *Section 6.3.5*).

3. Utilisation

   Assets are intensively utilised during the semi-dry season (second crop planting season), but not so intensively in the wet season (first crop planting season) and dry season (third crop planting season). By improving asset condition and capacity, the service area can be extended (improving the command area to irrigated area ratio), the crop intensity increased, and water and land productivity maximised. (*See Section 4.3.2 and Section 4.4*).

4. Management

   There were several constraints that limit the ability of irrigation offices to provide a good service. As well as a lack of capability of WUAs to carry out responsibility of MOM irrigation system and a low farmers' appreciation on the value of water. (*See Section 4.2.1, Section 4.3.1, Section 4.3.2, Section 4.3.4,* *Section 4.5.2.1 and Section 4.5.2.2*). The AMP is an improved mechanism allowing local resources to manage the transferred irrigation system in the most cost-effective and sustainable way. It provides an improved spending plan for asset maintenance that consists of budget priorities, budget planning and short, medium and long-term planning, which can be built on and developed over time. (*See Section 6.4*).

The performance and sustainability assessment and the priority of intervention approaches to improve irrigation and sustainability in the future results were based on independent measurements of quantitative data and systematic sampling of farmers and stakeholders. Based on these assessments, a set of physical and managerial upgrades needed to improve the irrigation performance and sustainability was reviewed. The majority of stakeholders prefer the physical irrigation system upgrades that do not required massive capital expenditure and moderate upgrades in irrigation system management.

The improved AMP were developed by considering those assessments as well as elements of needs based budgeting, budget constraints, turnover the O&M of irrigation system at tertiary level to water user associations, the level of current ISF to fund the O&M of the tertiary level irrigation system, and efficient O&M of tertiary level irrigation system. Tertiary irrigation network is an infrastructure network from secondary canal offtakes to tertiary channel networks and associated infrastructure attached to the networks that serves irrigation water directly to the paddy fields.

In general the improved AMP consists of short-term, medium-term and long-term plan. For the next five years, WUAs' authority should be limited to the carrying out of budget priorities while they focus on solving their organisation and funding issues. It is suggested that the ISF should be raised and the WUAs should take advantage of business opportunities in the irrigation systems to generate sideline income. Once they are able to solve these problems, then they can take bigger responsibility to carry out the short, medium and long-term capital investment plans. In the long run, it is expected that WUA organisations should be capable of funding the management, O&M of irrigation system from main system to tail-end while maintaining the efficiency of land and water resource in improving productivity.

7.5 Recommendations for Future Research

Since management the AMP can potentially have a major impact on the performance and sustainability of irrigated agriculture in developing countries, it is important to document the physical sustainability of irrigation systems following the implementation of the improved AMP. However, it is evidence that there is always a lack of historical documentation in irrigation system. Therefore a maintenance database should be established in tertiary level irrigation systems and WUAs should be required to maintain it accurately. By recording direct observations regarding the physical condition and functionality of the irrigation infrastructure, it is expected that database in the future can be used to assess the impact of the improved AMP implementation to the sustainability of irrigation system.

Further research also needed to assess the possibility of employing non-governmental management model alternatives that are expected to be better capable of managing medium or large –scale irrigation system. Examples include employing irrigation district, mutual companies, private companies, or contractor.

7.6 Overall Achievements, Outcomes and Applications

Overall, this research has expanded, adapted and integrated aspects of the previous methods proposed by organisations such as the Institute of Irrigation Study – the University of Southampton (1995), the Australian Asset Management Collaborative Group and the Cooperative Research Centre for Integrated Engineering Asset Management (2008) and the previously proposed methods by experts such as Burton et. al. (2003), Malano, Chien, and Turral (1999), and Malano, George and Davidson (1999).

The improved, sustainable, and cost-effective AMP developed in this study provides an appropriate way of running irrigation systems in an efficient, cost-effective and sustainable way and can be used by any organisations such as Water User Associations which do not have any previous experience of running management, O&M asset of irrigation systems. Often, for these organisations a government asset management system is not available or inapplicable.

To ensure that the improved AMP is successfully applied by the WUA, government attentions need to assist with regulation and transfer policies wich supports the WUAs bodies with their responsibilities as well as assistance in training and promoting effective and viable user associations (*see Section 6.3.2*). It should also be noted that the successful implementation of the improved AMP may take several years. As demonstrated in Chapter 6, it was suggested that the implementation of improved AMP following the sequence of steps as follows:

1. Budget priorities (for the first five years of implementing the plan): routine MOM costs for tertiary level irrigation systems.

   Until capacity-building is improved and the ISF is raised, WUAs' authority should be limited to the carrying out of budget planning. It is expected, in the next five years, WUAs able to consolidate its organisation and funding capabilities, so they can proceed with the subsequent plans.
2. Short-term planning

   Investment priorities at the tertiary level that begins in the tenth year of running plans: improves channel condition and networks, and increases the number of turnouts/offtakes to improve irrigation service and water distribution.
3. Budget planning

   Rehabilitation works of tertiary assets is needed when the asset condition is 25% - 60% of its original or occurs at 75% - 80% of an asset's useful life which is projected to happen in 16 to 20 years after implementing the plans.
4. Medium-term planning

   Capital planning: install suitable measuring devices to implement ISFs based on the volume of water used. Raise the ISF to recover fully all the costs of providing irrigation services. It is expected that this ISF could improve water use efficiency and to increase cost recovery.
5. Long-term planning

   Capital planning that begins in the 25th year after implementing the plans: implement pressurised irrigation methods and recirculate irrigation water to improve irrigation efficiency. Since it requires massive capital costs, the WUAs should look for government assistance or other funding opportunities to support this plan.

(*See Section 6.3.5 and Section 6.4*).

If WUAs demonstrate the ability to successfully apply budget priorities and short-term planning, greater responsibility can be allocated to them in the future. It is expected that by implementing and demonstrating proficiency in using the improved, sustainable, and cost-effective AMP that WUAs could eventually develop the capacity to independently fund the management, operation and maintain irrigation infrastructure. Successful application of this process will improve irrigation productivity while maintaining and enhancing the sustainability of irrigation land and water resources.

It is expected that the AMP developed can be applied to irrigation systems in developing countries, including Indonesia. Implementation of the AMP will have far-reaching effects on the livelihood of farmers and the sustainability of irrigation systems. However, it is vital that more rigorous and compelling research methods are used to assess the real impact of the AMP.

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APPENDIX A

Details of Preliminary Study:

A.1. A review of asset management by experts

A.2. A review of the impact of participation in irrigation management in some developing countries

A.3. The stages of irrigation development and irrigation policy change in Indonesia

A.4. Proposed indicators to assess irrigation system performance

A.5. Summary of performance assessment proposed by experts

A.6. The indicators of IPTRID and RAP and Benchmarking

A.7. Reported works on opinion survey of people (i.e. farmers)

A.8. The Four Tier of ISAF

A.1. A review of asset management by experts

No.	Researcher	Definition	Study site	Application
1.	Job, Charles, 2009	Asset management is managing infrastructure capital assets to minimise the total cost of owning and operating them, while delivering the service level that customers desire.	America's water infrastructure	Water system asset management as a way to address infrastructure in a comprehensive way and sustainable manner.
2.	Wei, Zhao, et.al., 2009	Asset management includes a process of asset's planning, construction, operation, maintenance, assessment, rehabilitation, and replacement, with an object of providing the required level of services to customers at a lower cost-benefit ratio (Malano, et.al. 1999).	Zhanghe irrigation District, China	Application of hierarchical structure model to assess service ability. - The top level is objective level: scoring result for serviceability, - The middle level is asset's classified character, - The bottom level is index level: describe the above levels's character in detail, and reflects the serviceability from all possible aspects directly.
3.	Hanson, Paul H., 2008	Effective asset management requires volume of information and an enormous number of details.	Greater Cincinnati Water Works	Geographic information system (GIS) software enables GCWW to manage information and provide answer to any question with a few clicks of a mouse.
4.	Santora, Marc & Rande Wilson, 2008	Infrastructure asset management is the life cycle management of a utility's physical assets to maximise the intrinsic value of ratepayers' investment.	Water sector in the U. S.	Incorporating risk management considerations into planning, design, repair, maintenance, and replacement of physical infrastructure is an important component of asset management. It includes: - bringing forward risk management considerations in the design, planning, and budgeting process, - combining design and construction specifications to address resiliency, redundancy, and physical hardening of critical assets, - adopting inherently lower-risk technologies.
5.	Stowe Jr., Joe, 2008	Asset management programs address various aspects of traditional asset managements: - maintenance management systems, - facility information systems, - laboratory information systems, - inventory control programs, - and instrumentation programs such as supervisory control and data acquisition.		Essential to provide programs that address people component such program to prepare skilled professional that directly related to the operation, programs that help organisation with the process of transferring the institutional knowledge of retiring to a new generation professionals.
6.	Thorp, William & James Sanchez, 2008	The agency's asset management database, the Turnpike Enterprise Asset Management (TEAMS), enables the agency to inventory the condition of its infrastructure and act in anticipation of future needs.	Florida's Turnpike Enterprise, a division of the Florida Department of Transportation, owns and operates the fourth-longest toll system in	Through TEAMS, Turnpike Enterprise staff can readily track asset conditions and identify, forecast, and prioritise capital expenditure required for periodic renewal and replacement throughout the network of toll roads.
7.	Yep, Ray, 2008	Asset management program (AMP) consist of core components: - asset inventory, - condition assessment, - risk assessment, - identification of levels of service, - renewal/replacement schedule, - and financial analysis and funding.	The Santa Clara Valley Water District (SCVWD)	The challenges in establishing asset management program (AMP): - difficultty in adhering to maintenance plans, - difficulty in decision-making, - difficulty in expanding districtwide.
8.	Davis, Jim, 2007	Asset management is a continous process-improvement startegy for improving the availability, safety, reliability, and longevity of plant assets, i.e., system, facilities, equipment, and process.	Australia and New Zealand	The primary purpose of an Asset management strategy (AMS) is to help you: - know exactly what assets you have, - know precisely where your assets are located, - know the condition of your assets at any given time, - understand the design criteria of your assets and how they are properly operated and under what conditions, - develop an asset care program that ensure each asset performs reliably when it is needed, - perform all of these activities to optimise the costs of operating your assets and extend their useful life to what was called for by the initial design and installation (if not beyond).
9.	Halfawy, Mahmoud R., et.al., 2006	Efficient management of infrastructure assets depends largely on the ability to efficiently share, exchange, and manage asset life-cycle information.	Municipal infrastructure asset management system	Utilisation of spatial data and geographic information system for interoperable and integrated infrastructure asset management system.
10.	Malano, H. M., et.al., 2005	Asset management framework (AMMF) allows the assessment of asset management strategies and costs associated with the operation of the irrigation system infrastructure.	Cu Chi irrigation system, Vietnam	Application of AMMF to the evaluation of asset ownership costs and LCC (life cycle cost) for - a database of assets consisting og geographical location of assets, design features, maintenance records, and asset condition and performance, - an analysis module ewhich enables the modelling of future asset strategies including the calculation of future liabilities and life cycle asset costing associated with alternative courses of action.
11.	Christen, Kris, 2004	Asset management essentially helps utilities allocate capital and maintenance resources more effectively and make better decisions about rehabilitating or replacing aging assets.	General Accounting Office, the U.S.	

A.1. A review of asset management by experts (continue)

No.	Researcher	Definition	Study site	Application
12.	Burton, Martin, et.a., 2003	Asset management is a structured and auditable process for planning, implementing, and monitoring investment in the maintenance of built infrastructure to provide users with a sustainable and defined level of service.	Transferred irrigation system in Albania	An important current application of asset management is in the process of transferring the management, operation, and maintenance of the irrigation and drainage system to water users associations.
13.	Cagle, Ron F., 2003	Asset management is embodied in - what you have, - what condition it is in, - what the financial burden will be to maintain it at a targeted condition. It refers to aset of processes or - maintaining a systematic record of individual assets (an inventory) with regard to acquisition cost, original and remaining useful life, physical condition, and cost history for repair and maintenance, - having a defined program for sustaining the aggregate body of assets through planned maintenance, repair, and/or replacement, - implementing and managing information systems in support of these elements.	The United States of America	Broad asset management implementation covers combination of legal enforcements, government regulation, government funding, finacial reporting, standards, physical security, and best management practice initiatives in the utility industry.
14.	Tran, Thi Xuan My, et.al., 2003	Asset management is an integrated approach to improvingh the ability of an irrigation system to deliver water at a defined level of service in the most cost-effective manner.	La Khe irrigation scheme, Vietnam	Application of the analytical hierarchy process (AHP) to prioritise irrigation asset renewals.
15.	Canning, Michael E., 2002	Asset management is a complex process that involves all aspects of the life cycle of the infrastructure. Initial capital investment, ongoing maintenance, refurbishment, replacement, financing, and planning all play key roles.	Water distribution infrastructure	Application of field-testing of infrastructure for assest evaluation. Six 'whats' of asset management: - what do you own, - what is it worth, - wahat is its condition, - what is the remaining service life, - what is the maintenance backlog, - what will you fix first.
16.	Moorhouse, Ian, 1999	Asset management is the systematic and structured combination of management, financial, economic, and engineering practices that are apllied to physical assets over their whole life cycle, with the objective of providing the required level of service in the most cost effective manner.	Goulburn-Murray Rural Water Authority	Asset management strategy places major emphasis on the integration of customer service, physical, financial, and risk issues. Key elements of the strategy are: - agreed level of service, - asset information, - organisational focus, - total life cycle approach, - maintenance and replacement, - renewals pricing, - cost reductions, - risk management, - focus on performance outputs, - statutory and due dilligence compliance, - efficient resourcing, - continous improvement.
17.	Malano, H. M., et.al., 1999	Asset management program is a strategy for the creation or acquisition, maintenance, operation, rehabilitation, modernisation, and disposal of irrigation and drainage assets to provide an agreed level of service in the most cost-effective and sustainable manner (Hofwagen & Malano 1997).	La Khe irrigation scheme, Vietnam	Element of asset management program: - asset operation and maintenance, - asset condition and performance monitoring, - asset accounting and economies, - asset audit and renewal, - asset management and system operation costs, - asset management information systems.
18.	Burton, M. A., et.al., 1996	Asset management planning (AMP) is a structured and auditable process for planning investment in infrastructure to provide users with a sustainable and defined level of service.	UK water industry	AMP developed for UK water industry can be applied, with modification, for irrigation. Six stages of an asset management plan (AMP): - defining system functions, - identifying the planning unit, - stratification and normalisation, - carrying out the asset survey, - assessing scheme performance, - engineering studies, - building cost model, - running the financial model, - pricing for cost recovery, - data transformation and presentation.
19.	Burton, M. A. & R.P. Hall, 1996	Asset management plan (AMP) identifies and independently certifies the asset condition, performance, and investment.	UK water industry	Application of irrigation serviceability matrix in preparing asset management plans and investment strategies for irrigation infrastructure. AMP major components: - asset condition and performance assessments, - asset databases or information systems, - asset planning, - level of service set by the DGWS (Directorate General of Water Resources) or by water company, - Asset monitoring, - investment planning systems (including analysis/scenario assessments), - cost estimating (unit cost and/or cost models), - demand forecasts, - capital and operation expenditure forecasts (capex and opex).

A.2. A review of the impact of participation in irrigation management in some developing countries

Study & country	Transfer unit	Size of transfer unit (ha)	New management *	Functions transferred		Ownership of assets	Irrigation type	Impact				
				O&M	Finance			Irrigation finance	Operation	Maintenance	Agricultural productivity	Economic Productivity
Oorthuizen & Kloezen, 1995, Philippines	Entire scheme	150-200	WUA	Partial	Partial	Govt.	SI	Reduced cost to farmers; 75% drop in budget. Fee collection rates rose from 20% to 81%.	Water distribution become less equitable	Worsened	n.a.	n.a.
Vijayaratna & Vermillion, 1994, Philippines	Laterals & entire scheme	500-5,000	WUA	Partial	Partial	Govt.	SI	Revenue from water charges increased from 24% in 1979 to 60% in 1990. Reduction in agency field staff. Diversification of revenue sources.	Improved water distribution equity; expansion of dry season irrigated area	n.a.	Increases in cropping productivity	n.a.
Bagadion, 1994, Philippines	Distributary canal	2,500	WUA	Partial	Partial	Govt.	LI	Budget losses converted to surpluses. Fee collection rate rose from 27% to 60%.	No increasing trend in service area	n.a.	n.a.	n.a.
Svendsen, 1992, Philippines	Distributary canal	<5,000	WUA	Partial	Partial	Govt.	SI, LI	Decrease in frequency of deficit budgets; increase in revenue from water charges and other income. 29% drop in the operating expenditures. Decline in staff from 13% to 75%. Government subsidy dropped from ₱25 million in 1976 to zero in 1982.	Equity of water distribution improved and 7% expansion of benefited area in the dry season.	n.a.	Rice yields incresed by 4% to 4t/ha in both wet and dry seasons.*	n.a.
Johnson & Reiss, 1993, Indonesia	Tube well	5-200	WUA	Partial	Full	Govt.	LI	Cost of water pumped increased five to seven times.	n.a.	Deterioration of pump sets accelerated.	n.a.	n.a.
Nguyen & Luong, 1994, Vietnam	Pump scheme	n.a.	Parastatal	Full	Full	Govt.	-	n.a.	Water consumption per hecatare dropped 36%. Area irrigated increased 71%.	n.a.	Cropping intensity increased from 170% to 250%. 14% increase in area cropped. Yield increased 13%.	Annual incremental benefits increased by US$193/ha or by $182/ha net of increased O&M cost.
Johnson et al, 1995, China	Scheme	5,000	Irrigation district	Full	Full	Govt.	SI	Per hectare cost of water to farmer rose 2.5 times. Growing importance of sideline revenue enterprises after reform.	A reduction in water duty from 11,000 m^3 to 4,500 m^3.	n.a.	Grain yields increased modestly.	Cases of both increase and decrease in net income.
IIMI & BAU, 1996, Bangladesh	Tube well	<100	WUA	Full	Full	Private	LI	O&M costs remained similar after privatisation, though loss of subsidies meant increased costs to farmerr. Diesel deep tube wells not financially viable without subsidy.	Declining numbers of farmers reporting adequate and timely water delivery.	Higher breakdown rates in smaller pumps; spare parts and repair easier.	Slight increase in cropping intensities. Mixed results for yields.	Small farmers (<1ha) becoming a growing share of pump owners and of expanding irrigated area (58% to 63%, 1989-94).
Rana et al, 1994, Nepal	Irrigation system	500-2,000	Agency/ WUA	Partial	Partial	Govt.	-		Irrigation discharge increased fourfold.	n.a.	n.a.	n.a.
Olin, 1994, Nepal	Tube well	120	WUA	Full	Full	Govt.	LI	Cost of water decrease 40-50%.	Drop in water consumption by 50%.	n.a.	n.a.	n.a.
Mishra & Molden, 1996, Nepal	Entire scheme	8,700	WUA	Partial	Partial	Govt.	SI	Cash and labour value raised from farmers increased to US$6.77/ha, and 77% of farmers paid water charges.	Inflow increased from 2.2 m^3/s to 7.9 m^3/s (26%-93% of design capacity).	n.a.	Rice yields increased from 2.2 t/ha to 3.4 t/ha. Wheat yields increased from 1.6 t/ha to 2.4 t/ha.	n.a.
Kloezen, 1996, Sri Lanka	Distributary canal	80-260	Agency/ WUA	Partial	Partial	Govt.	SI	Government subsidies for O&M continued. Farmer organisations invested mainly in input provisions and marketing, not in O&M. Annual government costs decrease 33%. Diversification of revenue sources.	Quality of water distribution did not change.	n.a.	Cropping intensities increased from 138% to 200%.	Gross annual value of output between US$944/ha and $1,136/ha after IMT.
Uphoff, 1992, Sri Lanka	Field	50-150	WUA	Full	Partial	Govt.	-		Improved equity of water distribution.	Maintenance activity and investment increased.	n.a.	n.a.
Pant, 1994, India	Tube well	84	Cooperative	Full	Partial	Govt.	LI	50% reduction in the cost of water. Budget deficits converted to surplus.	Reduced average irrigation time.	Maintanance work incresed.	Cropping intensities increased from 143% to 162%. Yields increased 10%.	n.a.
Srivastava & Brewer, 1994, India	Distributary canal	14,000	Intervillage committee	Partial	Partial	Govt.	-	n.a.	Improved equity; 27% more water to tail end; 205 increase in irrigated area in the dry season.	More maintenaance activity.	n.a.	n.a.
Rao, 1994, India	Minor canal	359-513	WUA	Partial	Partial	Govt.	-	n.a.	Improved equity of water distribution.	n.a.	n.a.	n.a.
Shah et al, 1994, India	Tube well	50-150	WUA	Partial	Partial	Govt.	LI	50% reduction in the cost of water.		n.a.	n.a.	n.a.
Kalro & Naik, 1995, India	Minor canal lift schemes	<400	WUA	Full & partial	Full & partial	Govt.	SI, LI	Increased costs and time required for farmers. Improved rate of recovery for water charges. No decline in government expenditures for O&M.	Adequacy and reliability of water distribution improved; as reported qualitatively.	n.a.	Increases in cropping intensities and crop diversivication. No change in yield.	n.a.

A.2. A review of the impact of participation in irrigation management in some developing countries (continue)

Study & country	Transfer unit	Size of transfer unit (ha)	New management *	Functions transferred		Ownership of assets	Irrigation type	Impact				
				O&M	Finance			Irrigation finance	Operation	Maintenance	Agricultural productivity	Economic Productivity
Azziz, 1994, Egypt	Field channels	20-60	WUA	Full	Partial	Govt.	SI	Dramatic decline in maintenace costs. Per hectar pumping costs decline from US$68-$79 to $45-$50 after rehabilitation and IMT.	Reduced irrigation time; better water adequacy.	n.a.	10-16% increase in main crop yields.	Increase in farm incomes by US$60/ha
Samad & Dingle, 1995, Sudan	Pump schemes	80-4,000	Private company/ WUA	Partial	Partial	Govt.	-	n.a.	Timeliness and water adequacy worse in schemes turned over.	n.a.	High yields per unit of water in parastatal schemes (17 kg/100 m^3) versus turned-over schemes (11 kg/100 m^3)	Gross margin three times higher in parastatal than in turned-over schemes. Productivity of land and water higher in parastatal than in turned-over
DSI, EDI & IIMI, 1996, Turkey	Schemes & subunits	50-34,000	Municipal govts.	Full	Full	Govt.	SI, LI	Increase in average water fee collection rate from 38% to 72% in the first year after IMT.	In first year, area served increased 20-40%.	n.a.	n.a.	n.a.
Maurya, 1993; Musa, 1994, Nigeria	Distributary canal	126-271	Agency/ WUA	Partial	Partial	Govt.	SI	Water fee collection rates rose from 50% to 90% after IMT.	Improved equity; 12% more water reached middle and tail reaches.	Increased maintenance activity.	Increase in dry-season cropped area by 80%.	n.a.
Wester, During & Oorthuizen, 1995, Senegal	Lift schemes	20	WUA	Full	Full	Private	-		Expansion of areas irrigated.	Deterotation of pump sets accelerated.	Cropping intensity rising and falling in different locations.	Cost of irrigataed rice production increased 78%.
Yap-Salinas, 1994, Dominican Rep.	Federated	5,240-9,240	WUA	Partial	Partial	Govt.	SI	Water fees increased 1,500% in * years. Fee collection rates increased from 12% to 80%.	Delivery efficiency improved 25-30%.	n.a.	n.a.	n.a.
Vermillion & Garces-Restrepo, 1996, Colombia	Irrigation district	14,000	WUA/ district	Partial	Full	Govt.	SI	44% average decline in total staff. Farmer emphasis on cost-cutting. No long-term major change in cost of irrigation. Cost of water relative to production fell 27%. Diversification of revenue sources, from 10% to 20% of revenue other than fees. Budget deficits converted to surpluses.	More responsive operations. Water adequacy satisfactory. 40-45% of farmers say operations improved. Temporary inefficiencies after IMT.	Good maintenance; 92-98% of farmers report quality of maintanance has not change.	Rice yields of 6.5 t/ha, sustained after IMT. Cultivataed area continued to expand. More crop diversification.	Net faram income rose 23%. Economic return to irrigation was US$11 - $12/100$m^3$ water. Gross value of output increased 400%, 1983-91.
Garces-Restrepo & Vermillion, 1994, Colombia	Schemes	1,000-25,000	WUA/ district	Full	Full	Govt.	SI, LI	Declining trend in fee levels. Reduction in staff by 38%. Shift from deficit to surplus budgets in all study casaes.	n.a.	n.a.	n.a.	n.a.
Johnson, 1996, Mexico	Blocks	5,000-30,000	WUA	Full	Full	Govt.	SI	45-180% increase in water charges. Increase in fee collection rates from 15%, originally, to 80% to 100%. Shortfall in financing declined rationally from US$66 million to $41 million annually. Local self-reliance increased from 43% to 78%.	No change in water delivered per hectare or in area irrigated.	n.a.	No change in cropping intensity or yields.	Annual economic returns (US$1,500-$1,900/ha) remained same or declined.
Svendsen & Vermillion, 1994, Washington State, USA	Irrigation district	77,000	WUA/ district	Full	Full	Govt.	SI	Decrease in government staff by 86%. Farmer emphasis on cost-cutting. Volumetric charges reduced by 16%. Diversification of revenue sources. Water charge was 80% of revenue before and 67% after IMT. Farmers raised capital replacement fund.	More responsive operations. Efficiency did not change. Equity improved slightly.	Good but slight declining trend detected.	Shift to less water-intensive crops but more due to changing water application technology and markets.	Average incomes rose 15% due to reduction in water cost.
Farley, 1994, New Zealand	Schemes	2,000	Mutual company	Full	Full	Private	SI	Farmer emphasis on cost-cutting. Average operational costs decline 66%. After IMT, water charges were a quarter to a half of the pre-IMT level.	n.a.	n.a.	n.a.	n.a.

A.3. The stages of irrigation development and irrigation policy change in Indonesia

Stage of Development		Objective and rationale	Implementation	Policy change	Legislation product	Consequence	Impact
Colonial era (1848-1949)		Objective: development of public irrigation system Rational: improvement of the welfare of the natives	Construction of new irrigation system in the area served by community irrigation system and in rainfed area		Ethical Policy launced by Queen Wilhelmina in the early 20th century Algemen Water Reglement (General Water Law) 1936	Change in principle of irrigation management: adoption of cultural plan Division of management responsibility between government and local community Maintaining capacity of local community to manage irrigation system and to open up new irrigated area	Overcome drought problem in Wast and Central Java Development of large-scale estate system to suit for cultivate export commodities such as sugarcane, indigo, and tobbacco as a result of Trade Liberalisation Policy. Small-scale community irrigation system were not suited for this system.
1950-1969		Objective: continous development of public irrigation system Rational: continous development of the welfare of the farmers	Construction of reservoirs and irrigation system in limited area			Maintain the same management responsibility with that during colonial era	
Centralised government and Green Revolution era (1970 -1999)	Consolidation (1969-1974)	Objective: rehabilitation of existing systrm and expansion of irrigated area Rational: achieving and maintaining rice self-sufficiency	Direct intervention by public agency in rehabilitation of tertiary and community irrigation system, and development of rice fields in new irrigated area	Emphasis on rehabilitation of infrastructure Initiation of rice intensification program		Weakened capacity of local community in irrigation management and land development	Positive impact on food security and poverty reduction
	Rapid growth (1974-1987)		Uniformed water user(s) association	Expansion of intensification base Expansion of irrigated area and harvested area Technology improvement Extractive natural resource management Centralistic extention service	Law 11/74; Management and Planning Function Government Regulation PP No. 22/1982; Water Management Government Regulation PP No. 23/1982; Irrigation Presidential Instruction INPRES 2/84; Guidance to WUAs		Positive impact on food security Significant poverty reduction Degradation of natural resources Negative impact on environment Increased dependency of farmers on government program (weaken social viability)

A.3. The stages of irrigation development and irrigation policy change in Indonesia (continue)

Stage of Development		Objective and rationale	Implementation	Policy change	Legislation product	Consequence	Impact
Centralised government and Green Revolution era (1970 -1999) (continue)	Slow down in agriculture growth (1987-1997)	Objective: rehabilitation of existing systrm and expansion of irrigated area Rational: achieving and maintaining rice self-sufficiency	Uniformed water user(s) association	Decrease fiscal support to agriculture Extractive natural resource management Libereralisation policy to support industry Removal of pesticide subsidy	Government Policy statement 1987; O&M irrigation System Presidential Instruction INPRES 42/89; System of Turnover of Small-scale Irrigation System and Management Authority to WUA Ministry of Public Work Ordinance No. 42/PRT/1989; Procedure for Turnover Ministry of Home Affairs Regulation No. 6/1992 and No. 19/1992; Irrigation Service Fee Ministry of Home Affairs Regulation No. 12/1992; Establishment and development of WUA Minister of Home Affairs Decree No. 179/1996; The Organizational Structure, Status, Task and Function of *Balai* as UPTD (Technical Implementation Unit)	Weakened capacity of local community in irrigation management and land development	Increase trend of import of rice Poverty reduction (less significant) Negative impact on environment Increased dependency of farmers on government program
	Economic crisis (1997-2001)			Mega project one million hectares of swamp land development discontinued Removal fertilisers subsidy High banking interest rate			Negative impact on food security Very significant increase in poverty Degradation of natural resources Negative impact on environment Increased dependency of farmers on government
Decentralise government (1999-...)	Empowerment of local community (1999-2004)	Objective: transfer of responsibility in irrigation management to local community Rational: to reduce the burden of the government	Provision of legal framework development of program to empower local community (Government regulation no. 77/2001)	Transfer authority to district government Support of the fiscal resources of district government	Presidential Decree 1/9/1999; Irrigation Management should Transfer in Gradual Manner, and, Coordination Team from 9 Ministers in Concern of O&M Infrastructure Law 22/1999; Role of Provincial Dinas and Cabang Dinas in Irrigation Management at District Level Law 25/1999; Fiscal Balance Central to Regional Government	Expected consequence: revitalised capacity of local community	Seemingly increased support of districts government to agricultural sector development
	Integrated approach to river basin management (2004-....)	Objective: development of legal framework Rational: cross sector management of water resources	Water law no. 7/2004: development of river basin organisation		Government regulation PP No. 77/2001; Empowering Local community in irrigation management Water law No. 7/2004; Integrated Water Resources Management Government regulatio No. 20/2006; Government Rules for Irrigation	Redefinition of multi-stakeholders' roles in water mangement Development of water rights	

Source: (Pasandaran, 2004)

A.4. Proposed indicators to assess irrigation system performance

No.	Researchers	Study site	Performance measures
1	Mishra, A., et. al., 2010	Minor irrigation	**Irrigation service measure:** Adequacy/sufficiency of irrigation water to meet crop water requirement Point of delivery of water Stream size of water/outlet stram size Timing of irrigation water supply Equity of water distribution among farmers per ha cultivated land Sufficiency in duration of irrigation water supply Frequency of irrigation water supply Prior knowledge/awareness about water delivery schedules Management decisions on cultivation practice based on irrigation water supply Certainty of irrigation water availability Performance of the canal system to cater for the irrigation requirement
2	Ulhaq, Asrar, 2010	84 WUAs, Punjab, Pakistan	**WUAs performance indicators:** Organisational development Irrigation service delivery (operation and regulation of channels, monitoring of recording of water delivery of cahannels and outlets to maintain equity) Management of physical condition of distributary - O&M of channels/works Dispute resolution and disposal of water theft and canal revenue cases Water charges (abiana) assessment and collection
3	Frija, Aymen, et. al., 2009	WUAs, Tunisia	Efficiency assessment with Data Envelopment Analysis (DEA) and Tobit Model
4	Kuscu, Hayrettin, et. al., 2009	Bursa-Karacabey	**Performance indicators:** Physical performance: the rate of irrigation, relative water supply Financial performance: the effectiveness of fee collection, financial sel-sufficiency, staffing number per unit area
5	Latif, Muhammad & Javaid A. Tariq, 2009	6 distributaries and	Relative water supply (RWS) Water delivery capacity (WDC) Delivery performance ratio (DPR) and reliability (PD) Cropping pattern and intensities, crop yields and cost recovery (ISF collection rate)
6	Le Grusse, et. al., 2009	2 farms at Gharb, Morocco and 2 farms at the Mitidja Plain, Algeria	Hydraulic performance indicators (results, objective, and environmental impact indicator) Agricultural performance indicators (results, objective, and environmental impact indicator) Economic performance indicators (results, objective, and environmental impact indicator)
7	Yercan, et.al., 2009	13 WUA and 38 cooperatives in Gediz River basin, Turkey	**Comparative performance indicators** (comparison of irrigation performance between WUA and cooperation): fee allocation rate, cost recovery, attendance at general meeting, irrigation intensity, personnel intensity
8	Kuscu, Hayrettin, et. al., 2008	Bursa-Mustafakemalpasa	Hydraulic performance indicators: Adequacy of irrigation water supplied to the farm Fairness of water distribution within the system Frequency of water distribution conflicts Timeliness of water delivery to the farm Irrigation fee policy Maintenance of irrigation canals Maintenance of drainage canals Maintenance of water control and distribution structures
9	Koc, 2007	4 irrigation schemes at Great Menderes Basin, Turkey	**Financial performance of WUA:** TIC = Irrigated area managed per person (ha/pers) TCW = Cost per person employed water delivery (US$/pers) TMC = MOM cost per unit irrigation area RCP = Fee collection performance (%) SRP = Secondary revenue performance (%) ARW = Average MOM revenue per unit irrigation water supplied ACW = Average MOM cost per unit irrigation water supplied (Cent/m3) FSS = Financial self sufficiency (ratio) PCR = Personnel cost to total MOM revenue ratio (%) PCC = Personnel cost to total MOM cost ratio (%) MCR = Maintenance cost to total MOM revenue ratio (%) MCC = Maintenance cost to total MOM cost ratio (%)
10	Olubode-Awosola, O.O., et. al., 2006	The Itoikin and Sepeteri irrigation project, Nigeria	Performance: Fee collection index: fee collection index, user's stake index Relative water cost and profit index: relative water cost index, relative irrigation profit index, Financial self-sufficiency index
11	Polge, Marc, et. al., 2006	France	AFEID (Association Français por l'Etude de l'Irrigation et du Drainage) benchmarking indicators: 9 financial indicators 2 indicators relating to organisational aspects 9 indicators relating to users satisfaction 19 technical indicators
12	Diaz, J.A. Rodriguez, et. al., 2005	5 irrigation districts in Andalusia, Spain	DEA (data envelopment analysis) technique and IPTRID performance indicators **Water delivery performance:** Total annual volume of irrigation water delivery (m3) Total annual volume of irrigation water supply (m3) Total annual volume of water supply (m3) Annual irrigation water supply per unit command area (m3/ha) Annual irrigation water supply per unit irrigated area (m3/ha) Main system water delivery efficiency Annual relative water supply Annual relative irrigation water supply Water delivery capacity Security of entitlement supply (%) Submergence of drainage outlet
12	Diaz, J.A. Rodriguez, et. al., 2005 (continue)	5 irrigation districts in Andalusia, Spain	**Financial performance indicators:** Cost recovery ratio Maintenance cost to revenue ratio Total MOM cost per unit area (€/ha) Total cost per person employed on water delivery (€/person) Revenue collection performance Staffing numbers per unit area (person/ha) Average revenue per cubic metre of irrigation water supplied (€/m3) Total MOM cost per unit volume supplied (€/ha) **Productive efficiency indicators:** Total annual value of agricultural production (€) Output per unit command area (€/ha) Output per unit irrigated area (€/ha) Output per unit irrigation delivery (€/m3) Output per unit irrigation supply (€/m3) Output per unit water supply (€/m3) Output per unit crop water demand (€/m3)
13	Diaz, J.A. Rodriguez, et. al., 2005	Andalusia, Spain	Computer application of IGRA (Irrigation Performance Indicator Application) **System operation:** Total annual volume of irrigation water delivered (m3) Total annual volume of irrigation water supply (m3) Total annual volume of water supply (m3) Annual irrigation water supply per unit command area (m3/ha) Annual irrigation water supply per unit irrigated area (m3/ha) Main system water delivery efficiency Annual relative water supply Annual relative irrigation water supply Water delivery capacity Security of entitlement supply (%) Submergence of drainage outlet Total annual volume of drainage water removal (m3/yr, m3/ha) **Financial indicators:** Cost recovery ratio Maintenance cost to revenue ratio Total MOM cost per unit area (€/ha) Total cost per person employed on water delivery (€/person) Revenue collection performance Staffing numbers per unit area (person/ha) Average revenue per cubic metre of irrigation water supplied (€/m3) Total MOM cost per unit volume supplied (€/ha) **Productive efficiency:** Total gross annual agricultural production (t) Total annual value of agricultural production (€) Output per unit command area (€/ha) Output per unit irrigated area (€/ha) Output per unit irrigation delivery (€/m3) Output per unit irrigation supply (€/m3) Output per unit water supply (€/m3) Output per unit crop water demand (€/m3) **Environmental performance:** Salinity of irrigation water (dS/m) Salinity of drainage water (dS/m) Water quality (irrigation, drainage): chemical (mg/l) Average depth to watertable (m) COD of irrigation water (mg/l) BOD of irrigation water (mg/l) COD of drainage water (mg/l) BOD of drainage water (mg/l) Change in water table depth over time (m) Salt balance (t)
14	Ghosh, Souvik, et. al., 2005	Nimapara branch canal, Puri Main Canal Irrigation System of Mahanadi Delta Irrigation Project, Orissa, India	Water delivery service measure: Tractability: quantity of water supply, point of water delivery, stream size, Convinience: timing of water arrival, flow rate of water, duration of water supply, frequency of getting water Predictability: knowledge of futur water supply, management decisions influenced by water supply, certainty of water availability
15	Gorantiwar, S. D. & I. K. Smout, 2005	-	Performance measures: Allocative measures: Productivity: gross, relative to input used Equity: resources to be targeted, base, parameter for measurement Scheduling measures: Adequacy: area basis, system capacity basis Reliability Flexibility: type, magnitude, sequence, level Sustainability: crop occupancy, irrigated area, groundwater rise, groundwater fall, problematic area Efficiency: application, distribution, conveyance
16	Smout, I.K, & S.D. Gorantiwar, 2005	Nazare medium Irrigation Scheme, India	AWAM (Area and Water Allocation Model): Area productivity, monetary productivity, equity, adequacy, excess
17	Vos, Jeroen, 2005	Large irrigation system of Chancay-Lambayeque, Peru	**Water delivery performance:** Relative water supply (RWS) Delivery performance ratio (DPR) and reliability (PD) **Management:** Skills of operators Organisational structure results in high accountability by pressure from the users Mutual control of the users in the tertiary block
18	Alexander, Peter J. & mathew O. Potter, 2004	40 water provider system, Australia	Key industry performance indicators: System operation (12 indicators) Environmental issues (14 indicators) Business processes (25 indicators) Financial (14 indicators)

A.4. Proposed indicators to assess irrigation system performance (continue)

No.	Researchers	Study site	Performance measures
19	Burt, Charles M., & Stuart W. Styles, 2004	-	Rapid Appraisal Process (RAP). **External indicators:** Total annual volume of irrigation water available at the user level Total annual volume of irrigation supply into the three-dimensional boundaries of the command area Total annual volume of irrigation water managed by authorities Total annual volume of water supply Total annual volume of irrigation water delivered to users by project authorities Total annual volume of groundwater pumped within/to the command area Total annual volume of field Etc in irrigated fields Peak net irrigation water Etc requirements Annual relative irrigation supply (RIS) Annual relative water supply (RWS) Command area irrigation efficiency (IE) Water delivery capacity
20	Cakmak, et. al., 2004	6 irrigation schemes in the DSI 10th Region, Turkey	Annual irrigation water delivery per unit command area (WDCA) (m3/ha) Annual irrigation water delivery per unit irrigated area (WDIA) (m3/ha) Annual relative water supply (RWS) Total MOM cost per unit area (US$/ha) Water fee collection performance Staffing numbers per unit area (person/ha) Output per unit service area (US$/ha) Output per unit irrigated area (US$/ha) Output per unit irrigation supply (US$/m3) Output per unit water consumed (US$/m3)
21	Ghazalli, Mohd. Azhari, 2004	8 granary schemes, Malaysia	**Service delivery performance** Total annual water delivery (MCM) Main system water delivery efficiency Relative water supply Relative irrigation supply Water delivery capacity System water supply (m3/s) Security of supply (%) **Financial performance:** Total cost recovery ratio Maintenance cost to revenue ratio Operating cost per unit area (US$/ha) Total cost per person employed (US$/person) Revenue collection performance Staffing numbers (person/ha) $/MCM **Production performance:** Gross agricultural production (t) Total value of agricultural output (M US$) Output per unit command area (US$/ha) Output per cropped area (US$/ha) Output per unit irrigation supply (US$/m3) Output per unit water consumed (US$/m3)
22	Jayatillake, H. M., 2004	Sri Lanka	Comparative assessment indicators: Annual cropping intensity Length of irrigation season demand Irrigation duty Water duty
23	Malano, et. al., 2004	-	**Service delivery performance:** Total annual volume of irrigation water delivery (m3/yr) Annual irrigation water delivery per unit irrigated area (m3/ha) Main system water delivery efficiency Annual relative water supply Annual relative irrigation supply Water delivery capacity Security of entitlement supply Total annual volume of drainage water removal (m3/yr, m3/ha) Total annual volume of drainage water treatment for reuse (m3/yr, m3/ha) Drainage ratio **Financial:** Cost recovery ratio Maintenance cost to revenue ratio Total MOM cost per unit area (US$/ha) Total cost per person employed on water delivery (US$/person) Revenue collection performance Staffing numbers per unit area (person/ha) Average revenue per cubic metre of irrigation water supplied (US$/m3) **Productive efficiency:** Total gross annual agricultural production (t) Total annual value of agricultural production (US$) Output per unit service area (US$/ha) Output per unit irrigated area (US$/ha) Output per unit irrigation supply (US$/m3) Output per unit water consumed (US$/m3) **Environmental performance:** Water quality (irrigation, drainage): salinity (mmhos/cm) Water quality (irrigation, drainage): biological (mg/l) Water quality (irrigation, drainage): chemical (mg/l) Average depth to groundwater (m) Change in water table over time (m) Salt balance (t)
24	Sodal, S. V., 2004	6 basin in Maharashtra, India	Performance evaluation parameters: Irrigation potential created and utilised Seasonwide and total annual irrigated area Water use efficiency Recovery of irrigation water charges Crop yields Socio-economic
25	Plantey, Jaques & Brunno Molle, 2003	Canal du Provence, France	**Water balance performance assessment:** Conveyance and distribution efficiency ratio Water delivery performance (line utilisation factor, network utilisation index) **Maintenance performance assessment:** **Environment performance assessment:** Water quality Compliance with environmental regulations Safety
25	Plantey, Jaques & Brunno Molle, 2003 (continue)	Canal du Provence, France	**Commercial performance assessment:** Satisfaction of customers Economic performance assessment Profitability of water delivered Cost-effectiveness of performance assessment
26	Sagardoy, J. A., 2003	4 large irrigation schemes, Mediterranean region	**System operation objectives and related indicators:** Reducing the losses of the irrigation system (2 indicators) Satisfying 100% of crop irrigation requirements (2 indicators) Distribute the water timely Measure the water delivered accurately (2 indicators) **Financial objectives and related indicators:** Achieving 100% of fee collection (2 indicators) Obtaining full acceptance of proposed budgets (2 indicators) Reducing the impact of O&M costs in the farmers benefit (2 indicators) **Maintanance objectives and related indicators:** To ensure that planned repairs are executed (3 indicators) **Management objectives and related indicators:** Having staff technically well prepared and motivated to undertake their job responsibilities (3 indicators)
27	Mainuddin, M., et. al., 2000	Phitsanulok irrigation System, Thailand	Key performance: Water distribution performance Agricultural performance Plan-implementation performance
28	Molden, David & R. Sakthivadivel, 1999	The Nile River, Egypt and A cascade tank in Sri Lanka	Indicators: Depleted fraction: of gross inflow, of available water Process fraction: of gross inflow, of available water, of depleted water Gross value of crop production ($) Gross value of crop production per gross inflow ($/m3) Available water ($/m3) Process consumed water ($/m3)
29	Sakthivadivel, R., et. al., 1999	Burkina Faso, Colombia, Egypt, India, Malaysia, Mexico, Nepal, Niger, Pakistan, Sri Lanka, Turkey & USA	**Comparative performance indicators:** Output per cropped area (US$/ha) Output per unit command (US$/ha) Output per unit irrigation supply (US$/m3) Output per unit water consumed (US$/m3) SGVP: the standardised gross value of production
30	Samad, Madar & Douglas L. Vermillion, 1999	Sri Lanka	**Financial performance indicators:** Annual operations and maintenance cost per hectare to government Irrigation cash costs per hectare to farmers Value of family labour contributions for canal maintenance Total irrigation costs per hectare to farmers farmer perceptions of changes in irrigation costs: **Operational performance indicators:** Relative irrigation water supply Relative total water supply Farmers perceptions about adequacy, timeliness and equity of water supply **Maintenance performance indicators:** Percentage of sample canal lengths with critical and noticeable defects after transfer Percentage of structures that are fully functional, partly functional, and dysfunctional after transfer Cost to repair dysfunctional structures relative to the annual average budget Farmer perceptions about canal conditions before and after transfer **Agricultural performance indicators:** Annual/seasonal cropping intensity Yield of major crop by season Farmers perceptions of changes in rice yield **Economic performance indicators:** Standardise gross value of output per hectare Standardise gross value of output per unit of water diverted
31	Johnson, Svendsen & Zhang, 1998	Bayi ID & Nanyao ID, China	Performance impacts of rural reforms: financial sustainability (irrigation fee collection rates, total collection), hydrologic efficiency (share of water, output per unit of water), and agronomic changes (yields)
32	Makombe, et. al., 1998	12 small holder irrigation schemes in Zimbabwe	Managerial ability to supply the required water to meet the crop water requirements
33	Bos, 1997	-	Indicators used in the Research Program on Irrigation Performance (RPIP)/40 multi-disciplinary performance indicators: **The agreed service level:** agreed service level **General features of performance indicators:** performance indicators level **Water balance indicators:** water delivery performance, water balance ratio (field application ratio, tertiary unit ratio, overall consumed ratio), conveyance ratio, distribution ratio, dependability (dependability of duration, dependability of irrigation interval) **Environmental sustainability and drainage:** sustainability of irrigation, depth of groundwater, pollution of water, salinity, organic matter, biological pollution, chemicals **Maintenance indicators:** sustainability of water level and head-discharge relationship (relative change of water level, discharge ratio, effectivity of infrastructure) **Socio-economic performance:** economic viability (financial self sufficiency, O&M fraction, fee collection performance), profitability of irrigated agriculture (yields vs. water cost ratio, yields vs. water supply ratio,relative water cost), social capacity (technical knowledge staff, users stake in irrigation system)
34	Svendsen & Small, 1990	-	Depth-related measures: adequacy, equity, timeliness Farm management-related measures: tractability, convinience, predictability Water quality-related measures: temperature, sediment content, salt content, nutrient content, toxics, pathogens

A.5. Summary of performance assessment proposed by experts

Performance measures						
Operational/water	**Physical**	**Productivity/agricultural**	**Financial/economic/comm**	**Environmental**	**WUAaccountability &**	**Sustainability**
Depth-related measures: adequacy, equity, timeliness	Performance of the canal system to cater for the irrigation requirement	Irrigation potential created and utilised	TIC = Irrigated area managed per person (ha/person)	Water quality (irrigation, drainage): salinity (mmhos/cm)/(dS/m)	Organisational development	**System operation sustainability:**
Farm management-related measures: tractability, convinience, predictability	Maintenance of water control and distribution structures (Maintenance of irrigation canals &	Length of irrigation season demand	Staffing numbers (person/ha)/Staffing numbers per unit area (person/ha)	Water quality (irrigation, drainage): biological/BOD (mg/l)	Irrigation service delivery (operation and regulation of channels, monitoring of recording of water delivery of channels and outlets to maintain equity)	Reducing the losses of the irrigation system
Water quality-related measures: temperature, sediment content, salt content, nutrient content, toxics, pathogens	Maintenance of drainage canals)	Irrigation duty	Total cost per person employed (US$/person)	Water quality (irrigation, drainage): chemical/COD (mg/l)	Management of physical condition of distributary - O&M of channels/works	Satisfying 100% of crop irrigation requirements
Tractability: quantity, point of water delivery, stream size,	Submergence of drainage outlet	Water duty	TCW = (Total) Cost per person employed on water delivery (US$/person)	Average depth to groundwater/watertable (m)	Dispute resolution and disposal of water theft and canal revenue cases	Measure the water delivered accurately
Convinience: timing/timeliness of water arrival, flow rate of water,	Percentage of sample canal lengths with critical and noticeable defects after	Cropping pattern and intensities	TMC = MOM cost per unit irrigation area/Total MOM cost per unit area (US$/ha)	Change in water table (depth) over time (m)	Water charges assessment and collection	**Financial Sustainability:**
Predictability: knowledge of future water supply/water delivery schedules, management decisions influenced by water supply, certainty of water availability	Percentage of structures that are fully functional, partly functional, and dysfunctional after transfer	Annual/seasonal cropping intensity	Total MOM cost per unit volume supplied (€/ha)	Salt balance (t)	Frequency of water distribution conflicts	Annual operations and maintenance cost per hectare to government
Equity/fairness: Equity of water distribution among farmers per ha cultivated land, resources to be	Cost to repair dysfunctional structures relative to the annual average budget	Crop yields	Operating cost per unit area (US$/ha)	Compliance with environmental regulations	Skills of operators (Having staff technically well prepared and motivated to undertake their job	Irrigation cash costs per hectare to farmers
Adequacy/sufficiency in duration of irrigation water supply: area basis, system capacity basis	sustainability of water level and head-discharge relationship (relative change of water level, discharge ratio, effectivity of infrastructure)	Yield of major crop by season	Output per unit service area (US$/ha)	Safety	Organisational structure results in high accountability by pressure from the users	Value of family labour contributions for canal maintenance
Reliability:	**(Farmer perceptions about canal conditions**	Productivity: gross, relative to input used	Output per unit irrigated area (US$/ha)		Mutual control of the users in the tertiary block	Total irrigation costs per hectare to farmers
Flexibility: type, magnitude, sequence, level		Area productivity, monetary productivity, equity,	Output per unit irrigation supply (US$/m3)		Management decisions on cultivation practice based on	Farmer perceptions of changes in irrigation costs:
Sustainability: crop occupancy, irrigated area, groundwater rise, groundwater fall, problematic area		Available water ($/m3)	Output per unit water consumed (US$/m3)		Irrigation fee policy	Reducing the impact of O&M costs in the farmers benefit
Efficiency: application, distribution, conveyance		Process consumed water ($/m3)	Average revenue per cubic metre of irrigation water supplied (€/m3)			**Socio-economic sustainability:**
Depleted fraction: of gross inflow, of available water		Output per unit command area (€/ha)	ARW = Average MOM revenue per unit irrigation water supplied			Ecconomic viability (financial self sufficiency, O&M fraction, fee collection performance), Profitability of irrigated agriculture (yields vs. water cost ratio, yields vs. water supply ratio, relative water cost), social capacity (technical knowledge staff, users stake in irrigation system)

A.5. Summary of performance assessment proposed by experts (continue)

			Performance measures			
Operational/water	**Physical**	**Productivity/agricultural**	**Financial/economic/comm**	**Environmental**	**WUAaccountability &**	**Sustainability**
Process fraction: of gross inflow, of available water, of depleted water		Output per unit irrigated area (€/ha)/Output per unit service area (US$/ha)	ACW = Average MOM cost per unit irrigation water supplied (Cent/m3)			**Economic sustainability:**
		Output per unit irrigation delivery (€/m3)	SRP = Secondary revenue performance (%)			Standardise gross value of output per hectare
Seasonwide and total annual irrigated area		Output per unit irrigation supply (€/m3)	FSS = Financial self sufficiency (ratio)			Standardise gross value of output per unit of water diverted
(Annual) Relative water supply (RWS)		Output per unit water supply (€/m3)	PCR = Personnel cost to total MOM revenue ratio (%)			Performance impacts of rural reforms: financial sustainability (irrigation fee collection rates, total collection), hydrologic efficiency (share of water, output per unit of water), and agronomic changes (yields)
Annual relative irrigation water supply/Annual relative irrigation supply (RIS)		Output per unit crop water demand (€/m3)	PCC = Personnel cost to total MOM cost ratio (%)			Managerial ability to supply the required water to meet the crop water requirements
Annual irrigation water supply per unit command area (m3/ha)/Annual irrigation water delivery per unit command area (WDCA) (m3/ha)		Output per unit water consumed (US$/m3)	MCR = Maintenance cost to total MOM revenue ratio (%)/Maintenance cost to revenue ratio			**Environmental sustainability and drainage:**
Annual irrigation water supply per unit irrigated area (m3/ha)/Annual irrigation water delivery per unit irrigated area (WDIA) (m3/ha)		Output per cropped area (US$/ha)	MCC = Maintenance cost to total MOM cost ratio (%)			Sustainability of irrigation, depth of groundwater, pollution of water, salinity, organic matter, biological pollution, chemicals
Total annual volume of irrigation water delivery (m3)		Total gross annual agricultural production (t)/Gross agricultural production (t)	Cost recovery ratio/Total cost recovery ratio			**Sustainability**: crop occupancy, irrigated area, groundwater rise, groundwater fall, problematic area
Total annual volume of irrigation water supply (m3)/Total annual volume of irrigation water delivery (m3/yr)		Gross value of crop production ($)	Maintenance cost to revenue ratio			
Total annual volume of water supply (m3)/ Total annual water delivery (MCM)		Gross value of crop production per gross inflow ($/m3)	RCP = Fee collection performance (%)/Revenue collection performance/Water fee collection performance/Recovery of irrigation water charges/ISF collection rate/the effectiveness of fee collection			
Total annual volume of drainage water removal (m3/yr, m3/ha)		Total annual value of agricultural production (€)/Total value of agricultural output (M US$)	Fee collection index: fee collection index, user's stake index			
Total annual volume of irrigation water available at the user level		SGVP: the standardised gross value of production	Relative water cost and profit index: relative water cost index, relative irrigation profit index,			
Total annual volume of irrigation supply into the three-dimensional boundaries of the command area		Cost recovery (ISF collection rate)	Financial self-sufficiency index			
Total annual volume of irrigation water managed by authorities		**(Farmers perceptions of yield)**	**Commercial performance assessment:**			
Total annual volume of water supply			Satisfaction of customers			
Total annual volume of irrigation water delivered to users by project authorities			Profitability of water delivered			
Total annual volume of groundwater pumped within/to the command area			Cost-effectiveness of performance assessment			

A.5. Summary of performance assessment proposed by experts (continue)

Performance measures						
Operational/water	**Physical**	**Productivity/agricultural**	**Financial/economic/comm**	**Environmental**	**WUAaccountability &**	**Sustainability**
Total annual volume of field Etc in irrigated fields			**Socio-economic performance:**			
Total annual volume of drainage water treatment for reuse (m3/yr, m3/ha)			Ecconomic viability (financial self sufficiency, O&M fraction, fee collection performance), Profitability of irrigated agriculture (yields vs. water cost ratio, yields vs. water supply ratio, relative water cost), social capacity (technical knowledge staff, users stake in irrigation system)			
System water supply (m3/s)			**Economic performance indicators:**			
Peak net irrigation water Etc requirements			Standardise gross value of output per hectare			
Water delivery capacity (WDC)			Standardise gross value of output per unit of water diverted			
Main system water delivery efficiency			Performance impacts of rural reforms: financial sustainability (irrigation fee collection rates, total collection), hydrologic efficiency (share of water, output per unit of water), and agronomic changes (yields)			
Command area irrigation efficiency (IE)			Managerial ability to supply the required water to meet the crop water requirements			
Water use efficiency			(MOM = management, operation, and maintenance)			
Security of entitlement supply (%)/Security of supply (%)						
Delivery performance ratio (DPR) and reliability (PD)						
Drainage ratio						
Conveyance and distribution efficiency ratio						
Water delivery performance (line utilisation factor, network utilisation index)						
water delivery performance, water balance ratio (field application ratio, tertiary unit ratio, overall consumed ratio), conveyance ratio, distribution ratio, dependability (dependability of duration, dependability of irrigation interval)						
(Farmers perceptions about adequacy, timeliness and equity of water supply)						

Operational Performance Indicators

Operational performance indicators specifically specify the required level of service and to then determine the sustainability issues by measuring the current levels which are, or could be, provided by the assets (assuming there are no management constraints). The following information has to be gathered to determine the level of service that should be retained:

- population at risk of water shortage
- population at risk of low water pressure
- properties subject to unplanned supply interruptions
- population subject to canal bans

Fundamental normative indicators of irrigation performance differentiate the operational performance into: service quality (operational) and water quality (environment) performance indicators. Service quality performance indicators consist of depth-related measures (adequacy, equity, and timeliness) and farm management-related measures (tractability, convenience, and predictability). While, water quality performance indicators is dealing with water quality-related measures such as temperature, sediment content, salt content, nutrient content, toxics and pathogens).

The differentiation in service quality performance of irrigation and drainage, as described by Malano and Van Hofwegen (1999), is shown in Table A.5.1.

Table A.5.1. Service quality of irrigation and drainage

Service quality	Irrigation	Drainage
Adequacy	Ability to meet water demand for optimum plant growth	The ability to dispose excess water in minimal time to prevent damage
Reliability	Confidence in supply of water	Confidence in ability to dispose excess water
Equity	Fair distribution of share of water shortage risks	Fair distribution of inundation risks
Flexibility	Ability to choose the frequency, rate, and duration of supply	Ability to choose the time, rate, and duration of disposal

(Source: Malano and Van Hofwegen, 1999)

Maintenance Performance Indicators

Maintenance performance assesses the functional condition of the asset. Brewer and Sakthivadivel as cited from Madramoto, Lee, and Gopalakrishnan (2009) define the maintenance performance of minor channels as keeping the channels and structures in good enough physical condition to provide the desired service. Deterioration of irrigation systems will almost inevitably affect the most vulnerable users of the system.

To assess the condition of canal reach and structure performance, they proposed the criteria below to be applied:

a. Functional; A functional asset/structure is defined as one that can currently perform its basic design function and shows no signs of losing this capacity within the next year,
b. Nearly dysfunctional; A nearly dysfunctional structure is one that is considered likely to become unable to perform its basic function within the next year, and,
c. Dysfunctional; a dysfunctional structure is one that is unable to perform its basic function at the time of inspection.

In addition to applying the condition criteria of assets described above, a scale of criteria ratings can also be applied (Malano, Chien and Turral,1999 and Malano, George and Davidson, 2005). Assigning a scale to the condition of the assets provides a quick guide as to their condition. Table A5.2. outlines a sample quantitative condition rating for public irrigation assets.

Table A.5.2. Asset condition scale

Condition rating	Asset condition	Description	Expected residual life (year) (e.g. for a pipe line)
1	Excellent	Only normal maintenance required	> 50
2	Good, minor defects only	Minor maintenance required (5%)	20 – 50
3	Average, backlog maintenance required	Significant maintenance required	6 - 20
4	Fair, requires major renewal	Significant renewal/upgrade required	2 - 5
5	Poor, imminent failure	Over 50% of the asset requires replacement	< 1
6	Unserviceable, asset failed	Total replacement required	Zero residual life

(Source: Malan, Chien and Turral, 1999)

Within an irrigation system, some assets are more important or critical than others. This depends on the level of service of an asset and the cost of correcting preventable damage. Assigning an importance factor (IF) to each asset provides an indication of its relative importance and the consequence of its failure. The IF rating assists in determining prioritisation strategy for maintenance or replacement of assets. An example ratings system is shown in Table A.5.3:

Table A.5.3. Criteria for assessing asset importance

Importance factor	Effect of failure of asset
Highest (4 – 5)	Immediate and unacceptable impact on the levels of service, or
	The large number of farmers affected, or
	Results in considerable cost to the water service agency, or
	Affects the productivity/yields, or
	Affects the safety of water service agency staff or the community.
Middle (2 – 3)	Probably has an adverse effect on the levels of service, or
	Medium number of farmers affected, or
	Likely to cause long-term problems which are costly to rectify, or
	Potentially affects the productivity/yields, or
	Potentially unsafe conditions may result for water service agency staff or the community
Lowest (0 – 1)	Probably will not adversely affect the levels of service, or
	A small number of farmers affected, or
	Cause minor cost to the water service agency, or
	Unlikely to affect the productivity/yields, or
	Unlikely to affect the safety of water service agency staff or the community
Within each rating level, the following factors may influence the importance of an asset: • Fields damage, • Effect on productivity and essential service, • Damage to other utilities, and • Routing disruption	

Source: Queensland Government (2001)

The Institute of Irrigation Studies (IIS) differentiates between the general condition of an asset and its ability to perform its function (serviceability).

Table A.5.4. The criteria for condition grades and serviceability grades of asset

Asset type		Functions to be assessed	Components to Check	Condition & Serviceability
GROUP 1 – WATER CAPTURE	Weir	HYDRAULICS - Provide level - Pass offtake design flow - Pass design flood OPERATIONS - Gates - Gauge	Weir wall Dividing walls Abutments Crest Apron Sluice gate Offtake gates Stilling basin Superstructures	**The condition grades definition:** 1. GOOD: Generally sound with no deformation or damage. Well maintain with little or no signs of deterioration. 2. FAIR: Generally sound but with some degradation or damage. Needing maintenance attention. 3. POOR: Significant deterioration requiring urgent corrective work. 4. BAD: Serious problems requiring partial or complete replacement. **Serviceability** is measured by reference to two functional criteria: 1. Hydraulic function : This will normally be 'to pass the design flow safely' and, 2. Operations function : (where appropriate) 'to control flow across the required range' OR 'to control command (level) across the required range' AND/OR 'to allow measurement of flow' **The four serviceability grades:** 1. FULLY FUNCTIONAL Apparently properly designed and constructed with capacity to pass the design flow safely AND (where appropriate) fully capable of being operated to control flow (OR command) across the desired range AND (where appropriate) facilitating measurement of flow by means of its own components or an adjacent measuring structure. Performance is unaffected by silt or debris. 2. MINOR FUNCTIONAL SHORTCOMING Normally able to pass the required flows and capable (where appropriate) of being operated to control flow (OR command) in a measured manner but performance likely to be unsatisfactory under extreme conditions of demand or climate. Deficiencies may be due to design or construction inadequacies, insufficient maintenance, measuring devices which are difficult to read or due to the presence of silt and/or debris. 3. SERIOUSLY REDUCED FUNCTIONALITY One or more of the defined functions seriously impaired through deficiencies in design, construction or maintenance, or due to the presence of silt and/or debris. (Likely to have a significant detrimental effect on system performance). 4. CEASED TO FUNCTION Complete loss of one or more functions or serious reduction of all functions of the asset for whatever reason.
	Dams & impounding			
	Groundwater abstraction wells			
GROUP 2 – CONVEYANCE	Canal	HYDRAULICS - Pass design flow OPERATIONS - n/a	Embankment Side slopes (note type) Bed Conveyance	
	Hydraulic structure	HYDRAULICS - Pass design flow OPERATIONS - n/a	Support structure u/s wingwalls d/s wingwalls Stilling basin Structure	
	Supplementary structure	HYDRAULICS - Pass design flow OPERATIONS - n/a	Safety Other features	
GROUP 3 – OPERATIONS (CONTROL) FACILITIES	Head regulator	HYDRAULICS - Pass design flow OPERATIONS - Control flow - Gauge	Gate(s) Structure Notice board Shelter	
	Cross regulator *options - Fixed crest - Gate(s) - flume	HYDRAULICS - Pass design flow OPERATIONS - Control command level - Gauge	Control section* structure Notice board u/s wingwalls d/s wingwalls Gauge(s) Shelter	
	Measuring structure	HYDRAULICS - Pass design flow OPERATIONS - Measure flow	Control section Gauges structure Notice board u/s wingwalls d/s wingwalls Stilling box	
GROUP 4 – MANAGEMENT & GENERAL	Access road	OPERATIONS - access to system	Structure Surface Drains	
	Offices & laboratories Depots & workshops Field officers quarters Vehicle & plant Information technology			

(Source: IIS, 1995).

From the completion of asset construction, deterioration begins and the condition will degrade until depreciation life is reached and replacement is necessary. The condition of an asset can be valued using the Modern Equivalent Asset (MEA) measure to give an indication of the likely cost associated with restoration.

Agricultural, Financial and Economic Performance Indicators

According to Intizar (2007), there is a direct benefit, indirect benefit, overall benefit, and added value benefit of irrigation. Benefits include:

- irrigation-induced crop intensification and diversification towards high-value crops leading to increased crop productivity and overall crop production,
- non-crop farms and non-farm uses of water including non-consumptive uses of water supplied by irrigation infrastructure,
- improved employment opportunities and higher wage rates,
- improved incomes and expenditures, and enhanced food security,
- social benefits such as improved health and education,
- expansion in economic activities in related sectors resulting in overall improved growth of regional and national economics.

The direct productivity-related benefits are derived from the increase in average crop yield, ability to increase cropping intensity (the number of crops per year per unit of land), and reduced climatic risk, which make investments in other inputs more profitable and allow selection of higher-yielding over drought-tolerant crop varieties. According to Shahbaz, M., Shahbaz, K., and Mohsin (2009), a range of factors that can influence the net productivity benefits of irrigation:

a. Farm-level:
    - crop yield differences, differences in production methods and technologies,
    - land quality, types of cropping patterns, and degree of diversification towards high-value crops and other farm enterprise, and
    - farmer access to support measures such as information, input and output marketing.
b. System-level: condition of irrigation infrastructure and its management/maintenance, irrigation water allocation and distribution procedures and practices, and related institutions.

c. Policy: policies that influences land distribution patterns (equitable/inequitable) and the size of farms, and broader agricultural policies that influence access to agricultural support services and diversification of farm enterprises

Since it is not easy to assess the indirect benefit, overall benefit and added value benefit of irrigation, the performance assessment generally focuses on the direct benefits of irrigation i.e., agricultural productivity. Le Grusse *et al.* (2009) discussed the value of this indicator as total gross annual agricultural production (tonnes), total annual value of agricultural production (US$), output per unit of serviced area (US$/ha), output per unit of irrigated area (US$/ha), and output per unit of water consumed (US$/m^3).

Water User Associations (WUAs) Organisation and Accountability Indicators

Generally, farmers wish to work their fields rather than volunteer labour to maintain irrigation infrastructure. The turnover policy means that government personnel no longer have roles or authority in controlling water resources. The rule 'he who benefits must take responsibility for management and make investment' ensures that farmers are actively involved in managing and maintaining (minor) irrigation infrastructures.

The impacts of turnover that need to be examined are financial sustainability, hydrological efficiency, and economic changes under the WUA management. WUAs as business organisations/enterprises are able to use profits from sideline enterprises to maintain financial stability and to cover their costs in the face of constantly increasing expenditure, by actively exploring alternative revenue avenues. A primary task faced by WUA boards regarding hydrological performance is to match the area to be irrigated with the available water supply.

According to Koç (2007), financial administration of management, operation, and maintenance (MOM) service in irrigation systems is one of the most important functions of a WUA. It takes into account the receipt, maintenance, expenditure, and account of the assets of a person, business, government department, irrigation association or group. Without rigorous MOM and financial management, WUAs cannot operate or maintain irrigation drainage systems. Appropriate financial management not only ensures the economic viability and sustainability of WUAs, but also establishes and maintains confidence in its members. Koç also found that financial autonomy increases the efficiency of management, operation, and maintenance in irrigation tasks.

According to Vermillion (1997), the aspects of financial performance that are most related to management transfer are the cost of irrigation to the government (government savings), the cost of irrigation to farmers, the level of management staff (often the largest MOM cost), the level of water charges and collection rates, budget solvency, and revenue sources. Table A.5.5 identifies the principal financial revenues and expenditure of WUAs:

Table A.5.5. Principal financial revenues and expenditure of WUAs

Financial revenues	Financial expenditure
Contribution of users for adherence to the association	Maintenance, repair, and functioning expenditure
Water selling	WUA management expenditure
Revenues from other activities that WUA is allowed to undertake	Refunding loans
Conceivable subventions	Eventual investments
Various incomes	Unexpected expenditure

Source: (Institute of Irrigation Studies - University of Southampton, 1995)

Financial performance evaluations of WUAs are required to improve their financial and management performance.

Sustainability Indicators

Irrigation today must address the current challenges of water scarcity or over-supply, salinity, modernisation, efficiency and environmental water management.

A.6. The indicators of IPTRID and RAP and Benchmarking

<table>
<tr><th rowspan="4">NO</th><th colspan="3">RAP</th><th colspan="3">IPTRID GUIDELINES</th></tr>
<tr><th>INDICATORS</th><th>UNIT</th><th>DEFINITION</th><th>INDICATORS</th><th>UNIT</th><th>DEFINITION</th></tr>
<tr><th colspan="3" rowspan="2">WATER BALANCE INDICATORS</th><th colspan="3">SERVICE DELIVERY PERFORMANCE</th></tr>
<tr><th colspan="3">(a). System operation</th></tr>
<tr><td>1</td><td>Total annual volume of irrigation water available at the user level</td><td>MCM</td><td>Total volume of irrigation water (surface plus ground) directly available to users, MCM - using stated conveyance efficiencies for surface and ground water supplies. It includes water delivered by project authorities as well as water pumped by the users themselves. Water users in this context describe the recipients of irrigation service, these may include single irrigators or groups or irrigators organized into water user groups. This value is used to estimate field irrigation efficiency; it is not used to estimate project irrigation efficiency.</td><td>Total annual volume of irrigation water delivery</td><td>MCM</td><td>Total volume of water delivered to water users over the irrigation/agriculture year. Water users in this context describe the recipients of irrigation service, these may include single irrigators or groups or irrigators organized into water user groups.</td></tr>
<tr><td>2</td><td>Total annual volume of irrigation supply into the 3-D boundaries of the command area</td><td>MCM</td><td>This is the irrigation water that is imported into the project boundaries, to include river diversions, reservoir discharges, and NET groundwater extraction from the aquifer. This value is used to estimate project irrigation efficiency; it is not used in the computation of field irrigation efficiency.</td><td>Total annual volume of irrigation supply</td><td>MCM</td><td>Total annual volume of water diverted or pumped for irrigation (not including diversion of internal drainage)</td></tr>
<tr><td>3</td><td>Total annual volume of irrigation water managed by authorities (including internal well and recirculation pumps operated by authorities) (can include recirculated water; but does not include any drainage or groundwater that is pumped by farmers)</td><td>MCM</td><td>This is the irrigation water that is imported into the project boundaries, plus any internal groundwater pumped by the authorities. The value is not used to compute any efficiencies, as some of the internal pumping may be recirculation of original source water. However, this is the volume of water that the project authorities administer, so it is used for the computations related to costs.</td><td>Total annual volume of water supply</td><td>MCM</td><td>Total volume of surface diversion into the scheme and net ground water abstarction for irrigation, plus total rainfall, excluding any recirculating internal drainage within the scheme.</td></tr>
<tr><td>4</td><td>Total annual volume of water supply</td><td>MCM</td><td>Total annual volume of surface water diverted and net groundwater abstraction, plus total rainfall, excluding any recirculating internal drainage within the scheme.</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>Total annual volume of irrigation water delivered to users by project authorities</td><td>MCM</td><td>Total volume of water delivered to water users by the authorities over the year that was directly supplied by project authority (including WUA) diversions or pumps. Water users in this context describe the recipients of irrigation service, these may include single irrigators or groups or irrigators organized into water user groups. This does not include farmer pumps or farmer drainage diversions.</td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>Total annual volume of ground water pumped within/to command area</td><td>MCM</td><td>Total annual volume of groundwater that is pumped by authorities or farmers that is dedicated to irrigated fields within the command area. This groundwater can originate outside of the command area.</td><td></td><td></td><td></td></tr>
<tr><td>7</td><td>Total annual volume of field ET in irrigated fields</td><td>MCM</td><td>Total annual volume of crop ET. This includes evaporation from the soil as well as transpiration from the crop. Depending upon how the user entered the data, this may include off-season soil evaporation.</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td>Total annual volume of (ET - effective precipitation)</td><td>MCM</td><td>The volume of evapotranspiration that must be supplied by irrigation water. Regardless of how one enters data for ET, above, if one follows the guidelines in this manual, one obtains the same final answer of (ET – effective ppt.) – which is the net irrigation requirement.</td><td></td><td></td><td></td></tr>
<tr><td>9</td><td>Peak net irrigation water requirement</td><td>MCM</td><td>The net peak daily irrigation requirement (ET – effective rainfall) for the command area, based on actual cropping patterns for this year. (CMS)</td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>Total command area of the system</td><td>ha</td><td>The physical hectares of fields in the project that that are provided with irrigation infrastructure and/or wells.</td><td></td><td></td><td></td></tr>
</table>

A.6. The indicators of IPTRID and RAP and Benchmarking (continue)

NO	RAP			IPTRID GUIDELINES		
	INDICATORS	UNIT	DEFINITION	INDICATORS	UNIT	DEFINITION
	WATER BALANCE INDICATORS			SERVICE DELIVERY PERFORMANCE (a). System operation		
9	Peak net irrigation water requirement	MCM	The net peak daily irrigation requirement (ET – effective rainfall) for the command area, based on actual cropping patterns for this year. (CMS)			
10	Total command area of the system	ha	The physical hectares of fields in the project that that are provided with irrigation infrastructure and/or wells.			
11	Irrigated area, including multiple cropping	ha	The hectares of cropped land that received irrigation. If a 1 hectare field has two irrigated crops per year, the reported irrigated area would be 2.0 hectares.			
12	Annual irrigation supply per unit command area	m^3/ha	$\frac{\text{Total annual volume of irrigation water supply into the command area}}{\text{Total command area of the system}}$	Annual irrigation water delivery per unit command area	m^3/ha	$\frac{\text{Total annual volume of irrigation supply}}{\text{Total command area of the system}}$
13	Annual irrigation supply per unit irrigated area	m^3/ha	$\frac{\text{Total annual volume of irrigation water supply}}{\text{Total annual irrigated crop area}}$	Annual irrigation water delivery per unit irrigated area	m^3/ha	$\frac{\text{Total annual volume of irrigation water supply}}{\text{Total annual irrigated crop area}}$
14	Conveyance efficiency of project-delivered water (weighted for internal and external, using values	%	$\frac{\text{Volume of irrigation water delivered by authorities}}{\text{Total annual volume of project authority irrigation supply}}$			
15	Estimated conveyance efficiency for project groundwater	%	$\frac{\text{Annual volume of project groundwater delivered to users}}{\text{Annual volume of groundwater pumped by authorities}} \times 100$			
16	Annual Relative Water Supply (RWS)	none	$\frac{\text{Total annual volume of water supply}}{\text{Total annual volume of field ET in irrigated field}}$	Annual relative water supply		$\frac{\text{Total annual volume of water supply}}{\text{Total annual volume of crop water demand}}$
17	Annual Relative Irrigation Supply (RIS)	none	$\frac{\text{Total annual volume of irrigation water supply into the 3D boundaries}}{\text{Total annual volume of ET} - \text{effective precipitation}}$	Annual relative irrigation supply		$\frac{\text{Total annual volume of irrigation supply}}{\text{Total annual volume of crop irrigation demand}}$
18	Water delivery capacity	none	$\frac{\text{Canal capacity to deliver water at system head}}{\text{Peak irrigation water ET requirement}}$	Water delivery capacity		$\frac{\text{Canal capacity to deliver water at system head}}{\text{Peak irrigation water consumptive demand}}$
19	Security of entitlement supply	%	The frequency with which the irrigation organization is capable of supplying the established system water entitlements.	Security of entitlement supply		Irrigation water entitlement and probability of meeting entitlement
20	Average Field Irrigation Efficiency	%	$\frac{\text{ET} - \text{Effective precipitation} + \text{LR water}}{\text{Total public and private water delivered to fields}} \times 100$	Submergence of drainage outlet		Number of days with submerged outlet
21	Command area Irrigation Efficiency	%	$\frac{\text{ET} + \text{Leaching needs} - \text{Effective precipitation}}{\text{Surface irrigation imports} + \text{Net groundwater}} \times 100$	Main system water delivery efficiency		$\frac{\text{Total annual volume of irrigation water delivery}}{\text{Total annual volume of irrigation water supply}}$
22	Cost recovery ratio	none	$\frac{\text{Gross revenue collected}}{\text{Total MOM cost}}$	Cost recovery ratio		$\frac{\text{Gross revenue collected}}{\text{Total MOM cost}}$
23	Maintenance cost to revenue ratio	none	$\frac{\text{Maintenance cost}}{\text{Gross revenue collected}}$	Maintenance cost to revenue ratio		$\frac{\text{Maintenance cost}}{\text{Gross revenue collected}}$
24	Total MOM cost per unit area	US$/ha	$\frac{\text{Total MOM cost}}{\text{Total command area serviced by the system}}$	Total MOM cost per unit area	US$/ha	$\frac{\text{Total MOM cost}}{\text{Total command area serviced by the system}}$
25	Total cost per staff person employed	US$/person	$\frac{\text{Total number of personnel}}{\text{Total number of personnel}}$	Total cost per person employed on water delivery	US$/person	$\frac{\text{Total cost of personnel engaged in I\&D service}}{\text{Total number of personnel engaged in I\&D service}}$
26	Revenue collection performance	none	$\frac{\text{Gross revenue collected}}{\text{Gross revenue invoiced}}$	Revenue collection performance		$\frac{\text{Gross revenue collected}}{\text{Gross revenue invoiced}}$
27	Staff persons per unit irrigated area	Persons/ha	$\frac{\text{Total number of personnel engaged in I\&D service}}{\text{Total irrigated area serviced by the system}}$	Staffing numbers per unit area	Persons/ha	$\frac{\text{Total number of personnel engaged in I\&D service}}{\text{Total annual irrigated area serviced by the system}}$
28	Number of turnouts per field operator	None	$\frac{\text{Total number of turnouts (offtakes)}}{\text{Total number of personnel engaged in field and ID service}}$			
29	Average revenue per cubic meter of irrigation water delivered to water users by the project authorities	US$/m3	$\frac{\text{Gross revenue collected}}{\text{Total annual volume of project irrigation water delivered}}$	Average revenue per cubic metre of irrigation water supplied	US$/m3	$\frac{\text{Gross revenue collected}}{\text{Total annual volume of irrigation water delivery}}$
30	Total MOM cost per cubic meter of irrigation water delivered to water users by the project authorities	US$/m3	$\frac{\text{Total MOM cost}}{\text{Total annual volume of irrigation delivered by project authorities}}$	Total MOM cost per unit volume supplied		$\frac{\text{Total MOM cost}}{\text{Total annual volume of irrigation water delivery}}$

A.6. The indicators of IPTRID and RAP and Benchmarking (continue)

NO	RAP			IPTRID GUIDELINES		
	INDICATORS	UNIT	DEFINITION	INDICATORS	UNIT	DEFINITION
	AGRICULTURAL PRODUCTIVITY AND ECONOMIC INDICATORS			PRODUCTIVE EFFICIENCY Agricultural productivity and economics		
31				Total gross annual agricultural production	tonnes	Total annual tonnage of agricultural production by crop type.
32	Total annual value of agricultural production	US$	Total annual value of agricultural production received by producers.	Total annual value of agricultural production	US$	Total annual value of agricultural production received by producers.
33	Output per unit command area	US$/ha	$\frac{\text{Total annual value of agricultural production}}{\text{Total command area of the system}}$	Output per unit command area	US$/ha	$\frac{\text{Total annual value of agricultural production}}{\text{Total command area of the system}}$
34	Output per unit irrigated area, including multiple cropping	US$/ha	$\frac{\text{Total annual value of agricultural production}}{\text{Total annual irrigated crop area}}$	Output per unit irrigated area	US$/ha	$\frac{\text{Total annual value of agricultural production}}{\text{Total annual irrigated area}}$
35				Output per unit irrigation delivery	US$/m^3	$\frac{\text{Total annual value of agricultural production}}{\text{Total annual volume of irrigation water delivery}}$
36	Output per unit irrigation supply	US$/m^3	$\frac{\text{Total annual value of agricultural production}}{\text{Total annual volume of irrigation supply into the 3D boundaries of the command area}}$	Output per unit irrigation supply	US$/m^3	$\frac{\text{Total annual value of agricultural production}}{\text{Total annual volume of irrigation supply}}$
37	Output per unit water supply	US$/m^3	$\frac{\text{Total annual value of agricultural production}}{\text{Total annual volume of water supply}}$	Output per unit water supply	US$/m^3	$\frac{\text{Total annual value of agricultural production}}{\text{Total annual volume of water supply}}$
38	Output per unit of field ET	US$/m^3	$\frac{\text{Total annual value of agricultural production}}{\text{Total annual volume of field ET}}$	Output per unit crop water demand	US$/m^3	$\frac{\text{Total annual value of agricultural production}}{\text{Total annual volume of crop water demand}}$
	ENVIRONMENTAL INDICATORS			ENVIRONMENTAL PERFORMANCE		
39	Water quality: Average salinity of the irrigation supply	dS/m	Salinity (electrical conductivity) of the irrigation supply.	Water quality: Salinity	mmhos/cm	Salinity (electrical conductivity) of the irrigation supply and drainage water.
40	Water quality: Average salinity of the drainage water	dS/m	Salinity (electrical conductivity) of the drainage water that leaves the command area.			
41	Water quality, Biological: Average BOD of the irrigation supply	mgm/liter	Biological load of the irrigation supply expressed as Biochemical Oxygen Demand (BOD).	Water quality: Biological	mg/litre	Biological load of the irrigation supply and drainage water expressed as Biochemical Oxygen Demand (BOD)
42	Water quality, Biological: Average BOD of the drainage water	mgm/liter	Biological load of the drainage water expressed as Biochemical Oxygen Demand (BOD).			
43	Water quality, Chemical: Average COD of the irrigation supply	mgm/liter	Chemical load of the irrigation supply expressed as Chemical Oxygen Demand (COD).	Water quality: Chemical	mg/litre	Chemical load of the irrigation supply and drainage water expressed as Chemical Oxygen Demand (COD).
44	Water quality, Chemical: Average COD of the drainage water	mgm/liter	Chemical load of the drainage water expressed as Chemical Oxygen Demand (COD).			
45	Average depth to the shallow water table	m	Average annual depth of the shallow water table calculated from water table observations over the irrigation area.	Average depth to watertable	m	Average annual depth of watertable calculated from watertable observations over the irrigation area.
46	Change in shallow water table depth over last 5 years (+ is up)	m	Change in shallow water table depth over the last five years.	Change in watertable depth over time	m	Change in watertable depth over the last five years.
47				Salt balance	tonnes	Differences in the volume of incoming salt and outgoing salt.
	OTHER					
48	Percent of O&M expenses that are used for pumping	%				

A.7. Reported works on opinion survey of people (i.e. farmers)

Study, country, Irrigation type	Topic of farmers' perception	Methods & Analysis	Number of respondent	IMT model	Functions transferred		Assessmet aspects					
					O&M	Finance	Hydraulic/operational performance	Agricultural/productivity performance	Maintenance Performance	Financial performance	Management performance	Ecosystem management
Kuscu, H., et. al., 2008, Turkey, SI	Management transfer	Quantitative, cross-section survey, questionnaires, regression/Logit model	213, randomly selected	WUA	Main canal to the drains	No formal water right	Relative water supply has not shown any important change.	Irrigation ratio has shown insignificant change. IMT had no significant impact on water use efficiency.	Maintenance of irrigation canals, and water control and distribution structures has a positive effect but insignificant.	n.a.	Since irrigation service provided by WUA are not sufficient, frequency of water distribution conflicts increased. 61.5% of farms do not approve of the IMT.	n.a.
Mishra, A., et. al., 2010, India	Impact of rehabilitation and IMT in minor irrigation project	Quantitative, questionnaires, regression/Logit model	207, random sampling	WUA	Canal system	Fixation & collection water tax	Irrigation performance is good after rehabilitation and IMT.	Increase in cultivated area by 22%, irrigated area by 107%, irrigation intensity by 15%, cropping intensity, crop yield and diversified cropping pattern.	n.a.		Aspects such as decision making, fund generation, empathy, and social support need to improve for further strengthening of WUA functioning.	n.a.
Ghosh, Souvik, et.al, 2005, India	Irrigation service performance	Quantitative, interview, Fuzzy set theory	30, stratified random sampling	n.a.	n.a.	n.a.	Farmers' satisfaction increased in term of predictability, tractability, and convinience of water delivery system.	n.a.	n.a.	n.a.	n.a.	n.a.
Vandersypen, K., et. al., 2008, Mali, SI	Motivation for collective action	Quantitative, close-end questionnaires, binary logistic regression model, SPSS computer package	100, randomly selected	WUA	Tertiary level	n.a.	Low frequency of water delivery.	n.a.	n.a.	n.a.	n.a.	n.a.
Ghazouani, W., et. al., 2009, Tunisia, LI	Modernisation of a community-managed irrigation scheme	Qualitative, individual semi-directive on-farm interview, open-ended questions in-depth discussion, problem tree model to link cause and effect	25, selected carefully	WUA	n.a.	n.a.	Low frequency of water delivery turn, waterlogging and salinity.	Poor land productivity.	Better operation and maintenance of the system.	Water tax collection provides periodical fund generation.	The farmers tended to minimise their own responsibility, inadequate collective irrigation rules, raised question of sustainability.	n.a.
Abernethy, Charles L., et. al., 2001, Sri Lanka, SI	Opinions of water users of water projects	Quantitative, questionnaires, short interview, two pairs survey (first survey using positive and negative statements, second survey only use positive statements).	522 respondents in first interview, 519 respondents in second interview	Farmer's company	n.a.	n.a.	Farmer's satisfaction on water service is 79.6% in first survey and 85.1% in second survey.	Farmer's satisfaction on agricultural advice is 76.9%, agricultural input is 69.4%, and post-harvest facilities is 46.6%.	Farmer's satisfaction on maintenance of system is 72.0% in first survey and 74.0% in second survey.	Farmer's satisfaction on credit support is 56.1% in first survey and 60.1% in second survey; on marketing support is 49.3% on first survey and 27.9 in second survey.		
Kuscu, H., et. al., 2009, Turkey, SI	Irrigation performance assessment	Quantitative, cross-section survey, questionnaires, regression/Logit model	190, stratified random sampling	WUA	n.a.	n.a.	Farmers' satisfaction in term of adequacy, fairness, and timeliness are positive (>79%).	n.a.	Farmers are satisfy with the maintenance of irrigation and drainage canal	Profit has created from the cost recovery and has invested for infrastructure such as excavators, diggers, and other machinery and equipment.	80% of participants have been satisfied with the services provided by WUA. 43% of respondents are dissatisfied with the irrigation fee policy	n.a.

A.7. Reported works on opinion survey of people (i.e. farmers) (continue)

Study, country, Irrigation type	Topic of farmers' perception	Methods & Analysis	Number of respondent	IMT model	Functions transferred		Assessmet aspects					
					O&M	Finance	Hydraulic/operational performance	Agricultural/productivity performance	Maintenance Performance	Financial performance	Management performance	Ecosystem management
Mahoo, Henry F., et. al., 2007, Tanzania, SI	Productivity of water	Qualitative, direct close and open-ended questionnaires, focus group discussion,	428, random sampling	WUA			n.a.	Farmers understand productivity of water with reference to the yield from their field, economic value that attach to water and land, and monetary value for water through market pricing or willingness to pay.	n.a.	n.a.	n.a.	n.a.
Joshi, Ganesh & Pandey, Sushil, 2005, Nepal	Adoption of modern rice varieties	Quantitative, mean and standard deviation model	222, stratified random sampling	n.a.	n.a.	n.a.	n.a.	Modern varieties are superior in terms of productivity, drought tolerance, resistance to desease and insect, and for making special food. On the other hand, traditional varieties are superior in taste.	n.a.	n.a.	n.a.	n.a.
Duc, Nguyen Minh, 2007, Vietnam	Aquaculture	Quantitative, questionnaires, cumulative logistics model	120	n.a.	n.a.	n.a.	n.a.	Income from fish culture relative to farming income raises the farmer's satisfaction to fish culture.	n.a.	n.a.	n.a.	n.a.
Pavlikakis, Georgios, E., et. al., 2003, Greece	Acounting human opnion, preferences, and perception in ecosystem managemen	Quantitative method, questionnaires, interview on site. Multi-criteria decision making - decision making from human opinion method (analytical hierarchy method, the expected utility method, and compromise programming).	1598 local people sampling.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	Addressing 7 issue: agricultural & live stock, commersial fishing, tourist development, quality of aquatic system, quality of surface water, quantity of water, and environmental education. Rank of the alternative management plans are: (A1) the condition remains unchanges, trying to control water use and protect wetlands, (A2) reduction in the use of fertiliser and pesticides by 10%, (A3) possible lossess in agricultural income caused by (A2) can be restored by alternative solutions, and (A4) reduction in the use of fertiliser by 5%, pesticides remains unchange, increase agricultural income by 5%, and high rate of development.

Notes:

WUA = Water user’s associations

SI = surface irrigation, LI = lift irrigataion

n.a. = not available

*Adjusted for differences in nitrogen fertiliser use and rainfall

A.8. The four tier of ISAF

ISAF Tier Level			
Tier 1 - Sustainability Principle	**Tier 2 - High Level Objective**	**Tier 3 - Components Trees to Define Operational Objectives**	**Tier 4 - Indicators and Performance Measures**
PEOPLE	Irrigation authority staff	Have a motivated staff who support the organisational goals, have a sense of belonging to the organisation, and intend to stay with the organisation	Adequate salary
			Rewards for ememplary service
		Have an empowered and well-skilled workforce with an achievement-oriented culture	Frequency and adequacy of trainings
			Power to make decision
		Maintain the safety, health and well-being of the workforce	Availability of written procedure
			Frequency and adequacy of trainings
		Promote equity, including equal opportunity and local	Availability of written procedure
		Build capacity about sustainability	Training and development
			Sharing knowledge
		Promote relation with farmers (participation) and communities (water user right)	WUAs can provide a structure for participation in irrigation
			Clear water rights could help reduce conflict and facilitate trading and compensation arrangement for reallocation and efficient water resource utilisation
	Farmers	Satisfaction with the service provided	Satisfy with the water adequacy/sufficiency, time arrival, and flow rate
			Flexibility to chose the service according to needs (frequency, flow rate, time, duration)
			Equality in access to water
		Satisfaction on the quality of infrastructure	Water capture asset condition
			Conveyance asset condition
			Operation (control) facilities asset condition
			Management and general asset condition
		Satisfaction on the quality of staff to improve farmers - irrigation authority staff relationship	Staff effort to arrange water delivery service
			Responsiveness and communication of staff
			Staff skills and knowledge
		Satisfaction on the quality of WUA	Effectiveness of WUA to accommodate farmers' needs i.e. to influence real time
			Effectiveness of WUAs to resolve conflicts
		Satisfaction on the income generate from field activities	Productivity and yield
			ISF
			Annual income
	WUAs	Legal	
		Availability of appropriate policy/regulation and guidelines for legally financially independent WUAs	Legal basis for WUAs as business organisation
			Legal basis for WUAs to make links with other organisations to develop business relation
		Availability of appropriate guidelines for planning and operating the system under WUAs as business organisation	Developing an AMP
			Developing a program for business promotion
			Providing suport services for WUAs to respond to business opportunity
		Institutional	
		Improve WUAs organisational and institutional capacity to operate the system	Technical, financial and managerial supports
			Technical, financial and managerial trainings
		Improve WUAs as a business organisation	Strengthened WUAs capacity to make contract with third parties to generate sidelines income
			Strengthened WUAs capacity to make links with other organisations to develop business relation
			Pool WUAs resources to achieved economic of scale in running irrigated agricultural business
			Improve WUAs capacity to organise members to respond to the specific business opportunities that are present
		Improve trust/confidence in WUAs	Technical, financial and managerial supports
			Technical, financial and managerial trainings
	Community	Protection of people in the upper region and tail-end of irrigation system from impoverish	
		Better farming practice	Efficient agricultural practice (crop pattern)
			Water-efficient crop varieties
		Better addressing conflicting demands on the available water supply	Clear water rights could help reduce conflict and facilitate trading and compensation arrangement for reallocation and efficient water resource utilisation
			Compensation for communities in upper region and taile-end of irrigation system
		Social development	
		Protection of irrigated area	Conversion of irrigated land into other uses
		Better addressing conflicting demands on the available water supply	Clear water rights could help reduce conflict and facilitate trading and compensation
		Legal obligation	
		Policy, legislation and institutional framework	Dicretionary standard (good practice) reflecting local concern
			National environmental legislation and policies
			International obligations

A.8. The four tier of ISAF (continue)

ISAF Tier Level			
Tier 1 - Sustainability Principle	**Tier 2 - High Level Objective**	**Tier 3 - Components Trees to Define Operational Objectives**	**Tier 4 - Indicators and Performance Measures**
PLANET	Enhance appreciation of farmers to the value of water	Increase efficient utilisation of water for irrigation	Increase ISF
	Managing consumption in an efficient and effective manner	Increase efficient utilisation of water for irrigation	Increase ISF
		Increase distribution efficiency	Increase the conveyance efficiency
		Increase productivity	Diverting the non-beneficial consumption into beneficial consumption
	Maintenance of hydrological functions, ecosystem and biodiversity in system and basin level (reduce the impact of irrigation on the environment)		
	Direct impact	Irrigation system hydrological condition	Reduce evaporation in the system
			Increase groundwater recharge
			Rise water table
			Reduce drainage flow
			Reduce waterlogging
			Reduce soil salinity
			Reduce pollution of drainage water
	Indirect and complex impact	Downstream irrigation system hydrological condition	Reduce downstream river drainage discharge
			Increase average depth to shalow water table
			Reduce waterlogging at downstream area
			Reduce pollution of drainage water
		Downstream river water quality	Average salinity of drainage water discharge
			Average BOD of drainage water discharge
			Average COD of drainage water discharge
	Subsequent and intricate impact on natural, ecological and socioeconomic at the tail-end and downstream of irrigation system	Sorrounding environment hydrological condition	Increase surface water availability
			Increase groundwater inflow
			Reduce waterlogging
		Increase the natural habitats condition of flora and fauna	Reduce incoming polluted water

A.8. The four tier of ISAF (continue)

ISAF Tier Level			
Tier 1 - Sustainability Principle	**Tier 2 - High Level Objective**	**Tier 3 - Components Trees to Define Operational Objectives**	**Tier 4 - Indicators and Performance Measures**
PROFIT	Water balance, productivity and efficiency	Maintain stability of water supply for satisfying crop requirements	Eto
			Annual relative water supply (RWS)
			Annual relative irrigation supply (RIS)
			Water delivery capacity
			Security of entitlement supply
		Increase agricultural productivity	Total annual value of agricultural production
			Output per unit command
			Output per unit irrigated area
			Output per unit irrigation
			Output per unit field ET
		Increase efficiency of water used for agriculture	Conveyance efficiency
			Average field irrigation
			Command area irrigation
		Accurate measurement of the delivered water	Volumetric measurement readings
			ISF
	Financial, economic, and socioeconomic sustainability	Financial sustainability : Increase the value of irrigation system through targeted investment in existing and new irrigation facilities	At least, keep the aset in good condition
		Financial sustainability: Achieve financial and economic efficiency/profitability of irrigated agriculture	Cost recovery ratio
			Maintenance cost to revenue ratio
			Revenue collection performance
			Average revenue per cubic meter of irrigation water delivered to water users
		Financial sustainability: Achieve financial viability (finacial self-sufficiency)	ISF
			Promote financially legally independent WUAs
			Generate income from sidelines agricultural activities
		Economic sustainability: Lightened government burden on O&M costs	MOM costs per hectare to government
			Finacial self-sufficiency
		Socioeconomic sustainability: farmers	Irrigation cost per hectare to farmer
			Value of farmer labour contribution for maintenance
		Socioeconomic sustainability: Achieve a high level of good quality production	Good variety of crops, crop pattern and agricultural practice
	Asset sustainability	Ensure continuing asset serviceability	Water capture asset condition
			Conveyance asset condition
			Operation (control) facilities asset condition
			Management and general asset condition
		Ensure aset integrity is safeguard	Evidence of vandalism of structures
			Evidence of water are taken out when not allowed, or at flow rate greater than allowed
			Evidence of non-existence or unauthorised turnout from channels
	Business Management	Achieve managerial ability to supply the required water to meet crop water requirements	Cost recovery ratio
			Maintenance cost to revenue ratio
			Revenue collection performance
			Average revenue per cubic meter of irrigation water delivered to water users
		Enhance employee engagement with organisational goals, create loyalty, a sense of belonging and to make commitment to achieve and work beyond usual expectations	Adequate salary
			Rewards for ememplary service
		Adapt to new technology to improve system performance and improve cost savings, introduce new rice varieties and new methods of rice cultivation to increase yields	Improve infrastructure asset condition especially operation control facilities
			Introduce new rice varieties, crop pattern and agricultural practice
		Encourage participation of water users in the MOM of certain parts of the irrigation system	Legal basis for WUAs as business organisation
			Strengthened WUAs legality, and management and financial capability
		Compliance with legislative requirements	Constitutional policy and framework regarding irrigation system

APPENDIX B

Details of Methodology:

B.1. Research Official Permissions

B.2. The Farmers' Opinion Survey Questionnaire Form

B.3. Survey Form

B.4. RAP and Benchmarking

B.5. The Stakeholders' Opinion Survey Questionnaires Form

B.6. The goals, criteria and statements used to assess the viability

B.1. Research Official Permission

B.1.1. Ethics approval of research with low risk, Office of Research and Development, Human Research Ethics Committee, Curtin University

Curtin University

Memorandum

To	Ika Kustiani, Civil Engineering
From	Miss Linda Teasdale, Manager, Research Ethics
Subject	Protocol Approval **RD-37-10**
Date	14 September 2010
Copy	Prof David Scott, Civil Engineering

Office of Research and Development

Human Research Ethics Committee

Telephone 9266 2784
Facsimile 9266 3793
Email hrec@curtin.edu.au

Thank you for your "Form C Application for Approval of Research with Low Risk (Ethical Requirements)" for the project titled *"Water user association as business enterprise, government intervention on farmers participation on the management of irrigation's minor assets case study in Indonesia."*. On behalf of the Human Research Ethics Committee I am authorised to inform you that the project is approved.

Approval of this project is for a period of twelve months **10-09-10** to **09-09-11**.

The approval number for your project is **RD-37-10**. *Please quote this number in any future correspondence*. If at any time during the twelve months changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately.

Miss Linda Teasdale
Manager, Research Ethics
Office of Research and Development

Please Note: The following standard statement must be included in the information sheet to participants:
This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number RD-37-10). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784 or hrec@curtin.edu.au

B.1.2 Consent form

Curtin University of Technology
Civil Engineering Department

Participants' Information Sheet

Dear Participants,

I invite you to consider taking part in the study of farmers' participation on the management of irrigation's minor assets case study in Indonesia.

Purpose of Research
I am investigating the importance of irrigation management transfer policy in encouraging farmers' participation on the management of irrigation's minor assets and how this approach could improve the transferred irrigation system in rural Indonesia. This study is the requirement to complete Doctor of Philosophy Degree in Civil Engineering Department, Curtin University. It is expected that this study could provide the basis for better managing the rural irrigation scheme in a cost-effective way.

Your Role
I interested in finding out about your opinions regarding the current irrigation practice and the changes have been made by the irrigation management transfer policy. Your opinions are important in developing the asset management planning for rural transferred irrigation scheme. I will use a questionnaire that will take 30 minutes to respond to and a focus group discussion that will take approximately 90 minutes. The study will be conducted over several irrigation schemes with the same interview and questionnaire.

Consent to Participate
Your involvement in the research is entirely voluntary, and no explanation or justification is needed if you decide not to participate. If you wish to participate, please complete the questionnaires and this will be taken as consent to participate. Please note that your data is anonymous and so it cannot be withdrawn after you have handed in your answer.

Confidentiality
The information you provide during the survey will be anonymous and treated with high confidentiality. The interview transcript will not have your name or any other identifying information on it. No information may identify you will be used in any publication arising from this research. Only my Thesis Committee and I will have the access to any data. All electronic and paper format data produced will be stored in a safe and secure location in the Department of Civil Engineering at Curtin University for a period of 5 years after publication of thesis.

Further Information

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Protocol Approval RD-37-10). If you would like further information about the study, please feel free to contact us on:

Researcher	: Ika Kustiani
e-mail	: ikakustiani@postgrad.curtin.edu.au
phone	: 61 430 992332
Supervisor	: Prof. David Scott
e-mail	: d.scott@curtin.edu.au
Co-su[ervisor	: Prof. Hamid Nikraz
e-mail	: H.Nikraz@curtin.edu.au

Thank you very much for your considerations on taking parts this research. Your participation is greatly appreciated.

Your sincerely,
Ika Kustiani

B.1.3. Permission to undertake research

Curtin
University of Technology

Perth, 17th December 2010

To:
The Head of Irrigation and Human Settlement Services
The Province of Lampung
Bandar Lampung

Subject: Request for Research Data Collection Access

I am a lecturer at Civil Engineering Department the University of Lampung which undertaking PhD degree at Curtin University Western Australia. I am investigating the importance of irrigation management transfer policy in encouraging farmers' participation on the management of irrigation's minor assets and how this approach could improve the transferred irrigation system in rural Indonesia. This study is the requirement to complete Doctor of Philosophy Degree in Civil Engineering Department, Curtin University. It is expected that this case study in rural irrigation schemes in the Province of Lampung could provide the basis for developing a model in better managing rural irrigation scheme in a cost-effective way, not only for rural irrigation scheme in Indonesia but also in Asia. Along with this letter I attach documents as follow:

1. Summary of research
2. Ethical Approval from Curtin University
3. Translation of this letter in Bahasa

I am very grateful for your approval and help to provide me the access to data.

Kind regards,

Ika Kustiani

I endorsed and certify that Ika Kustiani is under my supervision and is conducting this research as part of her research studies.

D. Scott

Prof. David Scott
Department of Civil Engineering,
Curtin University of Technology,
GPO Box U1987, Perth, 6845, Australia
Phone +61 8 9266 7609 Fax +61 8 9266 2681

B.2. The Farmers' opinion survey questionnaire form

Farmers' Opinion Questionnaires on Irrigation Services, Irrigation Infrastructure Condition, Irrigation Management Practices, and Water Users' Association at the Current Condition, the Differences Before and After Participatory in Irrigation Program, and the Desired Level of Service in the Future

Demographic of repondent:

Location of interview : Irrigation District ....

Demographic of Respondent

Age:
a. < 30
b. 31 - 45
c. 46 – 60
d. > 61

Gender:
a. Male
b. Female

Membership status at WUA:
a. Member
b. Executive member
c. Non-member

Ownership of the plot:
a. Owner
b. Share-cropper
c. Rent
d. Employee/ seasonal wage labourer

Plot size:
a. < 1 ha
b. 1 – 2 ha
c. 2 – 5 ha
d. > 5 ha

Main water sources:
a. River
b. Reservoir
c. Well

Number of person living from the farm:
a. < 4 people
b. 5 - 8
c. 9 – 12
d. > 12

Family member work on at the farm:
a. < 2
b. 3 - 4
c. 5 – 6
d. > 7

Number of yield per year
a. Once
b. Twice
c. Three times

Yield per hectare:
a. < 5 tonnes
b. 5 – 7.5 tonnes
c. > 7.5 tonnes

Plot position on the irrigation system:
a. Primary canal
b. Secondary canal
c. Tertiary canal

Plot position on the canal:
a. Head
b. Middle
c. Tail-end

I. IRIGATION AND DRAINAGE SERVICES

Opinion on Current Level of Services

1. What is your perception, is the amount of water supplied is adequate/sufficient to meet the crop water requirement?
   a. (+) Adequate/satisfactory b. (-) Inadequate/unsatisfactory

2. What is your perception, is the water arrives when it is expected?
   a. (+) On time/slight delay/satisfactory b. (-) Excessive delay/unsatisfactory

3. What is your opinion, do you have flexibility/ability to choose the service in accordance to needs (frequency, flow rate, time, and duration)?

a. (+) Flexible b. (-) Rigid

4. What is your perception, is there any excessive variation in access to water and service along a canal, e.g. between head and tail enders?
   a. (+) Uniform/slight inequity b. (-) Very inequitable

5. What is your opinion, is the supply levels or flow rates during irrigation supply fluctuate a lot?
   a. (+) Uniform/slight variation b. (-) Large fluctuations

Opinion on the Difference of Services Before and After Participatory

6. What is your opinion about the amount of water supplied to meet the crop water requirement, is it better/worse after transfer?
   a. (+) Better b. (-) Insignificant change/worse

7. What is your perception about the expected time of water arrives is it better/worse after transfer?
   a. (+) Better b. (-) Insignificant change/worse

8. What is your perception about the ability to choose the service in accordance to needs (frequency, flow rate, time, and duration), is it better/ worse after transfer?
   a. (+) Better b. (-) Insignificant change/worse

9. What is your perception about the equality in access to water and service along a canal, e.g. between head and tail enders, is it better/worse after transfer?
   a. (+) Better b. (-) Insignificant change/worse

10. What is your opinion about the degree of supply levels or flow rates during irrigation supply, is it better /worse after transfer?
   a. (+) Better b. (-) Insignificant change/worse

Expectation on the Level of Services in the Future

11. What is your expectation on adequacy of water, is it needed to improve/not?
   a. No improvement needed b. Need significant improvement

12. What is your expectation on water arrival, is it needed to improve/not?
   a. No improvement needed b. Need significant improvement

13. What is your expectation on the ability to choose the service in accordance to needs (frequency, flow rate, time, and duration), is it needed to improve/not?
   a. No improvement needed b. Need significant improvement

14. What is your expectation on water equity between head and tail enders, is it needed to improve/not?
   a. No improvement needed b. Need significant improvement

15. What is your expectation on water supply levels or flow rates during irrigation supply, is it needed to improve/not?
   a. No improvement needed b. Need significant improvement

Opinion on Drainage Service

16. What is your opinion about the ability of the property to dispose of drainage excess water into the collector system?
    a. (+) Satisfactory   b. (-) deficient/poor/unsatisfactory

17. What is your perception about the ability of the property to dispose of drainage excess water into the collector system, is it better/worse after transfer?
    a. (+) Better   b. (-) Insignificant change/worse

18. What is your expectation on the ability of the property to dispose of drainage excess water into the collector system, is it needed to improve/not?
    a. No improvement needed   b. Need significant improvement

Willingness to Bear the Consequences if Service Levels Improved

19. What will you do if the level of service up grade?
    a. Change crop pattern (increase crop harvesting season)   b. Change crop variety (diversifying crop)

20. Will you pay if the cost of service increases as a result of up grading level of service?
    a. Doesn't want the irrigation cost increase   b. Willing to pay

II. INFRASTRUCTURE ASSET CONDITION

Opinion on Current Condition of Assets

21. What is your perception, is the canal condition directly to your farm satisfactory?
    a. (+) Satisfactory   b. (-) Poor/unsatisfactory

22. What is your perception of other immediate infrastructure (water control and distribution structure) condition to your farm?
    a. (+) Satisfactory   b. (-) Poor/unsatisfactory

Opinion on the Difference of Assets Condition Before and After Participatory

23. What is your perception about the canal condition directly to your farm, is it better/worse after transfer?
    a. (+) Better   b. (-) Insignificant change/worse

24. What is your perception about other immediate infrastructure (water control and distribution structure) condition to your farm, is it better/worse after transfer?
    a. (+) Better   b. (-) Insignificant change/worse

Expectation on the Level of Services in the Future

25. What is your expectation on the canal directly to your farm, is it needed to improve/not?
    a. No improvement needed   b. Need significant improvement

26. What is your expectation on other immediate infrastructure (water control and distribution structure) to your farm, is it needed to improve/not?
    a. No improvement needed   b. Need significant improvement

Willingness to Bear the Consequences if Infrastructure Upgrade

27. What will you do if the current level irrigation infrastructure up grade?
    a. Change crop pattern (increase crop harvesting season)
    b. Change crop variety (diversifying crop)

28. Will you contribute in rehabilitation/improvement activities in the primary and secondary system or level of irrigation system up grade?
    a. Doesn’t want to contribute
    b. Only want to contribute in manpower
    c. Willing to contribute the cost of rehabilitation

III. MANAGEMENT PRACTICE

Opinion on Current Management Practice

29. What is your perception, is the current standard of drainage service provided by the irrigation agency meets your needs?
    a. (+) Adequate/satisfactory
    b. (-) Poor/unsatisfactory

30. What is your view of the current standard of maintenance in the water supply system?
    a. (+) Satisfactory
    b. (-) Deficient/poor/unsatisfactory

31. What is your opinion, is the current standard of rehabilitation/renewal/improvement provided by the irrigation agency sufficient your needs?
    a. (+) Adequate/satisfactory
    b. (-) Poor/unsatisfactory

Opinion on the Difference of Management Practice Before and After Participatory

32. What is your opinion about the current standard of irrigation and drainage service provided by the irrigation agency to meets your needs, is it better/worse after transfer?
    a. (+) Better
    b. (-) Insignificant change/worse unsatisfactory
33. What is your view about the standard of maintenance in the water supply system, is it better/worse after transfer?
    a. (+) Better
    b. (-) Insignificant change/worse

34. What is your opinion about the current standard of rehabilitation/renewal/ improvement provided by the irrigation agency, is it better/worse after transfer?
    a. (+) Better
    b. (-) Insignificant change/worse

Expectation on the Management Practice in the Future

35. What is your expectation on the standard of irrigation and drainage service in the water supply system, is it needed to improve/not?
    a. No improvement needed
    b. Need significant improvement

36. What is your expectation on the standard of maintenance in the water supply system, is it needed to improve/not?
    a. No improvement needed
    b. Need significant improvement

37. What is your expectation on the standard of rehabilitation/renewal/ improvement in the system, is it needed to improve/not?
    a. No improvement needed
    b. Need significant improvement

Opinion on Current On-duty-staff

38. What is your opinion about the degree of agency staffs' effort to arrange water delivery?
    a. (+) Adequate/satisfactory b. (-) Poor/unsatisfactory

39. What is your perception of the degree of responsiveness of agency staff?
    a. (+) Immediate/satisfactory b. (-) Slowly/unresponsive/unsatisfactory

40. What is yor perception, is it easy for you to communicate with the agency staff.
    a. (+) Easily accessible/satisfactory b. (-) Inaccessible/unsatisfactory

41. What is your opinion about the degree of responsiveness from government to improve your knowledge and skill in agricultural practice/irrigation practice?
    a. (+) Satisfactory b. (-) Unsatisfactory

Opinion on the Difference of On-duty-staff Before and After Participatory

42. What is your perception about the degree of agency staffs' effort to arrange water delivery, is it better/worse after transfer?
    a. (+) Better b. (-) Insignificant change/worse

43. What is your perception about the degree of responsiveness from agency staff, is better/worse after transfer?
    a. (+) Better b. (-) Insignificant change/worse

44. What is your perception about the ease of communication between user and agency staff, is it better/worse after transfer?
    a. (+) Better b. (-) Insignificant change/worse

45. What is your perception about the degree of responsiveness from government to improve knowledge/ agricultural practice/ irrigation practice for farmer, is it better/worse after transfer?
    a. (+) Better b. (-) Insignificant change/worse

Expectation on On-duty-staff in the Future

46. What is your expectation on the degree of agency staffs' effort to arrange water delivery, is it needed to improve/not?
    a. No improvement needed b. Need significant improvement

47. What is your expectation expectation on the degree of responsiveness from government, is it needed to improve/not?
    a. No improvement needed b. Need significant improvement

48. What is your expectation on the ease of communication between user and agency staff, is it needed to improve/not?
    a. No improvement needed b. Need significant improvement

49. What is your expectation from government to improve your knowledge in agricultural practice/irrigation practice, is it needed to improve/not?
    a. No improvement needed b. Need significant improvement

50. Will you actively involve in government program if it is provide?
    a. Yes   b. No

Opinion on water measures practice and water tariff

51. What is your perception about the current water measures practice, is it fair?
    a. (+) Satisfactory   b. (-) Unsatisfactory

52. What is your perception about the current water measures practice, is better/worse after transfer?
    a. (+) Better   b. (-) Insignificant change/worse

53. What is your expectation on the current water measures practice, is it needed to improve/not?
    a. No improvement needed   b. Need significant

54. What is your opinion about the current water tariff, is it fairly affordable for you?
    a. (+) Inexpensive/ affordable   b. (-) Expensive/inaffordable

55. What is your perception about the current water tariff, is it better/worse after transfer?
    a. (+) Better   b. (-) Insignificant change/worse

56. What is your expectation on the current water tariff, is it needed to revise/not?
    a. No revision needed   b. Need significant revision

IV. WATER USERS' ASSOCIATION

57. What is your opinion about WUA, is it effective to accommodate your needs?
    a. (+) Effective/satisfactory   b. (-) Ineffective/unsatisfactory

58. What is your perception about the degree of effectiveness of water users group, is it better/worse after transfer?
    a. (+) Better   b. (-) Insignificant change/worse

59. What is your expectation on the degree of effectiveness of water users group, is it needed to improve/not?
    a. No improvement needed   b. Need significant improvement

60. What kind of involvement you wish to contribute at WUA?
    a. As a member   b. As an executive member

V. FARMERS' INCOME

61. What is you opinion about your crop pattern/agricultural practice at the moment?
    a. (+) Satisfactory   b. (-) Unsatisfactory

62. What is your opinion about the productivity of your land, is the yield is satisfactory?
    a. (+) Satisfactory   b. (-) Unsatisfactory

63. What is your view about the crop pattern/agricultural practice, is it better/worse after transfer?
    a. (+) Better   b. (-) Insignificant change/worse

64. What is your view about the degree of land productivity, is it better/worse after transfer?
    a. (+) Better   b. (-) Insignificant change/worse

65. What is your view about your annual income from agricultural activities, is it better/worse after transfer.
    a. (+) Better   b. (-) Insignificant change/worse

66. What is your expectation on current pattern/agricultural practice, is it needed to improve/not?
    a. No improvement needed   b. Need significant improvement

67. What is your expectation on land productivity, is it needed to improve/not?
    a. No improvement needed   b. Need significant improvement

68. What is your perception on your annual income from agricultural activities, is there any possibility to improve?
    a. Possible   b. Impossible

B.3. Survey Form

B.3.1. Survey guidelines

Asset type				Measurement	Unit	Functions to be assessed	Components to Check	Depreciation Life	Condition & Serviceability
GROUP 1 – WATER CAPTURE	Weirs	River offtake weirs	Permanent weir	(Arch height)3 x (arch width)	Unit installed	HYDRAULICS - Provide level - Pass offtake design flow - Pass design flood OPERATIONS - Gates - Gauge	Weir wall Dividing walls Abutments Crest Apron Sluice gate Offtake gates Stilling basin Superstructures	Civil: 50 years M&E: 10 years	The condition grades definition: 1. GOOD: Generally sound with no deformation or damage. Well maintain with little or no signs of deterioration. 2. FAIR: Generally sound but with some degradation or damage. Needing maintenance attention. 3. POOR: Significant deterioration requiring urgent corrective work. 4. BAD: Serious problems requiring partial or complete replacement. Serviceability is measured by reference to two functional criteria: 1. Hydraulic function : This will normally be 'to pass the design flow safely' and, 2. Operations function : (where appropriate) 'to control flow across the required range' OR 'to control command (level) across the required range' AND/OR 'to allow measurement of flow' The four serviceability grades: 1. FULLY FUNCTIONAL Apparently properly designed and constructed with capacity to pass the design flow safely AND (where appropriate) fully capable of being operated to control flow (OR command) across the desired range AND (where appropriate) facilitating measurement of flow by means of its own components or an adjacent measuring structure. Performance is unaffected by silt or debris. 2. MINOR FUNCTIONAL SHORTCOMING Normally able to pass the required flows and capable (where appropriate) of being operated to control flow (OR command) in a measured manner but performance likely to be unsatisfactory under extreme conditions of demand or climate. Deficiencies may be due to design or construction inadequacies, insufficient maintenance, measuring devices which are difficult to read or due to the presence of silt and/or debris. 3. SERIOUSLY REDUCED FUNCTIONALITY One or more of the defined functions seriously impaired through deficiencies in design, construction or maintenance, or due to the presence of silt and/or debris. (Likely to have a significant detrimental effect on system performance). 4. CEASED TO FUNCTION Complete loss of one or more functions or serious reduction of all functions of the asset for whatever reason.
			Barrage weir						
			Gabion weir						
		Water capture	Pump intake						
			Free intake						
	Dams & impounding reservoirs								
	Groundwater abstraction wells								
GROUP 2 – CONVEYANCE	Channel	Irrigation (Conveyance structure)	Primary	Design discharge	Length (km)	HYDRAULICS - Pass design flow OPERATIONS - n/a	Embankment Side slopes (note type) Bed Conveyance	Civil: 25 years M&E: 10 years	
			Secondary						
			Tertiary						
			Quaternary						
		Drainage	Primary						
			Secondary						
			Tertiary						
			Quarternary						
		Suppletion							
		Carrying channel							
	Hydraulics structure	Irrigation structure	Sand trap box	(Design discharge) x (length)	Unit installed	HYDRAULICS - Pass design flow OPERATIONS - n/a	Support structure u/s wingwalls d/s wingwalls Stilling basin Structure		
			Control structure						
			Division structure						
			Division with offtake structure						
			Offtake structure						
			Tertiary box						
			Tertiary box with spillway						
			Quarternary box						
			Culvert						
			Flume						
			Siphon						
			Drop structure						
			Spillway						
			Sediment flush box						
		Wasteway/discharge structure	Culvert						
			Cross culvert						
			Drop structure						
			Valve gate						
			Levee						
	Supplementary structure		Inspection road	(Width)3	Length (km)	HYDRAULICS - Pass design flow OPERATIONS - n/a	Safety Other features	Civil: 25 years M&E: 10 years	
			Farm road						
			Bridge		Unit installed				
			Foot bridge						
GROUP 3 – OPERATIONS (CONTROL) FACILITIES	Head regulator				Width Length	HYDRAULICS - Pass design flow OPERATIONS - Control flow - Gauge	Gate(s) Structure Notice board Shelter	Civil: 25 years M&E: 10 years	
	Cross regulator *options - Fixed crest - Gate(s) - Stop logs - flume					HYDRAULICS - Pass design flow OPERATIONS - Control command level - Gauge	Control section* structure Notice board u/s wingwalls d/s wingwalls Gauge(s) Shelter	Civil: 25 years M&E: 10 years	
	Measuring structure					HYDRAULICS - Pass design flow OPERATIONS - Measure flow	Control section Gauges structure Notice board u/s wingwalls d/s wingwalls Stilling box	Civil: 25 years	
GROUP 4 – MANAGEMENT & GENERAL	Access road					OPERATIONS - access to system	Structure Surface Drains	Civil: 25 years	
	Offices & laboratories								
	Depots & workshops								
	Field officers quarters								
	Vehicle & plant								
	Information technology systems								

B.3.2. Survey form (sample)

ASSET SURVEY
Form S for Channel

S

Irrigation System Detail

District :
UPTD :
Name :
No. Code :

Surveyed by:

Name :
Date :

Asset Detail

No. Code of Asset :
Name of Channel :
Location (STA) :

Service area (ha) :
Design Debit (l/dt) :

Age of asset (year) :	0 - 5	☐	5 - 10	☐	10 - 20	☐	+ 20	☐
Tipe of channel :	Irrigation	☐	Drainage	☐	Suppletion	☐	Carrying	☐
Classification of channel :	Primary	☐	Secondary	☐	Tertiary	☐	Quaternary/ other	☐
Topography type :	On a cut	☐	On a fill	☐	According to contour	☐		
Liner :	Right embankment	☐	Left embankment	☐	Bottom	☐		
Segment is distinguish by :	Segment change	☐	Lining change	☐	Topography change	☐	Structural change	☐
	Other (explain):	☐						

Upstream location marker (km) :

Segment length (km) :

Component condition

Left embankment :	1 - Good	☐	2 - Fair	☐	3 - Poor	☐	4 - Bad	☐
Right embankment :	1 - Good	☐	2 - Fair	☐	3 - Poor	☐	4 - Bad	☐
Perkuatan saluran :	1 - Good	☐	2 - Fair	☐	3 - Poor	☐	4 - Bad	☐
Pot. melintang saluran :	1 - Good	☐	2 - Fair	☐	3 - Poor	☐	4 - Bad	☐

Asset Serviceability

General serviceability :	1 - Fully functional	☐	2 - Minor functional shortcoming	☐	3 - Seriously reduced functionality	☐	4 - Ceased to function	☐

Note

B.4. RAP and Benchmarking

B.4.1. Worksheets for RAP

Worksheets Within the EXCEL File	**Worksheet Description**
1. Input – Year1	For an average water year, requires input (mostly monthly) of: - Crop names - Irrigation Water Salinity - Crop threshold ECe values - Field crop coefficients, by month - Areas of crops - Water supply - Precipitation - Recirculation and groundwater pumping - Special agronomic requirements
4. External Indicators *(ignore these, except to input needed "CI" values)*	Automatic computations of monthly and annual values of various water supply indicators. These are temporary values- except the user must input "CI" values. The final, important values can be found in the worksheet '14. World Bank BMTI Indicators'
5. Project Office Questions	Most of the data for this sheet are obtained from the Project office. They include: - General project conditions - Water supply location - Ownership of land and water - Currency - Budgets - Project operation, as described by office staff - Stated water delivery service at various levels in the system.
6. Project Employees	Requests information regarding employee training, motivation, dismissal, and work descriptions.
7. WUA	Data for Water User Associations (WUA) that were not obtained in the "Project Office Questions" are obtained here. This requires asking questions in the Project Office as well as having interviews with Water User Associations. Questions are related to: - Size of WUAs - Strength of organization - Functions - Budgets - Water charges
8. Main Canal	Data for the Main Canal, including - Control of flows - General canal characteristics - Cross regulators - General conditions - Operation rules - Turnouts - Communications - Regulating reservoirs - The level of service provided to the next lower level
9. Second Level Canals	Same as Main Canal
10. Third Level Canals	Same as Second Level Canals
11. Final Deliveries	Information regarding the level of water delivery service to individual ownership units, and at the last point of operation by paid employees.
12. Internal Indicators	This worksheet summarized the internal indicators that were calculated in the previous worksheets, plus asks for input regarding a few extra indicators. Weighted category indicators are computed for groups of sub-indicators.
13. Benchmark Indicators *(ignore these)*	This worksheet holds intermediate calculated values. Ignore this page.
14. World Bank BMIT Indicators	This, plus worksheet 12, provide the final summary for the exercise.

B.4.2. External performance indicators

ITEM DESCRIPTION	UNITS
Stated efficiencies	
Stated conveyance efficiency of imported canal water (accounts for seepage and spills and tail end flows)	%
Weighted *field* irrigation efficiency from stated efficiencies	%
Areas	
Physical area of irrigated cropland in the command area (not including multiple cropping)	Ha
Irrigated crop area in the command area, including multiple cropping	Ha
Cropping intensity in the command area including double cropping	none
External sources of water for the command area	
Surface *irrigation* water inflow from outside the *command area* (gross at diversion and entry points)	MCM
Gross precipitation in the irrigated fields in the command area	MCM
Effective precipitation to irrigated fields (not including salinity removal)	MCM
Net aquifer *withdrawal* due to irrigation in the command area	MCM
Total *external* **water** supply for the project – including gross ppt. and *net* aquifer withdrawal, but excluding internal recirculation	MCM
Total external irrigation supply for the project	MCM
"Internal" water sources	
Internal *surface* water recirculation by farmer or project in command area	MCM
Gross *groundwater* pumped by farmers within command area	MCM
Groundwater pumped by project authorities and applied to the command area	MCM
Gross total annual volume of project authority irrigation supply	MCM
Total groundwater pumped and dedicated to the command area	MCM
Groundwater pumped by project authorities and applied to the command area, minus net groundwater withdrawal (this is to avoid double counting. Also, all of net is applied to this term, although some might be applied to farmers)	MCH
Estimated total gross internal surface water + groundwater	MCM
Irrigation water delivered to users	
Internal authority water sources are stated to have a conveyance efficiency of:	%
Delivery of *external* surface ***irrigation*** water to *users* –– using stated conveyance efficiency	MCM
All other ***irrigation*** water to users (surface recirculation plus all well pumping, with stated conveyance efficiencies, using 100% for farmer pumping and farmer surface diversions)	MCM
Total *irrigation* water *deliveries to users* (external surface irrigation water + internal diversions and pumping water sources), reduced for conveyance efficiencies	MCM
Total irrigation water (internal plus external) –– just for intermed. value	MCM
Overall conveyance efficiency of project authority delivered water	%
Net field irrigation requirements	
ET of irrigated fields in the command area	MCM
ET of irrigation water in the command area (ET –– effective precipitation)	MCM
Irrigation water needed for salinity control (net)	MCM
Irrigation water needed for special practices	MCM
Total NET irrigation water requirements (ET–– eff ppt + salt control + special practices)	MCM
Other key values	
Flow rate *capacity* of main canal(s) at diversion point(s)	cms
Actual peak flow rate of the main canal(s) at diversion point(s) this year	cms
Peak NET irrigation requirement for field, including any special requirements	cms
Peak GROSS irrigation requirement, including all inefficiencies	cms
ANNUAL or one-time external INDICATORS for the command area	
Peak litres/sec/ha of surface irrigation inflows to canal(s) this year	LPS/ha
RWS: *Relative water supply* for the irrigated part of the command area (total external water supply)/(field ET during growing seasons + water for salt control –– effective precipitation)	none
Annual ***Command Area Irrigation Efficiency*** [100 x (crop ET + leaching needs –– effective ppt)/(Surface irrigation diversions + net groundwater)]	%
Field Irrigation Efficiency (computed) = [crop ET –– effective ppt + LR water]/[total water delivered to users] x 100	%
RGCC: *Relative Gross Canal Capacity* (peak monthly net irrigation requirement)/(main canal capacity)	none
RACF: *Relative Actual Canal Flow* (peak monthly net irrigation requirement)/(peak main canal flow rate)	none
Gross annual tonnage of agricultural production by crop type	m Tonnes
Total annual value of agricultural production	US$

B.4.3. Internal process indicators

INDICATOR LABEL	PRIMARY INDICATOR AND SUB-INDICATOR NAME
SERVICE and SOCIAL ORDER	
I-1	**Actual water delivery service to individual ownership units (e.g. field or farm)**
I-1A	Measurement of volumes
I-1B	Flexibility
I-1C	Reliability
I-1D	Apparent equity
I-2	**Stated water delivery service to individual ownership units (e.g. field or farm)**
I-2A to I-2B	Same sub-indicators as for I-1
I-3	**Actual water delivery service at the most downstream point in the system operated by a paid employee**
I-3A	Number of fields downstream of this point
I-3B	Measurement of volumes
I-3C	Flexibility
I-3D	Reliability
I-3E	Apparent equity
I-4	**Stated water delivery service at the most downstream point operated by a paid employee**
I-4A to I-4E	Same sub-indicators as for I-3
I-5	**Actual water delivery service by the main canals to the second level canals**
I-5A	Flexibility
I-5B	Reliability
I-5C	Equity
I-5D	Control of flow rates to the submain as stated
I-6	Stated water delivery service by the main canals to the second level canals
I-6A to I-6D	Same sub-indicators as for I-5
I-7	**Social "order" in the canal system operated by paid employees**
I-7A	Degree to which deliveries are ***NOT*** taken when not allowed, or at flow rates greater than allowed
I-7B	Noticeable ***non*** -existence of unauthorized turnouts from canals
I-7C	Lack of vandalism of structures
MAIN CANAL	
I-8	**Cross-regulator hardware (main canal)**
I-8A	Ease of cross-regulator operation under the current target operation
I-8B	Level of maintenance of the cross-regulators
I-8C	Lack of water level fluctuation
I-8D	Travel time of a flow rate change throughout this canal level
I-9	**Turnouts from the main canal**
I-9A	Ease of turnout operation under the current target operation
I-9B	Level of maintenance
I-9C	Flow rate capacities
I-l0	**Regulating reservoirs in the main canal**
I-10A	Suitability of the number of location(s)
I-10B	Effectiveness of operation
I-10C	Suitability of the storage/buffer capacities
I-10D	Maintenance

B.4.3. Internal process indicators (continue)

INDICATOR LABEL	PRIMARY INDICATOR AND SUB-INDICATOR NAME
I-11	**Communications for the main canal**
I-11A	Frequency of communications with the next *higher* level
I-11B	Frequency of communications by operators or supervisors with their customers
I-11C	Dependability of voice communications by phone or radio
I-11D	Frequency of visits by upper level supervisors to the field
I-11E	Existence and frequency of remote monitoring (either automatic or manual) at key spill points, including the end of the canal
I-11F	Availability of roads along the canal
I-12	**General conditions for the main canal**
I-12A	General level of maintenance of the canal floor and canal banks
I-12B	General lack of *undesired* seepage (note: If deliberate conjunctive use is practised, some seepage may be desired)
I-12C	Availability of proper equipment and staff to adequately maintain this canal
I-12D	Travel time from the maintenance yard to the most distant point along this canal
	(for crews and maintenance equipment)
I-13	**Operation of the main canal**
I-13A	How frequently do the headworks respond to realistic real time feedback from the operators/observers of this canal level?
I-13B	Existence and effectiveness of water ordering/delivery procedures to match actual demands
I-13C	Clarity and correctness of instructions to operators
I-13D	How frequently is the whole length of this canal checked for problems and reported to the office?
SECOND LEVEL CANALS	
I-14 to I-19	Same indicators as for main canal
THIRD LEVEL CANALS	
I-20 to I-25	Same indicators as for main and second level canals
BUDGETS, EMPLOYEES, WUAs	
I-26	**Budgets**
I-26A	What percentage of the total project (including WUA) O&M is collected as in-kind services, and/or water fees from water users?
I-26B	Adequacy of the actual dollars and in-kind services that are available (from all sources) to sustain adequate O&M with the present mode of operation
I-26C	Adequacy of spending on modernization of the water delivery operation/structures (as contrasted to rehabilitation or regular operation)
I-27	**Employees**
I-27A	Frequency and adequacy of training of operators and middle managers (not secretaries and drivers)
I-27B	Availability of written performance rules
I-27C	Power of employees to make decisions
I-27D	Ability of the project to dismiss employees with cause
I-27E	Rewards for exemplary service
I-27F	Relative salary of an operator compared to a day labourer
I-28	**WUAs**
I-28A	Percentage of all project users who have a functional, formal unit that participates in water distribution
I-28B	Actual ability of the strong WUAs to influence real-time water deliveries to the WUA
I-28C	Ability of the WUA to rely on effective outside help for enforcement of its rules
I-28D	Legal basis for the WUAs
I-28E	Financial strength of WUAs
I-29	**Mobility and size of operations staff, based on the ratio of operating staff to the number of turnouts**
I-30	**Computers for billing and record management: The extent to which computers are used for billing and record management**
I-31	**Computers for canal control: The extent to which computers (either central or on-site) are used for canal control**

B.4.4. System performance survey - RAP indicators

NO	INDICATORS	UNIT	DEFINITION	DATA SOURCE: System level	DATA SOURCE: Farm Level	DATA SOURCE: Data Type
			RAP - SYSTEM PERFORMANCE ASSESSMENT			
			Water Balance Indicators			
1	Total annual volume of irrigation water available at the user level (also called 'irrigation water delivered')	MCM	Total volume of irrigation water (surface plus ground) directly available to users, MCM - using stated conveyance efficiencies for surface and ground water supplies. It includes water delivered by project authorities as well as water pumped by the users themselves. Water users in this context describe the recipients of irrigation service, these may include single irrigators or groups or irrigators organized into water user groups. This value is used to estimate field irrigation efficiency; it is not used to estimate project irrigation efficiency.	x		Secondary data
2	Total annual volume of **irrigation** supply into the 3-D boundaries of the command area	MCM	This is the irrigation water that is imported into the project boundaries, to include river diversions, reservoir discharges, and NET groundwater extraction from the aquifer. This value is used to estimate project irrigation efficiency; it is not used in the computation of field irrigation efficiency.	x		Secondary data
3	Total annual volume of irrigation water managed by authorities (including internal well and recirculation pumps operated by authorities) (can include recirculated water; but does not include any drainage or groundwater that is pumped by farmers)	MCM	This is the irrigation water that is imported into the project boundaries, plus any internal groundwater pumped by the authorities. The value is not used to compute any efficiencies, as some of the internal pumping may be recirculation of original source water. However, this is the volume of water that the project authorities administer, so it is used for the computations related to costs.	x		Secondary data
4	Total annual volume of **water** supply	MCM	Total annual volume of surface water diverted and net groundwater abstraction, plus total rainfall, excluding any recirculating internal drainage within the scheme.	x		Secondary data
5	Total annual volume of irrigation water delivered to users by project authorities	MCM	Total volume of water delivered to water users by the authorities over the year that was directly supplied by project authority (including WUA) diversions or pumps. Water users in this context describe the recipients of irrigation service, these may include single irrigators or groups or irrigators organized into water user groups. This does not include farmer pumps or farmer drainage diversions.	x		Secondary data
6	Total annual volume of ground water pumped within/to command area	MCM	Total annual volume of groundwater that is pumped by authorities or farmers that is dedicated to irrigated fields within the command area. This groundwater can originate outside of the command area.	x		Secondary data
7	Total annual volume of field ET in irrigated fields	MCM	Total annual volume of crop ET. This includes evaporation from the soil as well as transpiration from the crop. Depending upon how the user entered the data, this may include off-season soil evaporation.	x		Secondary data
8	Total annual volume of (ET - effective precipitation)	MCM	The volume of evapotranspiration that must be supplied by irrigation water. Regardless of how one enters data for ET, above, if one follows the guidelines in this manual, one obtains the same final answer of (ET – effective ppt.) – which is the net irrigation requirement.	x		Secondary data
9	Peak net irrigation water requirement	MCM	The net peak daily irrigation requirement (ET – effective rainfall) for the command area, based on actual cropping patterns for this year. (CMS)	x		Secondary data
10	Total command area of the system	ha	The physical hectares of fields in the project that that are provided with irrigation infrastructure and/or wells.	x		Secondary data
11	Irrigated area, including multiple cropping	ha	The hectares of cropped land that received irrigation. If a 1 hectare field has two irrigated crops per year, the reported irrigated area would be 2.0 hectares.	x		Secondary data
12	Annual irrigation supply per unit command area	m^3/ha	$\frac{\text{Total annual volume of irrigation water supply into the command area}}{\text{Total command area of the system}}$	x		Secondary data
13	Annual irrigation supply per unit irrigated area	m^3/ha	$\frac{\text{Total annual volume of irrigation water supply}}{\text{Total annual irrigated crop area}}$	x		Secondary data
14	Conveyance efficiency of project-delivered water (weighted for internal and external, using values stated by project authorities)	%	$\frac{\text{Volume of irrigation water delivered by authorities}}{\text{Total annual volume of project authority irrigation supply}}$	x		Secondary data
15	Estimated conveyance efficiency for project groundwater	%	$\frac{\text{Annual volume of project groundwater delivered to users}}{\text{Annual volume of groundwater pumped by authorities}} \times 100$	x		Secondary data
16	Annual Relative Water Supply (RWS)	none	$\frac{\text{Total annual volume of water supply}}{\text{Total annual volume of field ET in irrigated field}}$	x		Secondary data
17	Annual Relative Irrigation Supply (RIS)	none	$\frac{\text{Total annual volume of irrigation water supply into the 3D boundaries}}{\text{Total annual volume of ET} - \text{effective precipitation}}$	x		Secondary data
18	Water delivery capacity	none	$\frac{\text{Canal capacity to deliver water at system head}}{\text{Peak irrigation water ET requirement}}$	x		Secondary data
19	Security of entitlement supply	%	The frequency with which the irrigation organization is capable of supplying the established system water entitlements.	x		Secondary data
20	Average Field Irrigation Efficiency	%	$\frac{\text{ET} - \text{Effective precipitation} + \text{LR water}}{\text{Total public and private water delivered to fields}} \times 100$	x		Secondary data
21	Command area Irrigation Efficiency	%	$\frac{\text{ET} + \text{Leaching needs} - \text{Effective precipitation}}{\text{Surface irrigation imports} + \text{Net groundwater}} \times 100$	x		Secondary data

B.4.4. System performance survey - RAP indicators (continue)

RAP - SYSTEM PERFORMANCE ASSESSMENT						
NO	INDICATORS	UNIT	DEFINITION	DATA SOURCE		
				System level	Farm Level	Data Type
			Financial Indicators			
22	Cost recovery ratio	none	Gross revenue collected / Total MOM cost	x		Secondary data
23	Maintenance cost to revenue ratio	none	Maintenance cost / Gross revenue collected	x		Secondary data
24	Total MOM cost per unit area	US$/ha	Total MOM cost / Total command area serviced by the system	x		Secondary data
25	Total cost per staff person employed	US$/person	Total number of personnel / Total number of personnel	x		Secondary data
26	Revenue collection performance	none	Gross revenue collected / Gross revenue invoiced	x		Secondary data
27	Staff persons per unit irrigated area	Persons/ha	Total number of personnel engaged in I&D service / Total irrigated area serviced by the system	x		Secondary data
28	Number of turnouts per field operator	None	Total number of turnouts (offtakes) / Total number of personnel engaged in field and ID service	x		Secondary data
29	Average revenue per cubic meter of irrigation water delivered to water users by the project authorities	US$/m3	Gross revenue collected / Total annual volume of project irrigation water delivered	x		Secondary data
30	Total MOM cost per cubic meter of irrigation water delivered to water users by the project authorities	US$/m3	Total MOM cost / Total annual volume of irrigation delivered by project authorities	x		Secondary data
			Agricultural Productivity and Economic Indicators			
31	Total annual value of agricultural production	US$	Total annual value of agricultural production received by producers.	x		Secondary data
32	Output per unit command area	US$/ha	Total annual value of agricultural production / Total command area of the system	x		Secondary data
33	Output per unit irrigated area, including multiple cropping	US$/ha	Total annual value of agricultural production / Total annual irrigated crop area	x		Secondary data
34	Output per unit irrigation supply	US$/$m^3$	Total annual value of agricultural production / Total annual volume of irrigation supply into the 3D boundaries of the command area	x		Secondary data
35	Output per unit water supply	US$/$m^3$	Total annual value of agricultural production / Total annual volume of water supply	x		Secondary data
36	Output per unit of field ET	US$/$m^3$	Total annual value of agricultural production / Total annual volume of field ET	x		Secondary data
			Environmental Indicators			
37	Water quality: Average salinity of the irrigation supply	dS/m	Salinity (electrical conductivity) of the irrigation supply.	x		Secondary data
38	Water quality: Average salinity of the drainage water	dS/m	Salinity (electrical conductivity) of the drainage water that leaves the command area.	x		Secondary data
39	Water quality, Biological: Average BOD of the irrigation supply	mgm/liter	Biological load of the irrigation supply expressed as Biochemical Oxygen Demand (BOD).	x		Secondary data
40	Water quality, Biological: Average BOD of the drainage water	mgm/liter	Biological load of the drainage water expressed as Biochemical Oxygen Demand (BOD).	x		Secondary data
41	Water quality, Chemical: Average COD of the irrigation supply	mgm/liter	Chemical load of the irrigation supply expressed as Chemical Oxygen Demand (COD).	x		Secondary data
42	Water quality, Chemical: Average COD of the drainage water	mgm/liter	Chemical load of the drainage water expressed as Chemical Oxygen Demand (COD).	x		Secondary data
43	Average depth to the shallow water table	m	Average annual depth of the shallow water table calculated from water table observations over the irrigation area.	x		Secondary data
44	Change in shallow water table depth over last 5 years (+ is up)	m	Change in shallow water table depth over the last five years.	x		Secondary data

B.4.4. System performance survey - RAP indicators (continue)

ADDITIONAL INFORMATION ON SYSTEM PERFORMANCE						
				DATA SOURCE		
NO	INDICATORS	UNIT	DEFINITION	System level	Farm Level	Data Type
Financial Performance Indicators						
45	Annual operations and maintenance cost per hectare to government	US$/ha		x		Secondary data
46	Irrigation cash costs per hectare to farmer	US$/ha			x	Farmer survey
47	Value of family labour contributions for canal maintenance	US$/m'			x	Farmer survey
48	Total irrigation costs per hectare to farmers	US$/h			x	Farmer survey
Maintenance Performance Indicators						
49	Percentage of sample canal lengths with critical and noticeable defects after transfer	%		x		Field inspection
50	Percentage of structures that are fully functional, partly functional, and dysfunctional after transfer	%		x		Field inspection
51	Cost to repair dysfunctional structures relative to the annual average budget	%		x		Field inspection
Agricultural performance indicators						
52	Annual/seasonal cropping intensity				x	Secondary
Economic Performance Indicators						
53	Standardise gross value of output per hectare	US$/ha		x		Estimated
54	Standardise gross value of output per unit of water diverted	US$/ha		x		Estimated

B.5. The Stakeholders' Opinion Survey Forms

B.5.1. English version

Institution/organisation: ………………………

QUESTIONNAIRES

BACKGROUND

Globally, the major issues of the sustainability of irrigation system rest on the sustainability of irrigation water availability and agricultural land availability (within the framework of the quantity and quality). In Indonesia, the issue of sustainability of the irrigation system is also linked to the low performance of irrigation systems (low water and land productivity, ageing, poor and diminishing capacity due to sedimentation irrigation infrastructure, increased Management, Operation and Maintenance (MOM) *costs and* low MOM costs recoveries, lack of government financing in irrigation, and lack of attention to the environmental impact caused by the irrigation activity). This study is aimed to find out the opinion of the principal irrigation stakeholders in Indonesia (regional planning board (*Bapeda*), irrigation authority, consultants and WUAs) regarding the proposed form of physically and organizationally (participatory approach) improvements below. It is expected that the results of this questionnaires could find the most suitable and appropriate irrigation system improvement approaches which are acceptable to all parties involved to improve the sustainability of irrigation systems in Indonesia.

To maintain and enhance the sustainability of irrigation systems, the Indonesia irrigation authorities need to apply the principles of Triple Bottom Line that emphasizes three important aspects in maintaining the continuity of an organization that is profit, people/community and environment (in the TBL it is termed as people, planet and profit). From the results of previous studies, the researcher found that to maintain the sustainability of irrigation systems in Indonesia, the following approaches are needed to be considered:

4. Modernising irrigation systems:
    1. Applying pressurised irrigation method and recirculate the irrigation water to improve irrigation efficiency,
    2. Improving channels condition and increasing the number of turnouts/offtakes to improve water distribution,
    3. Expand the scope of irrigation service fee (ISF) by specifying water delivery service and install suitable measuring devices to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF to improve water use efficiency and to increase management, maintenance and operation (MOM) costs recoveries.

5. Improving irrigation system management, procedures, and communication by improving participatory in irrigation management:
    a. Diversifying agriculture and developing agricultural business
    It is difficult to obtain sufficient income from rice farming on small landplots (on average below 0.5 hectares). Moreover, rice production offers low and declining returns to farmers. Better income is more likely to achieve from horticultural crops, therefore there is an increasing demand to diversifying

agriculture and developing agricultural business. (Note: Government policy allows farmers choosing their own crops freely, even though this movement is constrained by continuing concerns to maintain self-sufficiency in rice production).

b. WUAs as business organisation/enterprises
PIM projects have always aimed to improve farmers' income, but have not directly aimed on income generation. One approach in strengthening WUA and increasing benefit to farmers may be through development of WUA as business organisation. WUA as business enterprises could organise members to respond to the specific business opportunities such as fisheries, joint purchase of agricultural inputs, marketing crops, and electric power generation that are present in the system.

c. Turnover Secondary Level/Larger System to WUAs
While turnover smaller systems/tertiary levels have done fairly success, turning over larger system/secondary and main levels still reluctant to proceed. In fact, shortage in staff, vehicles, communication equipment and operational budget constrain the ability of irrigation offices to provide services, make farmers are asked to assist with maintenance and operations of larger systems although it is not within the capacity of farmers to carry out. Therefore, the fact is worth to be followed up formally (Note: Even if larger systems are turned over, the government must retain the authority to supervise water allocation to maintained upstream system do not deprive downstream during periods of shortage. Reengineering of irrigation management should focus on how to best accomplish the key process of equitably distributing irrigation water to farmers).

From the above information, the following are questions to compare the above approaches. Choose (a) or (b), according to your opinions, that are more likely to be implemented in Indonesia irrigation systems.

I.		**Modernising irrigation systems**		
I.1.	a.	Applying pressurised irrigation method and recirculate the irrigation water	b.	Improving channels condition and increasing the number of turnouts/offtakes
I.2.	a.	Applying pressurised irrigation method and recirculate the irrigation water	b.	Expand the scope of irrigation service fee (ISF) by specifying water delivery service and install suitable measuring devices to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF
I.3.	a.	Improving channels condition and increasing the number of turnouts/offtakes	b.	Expand the scope of irrigation service fee (ISF) by specifying water delivery service and install suitable measuring devices to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF

II. Improving participatory in irrigation management

II.1.	a.	Diversifying agriculture and developing agricultural business	b.	WUAs as business organisation/ enterprises
II.2.	a.	Diversifying agriculture and developing agricultural business	b.	Turnover Secondary Level/Larger System to WUAs
II.3.	a.	WUAs as business organisation/ enterprises	b.	Turnover Secondary Level/Larger System to WUAs

III. Modernising irrigation systems vs. Improving participatory in irrigation management

III.1.	a.	Applying pressurised irrigation method and recirculate the irrigation water	b.	Diversifying agriculture and developing agricultural business
III.2.	a.	Applying pressurised irrigation method and recirculate the irrigation water	b.	WUAs as business organisation/ enterprises
III.3.	a.	Applying pressurised irrigation method and recirculate the irrigation water	b.	Turnover Secondary Level/Larger System to WUAs
III.4.	a.	Improving channels condition and increasing the number of turnouts/offtakes	b.	Diversifying agriculture and developing agricultural business
III.5.	a.	Improving channels condition and increasing the number of turnouts/offtakes	b.	WUAs as business organisation/ enterprises
III.6.	a.	Improving channels condition and increasing the number of turnouts/offtakes	b.	Turnover Secondary Level/Larger System to WUAs
III.7.	a.	Expand the scope of irrigation service fee (ISF) by specifying water delivery service and install suitable measuring devices to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF	b.	Diversifying agriculture and developing agricultural business
III.8.	a.	Expand the scope of irrigation service fee (ISF) by specifying water delivery service and install suitable measuring devices to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF	b.	WUAs as business organisation/ enterprises
III.9.	a.	Expand the scope of irrigation service fee (ISF) by specifying water delivery service and install suitable measuring devices to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF	b.	Turnover Secondary Level/Larger System to WUAs

B.5.2. Bahasa Indonesian version

Lembaga / organisasi: ....

Kuisioner

LATAR BELAKANG

Secara global, keberlanjutan sistem irigasi terutama tergantung pada keberlanjutan ketersediaan air irigasi dan ketersediaan lahan pertanian (baik secara kuantitas maupun kualitas). Di Indonesia, keberlanjutan sistem irigasi juga dipengaruhi oleh kinerja sistem irigasi yang perlu ditingkatkan (produktivitas air dan lahan rendah, kondisi infrastruktur irigasi yang perlu peningkatan dan butuh peremajaan serta berkurangnya kapasitas akibat sedimentasi, kenaikan biaya Manajemen, Operasi dan Pemeliharaan (MOM) serta tidak adanya pemasukan untuk biaya MOM, berkurangnya subsidi dan pendanaan irigasi dari pemerintah, serta kurangnya perhatian pada dampak lingkungan yang disebabkan oleh aktivitas irigasi). Penelitian ini bertujuan untuk mengetahui pendapat para pelaku utama irigasi di Indonesia (Bapeda, staf dinas irigasi, konsultan dan WUAs) tentang usulan peningkatan sistem irigasi berikut ini baik secara fisik maupun secara organisasi (pendekatan partisipasi). Diharapkan hasil dari kuisioner ini dapat menemukan pendekatan peningkatan sistem irigasi yang paling tepat dan dapat diterima oleh semua pihak yang terlibat untuk meningkatkan keberlanjutan sistem irigasi di Indonesia.

Untuk menjaga dan meningkatkan keberlanjutan system irigasi, otoritas irigasi Indonesia perlu menerapkan prinsip *Triple Bottom Line* yang menekankan tiga aspek penting dalam menjaga kelangsungan sebuah organisasi yaitu keuntungan (*profit*), masyarakat (*people*), dan lingkungan (*planet*). Dari hasil studi sebelumnya, peneliti menemukan bahwa untuk menjaga dan meningkatkan keberlanjutan system irigasi di Indonesia, pendekatan-pendekatan berikut ini perlu dipertimbangkan:

I. Modernisasi system irigasi:
   1. Menerapkan metode irigasi bertekanan (pompa dan saluran tertutup) dan re-sirkulasi air irigasi untuk meningkatkan efisiensi penggunaan air irigasi,
   2. Meningkatkan kondisi saluran dan meningkatkan jumlah bangunan bagi/sadap untuk meningkatkan distribusi air,
   3. Memperluas cakupan iuran pelayanan air irigasi (IPAIR) dengan menetapkan pelayanan penyaluran air dan memasang alat ukur yang cocok untuk menerapkan IPAIR berdasarkan volume air yang digunakan dan menaikkan IPAIR untuk meningkatkan efisiensi penggunaan air dan mendapatkan biaya untuk pengelolaan, pemeliharaan dan operasi sistem irigasi.

II. Meningkatkan sistem, prosedur, dan komunikasi dalam pengelolaan irigasi dengan meningkatkan partisipasi dalam pengelolaan irigasi:
   1. Diversifikasi pertanian dan mengembangkan badan usaha/bisnis pertanian
      Sulit untuk memperoleh pendapatan yang baik dari pertanian padi dengan lahan yang kecil (rata-rata di bawah 0,5 hektar). Selain itu, keuntungan dari pertanian padi kecil dan makin lama makin kecil. Perbaikan pendapatan petani

lebih mungkin dicapai melalui tanaman hortikultura, sehingga timbul kecenderungan untuk mendiversifikasi pertanian dan pengembangan usaha pertanian. (Catatan: kebijakan pemerintah membebaskan petani memilih tanaman, namun hal ini perlu juga dibatasi untuk mempertahankan swasembada produksi beras).

2. WUAs sebagai organisasi/badan usaha bisnis
   Proyek partisipasi pengelolaan irigasi selalu bertujuan untuk meningkatkan pendapatan petani, tetapi tidak secara langsung ditujukan untuk menghasilkan pendapatan. Salah satu pendekatan dalam memperkuat WUA dan meningkatkan manfaat bagi petani dimungkinkan melalui mengembangkanWUA sebagai organisasi/badan usaha. WUA sebagai badan usaha dapat mengatur anggota untuk menangkap peluang usaha tertentu yang terdapat dalam sistem irigasi seperti perikanan, pembelian bersama input pertanian, pemasaran hasil panen, dan pembangkit tenaga listrik.

3. Mendelegasikan pengelolaan level sekunder/sistem irigasi yang lebih besar dari 500 hektar kepada WUAs
   Mendelegasikan pengelolaan irigasi di level tersier dan sistem irigasi kecil di bawah 500 hektar diketahui cukup sukses, namun pendelegasian pengelolaan sistem irigasi yang lebih besar/level sekunder dan primer masih enggan dilaksanakan. Berdasarkan fakta mengenai kurangnya staf, kendaraan, peralatan komunikasi dan anggaran operasional membatasi kemampuan dinas pengairan untuk memberikan layanan dan petani diminta untuk berpartisipasi dalam pemeliharaan dan operasi dari sistem yang lebihbesar/level sekunder dan primer meskipun ini bukan dalam kapasitas petani untuk melaksanakannya. Oleh sebab itu, fakta ini cukup bernilai untuk ditindaklanjuti secara formal. (Catatan: jika sistem yang lebih besar diserahkan, pemerintah harusmempertahankan wewenang untuk mengawasi alokasi air untuk mempertahankan sistem di hulu tidak mengabaikan bagian hilir selama periode kekurangan air. Rekayasa pengelolaan irigasi harus focus pada bagaimana cara terbaik mendistribusikan air irigasi untuk petani secara adil).

Dari informasi di atas, berikut ini adalah pertanyaan untuk membandingkan pendekatan di atas. Pilih (a) atau (b), menurut pendapat Anda, yang lebih mungkin untuk diterapkan di sistem irigasi Indonesia.

I.		**Modernising irrigation systems**		
I.1.	a.	Applying pressurised irrigation method and recirculate the irrigation water	b.	Improving channels condition and increasing the number of turnouts/offtakes
I.2.	a.	Applying pressurised irrigation method and recirculate the irrigation water	b.	Expand the scope of irrigation service fee (ISF) by specifying water delivery service and install suitable measuring devices to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF
I.3.	a.	Improving channels condition and increasing the number of turnouts/offtakes	b.	Expand the scope of irrigation service fee (ISF) by specifying water delivery service and install suitable measuring devices to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF

II. Improving participatory in irrigation management				
II.1.	a.	Diversifying agriculture and developing agricultural business	b.	WUAs as business organisation/ enterprises
II.2.	a.	Diversifying agriculture and developing agricultural business	b.	Turnover Secondary Level/Larger System to WUAs
II.3.	a.	WUAs as business organisation/ enterprises	b.	Turnover Secondary Level/Larger System to WUAs
III. Modernising irrigation systems vs. Improving participatory in irrigation management				
III.1.	a.	Applying pressurised irrigation method and recirculate the irrigation water	b.	Diversifying agriculture and developing agricultural business
III.2.	a.	Applying pressurised irrigation method and recirculate the irrigation water	b.	WUAs as business organisation/ enterprises
III.3.	a.	Applying pressurised irrigation method and recirculate the irrigation water	b.	Turnover Secondary Level/Larger System to WUAs
III.4.	a.	Improving channels condition and increasing the number of turnouts/offtakes	b.	Diversifying agriculture and developing agricultural business
III.5.	a.	Improving channels condition and increasing the number of turnouts/offtakes	b.	WUAs as business organisation/ enterprises
III.6.	a.	Improving channels condition and increasing the number of turnouts/offtakes	b.	Turnover Secondary Level/Larger System to WUAs
III.7.	a.	Expand the scope of irrigation service fee (ISF) by specifying water delivery service and install suitable measuring devices to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF	b.	Diversifying agriculture and developing agricultural business
III.8.	a.	Expand the scope of irrigation service fee (ISF) by specifying water delivery service and install suitable measuring devices to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF	b.	WUAs as business organisation/ enterprises
III.9.	a.	Expand the scope of irrigation service fee (ISF) by specifying water delivery service and install suitable measuring devices to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF	b.	Turnover Secondary Level/Larger System to WUAs

B.6. The goals, criteria and statements used to assess the viability

B.6.1. The goals, criteria and statements used to assess the viability of modernising irrigation system approaches

Key Issue	Goal/objective	Criteria	Statement: Pressurised irrigation method, recirculate the irrigation water and install volumetric measurement devices to improve irrigation efficiency	Statement: Improving channel condition and increasing the number of turnouts/offtakes to improve irrigation service and water distribution	Statement: Install volumetric measuring devices and expand the scope of the irrigation service fee (ISF) & raise the ISF to increase management, maintenance and operation (MOM) costs recoveries
Technical and economic aspects	Technical viability	Suply reliability/ serviceability	Stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability	Stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability	Stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability
		Efficiency	Efficiency of irrigation water: application, distribution and conveyance, and reducing the losses of the irrigation system	Efficiency of irrigation water: application, distribution and conveyance, and reducing the losses of the irrigation system	Efficiency of irrigation water: application, distribution and conveyance, and reducing the losses of the irrigation system
		Operation and maintenance	Level of skill required to operate and maintain the pressurised irrigation and recirculate the irrigation water	Level of skill required to operate and maintain the channels and turnouts/offtakes	Level of skill required to operate and maintain the volumetric measuring devices
		Utilise existing infrastructure	Potential to utilise existing infrastructure	Potential to utilise existing infrastructure	Potential to utilise existing infrastructure
		Upgradeability	Adapability to new technology and ability to be expanded to improve the system	Adapability to new technology and ability to be expanded to improve the system	Adapability to new technology and ability to be expanded to improve the system
	Technical sustainability	Future demand	Ability to cope with the increasing demand in the future	Ability to cope with the increasing demand in the future	Ability to cope with the increasing demand in the future
		Flexibility	Matching complex demands for water with constraints in supply and delivery	Matching complex demands for water with constraints in supply and delivery	Matching complex demands for water with constraints in supply and delivery
		Long-term operation and maintenance	Ensure continuing asset serviceability	Ensure continuing asset serviceability	Ensure continuing asset serviceability
	Economical viability	Investment cost	The cost of implementing the pressurised irrigation method and recirculate irrigation water	The cost of improving channels conditions and increasing the number of turnouts/offtakes	The cost of installing volumetric measuring devices
		O&M cost efficiency	Difference in the overall O&M cost of supplying closed-channel pressurised irrigation water and open-channel gravity irrigation	Difference in the O&M cost by improving channels condition and increasing the number of turnouts/offtakes	Difference in the O&M cost of supplying irrigation water through volumetric and flow rate measuring devices
		Pricing irrigation water accurately	With the ability to measure irrigation water use accurately, the cost of irrigation water can be determined accurately	By increasing the number of offtakes, it is easier to measure irrigation water use and the cost of irrigation water can be determined accordingly	With the ability to measure irrigation water use accurately, the cost of irrigation water can be determined accurately
		Agricultural productivity	Improve agricultural productivity (annual value of agricultural production, output per unit irrigated area, output per unit water supply)	Improve agricultural productivity (annual value of agricultural production, output per unit irrigated area, output per unit water supply)	Improve agricultural productivity (annual value of agricultural production, output per unit irrigated area, output per unit water supply)
	Economical sustainability	Financial sustainability	Achieve financial self-sufficiency, O&M fraction, fee collection performance	Achieve financial self-sufficiency, O&M fraction, fee collection performance	Achieve financial self-sufficiency, O&M fraction, fee collection performance
Social, institutional, and legal aspects	Social viability	Complain/dissatisfaction*	Dissatisfaction on the existing open channel gravity irrigation method serviceability	Dissatisfaction on the existing open channel gravity irrigation method serviceability	Dissatisfaction on the existing open channel gravity irrigation method serviceability
		Acceptance	Acceptance of pressurised irrigation system by the farmers	Acceptance of improving channels conditions and increasing the number of turnouts/offtakes by the farmers	Acceptance of expanding the scope of the irrigation service fee (ISF), raising the ISF and installing volumetric measuring devices by the farmers
		Trust/confidence	Farmers' trust and confidence in the ability of irrigation authority to provide pressurised irrigation	Farmers' trust and confidence in the ability of irrigation authority to improving channels conditions and increasing the number of turnouts/offtakes	Farmers' trust and confidence in the ability of irrigation authority to expand the scope of the irrigation service fee (ISF), raise the ISF and install volumetric measuring devices
	Institutional viability	Local capacity	Availability of institutional capacity to operate the system	Availability of institutional capacity to operate the improvement	Availability of institutional capacity to operate the improvement
		Acceptance	Acceptance of the pressurised irrigation system by decision makers	Acceptance of improving channels conditions and increasing the number of turnouts/offtakes by decision makers	Acceptance of expanding the scope of the irrigation service fee (ISF), raising the ISF and installing volumetric measuring devices by decision makers
	Legal viability	Legislation/regulation	Regulation/by-laws available to guide system planning and operation	Regulation/by-laws available to guide system planning and operation	Regulation/by-laws available to guide system planning and operation
Environmental, and public health and safety aspects	Environmental viability	In the irrigation project	Reduced waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna	Reduce waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna	Reduce waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna
		Downstream of the project	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water
		Irrigation water efficiency	Reduction in irrigation water use due to irrigation infrastructure improvements, accurate water use measurement, and appropriate price of water	Reduction in irrigation water use due to irrigation infrastructure improvements, water use measurement, and appropriate price of water	Reduction in irrigation water use due to accurate water use measurement, and appropriate price of water
	Public health and safety	Monitoring and controlling	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)
			Increase quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)	Quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)Increase q	Increase quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)
			Reduce the environmental effects often impoverish tail-end farmers.	Reduce the environmental effects often impoverish tail-end farmers.	Reduce the environmental effects often impoverish tail-end farmers.
		Education/awareness	The value of water (water footprint concept, virtual water concept, global environmental issues)	The value of water (water footprint concept, virtual water concept, global environmental issues)	The value of water (water footprint concept, virtual water concept, global environmental issues)

B.6.2. The goals, criteria and statements used to assess the viability of improving management of irrigation system approaches

Key Issue	Goal/ objective	Criteria	Statement: Diversifying agriculture and developing agricultural business	Statement: WUAs as business organisation/enterprises	Statement: Turnover Secondary Level/Larger System to WUAs
Technical and economic aspects	Technical viability	Suply reliability/ serviceability	Ability to satisfying and matching complex demands for water with constraints in supply and delivery	Maintain stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability by mapping the problematic areas (matching for water with constraints in supply and delivery)	Maintain stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability by mapping the problematic areas (matching for water with constraints in supply and delivery)
		Efficiency	Horticultural crops require lower water than rice crops	Maintain efficiency of irrigation water by perform irrigation services (application, distribution and conveyance) in an efficient and effective manner and reducing the losses of the irrigation system	Maintain efficiency of irrigation water by perform irrigation services (application, distribution and conveyance) in an efficient and effective manner and reducing the losses of the irrigation system
		Operation and maintenance	Level of skill required to operate the systems according to the varying water requirements	Level of skill required to provide irrigation services	Level of skill required to operate the systems according to the varying water requirements
		Utilise existing infrastructure	Potential to utilise existing infrastructure	Potential to utilise existing infrastructure	Potential to utilise existing infrastructure
		Upgradeability/ adaptability	Farmers need to coordinate their crop planning so that flooding of rice fields does not interfere with other crops which have less tolerance of flooding	Opportunities to generate income for WUAs (from a range of activities from fisheries, joint purchase of agricultural inputs, marketing of crops, to electric power generation),enable them to perform their functions in an effective and efficient manner and achieved financial viability (financial self-sufficiency, O&M fraction, fee collection performance)	Opportunities for WUAs to extend their participation in irrigation management and generate income in performing their functions in an effective and efficient manner (achieved financial viability: financial self-sufficiency, O&M fraction, fee collection performance)
	Technical sustainability	Future demand	Ability to cope with the increasing demand in the future	WUAs could organise members to respond to the specific business opportunities that are present in a particular system and run their irrigated agriculture business organisation	Shortage in staff, vehicles, communication equipment and operational budget constrain the ability of irrigation offices to provide services, make farmers are asked to assist with maintenance and operations of larger systems although it is not within the capacity of farmers to carry out
		Flexibility	Farmers have greater freedom in choosing their own crops	Facilitate members' access to support services in an effective and efficient manner	Flexibility of WUAs to determine services in an effective and efficient manner
		Long-term operation and maintenance	If agriculture more profitable, then the farmers will be more interested in irrigation management	Pool their resources to achieved economic of scale in running irrigated agricultural business making the utilisation of water and land for irrigation more efficiently and effectively	Achieved financial viability: financial self-sufficiency, O&M fraction, fee collection performance in provideing irrigation services efficiently and effectively
	Economical viability	Implementation cost	The cost of implementing the diversifying agriculture and developing agricultural business (disseminating, training and supporting, and providing water measurement devices to measure water accurately)	Providing a program of business promotion and appropriate technical, managerial and support services for WUAs to respond to business opportunities	Providing appropriate technical, managerial and support services for WUAs to respond to business opportunities
		O&M cost efficiency	Difference in the overall O&M cost of supplying water for monocultivation of rice and diversifying cultivation	Savings to government (enlightened the government burden on O&M cost/less dependence on government support)	Savings to government (enlightened the government burden on O&M cost/less dependence on government support)
		Pricing irrigation water accurately	The ability to satisfy and match complex demands for water requires measuring irrigation water use accurately, therefore the cost of irrigation water can be determined accurately	The ability to satisfy demands for water requires measuring irrigation water use accurately, therefore the cost of irrigation water can be determined accurately	The ability to satisfy demands for water requires measuring irrigation water use accurately, therefore the cost of irrigation water can be determined accurately
		Agricultural productivity	Better farmers income more likely to achieve from horticultural crops and and developing agricultural business	Achieved financial and economic efficiency (standardise gross value of output per hectare, standardise gross value of output per unit of water diverted)	Achieved financial and economic efficiency (standardise gross value of output per hectare, standardise gross value of output per unit of water diverted)
	Economical sustainability	Financial sustainability	Achieve financial self-sufficiency, O&M fraction, fee collection performance	Achieve financial self-sufficiency, O&M fraction, fee collection performance	Achieve financial self-sufficiency, O&M fraction, fee collection performance
Social, institutional, and legal aspects	Social viability	Complain/dissatisfaction*	Dissatisfaction on the existing monocultivation method	Dissatisfaction on the existing government manage irrigation system	Dissatisfaction on the existing government manage irrigation system
		Acceptance	Acceptance of diversifying agriculture by the farmers	Acceptance of WUAs as a business organisation by the farmers	Acceptance of WUAs having extended authority by the farmers
		Trust/confidence	Farmers' trust and confidence in the ability of irrigation authority to satisfy complex water requirement demands	Farmers' trust and confidence in the ability of WUAs to provide irrigation services	Farmers' trust and confidence in the ability of WUAs to provide equitably irrigation services
	Institutional viability	Local capacity	Availability of institutional capacity to operate the system in a different way to satisfy more complex water requirements	Technical capability in managing irrigation system and financial and managerial capability to manage the organisation	Technical capability in managing irrigation system and financial and managerial capability to manage the organisation
		Acceptance	Financial support such as: resource mobilitation, credit and subsidy (advisory assistance and credit may be required from government, bank or financial institution, and subsidies) in developing agricultural business	Financial and managerial support such as: resource mobilization, credit and subsidy (advisory assistance and credit may be required from government, bank or financial institution, and subsidies may be continued on a gradually declining basis)	Financial and managerial support such as resource mobilization, credit and subsidy (advisory assistance and credit may be required from government, bank or financial institution, and subsidies may be continued on a gradually declining basis)
	Legal viability	Legislation/regulation	Institutional and legal basis for farmers to enable them to diversify agrriculture and develop agricultural business; and regulation/by-laws available to guide implementation in accordance to system planning and operation of the system	Institutional and legal basis for WUA to develop and grow as business organisation, and develop links in relation to business between WUAs and other organisations (including private sector organisations)	Institutional and legal basis for farmers to enable them to participate in a larger system and regulation/by-laws available to guide implementation in accordance to system planning and operation of the system
Environmental, and public health and safety aspects	Environmental viability	In the irrigation project	Reduce waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna	Reduce waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna	Reduce waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna
		Downstream of the project	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water
		Irrigation water efficiency	Reduction in irrigation water use due to accurate water use measurement, and appropriate price of water	Reduction in irrigation water use due to accurate water use measurement, and appropriate price of water	Reduction in irrigation water use due to accurate water use measurement, and appropriate price of water
	Public health and safety	Monitoring and controlling	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)
			Increase quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)	Increase quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)	Increase quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)
			Reduce the environmental effects often impoverish tail-end farmers.	Reduce the environmental effects often impoverish tail-end farmers.	Reduce the environmental effects often impoverish tail-end farmers.
		Education/awareness	The value of water (water footprint concept, virtual water concept, global environmental issues)	The value of water (water footprint concept, virtual water concept, global environmental issues)	The value of water (water footprint concept, virtual water concept, global environmental issues)

APPENDIX C

Details of Assessing the Irrigation Performance:

C.1. SPSS – Farm characteristics

C.2. SPSS – Opinion survey

C.3. Irrigation systems' map of location, layout and network

C.4. Irrigation system asset type and condition

C.5. WUAs

C.6. RAP and Benchmarking

C.7. Summary of irrigation system performance

C.1. SPSS – Farm characteristics

Plot position according to the level of channel			Age				Total	Sex		Total	Status			Total	Ownership				Total
			< 30	31 - 45	46 - 60	> 61		Female	Male		Ordinary member	Board member	Non-member		Owner	Share-cropper	Rent	Seasonal labour	
Primary channel	Irrigation system	Small	0	0	3	2	5	0	5	5	1	3	1	5	4	1	0	0	5
		Medium	2	1	0	0	3	1	2	3	2	1	0	3	0	3	0	0	3
		Large	0	0	1	0	1	0	1	1	0	1	0	1	1	0	0	0	1
	Total		2	1	4	2	9	1	8	9	3	5	1	9	5	4	0	0	9
Secondary channel	Irrigation system	Small	2	8	4		14	0	14	14	3	11		14	13	0	0	1	14
		Medium	3	1	1		5	1	4	5	2	3		5	1	3	1	0	5
		Large	0	0	2		2	0	2	2	0	2		2	2	0	0	0	2
	Total		5	9	7		21	1	20	21	5	16		21	16	3	1	1	21
Tertiary channel	Irrigation system	Small	0	11	4	0	15		15	15	2	12	1	15	7	2	2	4	15
		Medium	5	9	7	2	23		23	23	4	15	4	23	12	9	1	1	23
		Large	0	6	12	1	19		19	19	8	10	1	19	16	2	1	0	19
	Total		5	26	23	3	57		57	57	14	37	6	57	35	13	4	5	57
Total	Irrigation system	Small	2	19	11	2	34	0	34	34	6	26	2	34	24	3	2	5	34
		Medium	10	11	8	2	31	2	29	31	8	19	4	31	13	15	2	1	31
		Large	0	6	15	1	22	0	22	22	8	13	1	22	19	2	1	0	22
	Total		12	36	34	5	87	2	85	87	22	58	7	87	56	20	5	6	87
Total	Irrigation system	Small	2	22	13	2	39	0	39	39	7	30	2	39	28	3	2	6	39
		Medium	11	13	9	2	36	2	33	36	9	22	5	36	15	17	2	1	36
		Large	0	7	17	1	25	0	25	25	9	15	1	25	22	2	1	0	25
	Total		14	41	39	6	100	2	98	100	25	67	8	100	64	23	6	7	100

C.1. SPSS – Farm characteristics (continue)

Plot position according to the level of channel			Landplot size				Total	Alternative water soirce for the			Total	Number of people living from the plot				Total
			< 1 hectares	1 - 2 hectares	2 - 5 hectares	> hectares		River	Reservoa r	Well		< 4 people	5 - 8 people	9 - 12 people	> 12 people	
Primary channel	Irrigation system	Small	3	0	0	2	5	4	0	1	5	1	4	0	0	5
		Medium	3	0	0	0	3	3	0	0	3	2	1	0	0	3
		Large	0	0	0	1	1	1	0	0	1	1	0	0	0	1
	Total		6	0	0	3	9	8	0	1	9	4	5	0	0	9
Secondary channel	Irrigation system	Small	12	1	0	1	14	14	0	0	14	7	5	1	1	14
		Medium	3	0	1	1	5	5	0	0	5	3	1	0	1	5
		Large	0	1	0	1	2	2	0	0	2	2	0	0	0	2
	Total		15	2	1	3	21	21	0	0	21	12	6	1	2	21
Tertiary channel	Irrigation system	Small	14	0	1	0	15	15	0	0	15	8	7	0	0	15
		Medium	21	2	0	0	23	15	8	0	23	12	11	0	0	23
		Large	11	5	2	1	19	19	0	0	19	14	5	0	0	19
	Total		46	7	3	1	57	49	8	0	57	34	23	0	0	57
Total	Irrigation system	Small	29	1	1	3	34	33	0	1	34	16	16	1	1	34
		Medium	27	2	1	1	31	23	8	0	31	17	13	0	1	31
		Large	11	6	2	3	22	22	0	0	22	17	5	0	0	22
	Total		67	9	4	7	87	78	8	1	87	50	34	1	2	87
Total	Irrigation system	Small	33	1	1	3	39	38	0	1	39	18	18	1	1	39
		Medium	31	2	1	1	36	26	9	0	36	20	15	0	1	36
		Large	13	7	2	3	25	25	0	0	25	20	6	0	0	25
	Total		77	10	5	8	100	90	9	1	100	57	39	1	2	100

C.1. SPSS – Farm characteristics (continue)

Plot position according to the level of channel			Number of people works for the			Total	Number of harvests per year			Total	Volume of yields per hectare			Total	Plot position at the channel			Total
			< 2 people	3 - 4 people	5 - 6 people		Once per year	Twice per year	Three times per year		< 5 tons per hectare	5 - 7.5 per hectare	> 7.5 per hectare		Head	Middle	Tail-end	
Primary channel	Irrigation system	Small	1	4	0	5	0	3	2	5	5	0	0	5	3	1	1	5
		Medium	3	0	0	3	0	3	0	3	2	1	0	3	0	3	0	3
		Large	0	1	0	1	0	0	1	1	1	0	0	1	0	1	0	1
	Total		4	5	0	9	0	6	3	9	8	1	0	9	3	5	1	9
Secondary channel	Irrigation system	Small	4	7	3	14	0	11	3	14	8	5	1	14	4	9	1	14
		Medium	3	2	0	5	0	5	0	5	4	1	0	5	1	2	2	5
		Large	2	0	0	2	1	1	0	2	0	2	0	2	0	2	0	2
	Total		9	9	3	21	1	17	3	21	12	8	1	21	5	13	3	21
Tertiary channel	Irrigation system	Small	8	7	0	15	1	13	1	15	9	6	0	15	3	7	5	15
		Medium	14	8	1	23	5	18	0	23	14	9	0	23	3	8	12	23
		Large	7	10	2	19	4	14	1	19	11	8	0	19	1	14	4	19
	Total		29	25	3	57	10	45	2	57	34	23	0	57	7	29	21	57
Total	Irrigation system	Small	13	18	3	34	1	27	6	34	22	11	1	34	10	17	7	34
		Medium	20	10	1	31	5	26	0	31	20	11	0	31	4	13	14	31
		Large	9	11	2	22	5	15	2	22	12	10	0	22	1	17	4	22
	Total		42	39	6	87	11	68	8	87	54	32	1	87	15	47	25	87
Total	Irrigation system	Small	15	21	3	39	1	31	7	39	25	13	1	39	11	20	8	39
		Medium	23	11	1	36	6	30	0	36	23	13	0	36	5	15	16	36
		Large	10	13	2	25	6	17	2	25	14	11	0	25	1	20	5	25
	Total		48	45	7	100	13	78	9	100	62	37	1	100	17	54	29	100

C.2. Opinion survey

C.2.1. Opinion survey summary on irrigation and drainage service

I. IRIGATION AND DRAINAGE SERVICES	Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the channel	Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)		
Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
Irrigation																											
1. Water supply adequacy	9	1	21	3	40	25	70	30	100	9	1	22	2	57	8	89	11	100	2	8	0	24	1	64	3	97	100
2. Water arrival timely	8	2	20	5	39	26	67	33	100	10	0	21	3	61	5	92	8	100	0	10	2	22	2	63	5	95	100
3. Flexibility of service	9	1	20	5	47	18	76	24	100	10	0	24	0	61	5	95	5	100	2	8	1	23	2	63	6	94	100
4. Equity of service	8	2	23	1	55	10	86	14	100	9	1	23	1	55	10	87	13	100	0	10	2	22	1	64	3	97	100
5. Supply levels or flow rates fluctuation	9	1	21	3	52	14	82	18	100	9	1	23	1	57	8	90	10	100	1	9	3	21	2	63	7	93	100
Total	**9**	**2**	**21**	**3**	**47**	**19**	**76**	**24**	**100**	**10**	**1**	**23**	**2**	**58**	**7**	**91**	**9**	**100**	**1**	**9**	**2**	**22**	**2**	**64**	**5**	**95**	**100**
Drainage																											
6. Ability dispose of excess water	5	6	9	15	23	43	37	63	100	7	3	16	8	49	16	72	28	100	3	7	1	23	7	59	11	89	100

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

I. IRIGATION AND DRAINAGE SERVICES	Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the system	Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)		
Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
Irrigation																											
1. Water supply adequacy	26	13	23	13	21	5	70	30	100	33	6	32	3	23	2	89	11	100	2	37	1	34	0	25	3	97	100
2. Water arrival timely	25	14	21	15	21	5	67	33	100	32	7	34	1	25	0	92	8	100	0	39	3	32	1	24	5	95	100
3. Flexibility of service	28	11	26	9	22	3	76	24	100	36	3	34	1	25	0	95	5	100	1	38	5	31	0	25	6	94	100
4. Equity of service	34	5	28	8	24	1	86	14	100	36	3	29	7	23	2	87	13	100	0	39	3	32	0	25	3	97	100
5. Supply levels or flow rates fluctuation	34	5	26	9	21	5	82	18	100	33	6	32	3	24	1	90	10	100	1	38	6	30	0	25	7	93	100
Total	**30**	**9**	**25**	**11**	**22**	**4**	**76**	**24**	**100**	**34**	**5**	**32**	**3**	**24**	**1**	**91**	**9**	**100**	**1**	**38**	**4**	**32**	**0**	**25**	**5**	**95**	**100**
Drainage																											
6. Ability dispose of excess water	8	31	22	14	7	18	37	63	100	24	15	25	10	23	2	72	28	100	1	38	9	26	1	24	11	89	100

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

I. IRIGATION AND DRAINAGE SERVICES	Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the channel	Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)		
Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
Irrigation																											
1. Water supply adequacy	15	2	37	17	18	10	70	30	100	16	1	48	6	24	5	89	11	100	16	0	54	2	26	3	97	100	100
2. Water arrival timely	14	3	38	16	15	14	67	33	100	16	1	49	5	26	2	92	8	100	17	3	51	1	28	5	95	100	100
3. Flexibility of service	15	2	40	14	21	8	76	24	100	16	1	54	0	25	3	95	5	100	17	3	51	2	26	6	94	100	100
4. Equity of service	16	1	47	7	23	6	86	14	100	16	1	48	6	23	6	87	13	100	17	1	53	2	26	3	97	100	100
5. Supply levels or flow rates fluctuation	16	1	43	11	23	6	82	18	100	16	1	49	5	24	5	90	10	100	17	6	48	1	28	7	93	100	100
Total	**15**	**2**	**41**	**13**	**20**	**9**	**76**	**24**	**100**	**16**	**1**	**50**	**4**	**25**	**4**	**91**	**9**	**100**	**17**	**3**	**51**	**2**	**27**	**5**	**95**	**100**	**100**
Drainage																											
6. Ability dispose of excess water	9	8	14	40	14	15	37	63	100	15	2	38	16	20	9	72	28	100	1	16	6	48	5	24	11	89	100

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

C.2.2. Opinion survey summary on infrastructure asset condition

II. INFRASTRUCTURE ASSET CONDITION		Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
	Plot position on the channel	Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)		
	Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
1.	Canal	7	3	17	7	34	31	59	41	100	9	1	18	6	46	20	74	26	100	2	37	2	33	0	25	5	95	100
2.	Water control and distribution structure	8	2	20	5	44	22	71	29	100	8	2	20	5	54	11	82	18	100	0	39	3	32	1	24	5	95	100
	Total	**7**	**3**	**18**	**6**	**39**	**26**	**65**	**35**	**100**	**9**	**2**	**19**	**5**	**50**	**16**	**78**	**22**	**100**	**1**	**38**	**3**	**33**	**1**	**25**	**5**	**95**	**100**

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

II. INFRASTRUCTURE ASSET CONDITION		Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
	Plot position on the system	Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)		
	Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
1.	Canal	22	17	22	14	15	10	59	41	100	30	9	24	11	20	6	74	26	100	4	31	2	33	1	24	7	88	100
2.	Water control and distribution structure	29	10	22	14	21	5	71	29	100	30	9	30	6	22	3	82	18	100	2	37	1	34	0	25	3	97	100
	Total	**25**	**14**	**22**	**14**	**18**	**7**	**65**	**35**	**100**	**30**	**9**	**27**	**9**	**21**	**5**	**78**	**22**	**100**	**3**	**34**	**2**	**34**	**1**	**25**	**5**	**95**	**100**

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

II. INFRASTRUCTURE ASSET CONDITION		Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
	Plot position on the channel	Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)		
	Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
1.	Canal	14	3	26	28	18	10	59	41	100	14	3	40	14	20	9	74	26	100	0	17	2	52	2	26	5	95	100
2.	Water control and distribution structure	16	1	36	18	20	9	71	29	100	13	5	47	7	22	7	82	18	100	1	16	1	53	2	26	5	95	100
	Total	**15**	**2**	**31**	**23**	**19**	**10**	**65**	**35**	**100**	**13**	**4**	**44**	**10**	**21**	**8**	**78**	**22**	**100**	**1**	**17**	**2**	**52**	**2**	**26**	**5**	**95**	**100**

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

C.2.3. Opinion survey summary on management practice

III. MANAGEMENT PRACTICE	Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the channel	Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)		
Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
Management Practice																											
1. Standard of service	7	3	13	11	40	25	60	40	100	8	2	21	3	53	13	82	18	100	0	10	1	23	1	64	2	98	100
2. Standard of maintenance	7	3	13	11	39	26	59	41	100	8	2	17	7	54	11	79	21	100	0	10	1	23	2	63	3	97	100
3. Standard of rehabilitation/renewal/improvement	8	2	15	9	41	24	64	36	100	8	2	17	7	52	14	77	23	100	0	10	1	23	2	63	3	97	100
Total	**7**	**3**	**13**	**11**	**40**	**25**	**61**	**39**	**100**	**8**	**2**	**18**	**6**	**53**	**13**	**79**	**21**	**100**	**0**	**10**	**1**	**23**	**2**	**64**	**3**	**97**	**100**
Staff																											
4. Effort to arrange water delivery	9	1	21	3	57	8	87	13	100	8	2	23	1	54	11	85	15	100	0	10	0	24	6	60	6	94	100
5. Responsiveness	8	2	21	3	49	16	78	22	100	9	1	21	3	53	13	83	17	100	1	9	2	24	2	62	6	94	100
6. Easyness to communicate	8	2	21	3	55	10	84	16	100	9	1	22	2	54	11	85	15	100	0	10	0	24	3	62	3	97	100
7. Efforts to improve farmers' knowledge and skill	10	0	20	5	45	21	75	25	100	8	2	20	5	54	11	82	18	100	1	9	0	24	2	63	3	97	100
Total	**12**	**2**	**27**	**5**	**69**	**18**	**108**	**25**	**133**	**11**	**2**	**28**	**4**	**72**	**16**	**111**	**22**	**133**	**1**	**13**	**1**	**32**	**5**	**82**	**6**	**127**	**133**

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

III. MANAGEMENT PRACTICE	Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the system	Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)		
Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
Management Practice																											
1. Standard of service	13	26	28	8	20	6	60	40	100	31	8	29	7	22	3	82	18	100	0	39	1	34	1	24	2	98	100
2. Standard of maintenance	17	22	25	10	16	9	59	41	100	29	10	29	7	22	3	79	21	100	1	38	2	33	0	25	3	97	100
3. Standard of rehabilitation/renewal/improvement	18	21	25	10	21	5	64	36	100	30	9	26	9	21	5	77	23	100	1	38	2	33	0	25	3	97	100
Total	**16**	**23**	**26**	**10**	**19**	**7**	**61**	**39**	**100**	**30**	**9**	**28**	**8**	**21**	**4**	**79**	**21**	**100**	**1**	**38**	**2**	**34**	**0**	**25**	**3**	**97**	**100**
Staff																											
4. Effort to arrange water delivery	38	1	25	10	24	1	87	13	100	34	5	25	10	25	0	85	15	100	0	39	5	31	1	24	6	94	100
5. Responsiveness	34	5	20	16	24	1	78	22	100	36	3	23	13	24	1	83	17	100	2	37	3	33	0	25	6	94	100
6. Easyness to communicate	38	1	22	14	24	1	84	16	100	38	1	24	11	23	2	85	15	100	0	39	3	32	0	25	3	97	100
7. Efforts to improve farmers' knowledge and skill	31	8	23	13	21	5	75	25	100	31	8	26	9	24	1	82	18	100	0	39	3	32	0	25	3	97	100
Total	**47**	**5**	**30**	**18**	**31**	**3**	**108**	**25**	**133**	**46**	**6**	**33**	**15**	**32**	**2**	**111**	**22**	**133**	**1**	**51**	**5**	**43**	**0**	**33**	**6**	**127**	**133**

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

DNSI : do not need significant improvement
NSI : need significant improvement

III. MANAGEMENT PRACTICE	Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the channel	Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)		
Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
Management Practice																											
1. Standard of service	10	7	32	22	17	11	60	40	100	16	1	45	9	21	8	82	18	100	0	17	1	53	1	28	2	98	100
2. Standard of maintenance	15	2	29	25	15	14	59	41	100	16	1	43	11	21	8	79	21	100	0	17	1	53	2	26	3	97	100
3. Standard of rehabilitation/renewal/improvement	13	5	33	21	18	10	64	36	100	16	1	43	11	18	10	77	23	100	0	17	1	53	2	26	3	97	100
Total	**13**	**5**	**31**	**23**	**17**	**12**	**61**	**39**	**100**	**16**	**1**	**43**	**11**	**20**	**9**	**79**	**21**	**100**	**0**	**17**	**1**	**53**	**2**	**27**	**3**	**97**	**100**
Staff																											
4. Effort to arrange water delivery	16	1	48	6	23	6	87	13	100	16	1	48	6	21	8	85	15	100	1	16	2	52	2	26	6	94	100
5. Responsiveness	17	0	44	10	17	11	78	22	100	16	1	46	8	21	8	83	17	100	0	17	1	53	2	26	3	97	100
6. Easyness to communicate	16	1	48	6	20	9	84	16	100	16	1	47	7	22	7	85	15	100	0	17	1	53	2	26	3	97	100
7. Efforts to improve farmers' knowledge and skill	14	3	45	9	16	13	75	25	100	14	3	46	8	22	7	82	18	100	0	17	1	53	2	26	3	97	100
Total	**21**	**2**	**62**	**10**	**25**	**13**	**108**	**25**	**133**	**21**	**2**	**62**	**10**	**28**	**10**	**111**	**22**	**133**	**0**	**23**	**2**	**70**	**3**	**35**	**6**	**127**	**133**

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

C.2.4. Opinion survey summary on WUAs

IV. WUAs		Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the channel		Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)		
Opinion		E	I	E	I	E	I	E	I	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
1.	Effectiveness to accommodate farmers' needs	9	1	23	1	63	2	95	5	100	9	1	23	1	62	3	94	6	100	1	9	2	22	5	61	8	92	100

Note:
E : effective
I : ineffective

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

IV. WUAs		Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the channel		Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)		
Opinion		E	I	E	I	E	I	E	I	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
1.	Effectiveness to accommodate farmers' needs	38	1	33	2	24	1	95	5	100	38	1	31	5	25	0	94	6	100	2	37	6	30	0	25	8	92	100

Note:
E : effective
I : ineffective

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

IV. WUAs		Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the channel		Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)		
Opinion		E	I	E	I	E	I	E	I	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
1.	Effectiveness to accommodate farmers' needs	16	1	53	1	26	2	95	5	100	16	1	52	2	26	2	94	6	100	1	16	3	51	3	25	8	92	100

Note:
E : effective
I : ineffective

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

C.2.5. Opinion survey summary on water measure and tariff

V. WATER MEASURE & TARIFF	Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the channel	Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)		
Opinion	F/A	UF/UA	F/A	UF/UA	F/A	UF/UA	F/A	UF/UA	Tot	B	W	B	W	B	W	B	W	Tot	DNSI/R	NSI/R	DNSI/R	NSI/R	DNSI/R	NSI/R	DNSI/R	NSI/R	Tot
1. Water measures	9	1	20	5	43	23	71	29	100	10	0	21	3	54	11	85	15	100	2	8	1	24	3	61	7	93	100
2. Water tariff	8	2	24	0	55	10	87	13	100	8	2	22	2	57	8	87	13	100	2	8	7	17	17	48	26	74	100

Note:
F/A : fair A : affordable
A : unfair UA : unaffordable

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement/revision
NSI : need significant improvement/revision

V. WATER MEASURE & TARIFF	Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the channel	Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)		
Opinion	F/A	UF/UA	F/A	UF/UA	F/A	UF/UA	F/A	UF/UA	Tot	B	W	B	W	B	W	B	W	Tot	DNSI/R	NSI/R	DNSI/R	NSI/R	DNSI/R	NSI/R	DNSI/R	NSI/R	Tot
1. Water measures	26	13	26	9	18	7	71	29	100	33	6	28	8	24	1	85	15	100	1	38	5	32	1	24	7	93	100
2. Water tariff	34	5	29	7	24	1	87	13	100	34	5	29	7	24	1	87	13	100	11	28	11	24	3	22	26	74	100

Note:
F/A : fair A : affordable
A : unfair UA : unaffordable

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement/revision
NSI : need significant improvement/revision

V. WATER MEASURE & TARIFF	Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
Plot position on the channel	Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)		
Opinion	F/A	UF/UA	F/A	UF/UA	F/A	UF/UA	F/A	UF/UA	Tot	B	W	B	W	B	W	B	W	Tot	DNSI/R	NSI/R	DNSI/R	NSI/R	DNSI/R	NSI/R	DNSI/R	NSI/R	Tot
1. Water measures	14	3	39	15	18	10	71	29	100	16	1	46	8	23	6	85	15	100	0	17	1	53	5	24	6	94	100
2. Water tariff	16	1	48	6	23	6	87	13	100	16	1	48	6	23	6	87	13	100	3	14	14	40	9	20	26	74	100

Note:
F/A : fair A : affordable
A : unfair UA : unaffordable

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement/revision
NSI : need significant improvement/revision

C.2.6. Opinion survey summary on farmers' income

VI. FARMERS' INCOME		Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
	Plot position on the channel	Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)			Primary		Secondary		Tertiary		Total (%)		
	Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
1.	Crop pattern/agricultural practice	7	3	21	3	54	11	82	18	100	7	3	18	6	57	8	83	17	100	0	10	1	23	3	62	5	95	100
2.	Productivity of land	8	2	21	3	43	23	71	29	100	10	0	21	3	60	6	91	9	100	0	10	2	22	0	66	2	98	100
3.	Annual income from agricultural activities	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	9	1	22	2	57	8	89	11	100	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

VI. FARMERS' INCOME		Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
	Plot position on the channel	Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)			Small		Medium		Large		Total (%)		
	Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
1.	Crop pattern/agricultural practice	30	9	28	8	24	1	82	18	100	31	8	26	9	25	0	83	17	100	0	39	3	32	1	24	5	95	100
2.	Productivity of land	25	14	28	8	18	7	71	29	100	37	2	30	6	24	1	91	9	100	1	38	1	34	0	25	2	98	100
3.	Annual income from agricultural activities	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	37	2	28	8	24	1	89	11	100	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

VI. FARMERS' INCOME		Current Level of Services									The Difference of Services Before and After the Project									Expectation on the Level of Services in the Future								
	Plot position on the channel	Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)			Head		Middle		Tail-end		Total (%)		
	Opinion	S	D	S	D	S	D	S	D	Tot	B	W	B	W	B	W	B	W	Tot	DNSI	NSI	DNSI	NSI	DNSI	NSI	DNSI	NSI	Tot
1.	Crop pattern/agricultural practice	15	2	45	9	22	7	82	18	100	14	3	48	6	21	8	83	17	100	1	16	2	52	1	28	5	95	100
2.	Productivity of land	15	2	37	17	20	9	71	29	100	17	0	49	5	24	5	91	9	100	0	17	1	53	1	28	2	98	100
3.	Annual income from agricultural activities	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	17	0	49	5	22	7	89	11	100	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note:
S : satisfied
D : dissatisfied

Note:
B : better
W : worse

Note:
DNSI : do not need significant improvement
NSI : need significant improvement

VI. FARMERS' INCOME		Plot Position									Irrigation System									Plot Position								
	Plot position on the channel	Primary		Secondary		Tertiary		Total (%)			Small		Medium		Large		Total (%)			Head		Middle		Tail-end		Total (%)		
	Opinion	P	IP	P	IP	P	IP	P	IP	Tot	P	IP	P	IP	P	IP	P	IP	Tot	P	IP	P	IP	P	IP	P	IP	Tot
4.	Possibility to improve productivity/income	0	10	1	23	0	66	1	99	100	0	39	1	34	0	25	1	99	100	0	17	0	54	1	28	1	99	100

Note:
P : possible
IP : impossible

C.2.7. Opinion survey summary on willingness if farmers

Landplot position on the channel	Primary			Secondary			Tertiary			Total (%)			
Level of service upgraded													
Opinion	AGS	VC		AGS	VC		AGS	VC		AGS	VC		Tot
1. Add growing season/vary crop	8	1		14	7		36	33		59	41		100
Opinion	Yes	No		Yes	No		Yes	No		Yes	No		Tot
2. Pay higher ISF: yes/no	0	10		18	6		41	24		60	40		100
Infrastructure upgraded													
Opinion	AGS	VC		AGS	VC		AGS	VC		AGS	VC		Tot
3. Add growing season/vary crop	8	2		16	8		43	23		67	33		100
Opinion	No	Labour	Money	No	Labour	Money	No	Labour	Money	No	Labour	Money	Tot
4. Contributution in improvement activities: no/labour only/money	2	8	0	3	13	8	11	39	15	17	60	23	100
Involve in government program													
Opinion	Yes	No		Yes	No		Yes	No		Yes	No		Tot
5. Willingness to involve in government program	9	1		23	1		62	3		94	6		100
Involve in WUAS													
Opinion	M	EM		Yes	No		Yes	No		Yes	No		Tot
6. Kind of involvement in WUA	2	8		8	16		26	39		37	63		100

Landplot position on the channel	Small			Medium			Large			Total (%)			
Level of service upgraded													
Opinion	AGS	VC		AGS	VC		AGS	VC		AGS	VC		Tot
1. Add growing season/vary crop	24	11		19	13		16	16		59	41		100
Opinion	Yes	No		Yes	No		Yes	No		Yes	No		Tot
2. Pay higher ISF: yes/no	17	22		17	18		6	20		40	60		100
Infrastructure upgraded													
Opinion	AGS	VC		AGS	VC		AGS	VC		AGS	VC		Tot
3. Add growing season/vary crop	26	13		23	13		17	8		67	33		100
Opinion	No	Labour	Money	No	Labour	Money	No	Labour	Money	No	Labour	Money	Tot
4. Contributution in improvement activities: no/labour only/money	10	23	6	7	20	9	0	17	8	17	60	23	100
Involve in government program													
Opinion	Yes	No		Yes	No		Yes	No		Yes	No		Tot
5. Willingness to involve in government program	38	1		33	2		23	2		94	6		100
Involve in WUAS													
Opinion	Yes	No		Yes	No		Yes	No		Yes	No		Tot
6. Kind of involvement in WUA	13	26		16	20		8	17		37	63		100

Landplot position on the channel	Head			Middle			Tail-end			Total (%)			
Level of service upgraded													
Opinion	AGS	VC		AGS	VC		AGS	VC		AGS	VC		Tot
1. Add growing season/vary crop	8	9		38	16		20	9		66	34		100
Opinion	Yes	No		Yes	No		Yes	No		Yes	No		Tot
2. Pay higher ISF: yes/no	9	8		36	18		15	14		60	40		100
Infrastructure upgraded													
Opinion	AGS	VC		AGS	VC		AGS	VC		AGS	VC		Tot
3. Add growing season/vary crop	8	9		40	14		18	10		67	33		100
Opinion	No	Labour	Money	No	Labour	Money	No	Labour	Money	No	Labour	Money	Tot
4. Contributution in improvement activities: no/labour only/money	2	9	6	7	38	9	8	13	8	17	60	23	100
Involve in government program													
Opinion	Yes	No		Yes	No		Yes	No		Yes	No		Tot
5. Willingness to involve in government program	16	1		51	3		28	1		94	6		100
Involve in WUAS													
Opinion	Yes	No		Yes	No		Yes	No		Yes	No		Tot
6. Kind of involvement in WUA	7	10		16	38		14	15		37	63		100

Note:

S : satisfied M : member

D : dissatisfied EM : executive meml

C.2.8. SPSS - Opinion survey

Irrigation System	Small						Medium						Large						Sum of Irrigation system (%)								
Plot position according to the level of channel	Primary		Secondary		Tertiary		Primary		Secondary		Tertiary		Primary		Secondary		Tertiary		Small		Medium		Large		Total		
	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	Tot
I. IRIGATION AND DRAINAGE SERVICES																											
Opinion on Current Level of Services																											
1. What is your perception, is the amount of water supplied is adequate/sufficient to meet the crop water requirement?	5	0	12	2	6	9	2	1	4	1	14	9	1	0	2	0	15	4	26	13	23	13	21	5	70	30	100
2. What is your perception, is the water arrives when it is expected?	4	1	11	3	7	8	2	1	4	1	12	11	1	0	2	0	15	4	25	14	21	15	21	5	67	33	100
3. What is your opinion, do you have flexibility/ability to choose the service in accordance to needs (frequency, flow rate, time, and duration)?	5	0	10	4	9	6	2	1	5	0	16	7	1	0	2	0	16	3	28	11	26	9	22	3	76	24	100
4. What is your perception, is there any excessive variation in access to water and service along a canal, e.g. between head and tail enders?	5	0	13	1	12	3	1	2	5	0	18	5	1	0	2	0	18	1	34	5	28	8	24	1	86	14	100
5. What is your opinion, is the supply levels or flow rates during irrigation supply fluctuate a lot?	5	0	12	2	13	2	2	1	4	1	17	6	1	0	2	0	15	4	34	5	26	9	21	5	82	18	100
Opinion on the Difference of Services Before and																											
6. What is your opinion about the amount of water supplied to meet the crop water requirement, is it better/worse after transfer?	5	0	13	1	11	4	2	1	4	1	22	1	1	0	2	0	17	2	33	6	32	3	23	2	89	11	100
7. What is your perception about the expected time of water arrives is it better/worse after transfer?	5	0	12	2	11	4	3	0	4	1	23	0	1	0	2	0	19	0	32	7	34	1	25	0	92	8	100
8. What is your perception about the ability to choose the service in accordance to needs (frequency, flow rate, time, and duration), is it better/ worse after transfer?	5	0	14	0	12	3	3	0	5	0	22	1	1	0	2	0	19	0	36	3	34	1	25	0	95	5	100
9. What is your perception about the equality in access to water and service along a canal, e.g. between head and tail enders, is it better/worse after transfer?	5	0	14	0	12	3	2	1	4	1	19	4	1	0	2	0	17	2	36	3	29	7	23	2	87	13	100
10. What is your opinion about the degree of supply levels or flow rates during irrigation supply, is it better /worse after transfer?	5	0	14	0	10	5	2	1	4	1	22	1	1	0	2	0	18	1	33	6	32	3	24	1	90	10	100
Expectation on the Level of Services in the Future																											
11. What is your expectation on adequacy of water, is it needed to improve/not?	2	3	0	14	0	15	0	3	0	5	1	22	0	1	0	2	0	19	2	37	1	34	0	25	3	97	100
12. What is your expectation on water arrival, is it needed to improve/not?	0	5	0	14	0	15	0	3	1	4	2	21	0	1	1	1	0	19	0	39	3	32	1	24	5	95	100
13. What is your expectation on the ability to choose the service in accordance to needs (frequency, flow rate, time, and duration), is it needed to improve/not?	1	4	0	14	0	15	1	2	1	4	2	21	0	1	0	2	0	19	1	38	5	31	0	25	6	94	100
14. What is your expectation on water equity between head and tail enders, is it needed to improve/not?	0	5	0	14	0	15	0	3	2	3	1	22	0	1	0	2	0	19	0	39	3	32	0	25	3	97	100
15. What is your expectation on water supply levels or flow rates during irrigation supply, is it needed to improve/not?	0	5	1	13	0	15	1	2	2	3	2	21	0	1	0	2	0	19	1	38	6	30	0	25	7	93	100

C.2.8. SPSS – Opinion survey (continue)

Irrigation System		Small						Medium						Large						Sum of Irrigation system (%)								
Plot position according to the level of channel		Primary		Secondary		Tertiary		Primary		Secondary		Tertiary		Primary		Secondary		Tertiary		Small		Medium		Large		Total		
		A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	Tot
Opinion on Drainage Service																												
16.	What is your opinion about the ability of the property to dispose of drainage excess water into the collector system?	1	4	3	11	3	12	2	1	5	0	12	11	1	0	0	2	5	14	8	31	22	14	7	18	37	63	100
17.	What is your perception about the ability of the property to dispose of drainage excess water into the collector system, is it better/worse after transfer?	3	2	8	6	10	5	2	1	4	1	16	7	1	0	2	0	17	2	24	15	25	10	23	2	72	28	100
18.	What is your expectation on the ability of the property to dispose of drainage excess water into the collector system, is it needed to improve/not?	1	4	0	14	0	15	2	1	1	4	5	18	0	1	0	2	1	18	1	38	9	26	1	24	11	89	100
Willingness to Bear the Consequences if Service																												
19.	What will you do if the level of service up grade?	4	1	10	4	9	6	3	0	3	2	12	11	1	0	1	1	14	15	24	11	19	13	16	16	59	41	100
20.	Will you pay if the cost of service increases as a result of up grading level of service?	5	0	2	12	8	7	3	0	2	3	10	13	1	0	1	1	3	16	17	22	17	18	6	20	40	60	100
II. INFRASTRUCTURE ASSET CONDITION																												
Opinion on Current Condition of Assets																												
21.	What is your perception, is the canal condition directly to your farm satisfactory?	3	2	9	5	7	8	2	1	4	1	13	10	1	0	2	0	10	9	22	17	22	14	15	10	59	41	100
22.	What is your perception of other immediate infrastructure (water control and distribution structure) condition to your farm?	4	1	11	3	10	5	2	1	4	1	13	10	1	0	2	0	15	4	29	10	22	14	21	5	71	29	100
Opinion on the Difference of Assets Condition																												
23.	What is your perception about the canal condition directly to your farm, is it better/worse after transfer?	4	1	11	3	11	4	3	0	3	2	15	8	1	0	2	0	14	5	30	9	24	11	20	6	74	26	100
24.	What is your perception about other immediate infrastructure (water control and distribution structure) condition to your farm, is it better/worse after transfer?	4	1	13	1	9	6	2	1	2	3	22	1	1	0	2	0	16	3	30	9	30	6	22	3	82	18	100
Expectation on the Level of Services in the Future																												
25.	What is your expectation on the canal directly to your farm, is it needed to improve/not?	0	5	2	12	0	15	0	3	0	5	2	21	0	1	0	2	0	19	2	37	2	33	0	25	5	95	100
26.	What is your expectation on other immediate infrastructure (water control and distribution structure) to your farm, is it needed to improve/not?	0	5	0	14	0	15	0	3	1	4	2	21	0	1	0	2	1	18	0	39	3	32	1	24	5	95	100
Willingness to Bear the Consequences if																												
27.	What will you do if the current level irrigation infrastructure up grade?	3	2	10	4	10	5	3	0	2	3	15	8	1	0	2	0	12	7	26	13	23	13	17	8	67	33	100
28.	Will you contribute in rehabilitation/improvement activities in the primary and secondary system or level of irrigation system up grade?	1	4	3	7	5	9	1	2	0	3	5	12	0	1	0	1	0	13	13	30	9	25	0	22	22	78	100
III. MANAGEMENT PRACTICE																												
Opinion on Current Management Practice																												
29.	What is your perception, is the current standard of irrigation & drainage service provided by the irrigation agency meets your needs?	3	2	4	10	4	11	2	1	5	0	17	6	1	0	2	0	14	5	13	26	28	8	20	6	60	40	100
30.	What is your view of the current standard of maintenance in the water supply system?	3	2	6	8	6	9	2	1	3	2	17	6	1	0	2	0	11	8	17	22	25	10	16	9	59	41	100
31.	What is your opinion, is the current standard of rehabilitation/renewal/improvement provided by the irrigation agency sufficient your needs?	4	1	7	7	5	10	2	1	4	1	16	7	1	0	2	0	15	4	18	21	25	10	21	5	64	36	100

C.2.8. SPSS – Opinion survey (continue)

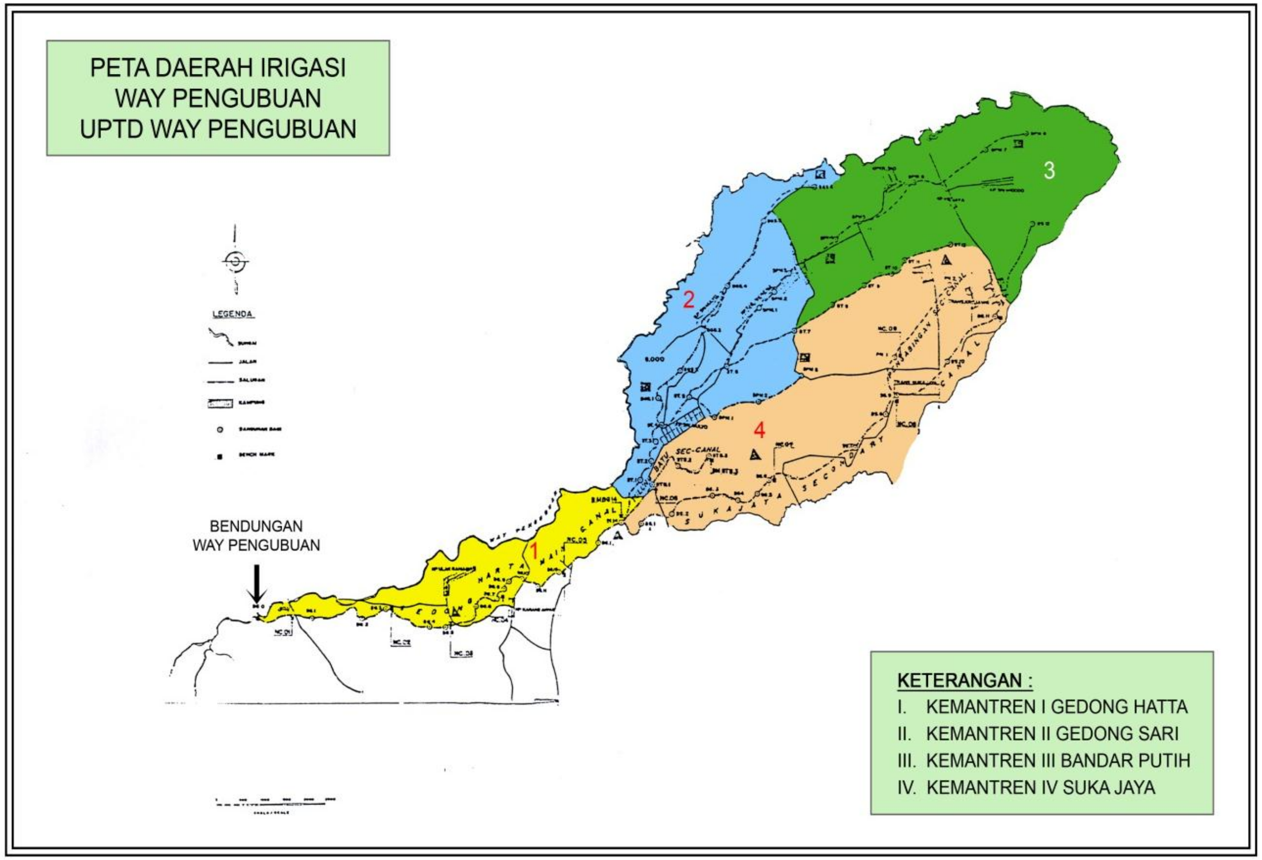
Irrigation System		Small						Medium						Large						Sum of Irrigation system (%)								
Plot position according to the level of channel		Primary		Secondary		Tertiary		Primary		Secondary		Tertiary		Primary		Secondary		Tertiary		Small		Medium		Large		Total		
		A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	Tot
Opinion on the Difference of Management Practice																												
32.	What is your opinion about the current standard of irrigation and drainage service provided by the irrigation agency to meets your needs, is it better/worse after transfer?	4	1	13	1	10	5	2	1	3	2	20	3	1	0	2	0	16	3	31	8	29	7	22	3	82	18	100
33.	What is your view about the standard of maintenance in the water supply system, is it better/worse after transfer?	3	2	10	4	12	3	3	0	3	2	19	4	1	0	2	0	16	3	29	10	29	7	22	3	79	21	100
34.	What is your opinion about the current standard of rehabilitation/renewal/ improvement provided by the irrigation agency, is it better/worse after transfer?	4	1	10	4	12	3	2	1	3	2	18	5	1	0	2	0	15	4	30	9	26	9	21	5	77	23	100
Expectation on the Management Practice in the																												
35.	What is your expectation on the standard of irrigation and drainage service in the water supply system, is it needed to improve/not?	0	5	0	14	0	15	0	3	0	5	1	22	0	1	1	1	0	19	0	39	1	34	1	24	2	98	100
36.	What is your expectation on the standard of maintenance in the water supply system, is it needed to improve/not?	0	5	0	14	1	14	0	3	1	4	1	22	0	1	0	2	0	19	1	38	2	33	0	25	3	97	100
37.	What is your expectation on the standard of rehabilitation/renewal/ improvement in the system, is it needed to improve/not?	0	5	0	14	1	14	0	3	1	4	1	22	0	1	0	2	0	19	1	38	2	33	0	25	3	97	100
Opinion on Current On-duty-staff																												
38.	What is your opinion about the degree of agency staffs' effort to arrange water delivery?	5	0	13	1	15	0	2	1	3	2	17	6	1	0	2	0	18	1	38	1	25	10	24	1	87	13	100
39.	What is your perception of the degree of responsiveness of agency staff?	5	0	13	1	12	3	1	2	3	2	13	10	1	0	2	0	18	1	34	5	20	16	24	1	78	22	100
40.	What is yor perception, is it easy for you to communicate with the agency staff.	5	0	13	1	15	0	1	2	3	2	15	8	1	0	2	0	18	1	38	1	22	14	24	1	84	16	100
41.	What is your opinion about the degree of responsiveness from government to improve your knowledge and skill in agricultural practice/irrigation practice?	5	0	12	2	10	5	3	0	4	1	13	10	1	0	1	1	16	3	31	8	23	13	21	5	75	25	100
Opinion on the Difference of On-duty-staff Before																												
42.	What is your perception about the degree of agency staffs' effort to arrange water delivery, is it better/worse after transfer?	4	1	13	1	13	2	2	1	5	0	15	8	1	0	2	0	19	0	34	5	25	10	25	0	85	15	100
43.	What is your perception about the degree of responsiveness from agency staff, is better/worse after transfer?	5	0	13	1	13	2	2	1	3	2	15	8	1	0	2	0	18	1	36	3	23	13	24	1	83	17	100
44.	What is your perception about the ease of communication between user and agency staff, is it better/worse after transfer?	5	0	14	0	14	1	2	1	3	2	16	7	1	0	2	0	17	2	38	1	24	11	23	2	85	15	100
45.	What is your perception about the degree of responsiveness from government to improve knowledge/ agricultural practice/ irrigation practice for farmer, is it better/worse after transfer?	4	1	12	2	11	4	2	1	3	2	18	5	1	0	2	0	18	1	31	8	26	9	24	1	82	18	100

C.2.8. SPSS – Opinion survey (continue)

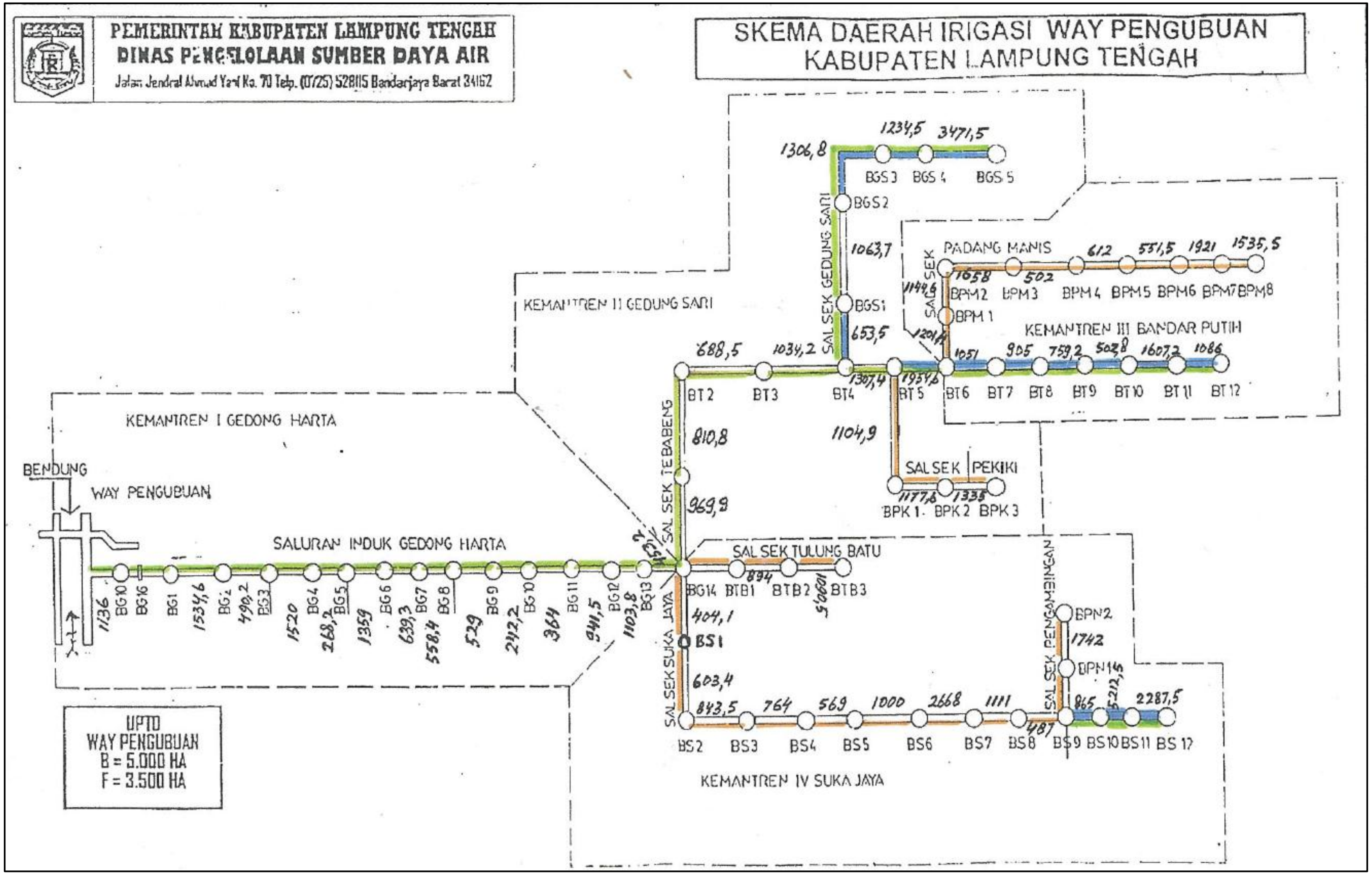
Irrigation System		Small						Medium						Large						Sum of Irrigation system (%)								
Plot position according to the level of channel		Primary		Secondary		Tertiary		Primary		Secondary		Tertiary		Primary		Secondary		Tertiary		Small		Medium		Large		Total		
		A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	A/S	IA/US	Tot
Expectation on On-duty-staff in the Future																												
46.	What is your expectation on the degree of agency staffs' effort to arrange water delivery, is it needed to improve/not?	0	5	0	14	0	15	0	3	0	5	4	19	0	1	0	2	1	18	0	39	5	31	1	24	6	94	100
47.	What is your expectation expectation on the degree of responsiveness from government, is it needed to improve/not?	1	4	1	14	0	15	0	3	1	5	2	21	0	1	0	2	0	19	2	37	3	33	0	25	6	94	100
48.	What is your expectation on the ease of communication between user and agency staff, is it needed to improve/not?	0	5	0	14	0	15	0	3	0	5	3	20	0	1	0	2	0	19	0	39	3	32	0	25	3	97	100
49.	What is your expectation from government to improve your knowledge in agricultural practice/irrigation practice, is it needed to improve/not?	0	5	0	14	0	15	1	2	0	5	2	21	0	1	0	2	0	19	0	39	3	32	0	25	3	97	100
50.	Will you actively involve in government program if it is provide?	5	0	13	1	15	0	2	1	5	0	22	1	1	0	2	0	17	2	38	1	33	2	23	2	94	6	100
Opinion on water measures practice and water tariff																												
51.	What is your perception about the current water measures practice, is it fair?	4	1	10	4	9	6	3	0	5	0	15	8	1	0	2	0	13	6	26	13	26	9	18	7	71	29	100
52.	What is your perception about the current water measures practice, is better/worse after transfer?	5	0	12	2	12	3	3	0	4	1	17	6	1	0	2	0	18	1	33	6	28	8	24	1	85	15	100
53.	What is your expectation on the current water measures practice, is it needed to improve/not?	1	4	0	14	0	15	1	2	1	5	2	21	0	1	0	2	1	18	1	38	5	32	1	24	7	93	100
54.	What is your opinion about the current water tariff, is it fairly affordable for you?	4	1	14	0	12	3	2	1	5	0	18	5	1	0	2	0	18	1	34	5	29	7	24	1	87	13	100
55.	What is your perception about the current water tariff, is it better/worse after transfer?	4	1	13	1	13	2	2	1	4	1	19	4	1	0	2	0	18	1	34	5	29	7	24	1	87	13	100
56.	What is your expectation on the current water tariff, is it needed to revise/not?	1	4	5	9	4	11	1	2	1	4	8	15	0	1	0	2	3	16	11	28	11	24	3	22	26	74	100
IV. WATER USERS' ASSOCIATION																												
57.	What is your opinion about WUA, is it effective to accommodate your needs?	5	0	13	1	15	0	2	1	5	0	22	1	1	0	2	0	18	1	38	1	33	2	24	1	95	5	100
58.	What is your perception about the degree of effectiveness of water users group, is it better/worse after transfer?	5	0	14	0	14	1	2	1	4	1	21	2	1	0	2	0	19	0	38	1	31	5	25	0	94	6	100
59.	What is your expectation on the degree of effectiveness of water users group, is it needed to improve/not?	1	4	1	13	0	15	0	3	1	4	4	19	0	1	0	2	0	19	2	37	6	30	0	25	8	92	100
60.	What kind of involvement you wish to contribute at WUA?	1	4	4	10	6	9	1	2	3	2	10	13	0	1	0	2	7	12	13	26	16	20	8	17	37	63	100
V. FARMERS' INCOME																												
61.	What is you opinion about your crop pattern/agricultural practice at the moment?	4	1	12	2	10	5	1	2	4	1	19	4	1	0	2	0	18	1	30	9	28	8	24	1	82	18	100
62.	What is your opinion about the productivity of your land, is the yield is satisfactory?	4	1	12	2	6	9	2	1	4	1	18	5	1	0	2	0	13	6	25	14	28	8	18	7	71	29	100
63.	What is your view about the crop pattern/agricultural practice, is it better/worse after transfer?	3	2	11	3	13	2	2	1	3	2	18	5	1	0	2	0	19	0	31	8	26	9	25	0	83	17	100
64.	What is your view about the degree of land productivity, is it better/worse after transfer?	5	0	12	2	15	0	3	0	4	1	19	4	1	0	2	0	18	1	37	2	30	6	24	1	91	9	100
65.	What is your view about your annual income from agricultural activities, is it better/worse after transfer.	5	0	13	1	14	1	2	1	4	1	18	5	1	0	2	0	18	1	37	2	28	8	24	1	89	11	100
66.	What is your expectation on current pattern/agricultural practice, is it needed to improve/not?	0	5	0	14	0	15	0	3	1	4	2	21	0	1	0	2	1	18	0	39	3	32	1	24	5	95	100
67.	What is your expectation on land productivity, is it needed to improve/not?	0	5	1	13	0	15	0	3	1	4	0	23	0	1	0	2	0	19	1	38	1	34	0	25	2	98	100
68.	What is your perception on your annual income from agricultural activities, is there any possibility to improve?	0	5	0	14	0	15	0	3	1	4	0	23	0	1	0	2	0	19	0	39	1	34	0	25	1	99	100

C.3. Irrigation system' layouts and networks

C.3.1. Way Pengubuan

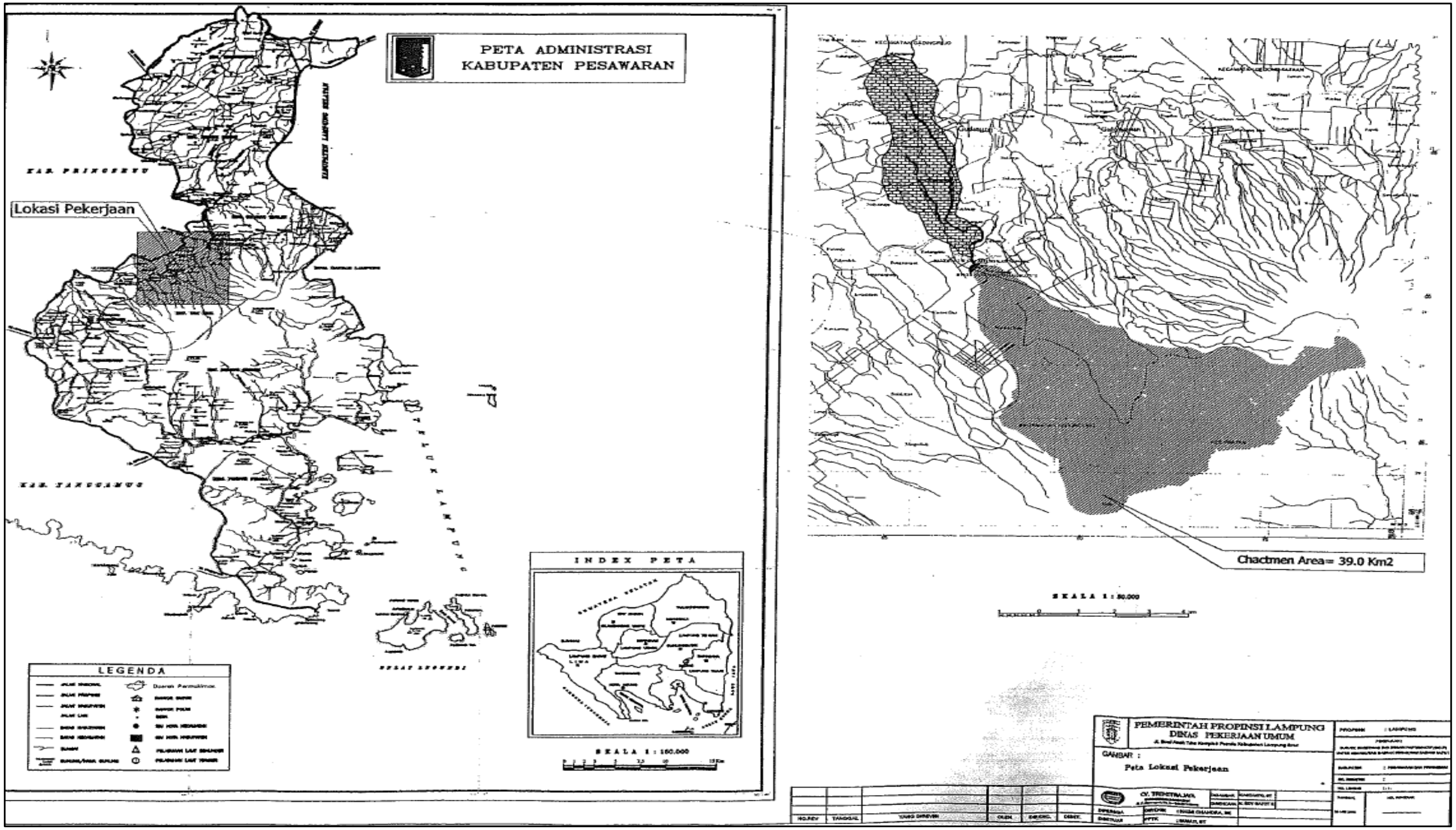


WAY PENGUBUAN IRRIGATION SYSTEM LOCATION MAP

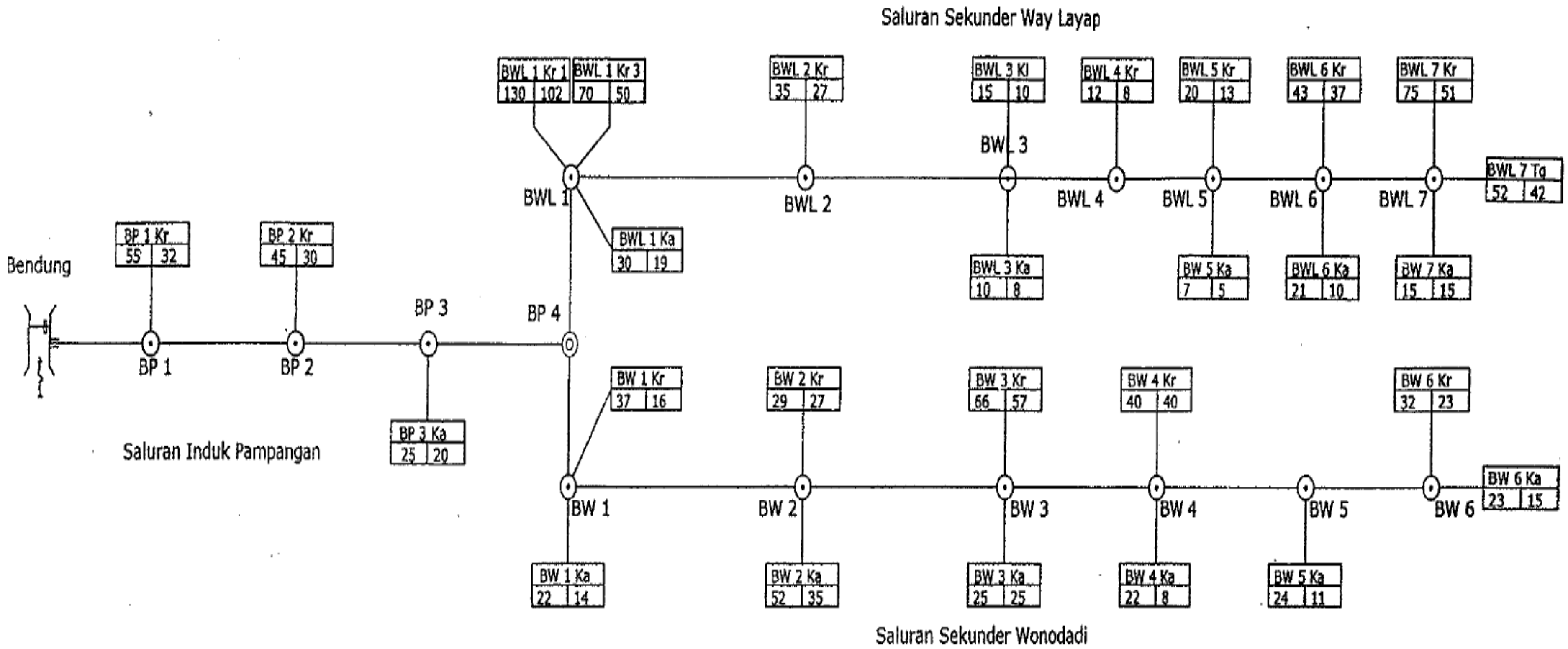


WAY PENGUBUAN IRRIGATION SYSTEM LAYOUT

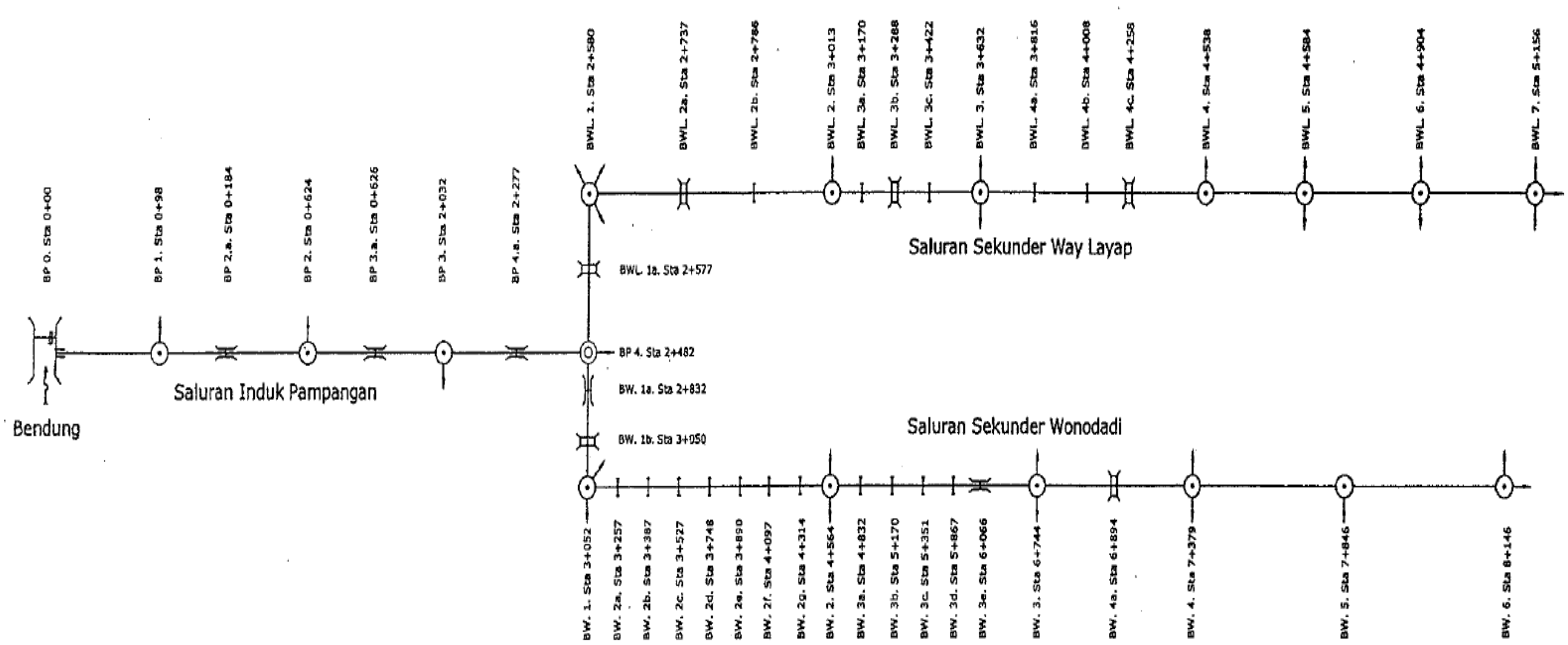
C.3.2. Way Padang Ratu



WAY PADANG RATU IRRIGATION SYSTEM LOCATION MAP

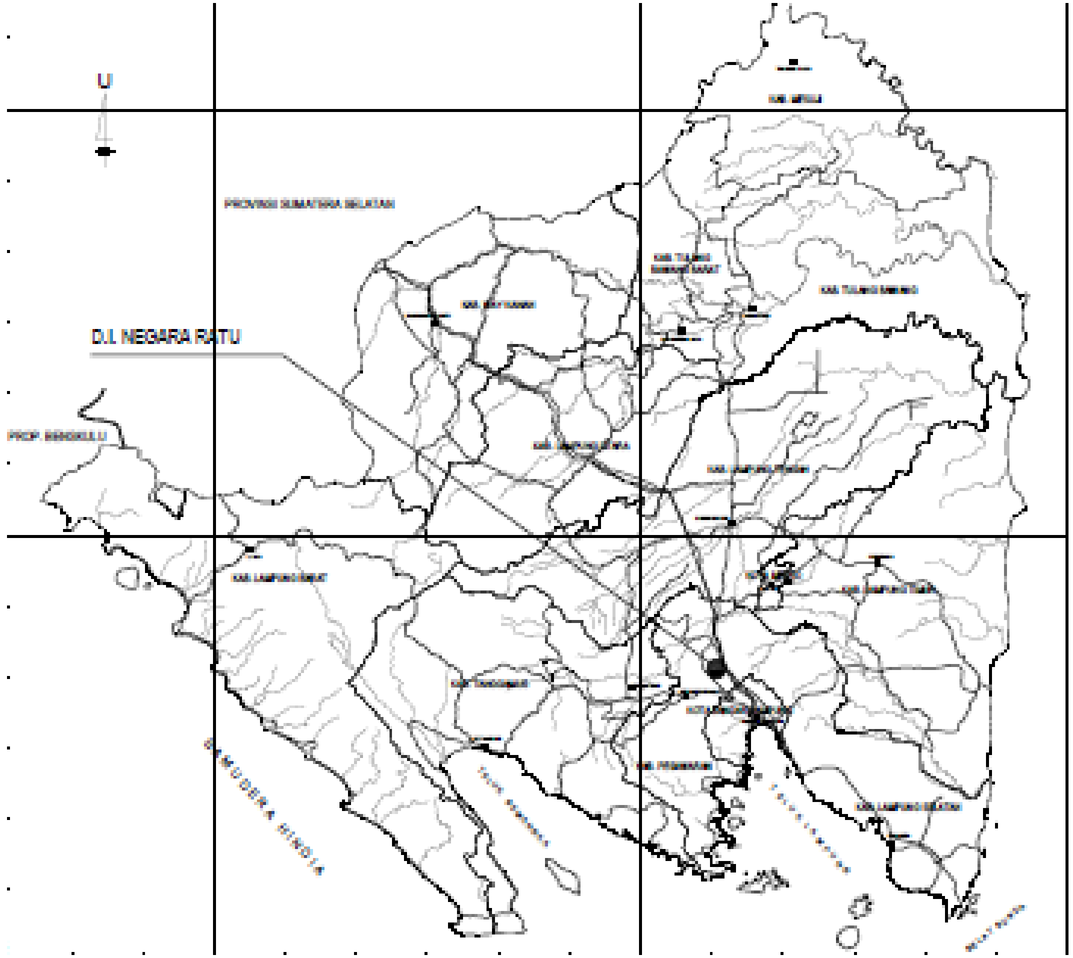


WAY PADANG RATU IRRIGATION SYSTEM LAYOUT

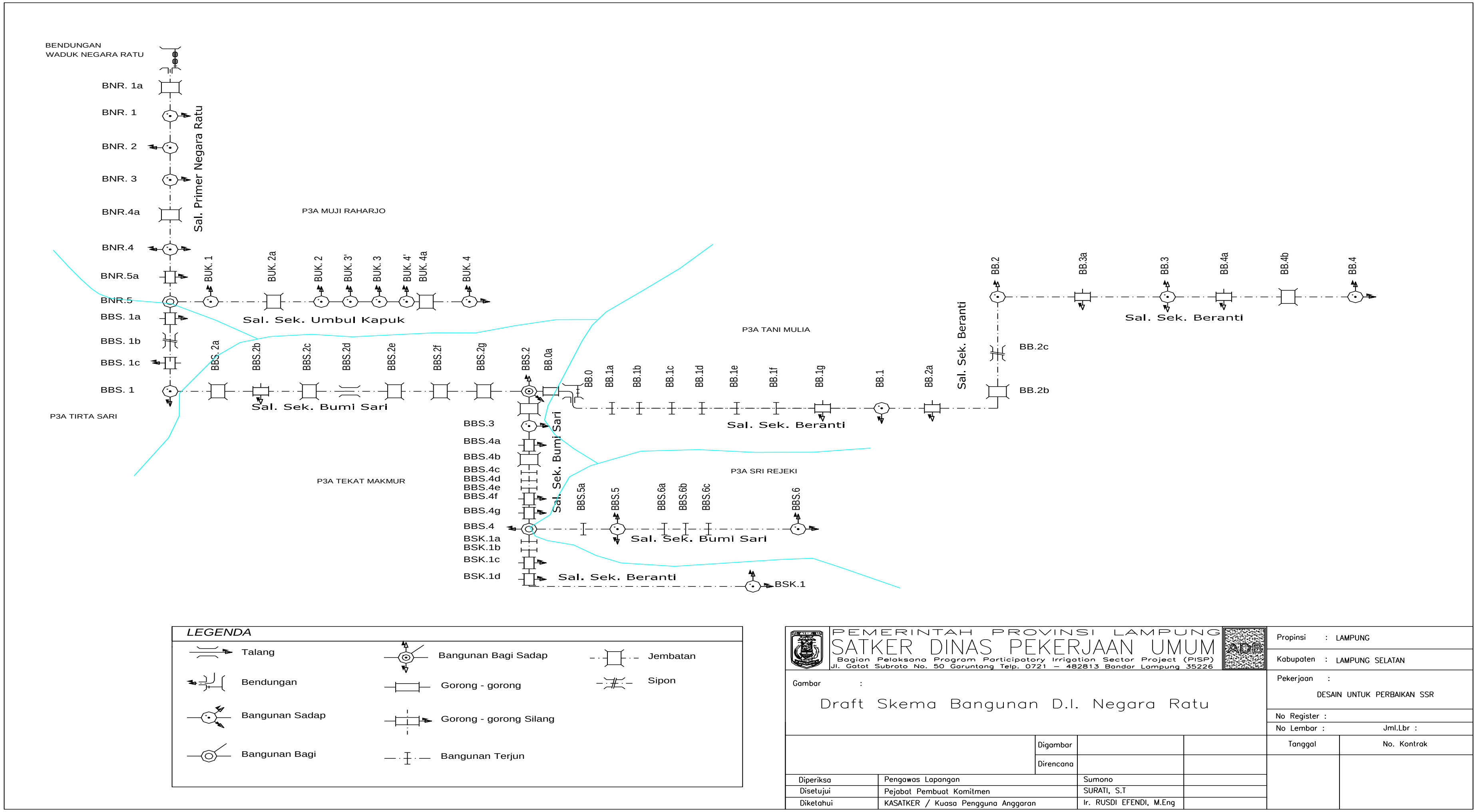


WAY PADANG RATU IRRIGATION SYSTEM LAYOUT

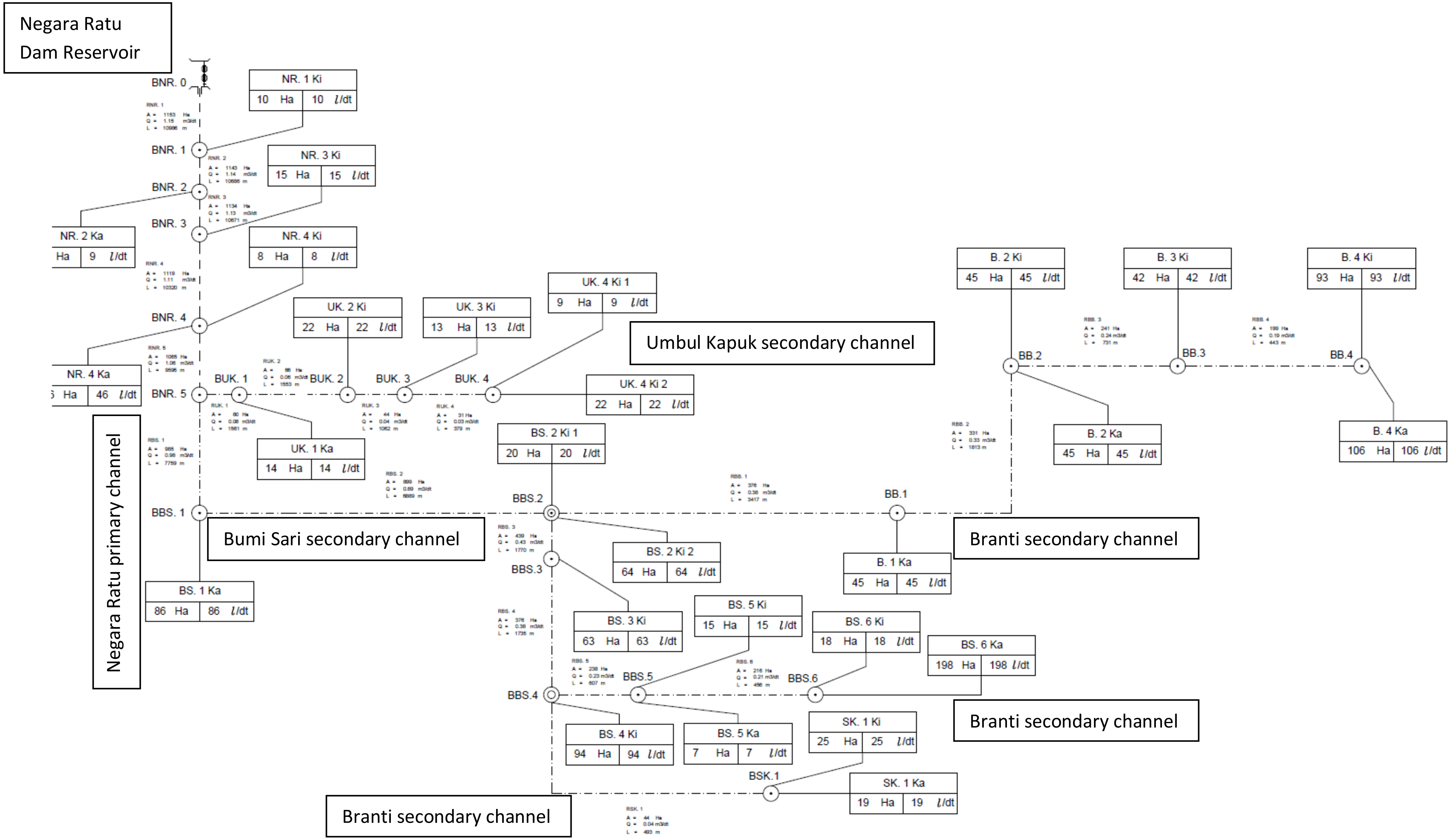
C.3.3. Way Negara Ratu



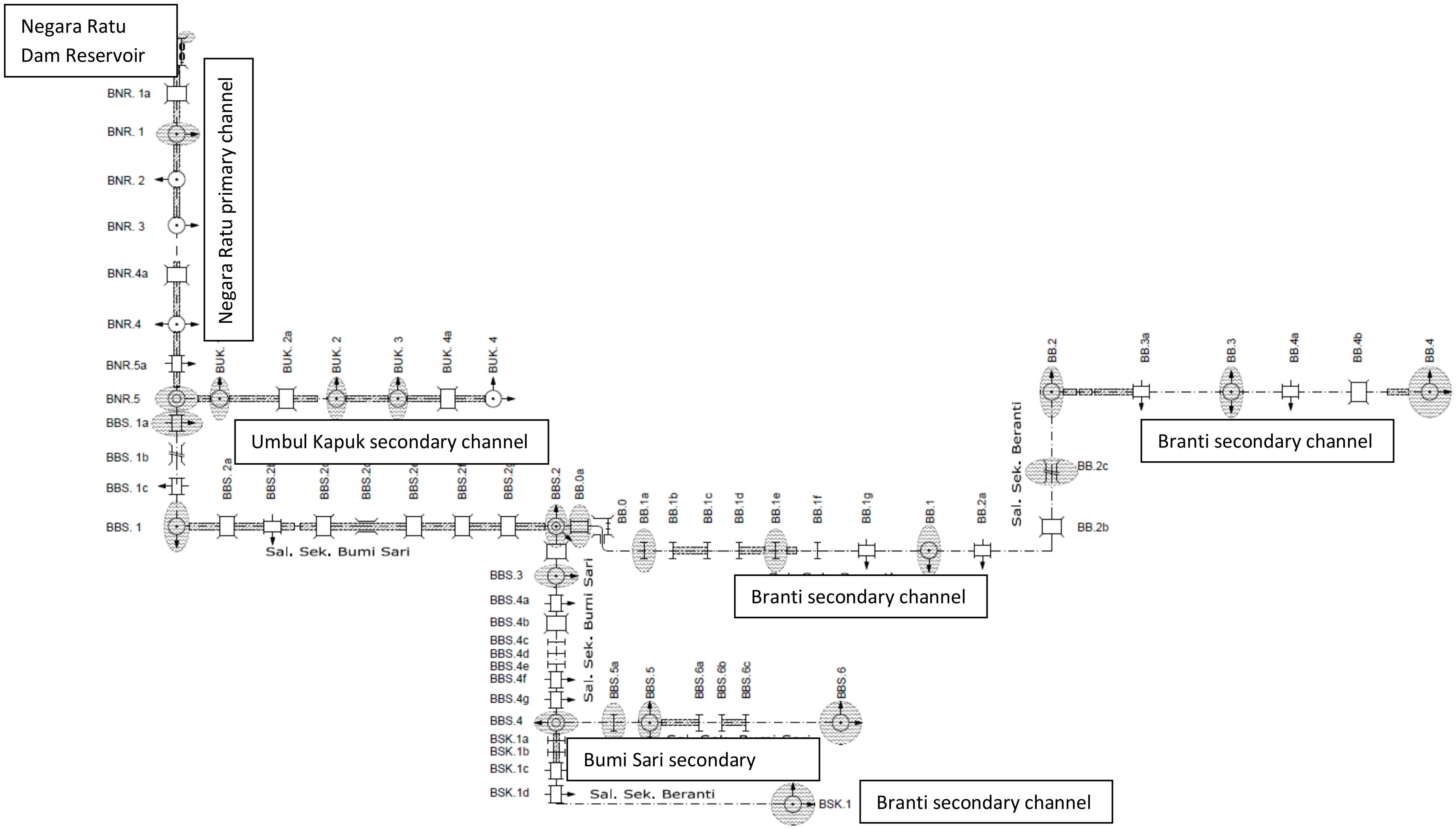
WAY NEGARA RATU IRRIGATION SYSTEM LOCATION MAP



WAY NEGARA RATU IRRIGATION SYSTEM LAYOUT

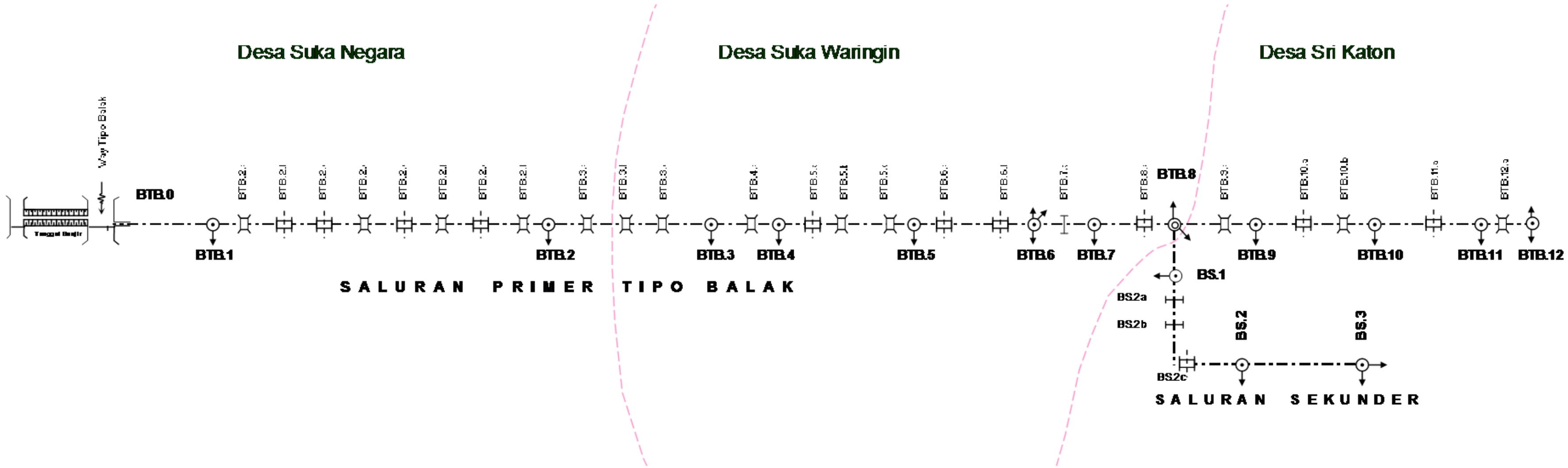


WAY NEGARA RATU IRRIGATION SYSTEM LAYOUT

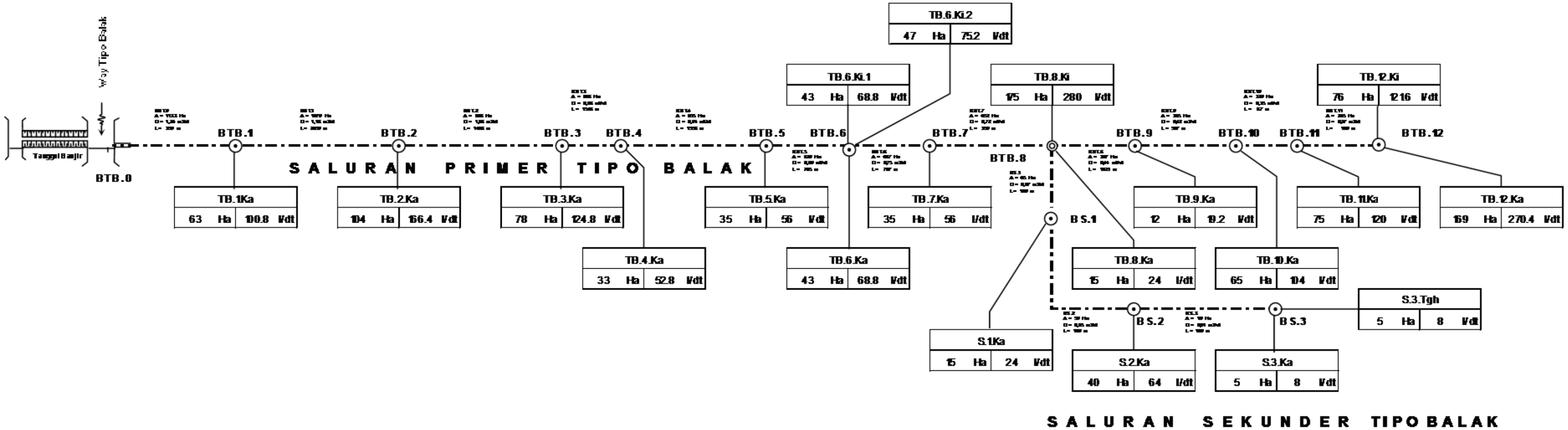


WAY NEGARA RATU IRRIGATION SYSTEM LAYOUT

C.3.4. Way Tipo Balak



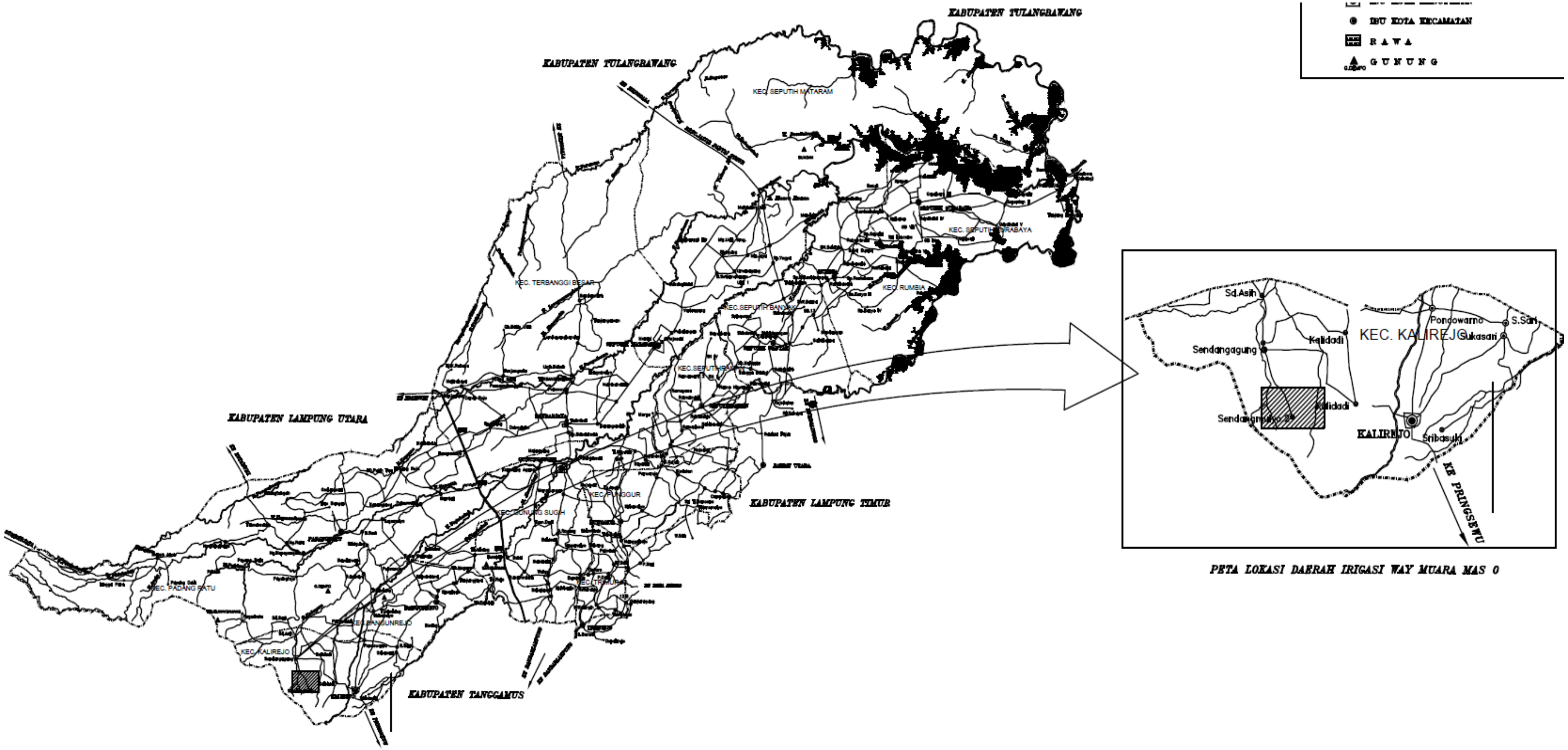
WAY TIPO BALAK IRRIGATION SYSTEM LAYOUT



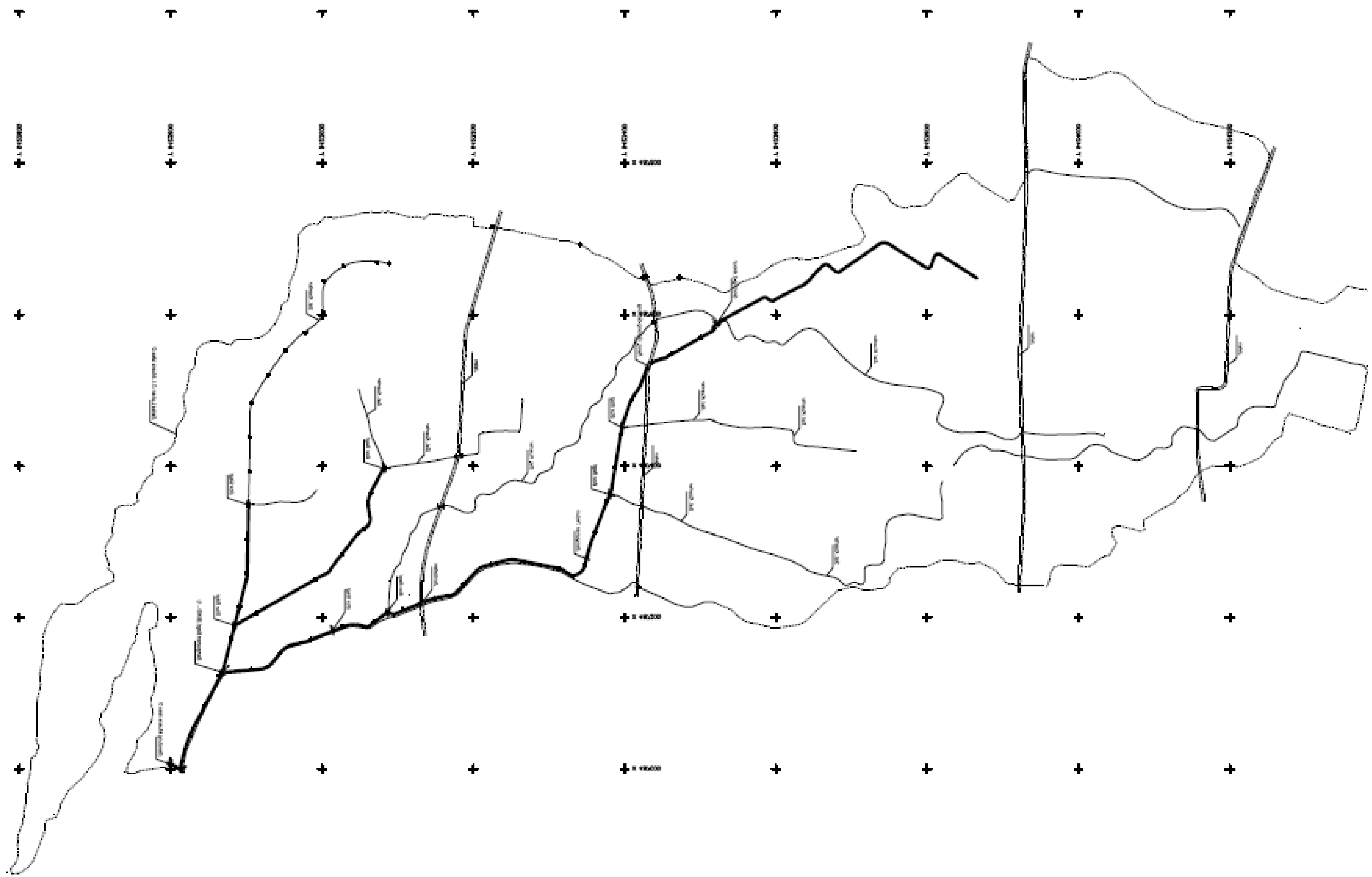
WAY TIPO BALAK IRRIGATION SYSTEM LAYOUT

C.3.5. Way Muara Mas

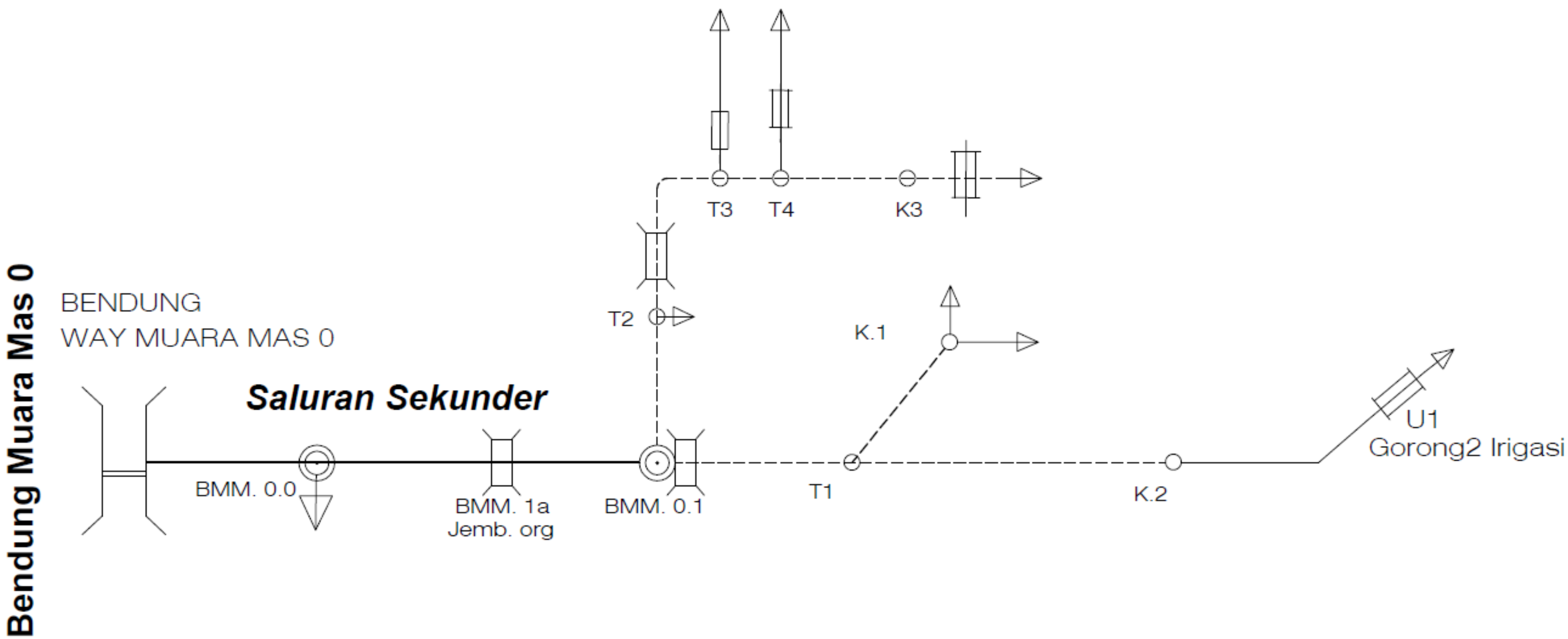
WAY MUARA MAS, MUARA MAS I, MUARA MAS II & MUARA MAS III (SENDANG AGUNG) IRRIGATION SYSTEM LOCATION MAP



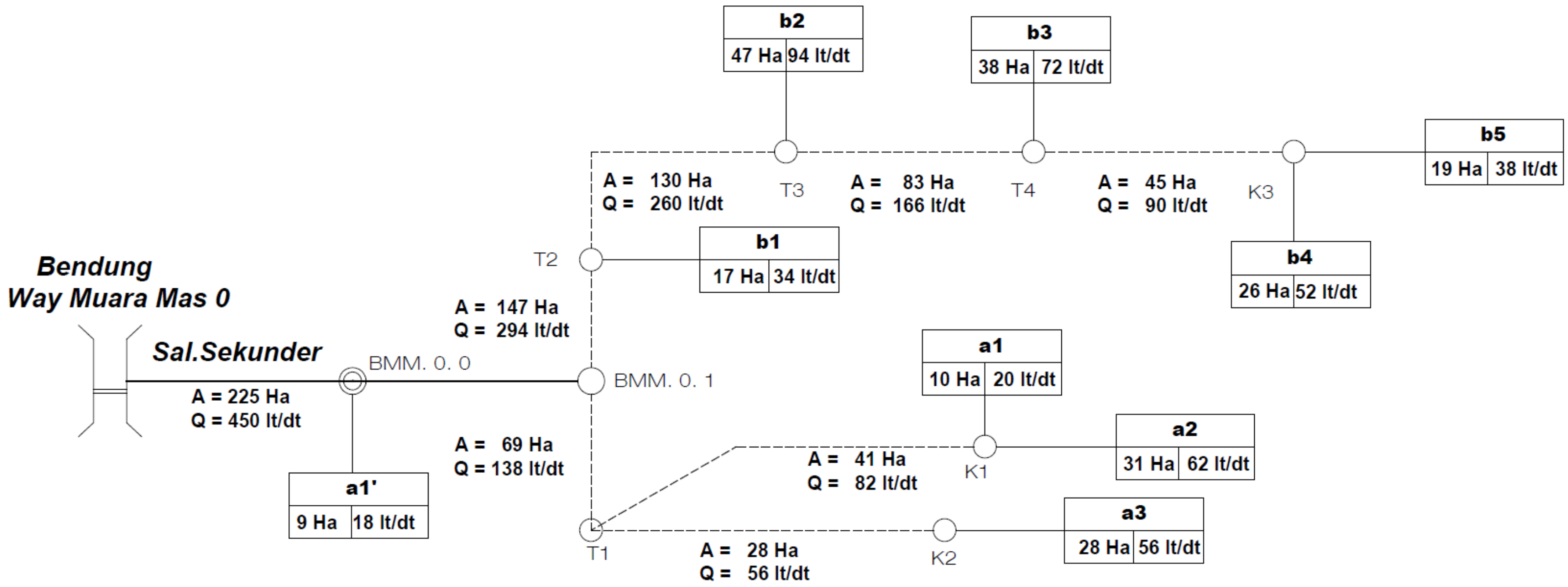
WAY MUARA MAS IRRIGATION SYSTEM LOCATION MAP



WAY MUARA MAS IRRIGATION SYSTEM LAYOUT



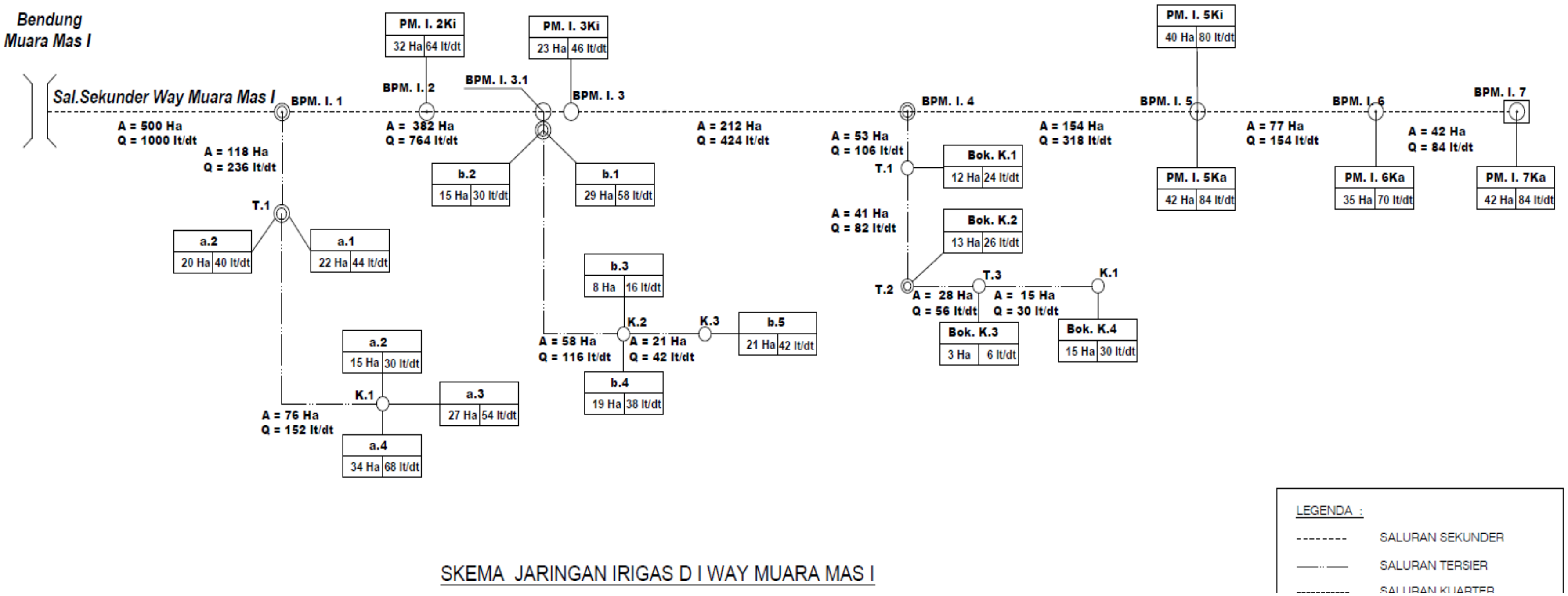
WAY MUARA MAS I IRRIGATION SYSTEM LAYOUT



WAY MUARA MAS IRRIGATION SYSTEM LAYOUT

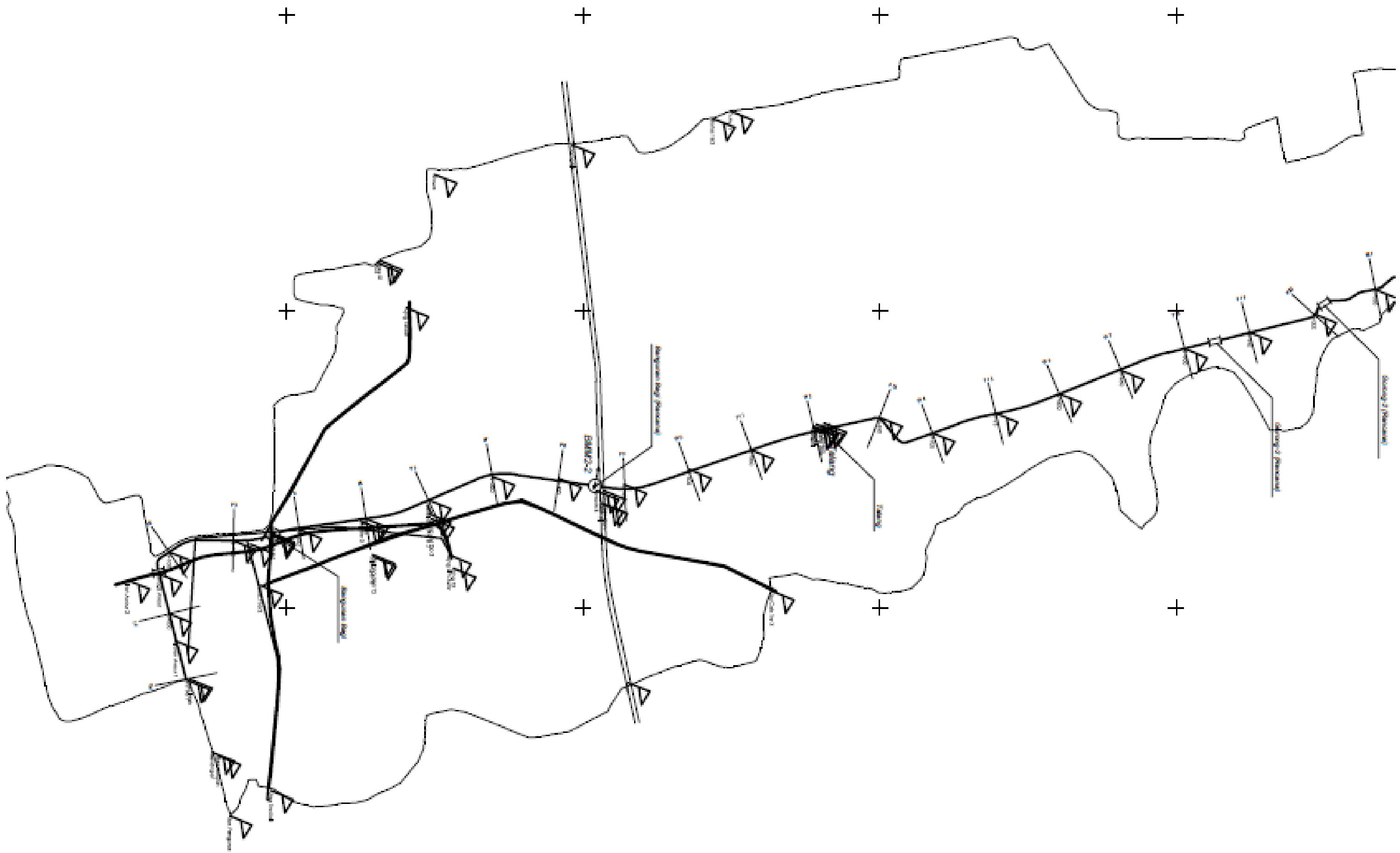
C.3.6. Way Muara Mas I

WAY MUARA MAS I IRRIGATION LOCATION MAP

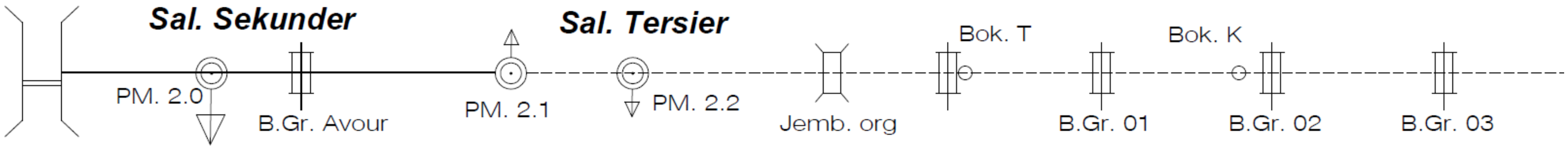


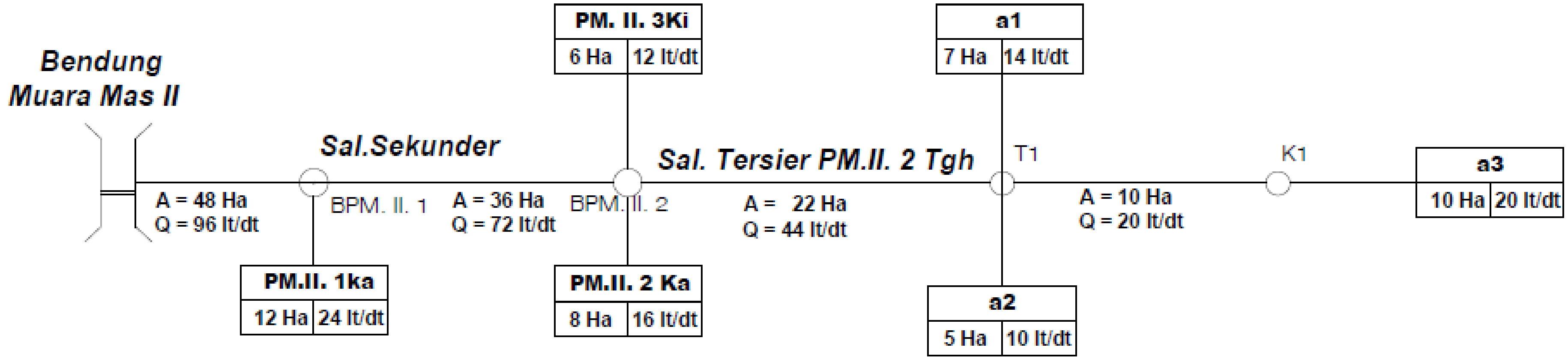
WAY MUARA MAS I IRRIGATION SYSTEM LAYOUT

C.3.7. Way Muara Mas II



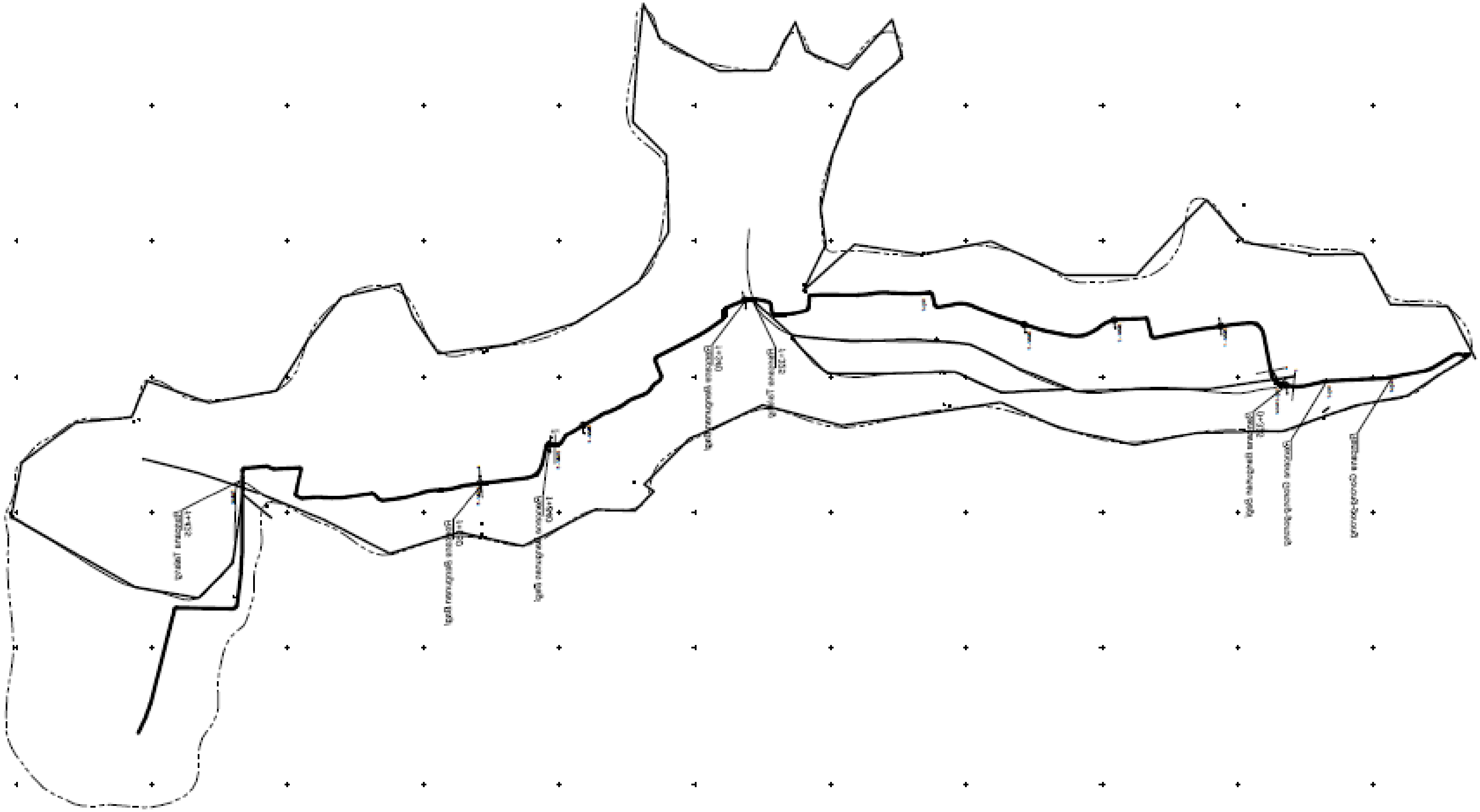
WAY MUARA MAS II IRRIGATION SYSTEM LAYOUT



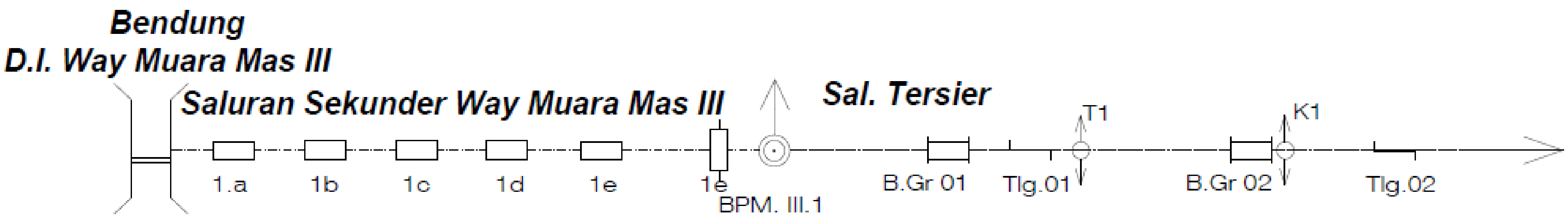


SKEMA JARINGAN IRIGASI WAY MUARA MAS II (Review)

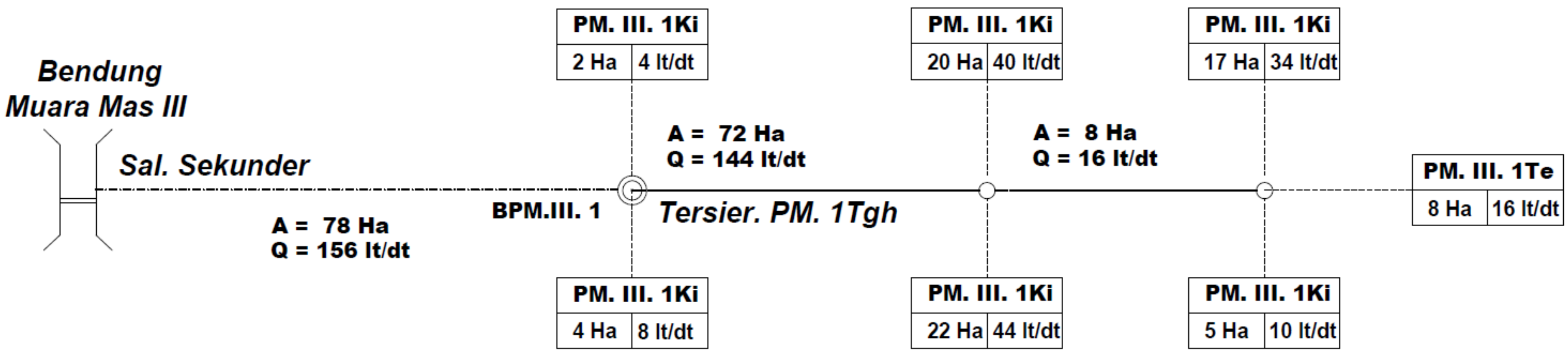
C.3.8. Way Muara Mas III



WAY MUARA MAS III IRRIGATION SYSTEM LAYOUT

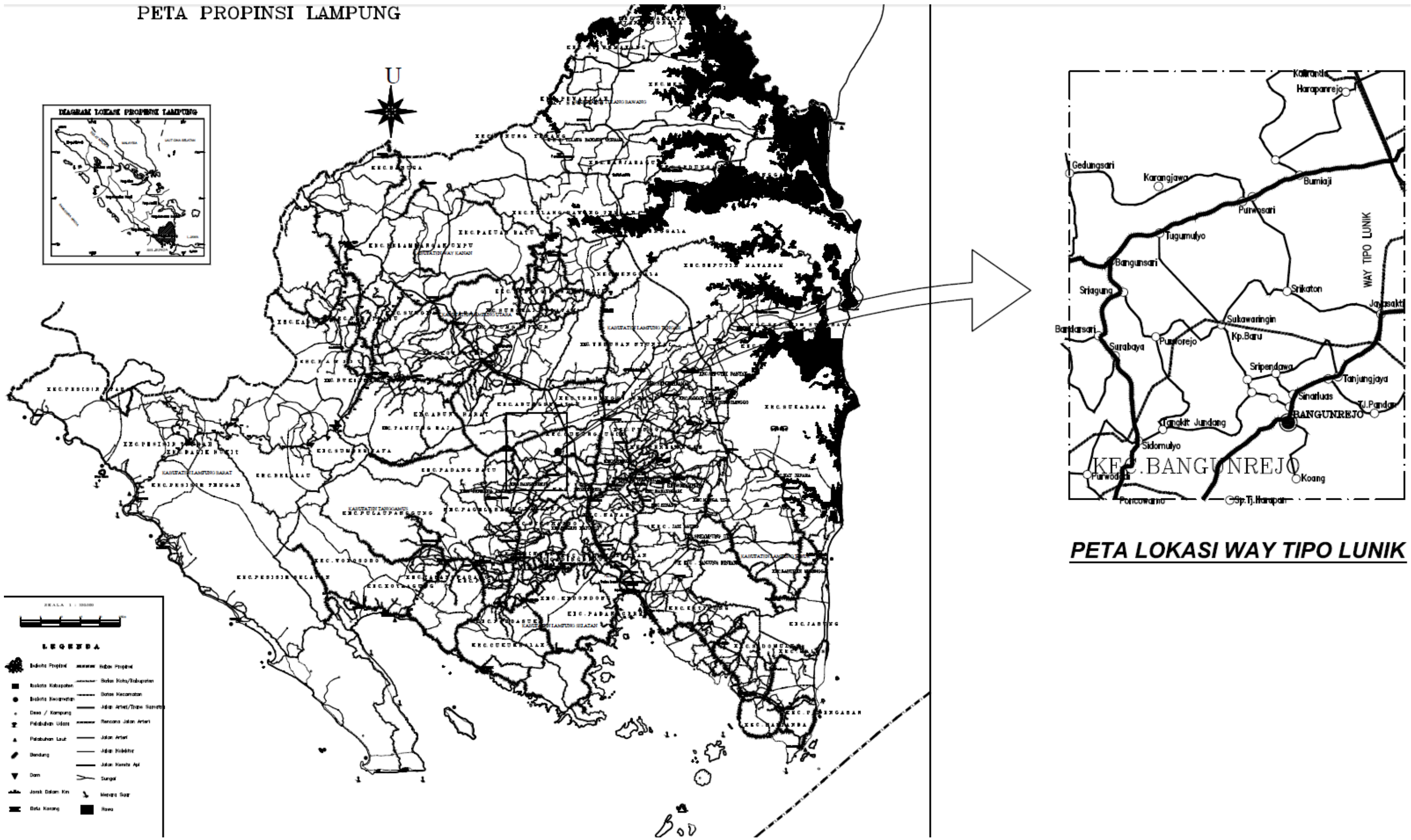


SKEMA BANGUNAN WAY MUARA MAS III (Review)

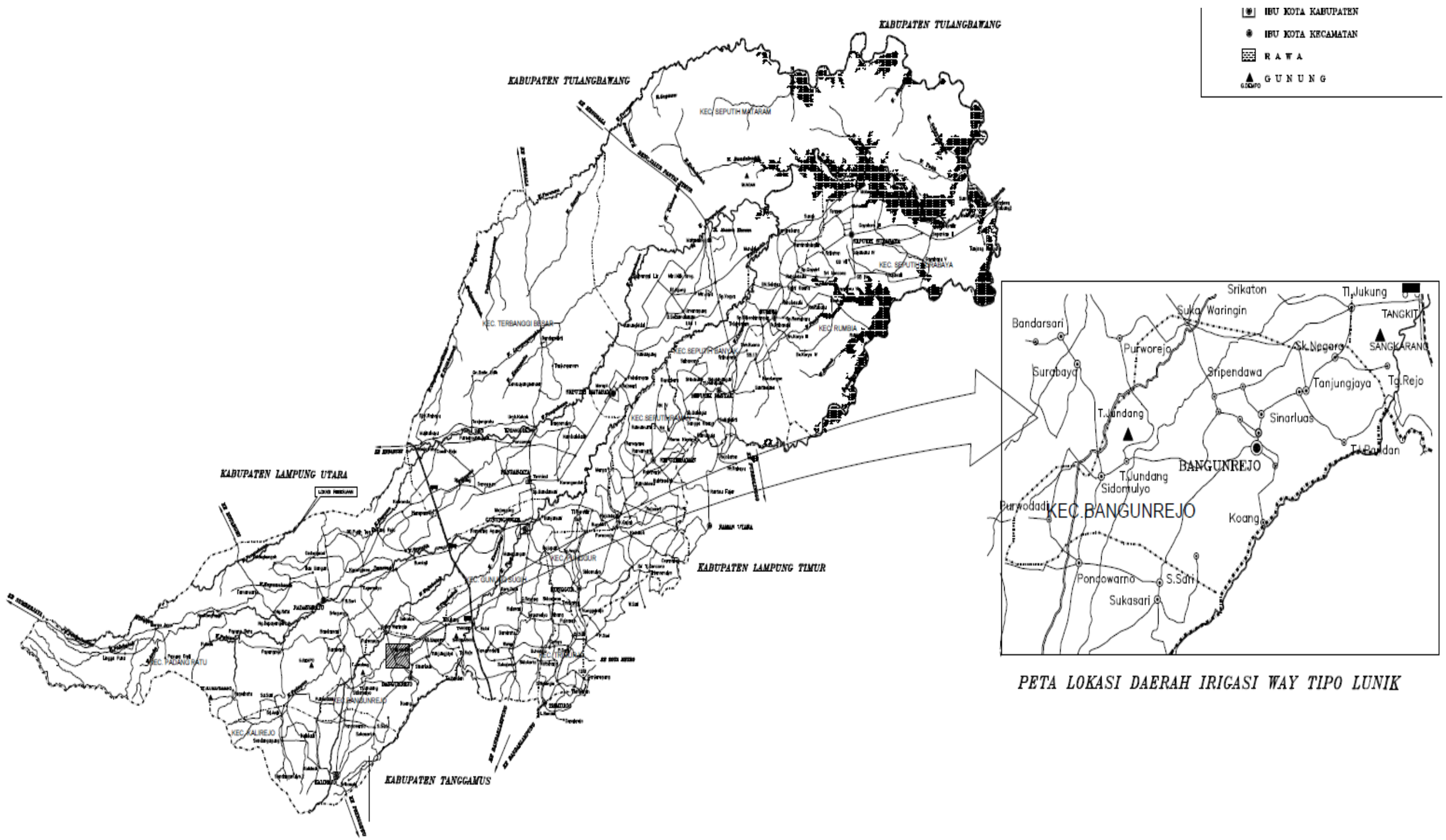


SKEMA JARINGAN D I WAY MUARA MAS III (Review)

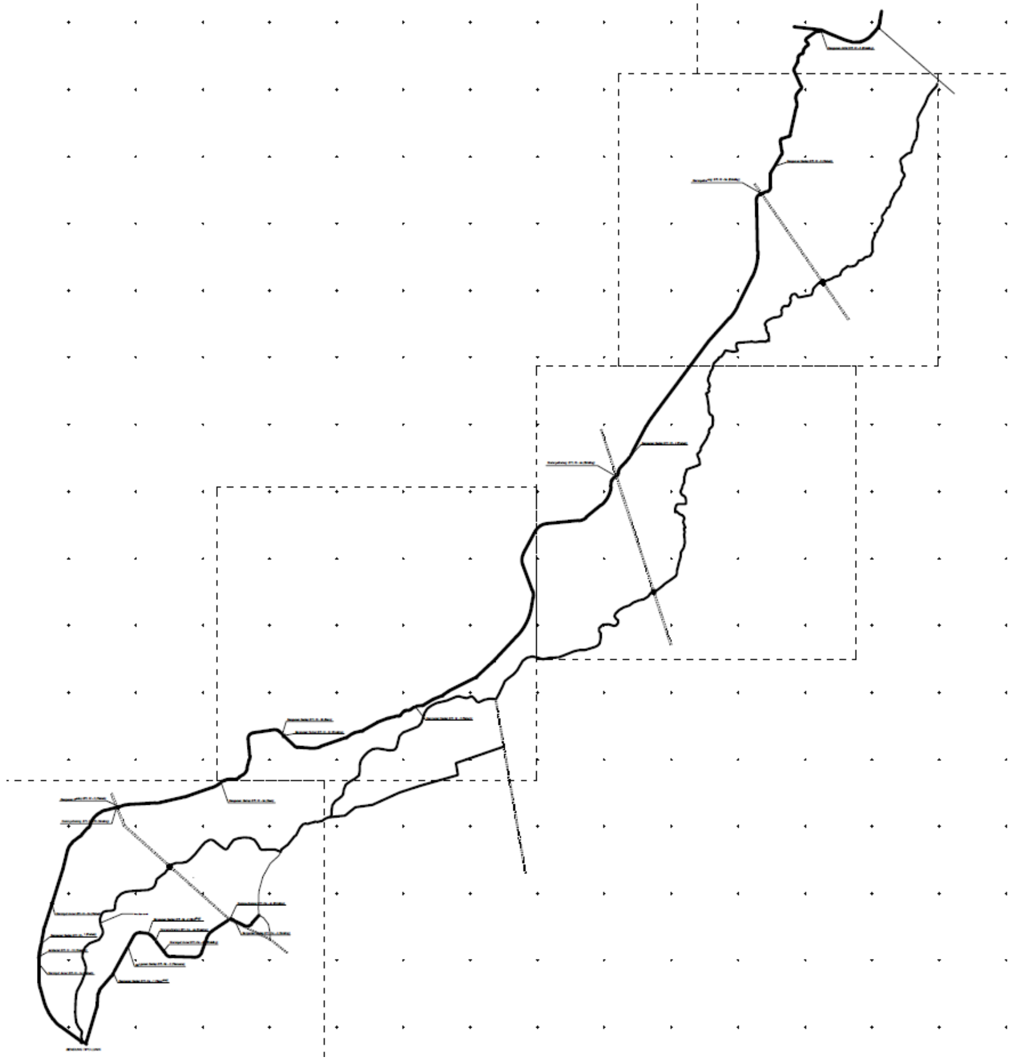
C.3.9. Way Tipo Lunik



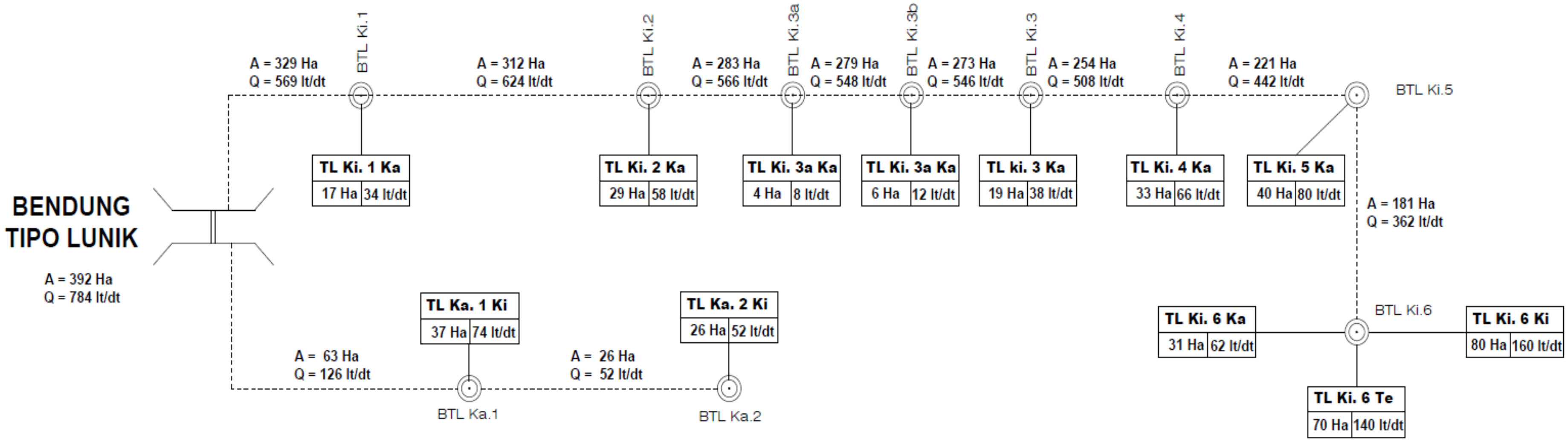
WAY TIPO LUNIK IRRIGATION SYSTEM LOCATION



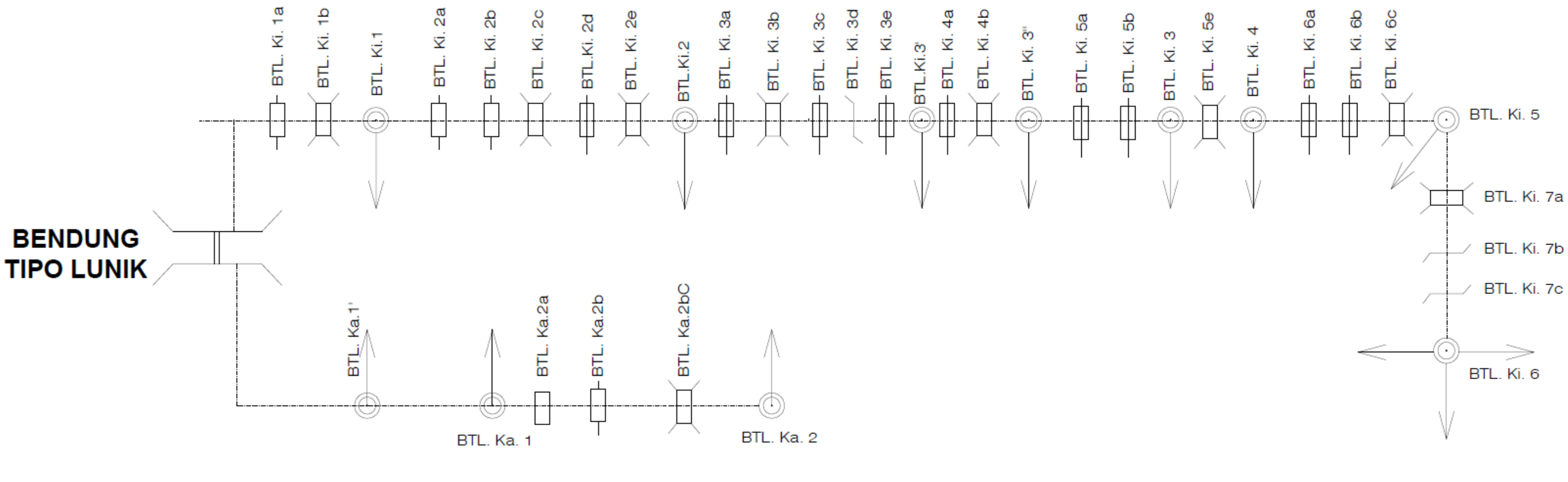
WAY TIPO LUNIK IRRIGATION SYSTEM LOCATION



WAY TIPO LUNIK IRRIGATION SYSTEM LAYOUT

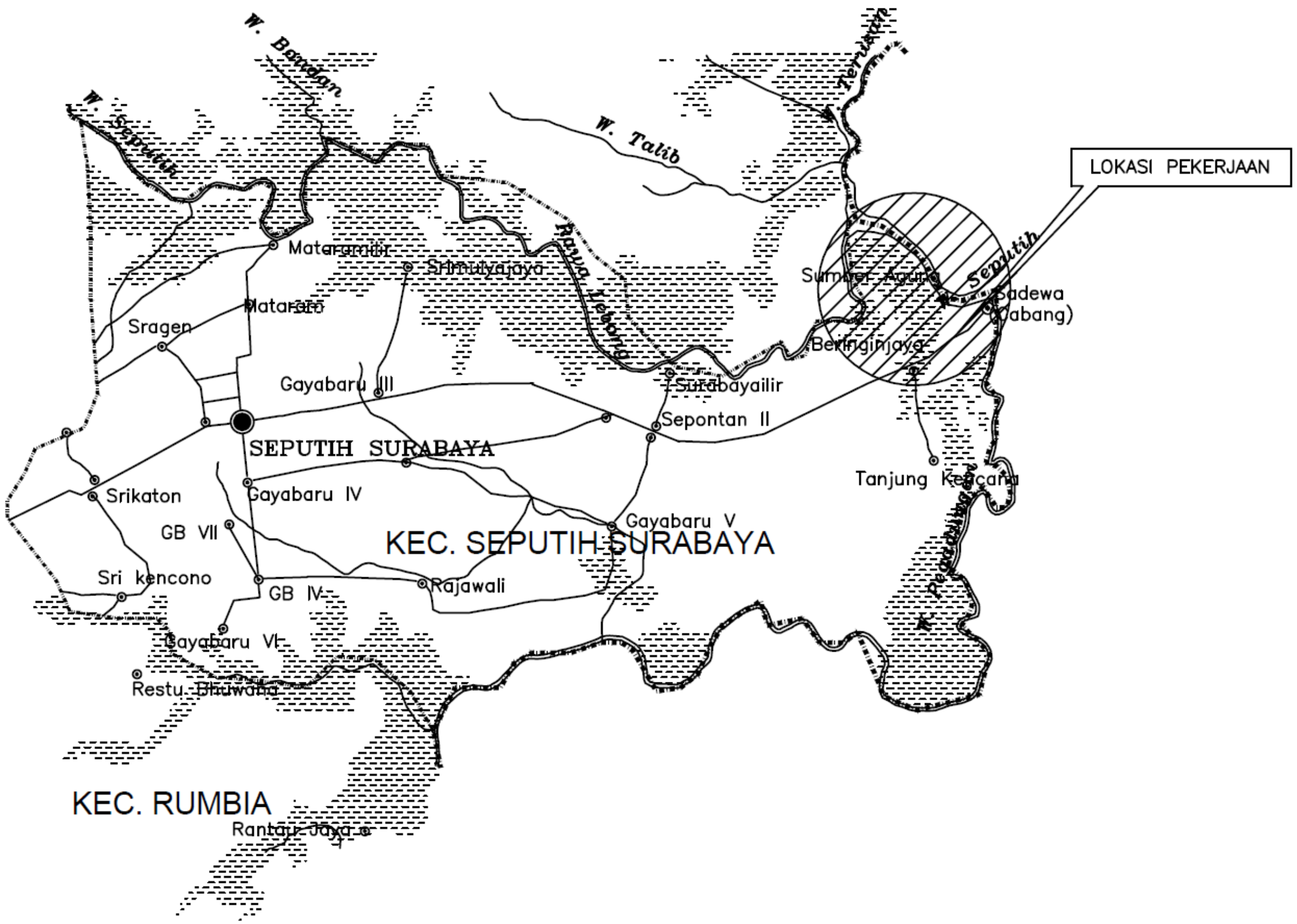


SKEMA JARINGAN IRIGASI D. I. WAY TIPO LUNIK

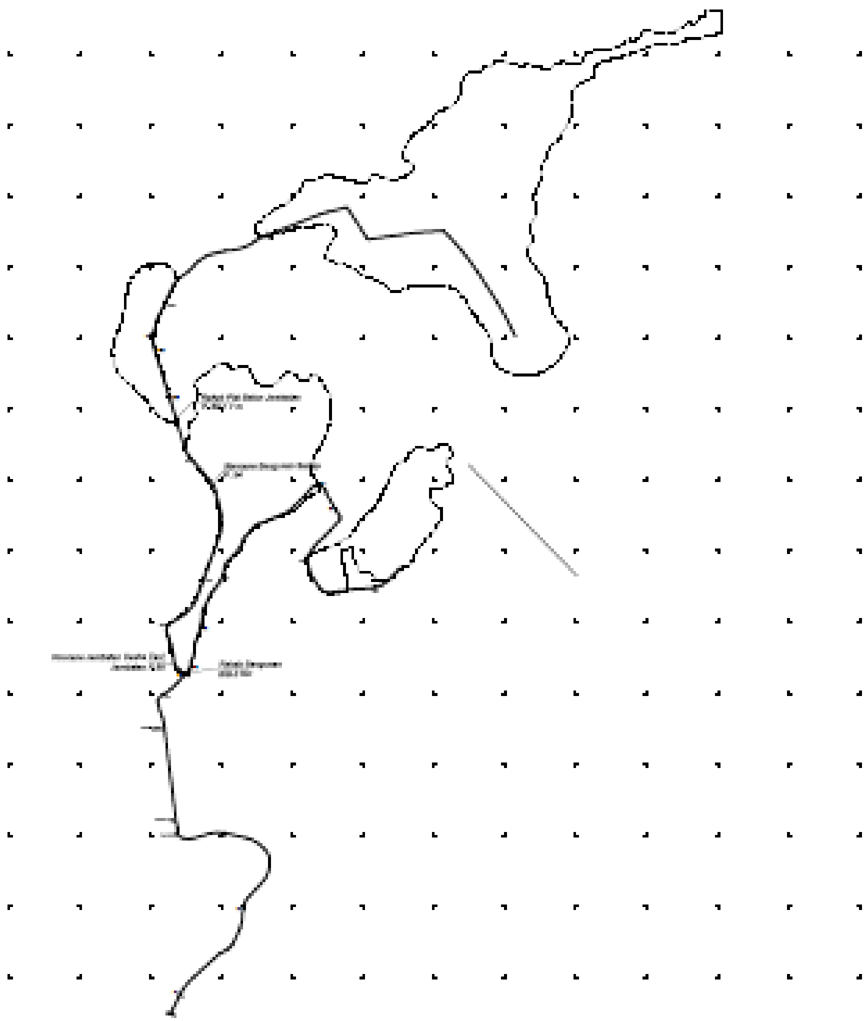


SKEMA BANGUNAN IRIGASI D. I. WAY TIPO LUNIK

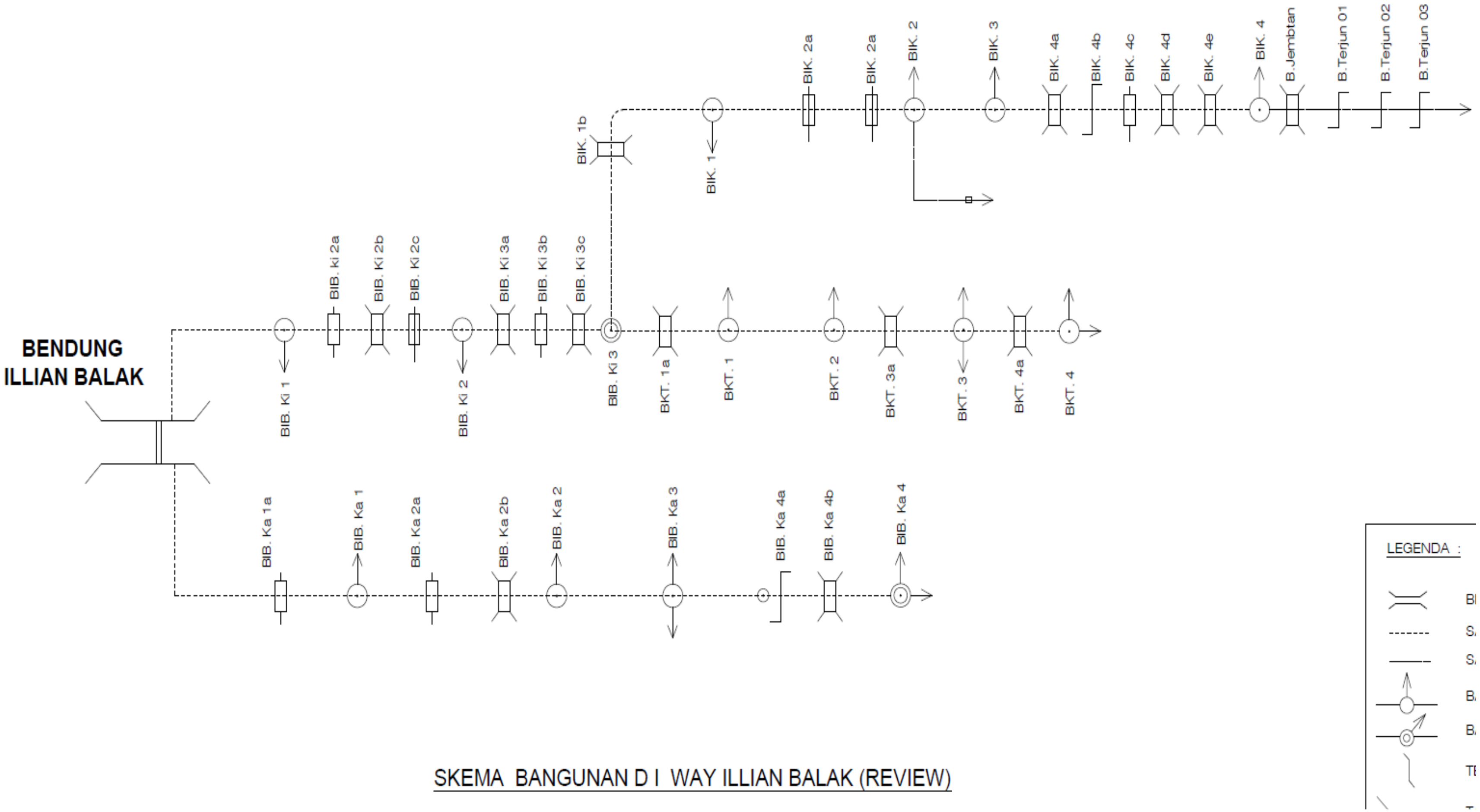
C.3.10.Way Ilihan Balak



WAY ILIHAN BALAK IRRIGATION SYSTEM LOCATION MAP

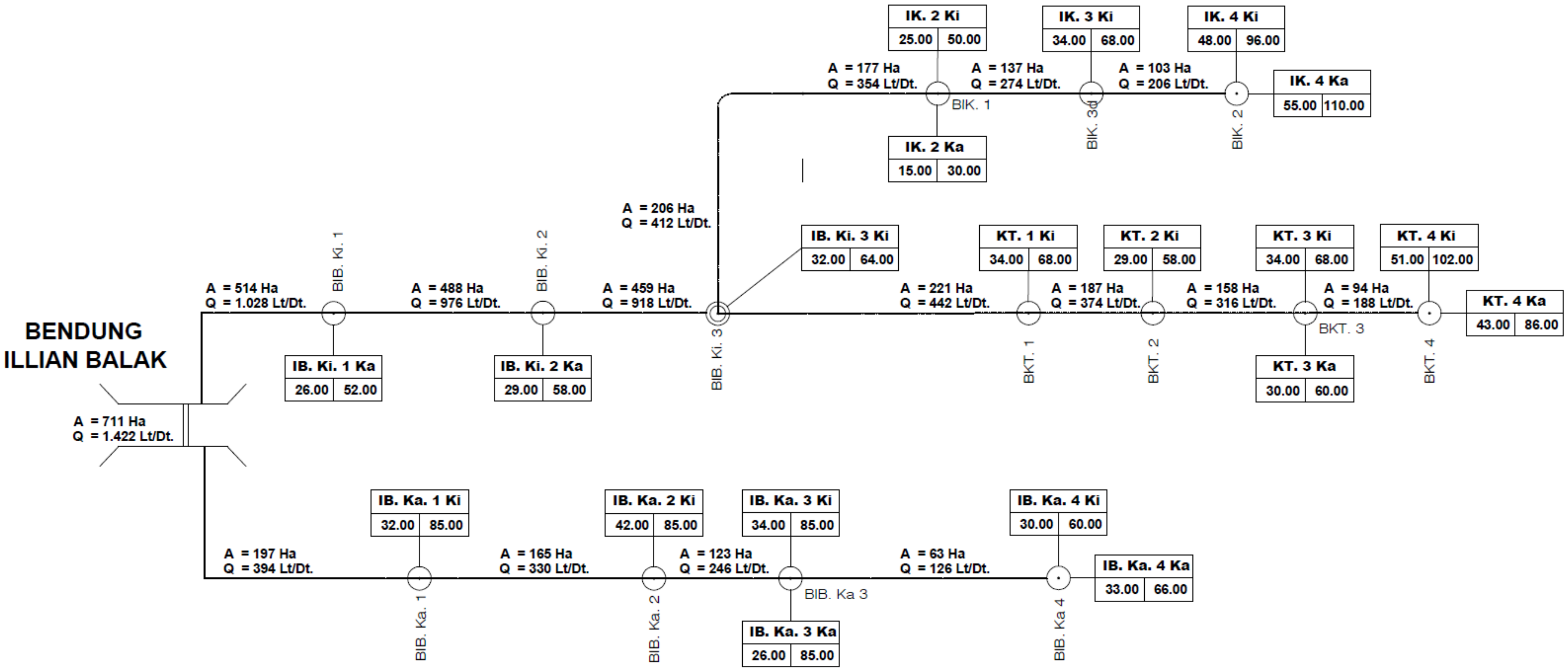


WAY ILIHAN BALAK IRRIGATION SYSTEM LAYOUT



SKEMA BANGUNAN D I WAY ILLIAN BALAK (REVIEW)

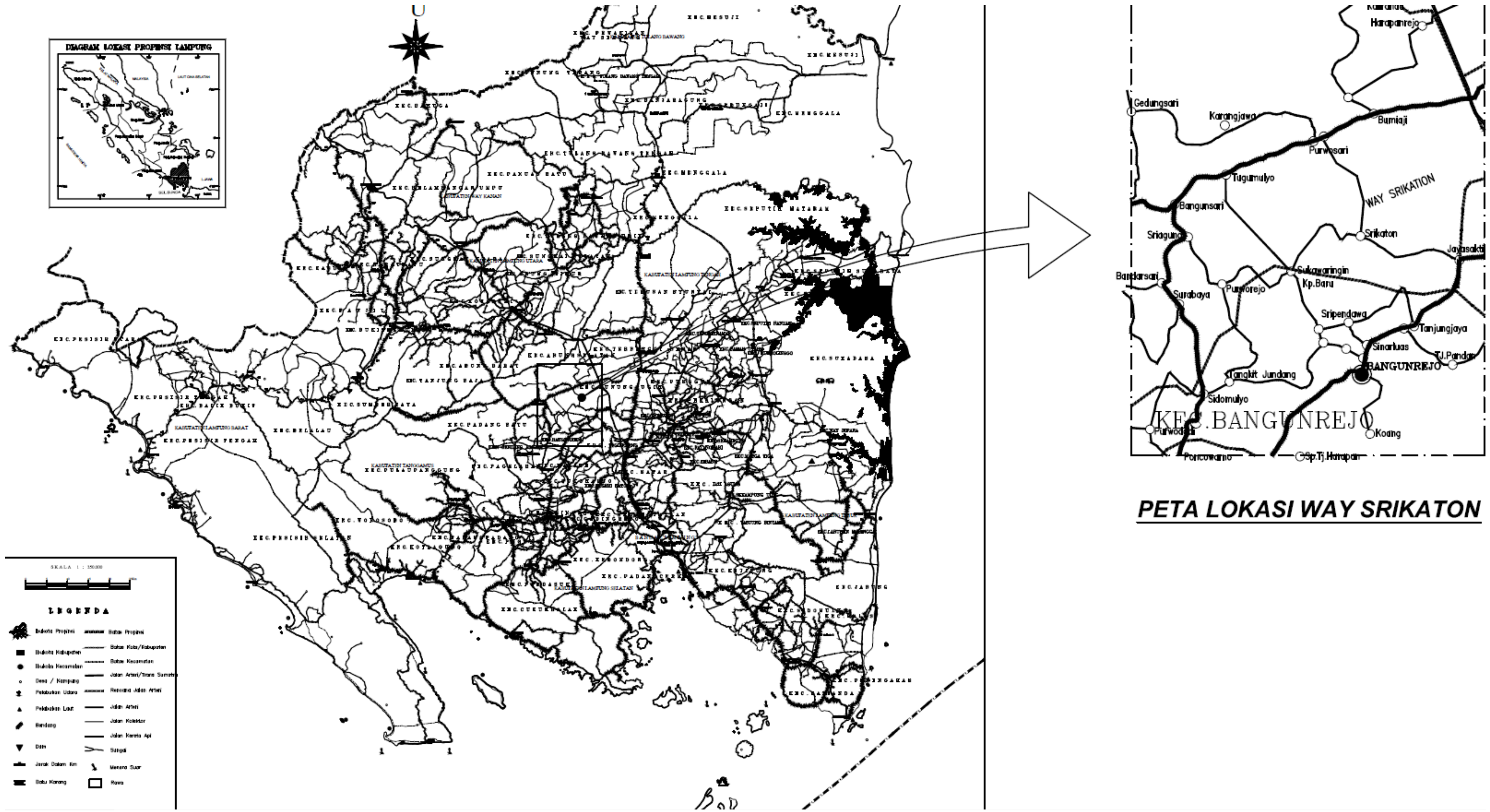
WAY ILIHAN BALAK IRRIGATION SYSTEM LAYOUT



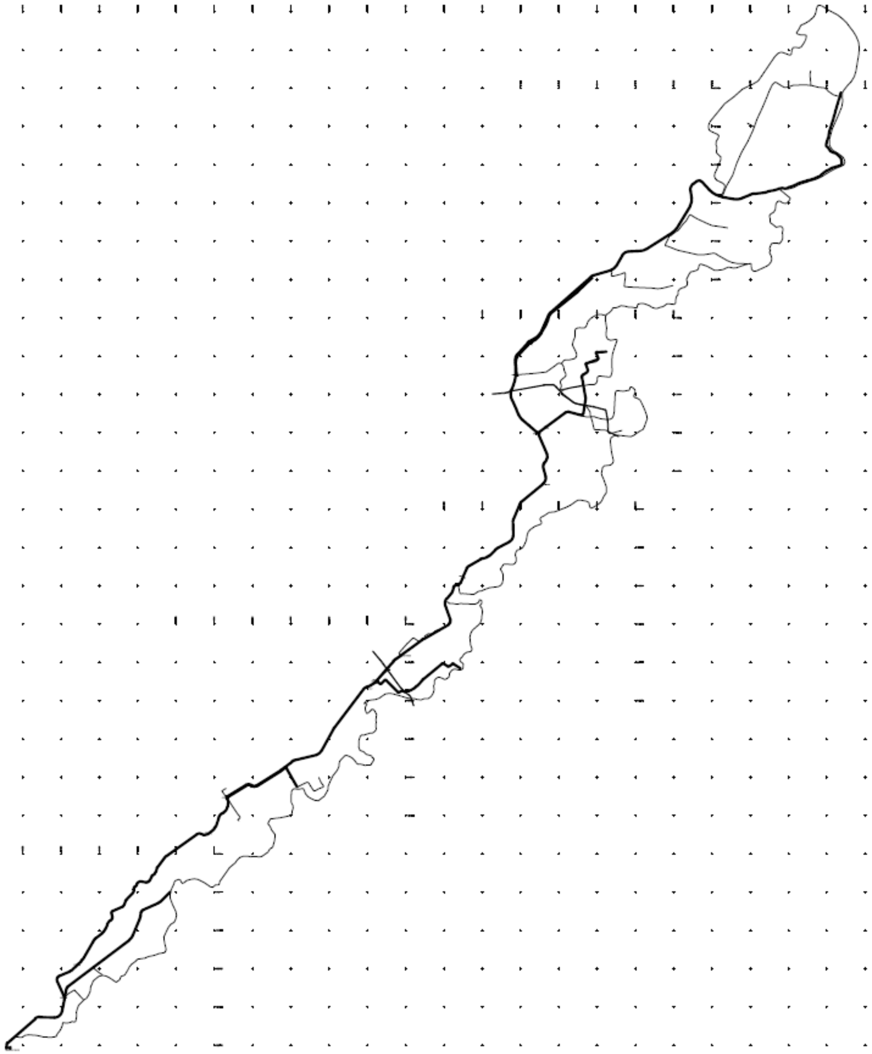
SKEMA JARINGAN D I WAY ILIAN BALAK

WAY ILIHAN BALAK IRRIGATION SYSTEM LAYOUT

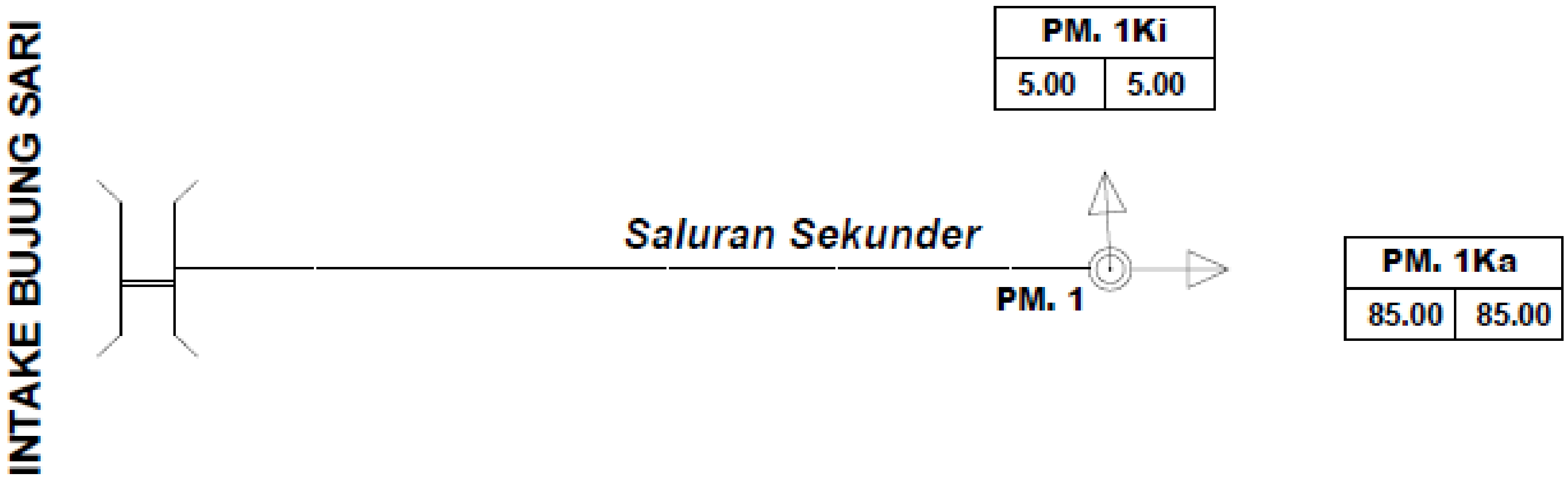
C.3.11. Way Srikaton



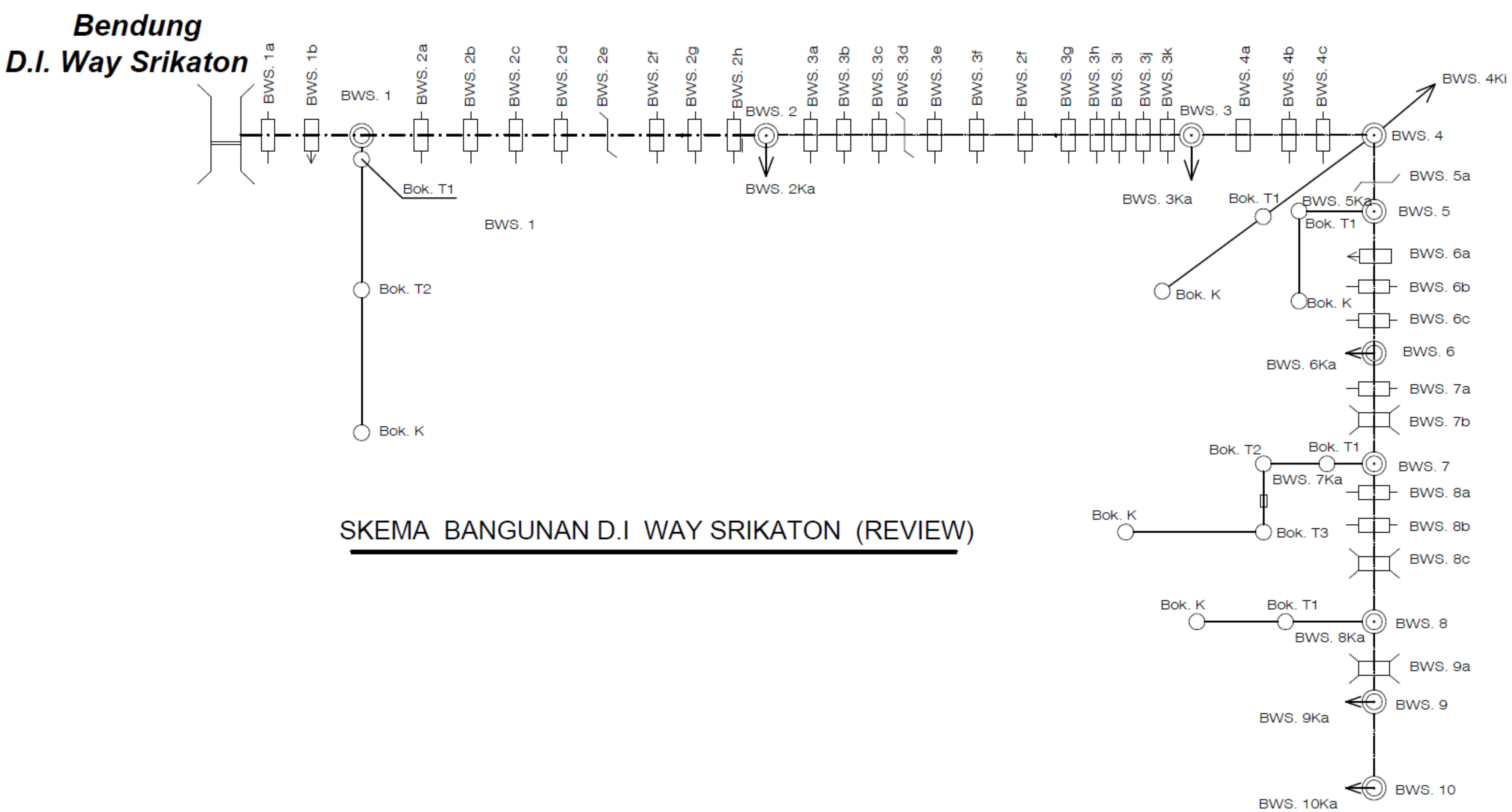
WAY SRIKATON IRRIGATION SYSTEM LOCATION



WAY SRIKATON IRRIGATION SYSTEM LAYOUT

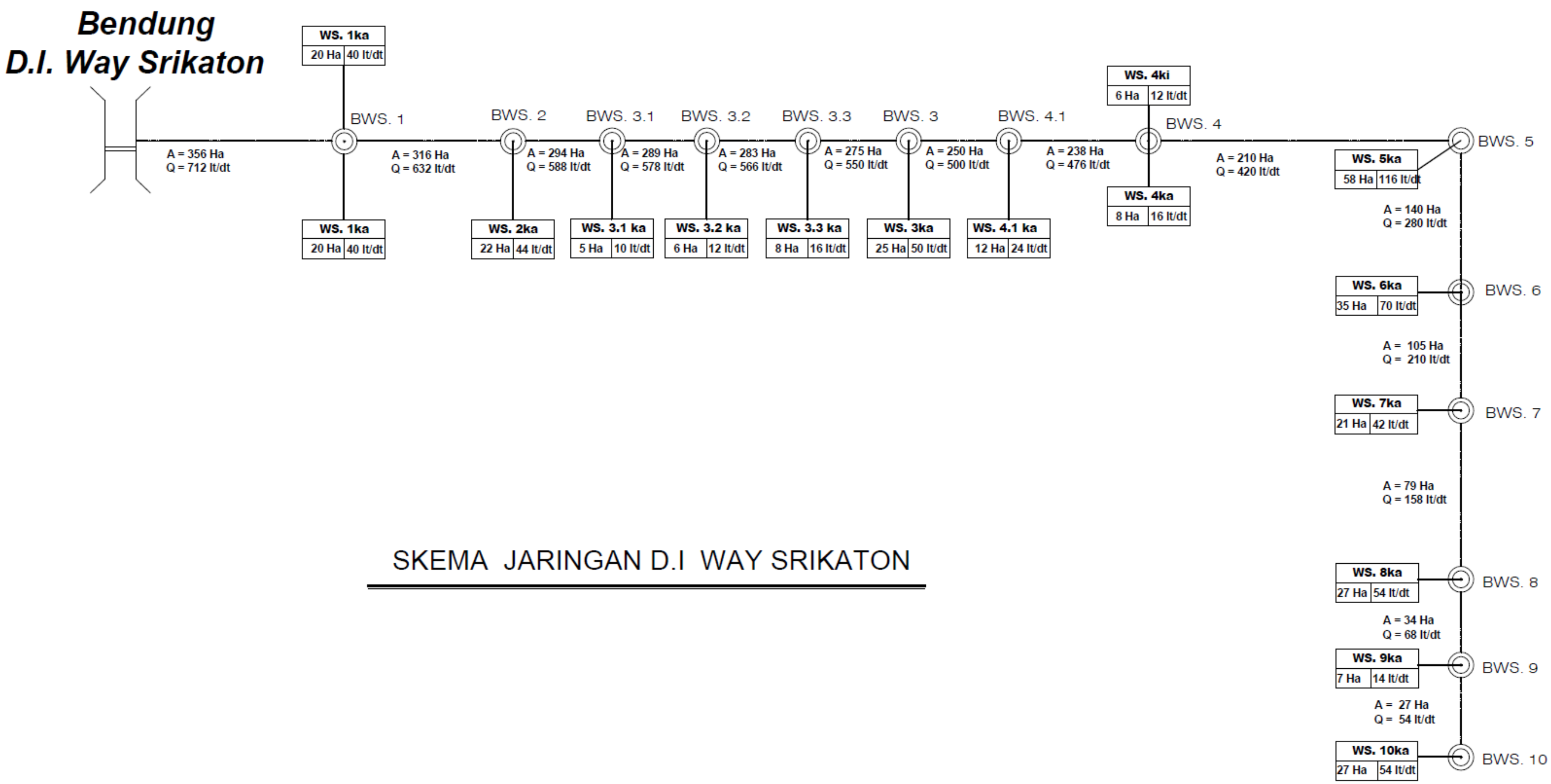


WAY SRIKATON IRRIGATION SYSTEM



SKEMA BANGUNAN D.I WAY SRIKATON (REVIEW)

WAY SRIKATON IRRIGATION SYSTEM



SKEMA JARINGAN D.I WAY SRIKATON

C.4. Irrigation system asset type and condition

C.4.1. Summary of irrigation system asset type and condition

					Irrigation System										
					Large	Medium			Small						
					Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton
Asset Group	Conveyance	Channel	Tertiary	(m)	102,450				3,000	500	1,050	2,445		1,770	4,000
			Quartenary	(m)	168,497	7,670	9,320	575					1,770		
			Drainage	(m)	4,000	4,000									
		Hydraulic	Off-take structure	(unit)	46	16	2	20	1	6	3	1	10	1	14
			Division structure with off-takes	(unit)		1	1	1						12	
		Supplementary	Inspection road	(m)		750									
	Operation & Controlling Facilities		Regulators	(unit)	51	17	17	21	9	17	9	3	10	13	27
	Management & General		Guard post	(unit)	9	3	3	2	2	1	1	2	1	1	1

(Note: Table C.4.1 illustrate a summary of asset type and condition of Way Pengubuan irrigation system. Summary of Way Negara Ratu, Way Tipo Balak, Way Muara Mas, Way Muara Mas I, Way Muara Mas II, Way Muara Mas III, Way Tipo Lunik, Way Ilihan Balak and Way Srikaton irrigation system are not given here).

C.4.2. Summary of asset type and condition of Way Pengubuan irrigation system

No	Asset Type/Code of Asset	Location (STA or at Canal)		Volume (unit or m)	Year Constructed	Quartenary Block Served			Repair History				Asset Survey 2008				Renewal		Note
						Code of Block	Widht		I		II		Condition	Condition Grades	Serviceability Grades	Note	Cost (Rp)	Year	
		From	To				Raw	Fungsional	Year	Cost (Rp)	Year	Cost (Rp)							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Dam	STA 0 + 000		1 Unit	1975-1978									2	2	In general, dam main structures was in good condition, however its components were in poor (3) or bad condition (4) and seriously reduced its functionality (3) or ceased to function (4).		2008	Rehabilitation was funded by ADB loan, APBN & APBD (local government funding)
	Gate			3 Unit									Corrotion						
	Drain gate												Corrotion						
	Fiscal												Major damage						
	Mercu Bendung (crow's weir)			Unit									Crack						
2	Gedong Harta Primary Channel				1975-1978														
	Primary channel			10,525.90 m					1992		2007			2	2	In general, the channel was in fair condition (2), and minor functional shortcoming (2)		2008	In 1992, channels were rehabilitated using OECF - IP loan funding. In 2007, primary channel was rehabilitated using APBN (central government funding). In 2008, rehabilitation was funded by ADB loan, APBN & APBD (local government funding)
	RP 1			518.20 m									Lining damage						
	RP 2			1,534.60 m									Lining damage						
	RP 3			490.20 m															
	RP 4			1,528.20 m															
	RP 5			268.20 m															
	RP 6			1,395.00 m															
	RP 7		to	639.30 m															
	RP 8a			158.00 m									Embankment landslide						
	RP 8			360.40 m															
	RP 9			529.00 m															
	RP 10			242.20 m															
	RP 11			364.00 m															
	RP 12		to	941.50 m															
	RP 13			1,103.80 m															
	RP 14		to	453.30 m															
	Off-take structure			Unit										2	2	In general, offtake structures were in good condition, however its gates were in poor (3) or bad condition (4) and seriously reduced its functionality (3) or ceased to function (4). In general gates required urgent corrective work or partial or complete replacement.		2008	
	BG 1					BG 1 Ki	24	24											
	BG 2					BG 2 Ki	24	24											
	BG 3					BG 3 Ki	24	17											
	BG 4					BG 4 Ki	20	20											
	BG 5					BG 5 Ki	156	125											
	BG 6					BG 6 Ki	20	20											
	BG 7					BG 7 Ki	4	4											
	BG 8a					BG 8a Ki	6	6											
	BG 8					BG 8 Ki	36	36					Gate damage						
	BG 9					BG 9 Ki	6	6											
	BG 10					BG 10 Ki	30	30											
	BG 11					BG 11 Ki	49	49					Gate damage						
	BG 12					BG 12 Ki	83	82					Gate damage						
	BG 13					BG 13 Ki	36	26.5					Gate damage						
	Division structure with off-take			Unit										3	3			2008	
	BG 14					BG 14 Ka	6	5					Floor & wing wall damage						
3	Tebabeng Secondary Chanel				1975-1978														
	Secondary channel			6,186 m										2	2	In general, the channel was in fair condition (2), and minor functional shortcoming (2).		2008	
	RT 1																		
	RT 2																		
	RT 3																		
	RT 4																		
	RT 5																		
	RT 6																		
	RT 7			1,091.00															
	RT 8			908.00															
	RT 9			789.20															
	RT 10		to	502.80 m															
	RT 11		to	1,809.20 m															
	RT 12		to	1,086.00 m															
	Off-take structure			Unit										2	2	In general, offtake structures were in good condition, however its gates were in poor (3) or bad condition (4) and seriously reduced its functionality (3) or ceased to function (4).		2008	
	BT 11					BT 1 Ki	9	9											
						BT 2 Ki	12	11											
	BT 12					BT 3 Ki	16	16											
	BT 7					BT 7 Ki	79	60					Gate damage						
						BT 8 Ki	24	19											
	BT 8					BT 8 Ka	157	95					Gate damage						
	BT 9					BT 9 Ki	47	24					Gate damage						
						BT 9 Ka	26	19											
	BT 10					BT 10 Ki	22	15					Gate damage						
						BT 10 Ka	44	30											
	BT 11					BT 11 Ki	44	25					Gate damage						
						BT 11 Ka	50	25											
	BT 12					BT 12 Ki	18	18											
	Division structure with off-take			Unit										2	2	In general, division structures were in good condition, however its gates were in poor (3) or bad condition (4) and seriously reduced its functionality (3) or ceased to function (4).		2008	
	BT 4					BG 14 Ka	6	5											
	BT 5					BT 5 Ki	28	28					Gate damage						
						BT 5 Ka	20	5											
	BT 6					BT 6 Ki 1	41	32					Gate damage, BT 6c division box damage						
						BT 6 Ki 2	29	25											
						BT 6 Ki 3	45	25											
						BT 6 Ka	93	39											
	Bridge			Unit										2	2			2008	
	BT 3a												Need to be widened						
	BT 7d												Damage						
	Culvert			Unit										3	3			2008	
	BT 9b												Major damage						
	Drop structure			Unit										3	3				
	BT 7b												Floor damage						

C.4.2. Way Pengubuan (continue)

No	Asset Type/Code of Asset	Location (STA or at Canal) From	Location (STA or at Canal) To	Volume (unit or m)	Year Constructed	Quartenary Block Served: Code of Block	Quartenary Block Served: Widht Raw	Quartenary Block Served: Widht Fungsional	Repair History I: Year	Repair History I: Cost (Rp)	Repair History II: Year	Repair History II: Cost (Rp)	Asset Survey 2008: Condition	Asset Survey 2008: Condition Grades	Asset Survey 2008: Serviceability Grades	Asset Survey 2008: Note	Renewal: Cost (Rp)	Renewal: Year	Note
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4	Gedong Sari secondary channel				1975-1978													2008	
	Secondary channel RGS 1 RGS 2 RGS 3 RGS 4 RGS 5		to to to to to	m m m m m									Lining & floor damage Floor damage Flor spill Floor spill, sedimentation Floor damage under the drop structure	2	2	In general, the channel was in fair condition (2), and minor functional shortcoming (2)			
	Off-take structure BGS 1 BGS 2 BGS 3 BGS 4 BGS 5			5 Unit		BGS 1 Ki BGS 2 Ki BGS 2 Ka BGS 3 Ki 1 BGS 3 Ki 2 BGS 3 Ka BGS 4 Ki BGS 4 Ka BGS 5 Ki BGS 5 Ka BGS 5 Tg	100 65 25 48 90 34 58 66 50 20 60	47 65 11 48 89 29 54 35 25 15 59					Gate and wall damage Gate damage Gate minor damage Gate disappear			In general, off-take structures were in good condition, however its gates were in poor (3) or bad condition (4) and seriously reduced its functionality (3) or ceased to function (4).		2008	
	Bridge BGS 2b BGS 2c BGS 3a BGS 4a BGS 4b BGS 4c BGS 5a BGS 5c BGS 5d BGS 5f BGS 5i			Unit									Bridge collapses Major damage Lining damage Lining damage Bridge floor damage Bridge floor damage Major damage Major damage Minor damage Lining damage	4	4	Generally, bridges in this section were in bad condition (4) and ceased to function (4), so its required partial or complete replacement.		2008	
	Culvert BGS 5k			Unit									Major damage					2008	
	Drop structure BGS 2c BGS 3c BGS 5b BGS 5e BGS 5h BGS 5 j			Unit									Wing wall damage Floor and wing wall damage Wing wall damage Floor damage Wing wall damage Wing wall damage	3	3	In general, drop structures in this section were in poor condition (3) and seriously reduced its functionality (3), so its required urgent corrective work.		2008	
	Drainage BGS 4c												Drainage gate minor damage	2	2	Only gates required urgen corrective work, or partial or complete replacement.		2008	
5	Padang Manis secondary channel				1975-1978													2008	
	Secondary channel RPM 1 RPM 2 RPM 3 RPM 4 RPM 5 RPM 6 RPM 7 RPM 8		to to	9,726.00 m 1,201.40 m 1,144.60 m 1,658.00 m 502.00 m 812.00 m 951.50 m 1,921.00 m 1,535.50 m									Function diminish Lining seepage Lining seepage	2	2	In general, the channel was in fair condition (2), and minor functional shortcoming (2)			
	Off-take structure BPM 1 BPM 2 BPM 3 BPM 4 BPM 5 BPM 6 RPM 7 BPM 8			Unit		BPM 1 Ki BPM 2 Ki BPM 2 Ka BPM 3 Ki BPM 4 Ki BPM 4 Ka BPM 5 Ki BPM 5 Ka BPM 6 Ki BPM 6 Ka RPM 7 Ki RPM 7 Ka BPM 8 Tg	35 105 72 22 34 120 80 16 115 116 40 39 156	24 80 26 22 33 35 37 8 111 39 37 32 100					Structure & gate damage Gate damage Gate damage Gate damage Gate damage Gate damage			In general, offtake structures were in good condition, however its gates were in poor (3) or bad condition (4) and seriously reduced its functionality (3) or ceased to function (4).		2008	
	Bridge BPM 2c BPM 3e			Unit									Modest damage Modest damage	2	2			2008	
	Drainage BPM 3f												Drainage gate need to be replaced with embankment					2008	
6	Pekiki secondary channel				1975-1978													2008	
	Secondary channel RPK 1 RPK 2 RPK 3		to	m m m									Lining damage, sedimentation Lining damage, sedimentation Floor damage under the drop structure, need channel normalisation, sedimentation	2	2	In general, the channel was in fair condition (2), and minor functional shortcoming (2)			
	Off-take structure BPK 1 BPK 2 BPK 3			Unit		BPK 1 Ki BPK 2 Ki BPK 2 Ka BPK 3 Ki BPK 3 Ka BPK 3 Tg	12 37 35 51 66 110	12 35 28 36 35 114					Gate damage, wall crack	2	2	In general, offtake structures were in good condition, however its gates werein poor (3) or bad condition (4) and seriously reduced its functionality (3) or ceased to function (4).		2008	
	Bridge BPK 1 BPK 2b BPK 3			Unit									Major damage Major damage Major damage	3	3			2008	

C.4.2. Way Pengubuan (continue)

No	Asset Type/Code of Asset	Location (STA or at Canal) From	Location (STA or at Canal) To	Volume (unit or m)	Year Constructed	Quartenary Block Served: Code of Block	Widht: Raw	Widht: Fungsional	Repair History I: Year	Repair History I: Cost (Rp)	Repair History II: Year	Repair History II: Cost (Rp)	Asset Survey 2008: Condition	Condition Grades	Serviceability Grades	Note	Renewal: Cost (Rp)	Renewal: Year	Note
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7	Tulung Batu Secondary Channel																	2008	
	Secondary channel			2,706.70 m										2	2	In general, the channel was in fair condition (2), and minor functional shortcoming (2)			
	RTB 1			722.20 m									Floor damage						
	RTB 2			894.00 m									Lining damage						
	RTB 3			1,090.50 m									Lining damage						
	Off-take structure			Unit										2	2	In general, offtake structures were in good condition, however its gates were in poor (3) or bad condition (4) and seriously reduced its functionality (3) or ceased to function (4).		2008	
	BTB 1					BTB 1 Ka	16	16					Gate damage						
	BTB 2					BTB 2 Ka	22	22					Gate damage						
	BTB 3					BTB 3 Ki BTB 3 Ka	71 65	70 65											
	Bridge			Unit										3	3			2008	
	BTB 3c												Major damage						
	BTB 3c												Major damage						
	Culvert			Unit										3	3			2008	
	BTB 1b												Major damage						
	Drainage flume													3	3			2008	
	BTB 1a												Damage						
	BTB 1b												Damage						
8	Sukajaya Secondary Channel				1975-1978													2008	
	Secondary channel			14,865.00 m										2	2	In general, the channel was in fair condition (2), and minor functional shortcoming (2)			
	RS 1			404.10 m									Lining damage						
	RS 2			503.40 m									Lining and floor minor damage (at some spot are major damage)						
	RS 3			843.50 m									Lining damage						
	RS 4			764.00 m									Lining major damage						
	RS 5			599.00 m									Lining damage						
	RS 6			1,880.00 m									Lining damage						
	RS 7a			2,588.00 m									Lining damage						
	RS 7		to	m									Lining damage						
	RS 8			1,111.00 m									Lining damage						
	RS 9			487.00 m									Lining damage						
	RS 10a			885.00 m									Lining damage						
	RS 10			699.00 m									Lining damage						
	RS 11			1,813.50 m									Lining damage						
	RS 12			2,287.50 m									Lining and floor damage (at some spot floor major damage), sedimentation						
	Off-take structure			Unit										2	2	In general, offtake structures were in good condition, however its gates were in poor (3) or bad condition (4) and seriously reduced its functionality (3) or ceased to function (4).		2008	
	BS 1					BS 1 Ki	7 10	7 10					Gate & floor damage						
	BS 2					BS 2 Ki 1 BS 2 Ki 2	14	14					Gate, wall & floor damage						
	BS 3					BS 3 Ki	5	5					Gate damage						
	BS 4					BS 4 Ki BS 4 Ka	20 6	20 6					Gate & floor damage Gate & wing wall damage						
	BS 5					BS 5 Ki BS 5 Ka	24 36	24 34					Spill gate, division box gate & wing wall damage						
	BS 6					BS 6 Ki 1 BS 6 Ki 2 BS 6 Ka	11 4 50	11 4 47					Division box gate damage						
	BS 7a					BS 7a	83	83					Intake gate damage						
	BS 7					BS 7 Ki BS 7 Ka	82 102	73 34					Wall damage						
	BS 8					BS 8 Ki BS 8 Ka	34 14	30 14											
	BS 10a					BS 10a Ki BS 10a Ka	96 64	81 25											
	BS 10					BS 10 Ka	9	9											
	BS 11					BS 11 Ki BS 11 Ka BG 13 Tg	64 26 194	41 17 57											
	Division structure with off-take			Unit												In general, offtake structures were in good condition, however its gates were in poor (3) or bad condition (4) and seriously reduced its functionality (3) or ceased to function (4).		2008	
	BS 9					BS 9 Ki 1 BS 9 Ki 2 BS 9 Ka	65 48 4	58 48 4					Divison gate damage						
	Bridge			Unit										3	3	In general, bridges in this section are in poor condition (3) and seriously reduced functionality (3), so its required urgent corrective work. Bridges that in bad condition (4) and ceased to function (4) required partial or complete replacement.		2008	
	BS 2a												Lining damage						
	BS 3a												Foundation damage						
	BS 4a												Damage						
	BS 6a												Minor damage						
	BS 7a												Lining damage						
	BS 7k												Lining damage						
	BS 8b												Floor damage						
	BS 8f												Collapse						
	BS 9b												Lining damage						
	BS 10a												Floor damage						
	BS 10c												Collapse						
	BS E												Collapse						
	BS 10a a												Need to be widened						
	BS 10d												Lining damage						
	BS 12												Collapse						

C.4.2. Way Pengubuan (continue)

No	Asset Type/Code of Asset	Location (STA or at Canal)		Volume (unit or m)	Year Constructed	Quartenary Block Served			Repair History				Asset Survey 2008				Renewal		Note
						Code of Block	Widht		I		II		Condition	Condition Grades	Serviceability Grades	Note	Cost (Rp)	Year	
		From	To				Raw	Fungsional	Year	Cost (Rp)	Year	Cost (Rp)							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Culvert BS 2a BS 4a			Unit									 Burried Leak	3	3			2008	
	Drop structure BS 7i BS 7y BS 10a b BS 11c			Unit									 Floor damage Floor damage Floor damage Floor, wing wall & gate damage	3	3	In general, drop structures in this section were in poor condition (3) and seriously reduced its functionality (3), so its required urgent corrective work.		2008	
	Drainage Drainage culvert, BS 7k												 Damage					2008	
9	Pengambingan Secondary Channel Secondary channel RPN 1 RPN 2			 2,803.00 m 1,061.00 m 1,742.00 m	1975-1978								 Lining damage, sedimentation, need channel normalisation Floor under drop structure damage	 2	 2	 In general, the channel was in fair condition (2), and minor functional shortcoming (2)		2008	
	Off-take structure BPN 1 BPN 2			Unit		 BPN 1 Ki BPN 1 Ka BPN 2 Tg	 71 61 46	 32 30 20					 Gate damage	2	2	In general, offtake structures were in good condition, however its gates were in poor (3) or bad condition (4) and seriously reduced its functionality (3) or ceased to function (4).		2008	
	Drop structure BPN 1c BPN 1d BPN 1e BPN 1g BPN 2b BPN 2c												 Floor damage Floor damage Floor damage Wing damage Floor damage Floor, lining & wing wall damage	3	3	In general, drop structures in this section were in poor condition (3) and seriously reduced its functionality (3), so its required urgent corrective work.		2008	
	Bridge BPN 1b BPN 1f BPN 1h BPN 2a BPN 2b BPN 2c			Unit									 Need to be widened Major damage Major damage Major damage Major damage Major damage	3	3	In general, bridges in this section are in poor condition (3) and seriously reduced functionality (3), so its required urgent corrective work.		2008	
9	Inspection road Gedong Harta primary channel RP 1 RP 2 RP 3 RP 4 RP 5 RP 6 RP 7 RP 8a RP 8 RP 9 RP 10 RP 11 RP 12 RP 13 RP 14			 10,525.90 m 518.20 m 1,534.60 m 490.20 m 1,528.20 m 268.20 m 1,395.00 m 639.30 m 158.00 m 360.40 m 529.00 m 242.20 m 364.00 m 941.50 m 1,103.80 m 453.30 m	1975-1978								 Damage, total 1,562 m Damage 52 m Damage 200 m Damage 50 m Damage 50 m Good Damage 250 m Damage 500 m Good Damage 60 m Damage 50 m Good Damage 25 m Damage 100 m Damage 150 m Damage 75 m	2	2	In general, the inspection road in the primary and secondary channel were fair condition (2) and minor functional shortcoming, except in some spot were in poor condition (3) and seriously reduced functionality.		2008	
	SUMMARY OF ASSET Dam Primary channel Secondary channel Tebabeng Tulung Batu Sukajaya Pengambingan Padang Manis Gedong Sari Tertiary channel Quarternary channel Drainage channel Sand trap Check structure Division structure Off-take structure Flume Inverted syphon Bridge Culvert Side spillway Wasteway Wasteway culvert Inspection road Management & general facilities			 1 Unit 11,144.00 m 52,462.00 m 12,777.00 m 2,706.00 m 13,225.00 m 2,800.00 m 9,716.00 m 11,238.00 m 102,450.00 m 168,497.00 m 4,000.00 m 1 Unit 40 Unit 5 Unit 46 Unit 1 Unit 15 Unit 73 Unit 76 Unit 13 Unit 4 Unit 37 Unit m															

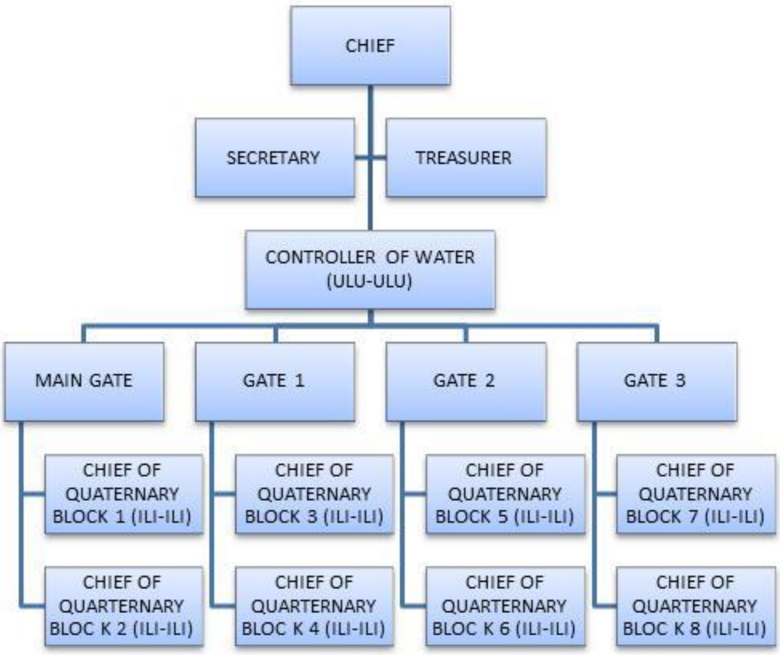
C.5. Water User Associations

C.5.1. WUAs of the case studies of irrigation systems

Irrigation systems		No.	WUA	Village
Large	Way Pengubuan	1.	Harapan Karya	Gedung Harta
		2.	Sanggar Karya	Sinar Negeri
		3.	Karya Jaya	Karang Anyar
		4.	Sampurna Jaya	Gilih Karang Jati
		5.	Harapan Jaya	Karang Anyar
		6.	Karya Makmur	Gedung Ratu
		7.	Setia Makmur	Bandar Putih Tua
		8.	Suka Makmur	Padang Ratu
		9.	Tunas Jaya	Suka Jaya
		10.	Tunas Karya	Suka Jaya
		11.	Harapan maju	Karang Jawa
		12.	Sidomulyo	Sri Mulyo
		13.	Suka Makmur	Gedung Sari
		14.	Talang Tengah	Gedung Ratu
		15.	Sidodadi	Sri Mulyo
		16.	Sodomaju	Sri mulyo
		17.	Karya Bakti	Gedung Sari
		18.	Nudi Makmur	Jagang
		19.	Karya Makmur	Gedung Sari
		20.	Jaya Lestari	Gedung Sari
		21.	**Wisma Tani**	
Medium	Way Padang Ratu	1.	Subur	Padang Ratu
		2.	Tunas Harapan	Pampangan
		3.	Tirta Bakti	Way layap
		4.	Suka Maju	Sidodadi
		5.	Raden Intan	Wonodadi
		6.	Bina Karya	Tulung Agung
		7.	**Bina Keluarga**	

Irrigation systems		No.	WUA	Village
Medium	Way Negara Ratu	1.	Muji Raharjo	Negeri Ratu
		2.	Tirta Sari	Tanjung Sari
		3.	Tekat Makmur	Bumi Sari
		4.	Sri Rejeki	Candi Mas
		5.	Tani Mulia	Branti Jaya
	Way Tipo Balak	1.	Tunas Karya	Suka Negara
		2.	Harapan Jaya	Suka Waringin
		3.	Tunas Harapan	Sri Katon
		4.	**WUAF**	In establishment process
Small	Way Muara Mas	1.	Sumber Rejeki	Sendang Mulyo
	Way Muara Mas I	1.	Harapan Makmur	Sendang Rejo
		2.	Rukun Makmur	Sendang Rejo
	Way Muara Mas II	1.	Tani Makmur	Sendang Agung
	Way Muara Mas III	1.	Semboja	Sendang Agung
	Way Tipo Lunik	1.	Sinar Harapan	Sri Pendawa
		2.	Srijaya	
	Way Ilihan Balak	1.	Karya Baru	Margo Rejo
	Way Sri Katon	1.	Karya Tirta	Karang Tanjung
		2.	Sumber Makmur	Bukit Rejo
		3.	Karya Hidup Baru	Sriwaya
		4.	Bina Putra	Margo Rejo
		5.	**WUAF**	In establishment process

C.5.2. Typical of WUAs' organizations



C.6. RAP and Benchmarking

C.6.1. Item description of external indicators

ITEM DESCRIPTION	UNITS
Stated efficiencies	
Stated conveyance efficiency of imported canal water (accounts for seepage and spills and tail end flows)	%
Weighted *field* irrigation efficiency from stated efficiencies	%
Areas	
Physical area of irrigated cropland in the command area (not including multiple cropping)	Ha
Irrigated crop area in the command area, including multiple cropping	Ha
Cropping intensity in the command area including double cropping	none
External sources of water for the command area	
Surface *irrigation* water inflow from outside the *command area* (gross at diversion and entry points)	MCM
Gross precipitation in the irrigated fields in the command area	MCM
Effective precipitation to irrigated fields (not including salinity removal)	MCM
Net aquifer *withdrawal* due to irrigation in the command area	MCM
Total *external* **water** supply for the project – including gross ppt. and *net* aquifer withdrawal, but excluding internal recirculation	MCM
Total external irrigation supply for the project	MCM
Internal water sources	
Internal *surface* water recirculation by farmer or project in command area	MCM
Gross *groundwater* pumped by farmers within command area	MCM
Groundwater pumped by project authorities and applied to the command area	MCM
Gross total annual volume of project authority irrigation supply	MCM
Total groundwater pumped and dedicated to the command area	MCM
Groundwater pumped by project authorities and applied to the command area, minus net groundwater withdrawal (this is to avoid double counting. Also, all of net is applied to this term, although some might be applied to farmers)	MCH
Estimated total gross internal surface water + groundwater	MCM
Irrigation water delivered to users	
Internal authority water sources are stated to have a conveyance efficiency of:	%
Delivery of *external* surface ***irrigation*** water to *users* — using stated conveyance efficiency	MCM

ITEM DESCRIPTION	UNITS
Irrigation water delivered to users	
All other ***irrigation*** water to users (surface recirculation plus all well pumping, with stated conveyance efficiencies, using 100% for farmer pumping and farmer surface diversions)	MCM
Total *irrigation* water *deliveries to users* (external surface irrigation water + internal diversions and pumping water sources), reduced for conveyance efficiencies	MCM
Total irrigation water (internal plus external) — just for intermed. value	MCM
Overall conveyance efficiency of project authority delivered water	%
Net field irrigation requirements	
ET of irrigated fields in the command area	MCM
ET of irrigation water in the command area (ET — effective precipitation)	MCM
Irrigation water needed for salinity control (net)	MCM
Irrigation water needed for special practices	MCM
Total NET irrigation water requirements (ET— eff ppt + salt control + special	MCM
Other key values	
Flow rate *capacity* of main canal(s) at diversion point(s)	cms
Actual peak flow rate of the main canal(s) at diversion point(s) this year	cms
Peak NET irrigation requirement for field, including any special requirements	cms
Peak GROSS irrigation requirement, including all inefficiencies	cms
Annual or one-time external indicators for the command area	
Peak litres/sec/ha of surface irrigation inflows to canal(s) this year	LPS/ha
RWS: *Relative water supply* for the irrigated part of the command area (total external water supply)/(field ET during growing seasons + water for salt control — effective precipitation)	none
Annual ***Command Area Irrigation Efficiency*** [100 x (crop ET + leaching needs — effective ppt)/(Surface irrigation diversions + net groundwater)]	%
Field Irrigation Efficiency (computed) = [crop ET — effective ppt + LR water]/[total water delivered to users] x 100	%
RGCC: *Relative Gross Canal Capacity* (peak monthly net irrigation requirement)/(main canal capacity)	none
RACF: *Relative Actual Canal Flow* (peak monthly net irrigation requirement)/(peak main canal flow rate)	none
Gross annual tonnage of agricultural production by crop type	m Tonnes
Total annual value of agricultural production	US$

C.6.2. Indicators of internal assessment

INDICATOR LABEL	PRIMARY INDICATOR AND SUB-INDICATOR NAME
SERVICE and SOCIAL ORDER	
I-1	**Actual water delivery service to individual ownership units (e.g. field or farm)**
I-1A	Measurement of volumes
I-1B	Flexibility
I-1C	Reliability
I-1D	Apparent equity
I-2	**Stated water delivery service to individual ownership units (e.g. field or farm)**
I-2A to I-2B	Same sub-indicators as for I-1
I-3	**Actual water delivery service at the most downstream point in the system operated by a paid employee**
I-3A	Number of fields downstream of this point
I-3B	Measurement of volumes
I-3C	Flexibility
I-3D	Reliability
I-3E	Apparent equity
I-4	**Stated water delivery service at the most downstream point operated by a paid employee**
I-4A to I-4E	Same sub-indicators as for I-3
I-5	**Actual water delivery service by the main canals to the second level canals**
I-5A	Flexibility
I-5B	Reliability
I-5C	Equity
I-5D	Control of flow rates to the submain as stated
I-6	Stated water delivery service by the main canals to the second level canals
I-6A to I-6D	Same sub-indicators as for I-5
I-7	**Social "order" in the canal system operated by paid employees**
I-7A	Degree to which deliveries are ***NOT*** taken when not allowed, or at flow rates greater than allowed
I-7B	Noticeable ***non*** -existence of unauthorized turnouts from canals
I-7C	Lack of vandalism of structures
MAIN CANAL	
I-8	**Cross-regulator hardware (main canal)**
I-8A	Ease of cross-regulator operation under the current target operation
I-8B	Level of maintenance of the cross-regulators
I-8C	Lack of water level fluctuation
I-8D	Travel time of a flow rate change throughout this canal level
I-9	**Turnouts from the main canal**
I-9A	Ease of turnout operation under the current target operation
I-9B	Level of maintenance
I-9C	Flow rate capacities
I-l0	**Regulating reservoirs in the main canal**
I-10A	Suitability of the number of location(s)
I-10B	Effectiveness of operation
I-10C	Suitability of the storage/buffer capacities
I-10D	Maintenance
I-11	**Communications for the main canal**
I-11A	Frequency of communications with the next *higher* level
I-11B	Frequency of communications by operators or supervisors with their customers
I-11C	Dependability of voice communications by phone or radio
I-11D	Frequency of visits by upper level supervisors to the field

INDICATOR LABEL	PRIMARY INDICATOR AND SUB-INDICATOR NAME
I-11	**Communications for the main canal**
I-11E	Existence and frequency of remote monitoring (either automatic or manual) at key spill points, including the end of the canal
I-11F	Availability of roads along the canal
I-12	**General conditions for the main canal**
I-12A	General level of maintenance of the canal floor and canal banks
I-12B	General lack of *undesired* seepage (note: If deliberate conjunctive use is practised, some seepage may be desired)
I-12C	Availability of proper equipment and staff to adequately maintain this canal
I-12D	Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment)
I-13	**Operation of the main canal**
I-13A	How frequently do the headworks respond to realistic real time feedback from the operators/observers of this canal level?
I-13B	Existence and effectiveness of water ordering/delivery procedures to match actual demands
I-13C	Clarity and correctness of instructions to operators
I-13D	How frequently is the whole length of this canal checked for problems and reported to the office?
SECOND LEVEL CANALS	
I-14 to I-19	Same indicators as for main canal
THIRD LEVEL CANALS	
I-20 to I-25	Same indicators as for main and second level canals
BUDGETS, EMPLOYEES, WUAs	
I-26	**Budgets**
I-26A	What percentage of the total project (including WUA) O&M is collected as in-kind services, and/or water fees from water users?
I-26B	Adequacy of the actual dollars and in-kind services that are available (from all sources) to sustain adequate O&M with the present mode of operation
I-26C	Adequacy of spending on modernization of the water delivery operation/structures (as contrasted to rehabilitation or regular operation)
I-27	**Employees**
I-27A	Frequency and adequacy of training of operators and middle managers (not secretaries and drivers)
I-27B	Availability of written performance rules
I-27C	Power of employees to make decisions
I-27D	Ability of the project to dismiss employees with cause
I-27E	Rewards for exemplary service
I-27F	Relative salary of an operator compared to a day labourer
I-28	**WUAs**
I-28A	Percentage of all project users who have a functional, formal unit that participates in water distribution
I-28B	Actual ability of the strong WUAs to influence real-time water deliveries to the WUA
I-28C	Ability of the WUA to rely on effective outside help for enforcement of its rules
I-28D	Legal basis for the WUAs
I-28E	Financial strength of WUAs
I-29	**Mobility and size of operations staff, based on the ratio of operating staff to the number of turnouts**
I-30	**Computers for billing and record management: The extent to which computers are used for billing and record management**
I-31	**Computers for canal control: The extent to which computers (either central or on-site) are used for canal control**

C.6.3. Summary of external performance indicators

1 Water Year of the data 2009/2010

Indicators		Unit	Large Irrigation Scheme	Medium Irrigation Scheme			Small Irrigation Scheme							Value	
			Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton	Range	Average
WATER BALANCE INDICATORS															
1	Total annual volume of irrigation water available at the user level	MCM	51.28	10.99	16.89	13.78	2.69	7.32	0.70	1.14	5.63	3.64	4.76	-	-
2	Total annual volume of irrigation supply into the 3-D boundaries of the command area	MCM	78.89	16.90	25.98	21.20	4.14	11.26	1.08	1.76	8.66	5.60	7.32	-	-
3	Total annual volume of irrigation water managed by authorities (including internal well and recirculation pumps operated by authorities) (can include recirculated water; but does not include any drainage or groundwater that is pumped by farmers)	MCM	78.89	16.90	25.98	21.20	4.14	11.26	1.08	1.76	8.66	5.60	7.32	-	-
4	Total annual volume of water supply	MCM	118.69	29.17	39.09	31.90	5.92	15.16	1.63	2.64	12.71	9.97	11.02	-	-
5	Total annual volume of irrigation water delivered to users by project authorities	MCM	51.28	10.99	16.89	13.78	2.69	7.32	0.70	1.14	5.63	3.64	4.76	-	-
6	Total annual volume of ground water pumped within/to command area	MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
7	Total annual volume of field ET in irrigated fields	MCM	34.67	5.43	11.64	10.05	2.24	3.88	0.55	0.89	3.50	3.65	3.68	-	-
8	Total annual volume of (ET - effective precipitation)	MCM	20.39	0.52	6.93	5.98	1.20	2.30	0.33	0.53	1.86	1.89	2.18	-	-
9	Peak net irrigation water requirement	MCM	1.55	0.25	0.57	0.53	0.11	0.21	0.03	0.05	0.21	0.23	0.20	-	0.36
10	Total command area of the system	ha	3,501.00	750.00	1,153.00	941.00	157.00	343.00	48.00	78.00	356.00	384.00	325.00	-	-
11	Irrigated area, including multiple cropping	ha	6,280.00	1,500.00	2,073.00	1,791.00	457.00	693.00	99.00	160.00	719.00	775.00	657.00	-	-
12	Annual irrigation supply per unit command area	m3/ha	22,533.33	22,533.33	22,533.33	22,533.33	26,337.58	32,827.99	22,533.33	22,533.33	24,325.84	14,583.33	22,533.33	-	23,255.28

C.6.3. Summary of external performance indicators (continued)

	Indicators	Unit	Large Irrigation Scheme	Medium Irrigation Scheme			Small Irrigation Scheme							Value	
			Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton	Range	Average
13	Annual irrigation supply per unit irrigated area	m3/ha	12,561.97	11,266.67	12,533.01	11,839.12	9,048.14	16,248.20	10,925.25	10,985.00	12,044.51	7,225.81	11,146.63	-	11,438.57
14	Conveyance efficiency of project-delivered water (weighted for internal and external, using values stated by project authorities)	%	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00
15	Estimated conveyance efficiency for project groundwater	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Annual Relative Water Supply (RWS)	none	3.42	5.37	3.36	3.17	2.64	3.91	2.95	2.96	3.63	2.73	3.00	2.64 - 5.37	3.38
17	Annual Relative Irrigation Supply (RIS)	none	3.87	32.22	3.75	3.55	3.44	4.89	3.32	3.33	4.64	2.97	3.36	2.97 - 32 - 22	6.30
18	Water delivery capacity	none	2.33	13.94	2.19	2.46	5.32	6.10	3.69	2.27	4.67	11.00	3.61	2.19 - 13.94	5.23
19	Security of entitlement supply	%	100.00	100.00	100.00	100.00	33.37	100.00	100.00	100.00	100.00	100.00	100.00	33.37 - 100	93.94
20	Average Field Irrigation Efficiency	%	44.27	16.13	46.47	49.55	61.42	36.14	53.23	53.08	39.45	72.98	52.67	16.13 - 72.98	47.76
21	Command area Irrigation Efficiency	%	28.78	10.48	30.20	32.21	39.92	23.49	34.60	34.50	25.64	47.44	34.24	10.48 - 47.44	31.05
FINANCIAL INDICATORS															
22	Cost recovery ratio	none	1.07	0.45	1.23	0.53	0.83	0.58	0.97	1.01	0.59	0.16	0.79	0.45 - 1.23	0.75
23	Maintenance cost to revenue ratio	none	0.30	0.38	0.32	0.48	0.23	0.32	0.21	0.21	0.34	1.05	0.29	0.34 - 0.48	0.38
24	Total MOM cost per unit area	US$/ha	51.47	130.17	51.26	83.64	106.20	107.44	96.93	95.20	117.81	133.20	87.31		96.42
25	Total cost per staff person employed	US$/person	377.25	387.71	383.89	510.26	234.93	294.51	90.14	146.11	529.74	317.35	302.38		324.93
26	Revenue collection performance	none	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
27	Staff persons per unit irrigated area	Persons/ha	0.03	0.03	0.03	0.02	0.03	0.04	0.12	0.08	0.03	0.03	0.04		0.04
28	Number of turnouts per field operator	None	1.67	0.41	0.78	1.05	1.20	1.35	1.25	0.83	1.22	1.33	1.79		1.17
29	Average revenue per cubic meter of irrigation water delivered to water users by the project authorities	US$/m3	0.00376	0.00397	0.00431	0.00301	0.00513	0.00291	0.00640	0.00657	0.00439	0.00220	0.00473	0.00220 - 0.00657	0.00431
30	Total MOM cost per cubic meter of irrigation water delivered to water users by the project authorities	US$/m3	0.00148	0.00375	0.00148	0.00241	0.00262	0.00213	0.00280	0.00275	0.00315	0.00594	0.00252	0.00148 - 0.00594	0.00282

C.6.3. Summary of external performance indicators (continued)

	Indicators	Unit	Large Irrigation Scheme	Medium Irrigation Scheme			Small Irrigation Scheme							Value	
			Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton	Range	Average
AGRICULTURAL PRODUCTIVITY AND ECONOMIC INDICATORS															
31	Total annual value of agricultural production	US$	16,307,522.22	3,357,444.44	5,548,711.11	4,784,088.89	1,210,500.00	1,839,833.33	260,500.00	422,000.00	1,909,166.67	2,058,500.00	1,743,833.33		3,585,645.45
32	Output per unit command area	US$/ha	4,657.96	4,476.59	4,812.41	5,084.05	7,710.19	5,363.95	5,427.08	5,410.26	5,362.83	5,360.68	5,365.64		5,366.51
33	Output per unit irrigated area, including multiple cropping	US$/ha	2,596.74	2,238.30	2,676.66	2,671.18	2,648.80	2,654.88	2,631.31	2,637.50	2,655.31	2,656.13	2,654.24		2,611.00
34	Output per unit irrigation supply	US$/m3	0.21	0.20	0.21	0.23	0.29	0.16	0.24	0.24	0.22	0.37	0.24	0.16 - 0.37	0.24
35	Output per unit water supply	US$/m3	0.16	0.12	0.17	0.18	0.24	0.10	0.13	0.13	0.15	0.21	0.16	0.10 - 0.24	0.16
36	Output per unit of field ET	US$/m3	0.61	0.62	0.63	0.65	0.73	0.67	0.68	0.67	0.56	0.56	0.48	0.48 - 0.68	0.62
ENVIRONMENTAL INDICATORS															0.00
37	Water quality: Average salinity of the irrigation supply	dS/m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
38	Water quality: Average salinity of the drainage water	dS/m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	Water quality, Biological: Average BOD of the irrigation supply	mgm/liter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	Water quality, Biological: Average BOD of the drainage water	mgm/liter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	Water quality, Chemical: Average COD of the irrigation supply	mgm/liter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42	Water quality, Chemical: Average COD of the drainage water	mgm/liter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	Average depth to the shallow water table	m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44	Change in shallow water table depth over last 5 years (+ is up)	m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER															0.00
45	Percent of O&M expenses that are used for pumping	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

C.6.4. Summary of external assessment

Item Description	Units	Irrigation System										
		Large	Medium			Small						
		Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton
Stated Efficiencies												
Stated conveyance efficiency of imported canal water (accounts for seepage and spills and tail end flows)	%	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00
Weighted field irrigation efficiency from stated efficiencies	%	50.69	46.93	50.00	50.00	60.05	50.09	50.28	50.23	50.08	50.07	50.10
Areas												
Physical area of irrigated cropland in the command area (not including multiple cropping)	Ha	3,501.00	750.00	1,153.00	941.00	157.00	343.00	48.00	78.00	356.00	384.00	325.00
Irrigated crop area in the command area, including multiple cropping	Ha	6,280.00	1,500.00	2,073.00	1,791.00	457.00	693.00	99.00	160.00	719.00	775.00	657.00
Cropping intensity in the command area including double cropping	none	1.79	2.00	1.80	1.90	2.91	2.02	2.06	2.05	2.02	2.02	2.02
External sources of water for the command area												
Surface irrigation water inflow from outside the command area (gross at diversion and entry points)	MCM	78.89	16.90	25.98	21.20	4.14	11.26	1.08	1.76	8.66	5.60	7.32
Gross precipitation in the irrigated fields in the command area	MCM	39.80	12.27	13.11	10.70	1.78	3.90	0.55	0.89	4.05	4.37	3.69
Effective precipitation to irrigated fields (not including salinity removal)	MCM	14.28	4.91	4.71	4.07	1.04	1.58	0.23	0.36	1.63	1.76	1.49
Net aquifer withdrawl due to irrigation in the command area	MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total external water supply for the project - including gross ppt. and net aquifer withdrawl, but excluding internal recirculation	MCM	118.69	29.17	39.09	31.90	5.92	15.16	1.63	2.64	12.71	9.97	11.02
Total external irrigation supply for the project	MCM	78.89	16.90	25.98	21.20	4.14	11.26	1.08	1.76	8.66	5.60	7.32
Internal Water Sources												
Internal surface water recirculation by farmer or project in command area	MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross groundwater pumped by farmers within command area	MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Groundwater pumped by Project Authorities and applied to the command area	MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross total annual volume of project authority irrigation supply	MCM	78.89	16.90	25.98	21.20	4.14	11.26	1.08	1.76	8.66	5.60	7.32
Total groundwater pumped and dedicated to the command area	MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Groundwater pumped by Project Authorities and applied to the command area, minus net groundwater withdrawl (this is to avoid double counting. Also, all of net is applied to this term, although some might be applied to farmers)	MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Estimated total gross internal surface water + groundwater	MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Irrigation water delivered to users												
Internal authority water sources are stated to have a conveyance efficiency of:	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Delivery of external surface irrigation water to users - using stated conveyance efficiency	MCM	51.28	10.99	16.89	13.78	2.69	7.32	0.70	1.14	5.63	3.64	4.76
All other irrigation water to users (surface recirculation plus all well pumping, with stated conveyance efficiencies, using 100% for farmer pumping and farmer surface diversions)	MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

C.6.4. Summary of external assessment (continue)

Item Description	Units	Irrigation System										
		Large	Medium			Small						
		Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton
Irrigation water delivered to users												
Total irrigation water deliveries to users (external surface irrigation water + internal diversions and pumping water sources), reduced for conveyance efficiencies	MCM	51.28	10.99	16.89	13.78	2.69	7.32	0.70	1.14	5.63	3.64	4.76
Total irrigation water (internal plus external) - just for intermed. value	MCM	78.89	16.90	25.98	21.20	4.14	11.26	1.08	1.76	8.66	5.60	7.32
Overall conveyance efficiency of project authority delivered water	%	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00
Net Field Irrigation requirements												
ET of irrigated fields in the command area	MCM	34.67	5.43	11.64	10.05	2.24	3.88	0.55	0.89	3.50	3.65	3.68
ET of irrigation water in the command area (ET - effective precipitation)	MCM	20.39	0.52	6.93	5.98	1.20	2.30	0.33	0.53	1.86	1.89	2.18
Irrigation water needed for salinity control (net)	MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Irrigation water needed for special practices	MCM	2.31	1.25	0.92	0.85	0.45	0.34	0.05	0.08	0.36	0.77	0.33
Total NET irrigation water requirements (ET - eff ppt + salt control + special practices)	MCM	22.70	1.77	7.85	6.83	1.65	2.65	0.37	0.61	2.22	2.66	2.51
Other Key Values												
Flow rate capacity of main canal(s) at diversion point(s)	cms	3.60	3.50	1.25	1.30	0.60	1.30	0.11	0.11	1.00	2.50	0.73
Actual peak flow rate of the main canal(s) at diversion point(s) this year	cms	3.50	2.57	1.15	1.24	0.45	1.00	0.10	0.10	0.78	1.93	0.71
Peak NET irrigation requirement for field, including any special requirements	cms	1.55	0.25	0.57	0.53	0.11	0.21	0.03	0.05	0.21	0.23	0.20
Peak GROSS irrigation requirement, including all inefficiencies	cms	5.37	2.39	1.89	1.64	0.28	0.91	0.09	0.14	0.84	0.48	0.59
Annual or One-Time External Indicators for the Command Area												
Peak liters/sec/ha of surface irrigation inflows to canal(s) this year	LPS/Ha	1.00	3.42	1.00	1.32	2.87	2.92	2.00	1.23	2.20	5.03	2.19
RWS Relative water supply for the irrigated part of the command area (Total external water supply)/(Field ET during growing seasons + water for salt control - Effective precipitation)	none	5.23	16.47	4.98	4.67	3.59	5.73	4.35	4.36	5.72	3.75	4.39
Annual **Command Area Irrigation Efficiency** [100 x (Crop ET + Leaching needs - Effective ppt)/(Surface irrigation diversions + Net groundwater)]	%	28.78	10.48	30.20	32.21	39.92	23.49	34.60	34.50	25.64	47.44	34.24
Field Irrigation Efficiency (computed) = [Crop ET-Effective ppt + LR water]/[Total Water Delivered to Users] x 100	%	44.27	16.13	46.47	49.55	61.42	36.14	53.23	53.08	39.45	72.98	52.67
RGCC - Relative Gross Canal Capacity - (Peak Monthly Net Irrigation Requirement)/(Main Canal Capacity)	none	0.43	0.07	0.46	0.41	0.19	0.16	0.27	0.44	0.21	0.09	0.28
RACF - Relative Actual Canal Flow - (Peak Monthly Net Irrigation Requirement)/(Peak Main Canal Flow Rate)	none	0.44	0.10	0.50	0.43	0.25	0.21	0.31	0.50	0.27	0.12	0.28
Gross annual tonnage of agricultural production by crop type (see Table 9 on each INPUT worksheet (1-3))												
Paddy Rice #1 (Wet season - Rendeng)	m Tons	21,706.20	4,500.00	7,148.60	5,834.20	1,395.00	2,126.60	297.60	483.60	2,207.20	2,380.80	2,015.00
Paddy Rice #2 (Dry season - Gadu)		13,409.60	2,485.00	5,336.00	4,930.00	1,305.00	1,989.40	278.40	452.40	2,064.80	2,227.20	1,885.00
Palawija (Corn)		3,502.50	1,265.00	0.00	0.00	52.50	52.50	22.50	30.00	52.50	52.50	52.50
Total annual value of agricultural production	$ US	16,307,522.22	3,357,444.44	5,548,711.11	4,784,088.89	1,210,500.00	1,839,833.33	260,500.00	422,000.00	1,909,167.00	2,058,500.00	1,743,833.33

C.6.5. Summary of internal performance indicators

Indicator Label	Primary Indicator Name	Value (0-4)													
		Large Irrigation Scheme	Medium Irrigation Scheme			Small Irrigation Scheme							Range	Average	Rating
		Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton			
SERVICE and SOCIAL ORDER															
I-1	Actual Water Delivery Service to Individual Ownership Units (e.g., field or farm)	2.18	2.64	2.18	2.18	2.64	2.18	2.18	2.18	2.64	2.27	2.18	2.18 - 2.64	2.31	Fair
I-2	Stated Water Delivery Service to Individual Ownership Units (e.g., field or farm)	2.64	2.18	2.64	2.64	2.64	2.64	2.64	2.64	2.27	2.27	2.64	2.18 - 2.64	2.53	Good
I-3	Actual Water Delivery Service at the most downstream point in the system operated by a paid employee	2.41	2.82	2.41	2.41	2.82	2.41	2.41	2.41	2.12	2.35	2.41	2.12 - 2.82	2.45	Fair
I-4	Stated Water Delivery Service at the most downstream point in the system operated by a paid employee	2.24	1.76	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	1.76 -2.24	2.19	Fair
I-5	Actual Water Delivery Service by the Main Canals to the Second Level Canals	3.00	3.00	3.00	3.00	n.a.	n.a.	n.a.	n.a.	n.a.	2.56	3.00	2.56 - 3.00	2.93	Good
I-6	Stated Water Delivery Service by the Main Canals to the Second Level Canals	2.78	1.89	2.78	2.78	2.78	2.78	2.78	2.78	1.89	1.89	2.78	1.89 - 2.78	2.54	Good
I-7	Social "Order" in the Canal System operated by paid employees	3.50	4.00	3.50	3.50	4.00	3.50	3.50	3.50	3.25	4.00	3.50	3.25 - 4.00	3.61	Good
MAIN CANAL						No main canal	No main canal	No main canal	No main canal	No main canal					
I-8	Cross regulator hardware (Main Canal)	1.71	2.86	2.86	2.57	n.a.	n.a.	n.a.	n.a.	n.a.	1.86	2.86	1.71 - 2.86	1.34	Poor
I-9	Turnouts from the Main Canal	2.33	2.33	2.33	2.33	n.a.	n.a.	n.a.	n.a.	n.a.	3.00	2.33	2.33 - 3.00	1.33	Poor
I-l0	Regulating Reservoirs in the Main Canal **(Note: No regulating reservoir in these systems)**	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
I-11	Communications for the Main Canal	2.27	2.27	2.27	2.27	n.a.	n.a.	n.a.	n.a.	n.a.	2.18	2.27	2.18 - 2.27	1.23	Poor
I-12	General Conditions for the Main Canal	1.80	1.80	1.20	1.20	n.a.	n.a.	n.a.	n.a.	n.a.	2.20	1.80	1.20 - 2.20	0.91	Poor
I-13	Operation of the Main Canal	2.66	2.66	2.14	2.14	n.a.	n.a.	n.a.	n.a.	n.a.	2.14	2.66	2.14 - 2.66	1.31	Poor

C.6.5. Summary of internal performance indicators (continued)

Indicator Label	Primary Indicator Name	Value (0-4): Large Irrigation Scheme	Medium Irrigation Scheme			Small Irrigation Scheme							Range	Average	Rating
		Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton			
SECOND LEVEL CANALS															
I-14	Cross regulator hardware (Second Level Canals)	2.00	2.86	2.00	2.00	2.71	2.00	2.00	2.00	1.86	3.57	1.43	1.43 - 3.57	2.22	Fair
I-15	Turnouts from the Second Level Canals	2.33	2.33	2.33	2.33	3.00	2.33	2.33	2.33	2.33	3.00	2.33	2.33 - 3.00	2.45	Fair
I-16	Regulating Reservoirs in the Second Level Canals **(Note: No regulating reservoir in these systems)**	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a	n.a	n.a.	n.a.	n.a
I-17	Communications for the Second Level Canals	2.27	2.55	2.27	2.27	2.09	2.27	2.27	2.27	2.09	2.09	2.27	2.09 - 2.27	2.25	Fair
I-18	General Conditions for the Second Level Canals	1.20	1.80	1.80	1.80	2.20	1.80	1.80	1.80	2.00	2.40	1.80	1.20 - 2.40	1.85	Fair
I-19	Operation of the Second Level Canals	2.40	2.34	2.40	2.40	1.78	2.40	2.40	2.40	2.14	2.34	2.40	1.78 - 2.40	2.31	Fair
THIRD LEVEL CANALS			**No 3rd level canal**							**No 3rd level canal**					
I-20	Cross regulator hardware (Third Level Canals)	0.86	n.a.	2.00	2.00	2.00	2.00	2.00	2.00	n.a.	1.86	1.14	0.86 - 2.00	1.44	Poor
I-21	Turnouts from the Third Level Canals	2.67	n.a.	2.67	2.67	3.00	2.67	2.67	2.67	n.a.	3.00	2.67	2.67 - 3.00	2.24	Fair
I-22	Regulating Reservoirs in the Third Level Canals **(Note: No regulating reservoir in these systems)**	n.a.	n.a.	0.00	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a
I-23	Communications for the Third Level Canals	2.09	n.a.	2.09	2.09	2.27	2.09	2.09	2.09	n.a.	2.18	2.09	2.09 - 2.27	1.74	Fair
I-24	General Conditions for the Third Level Canals	1.40	n.a.	1.40	1.40	2.20	1.40	1.40	1.40	n.a.	2.80	1.40	1.40 - 2.80	1.35	Poor
I-25	Operation of the Third Level Canals	2.40	n.a.	2.40	2.40	2.88	2.40	2.40	2.40	n.a.	2.34	2.40	2.34 - 2.40	2.00	Fair
BUDGETS, EMPLOYEES, AND WUAs															
I-26	Budgets	0.40	0.40	0.40	0.40	1.20	0.40	0.40	0.40	0.40	0.40	0.40	0.40 - 1.20	0.47	Bad
I-27	Employees	1.50	1.50	1.50	1.50	1.93	1.50	1.50	1.50	1.35	1.80	1.50	1.35 - 1.93	1.55	Fair
I-28	Water User Associations	3.23	3.23	3.23	3.23	3.08	3.23	3.23	3.23	2.92	2.92	3.23	2.92 - 3.23	3.16	Good
I-29	Mobility and Size of Operations Staff: Operation staff mobility and efficiency, based on the ratio of operating staff to the number of turnouts.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Bad
I-30	Computers for billing and record management: The extent to which computers are used for billing and record management	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Bad
I-31	Computers for canal control: The extent to which computers (either central or on-site) are used for canal control	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00 - 1.00	0.73	Poor

C.6.5. Summary of internal performance indicators (continued)

Indicator Label	Primary Indicator Name	Value (0-4)													
		Large Irrigation Scheme	Medium Irrigation Scheme			Small Irrigation Scheme							Range	Average	Rating
		Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton			
INDICATORS THAT WERE NOT PREVIOUSLY COMPUTED															
I-32	Ability of the present water delivery service to individual fields, to support pressurized irrigation methods	2.17	3.17	2.17	2.17	3.17	2.17	2.17	2.17	1.83	3.17	2.17	2.17 - 3.17	2.41	Fair
I-32A	Measurement and control of volumes to the field	2.50	3.50	2.50	2.50	3.50	2.50	2.50	2.50	2.50	3.50	2.50	2.50 - 3.50	2.77	Good
I-33	Changes required to be able to support pressurized irrigation methods	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	1.00	2.50	2.50	1.00 - 2.50	2.36	Fair
I-34	Sophistication in receiving and using feedback information. This does not need to be automatic.	2.00	1.00	2.00	2.00	1.00	2.00	2.00	2.00	1.00	1.00	2.00	1.00 - 2.00	1.64	Fair
SPECIAL INDICATORS THAT DO NOT HAVE A 0-4 RATING SCALE															
I-35	Turnout density: Number of water users downstream of employee-operated turnouts	2800	>1,000	2000	125	278	450	175	300	575	600	600	125 - 2800	718.45	Poor
I-36	Turnouts/Operator: (Number of turnouts operated by paid employees)/(Paid Employees)	1.67	0.41	0.78	1.05	0.60	1.35	0.83	0.83	1.22	0.56	1.79	0.41 - 1.79	1.01	Excellent
I-37	Main Canal Chaos: (Actual/Stated) Overall Service by the Main Canal	1.08	1.59	1.08	1.08	0.00	0.00	0.00	0.00	0.00	1.35	1.08	0.00 - 1.59	0.66	Over stated
I-38	Second Level Chaos: (Actual/Stated) Overall Service at the most downstream point operated by a paid employee	1.08	1.60	1.08	1.08	1.26	1.08	1.08	1.08	0.95	1.05	1.08	0.95 - 1.60	1.13	Slightly understated
I-39	Field Level Chaos: (Actual/Stated) Overall Service to the Individual Ownership Units	0.83	1.21	0.83	0.83	1.00	0.83	0.83	0.83	1.16	1.00	0.83	1.00 - 1.21	0.92	Slightly overstated

C.6.6. Summary of internal assessment

Indicator Label	Primary Indicator Name	Sub-Indicator Name	Weighting Factor	Old Indicator Label (FAO Water Reports 19)	Worksheet Location	Value (0-4)										
						Irrigation System										
						Large	Medium			Small						
						Way Pengubua	Way Padang	Way Negara	Way Tipo Balak	Way Muara	Way Muara	Way Muara	Way Muara	Way Tipo Lunik	Way Ilihan	Way Srikaton
SERVICE and SOCIAL ORDER																
I-1	Actual Water Delivery Service to Individual Ownership Units (e.g., field or farm)			*I-1*	Final deliveries	2.18	2.64	2.18	2.18	2.64	2.18	2.18	2.18	2.64	2.27	2.18
I-1A		Measurement of volumes	1	*I-1A*		0	1	0	0	1	0	0	0	1	1	0
I-1B		Flexibility	2	*I-1B*		2	2	2	2	2	2	2	2	2	0	2
I-1C		Reliability	4	*I-1C*		2	2	2	2	2	2	2	2	2	2	2
I-1D		Apparent equity.	4	*I-1D*		3	4	3	3	4	3	3	3	4	4	3
I-2	Stated Water Delivery Service to Individual Ownership Units (e.g., field or farm)			*I-5*	Project Office Questions	2.64	2.18	2.64	2.64	2.64	2.64	2.64	2.64	2.27	2.27	2.64
I-2A		Measurement of volumes	1	*I-5A*		1	0	1	1	1	1	1	1	1	1	1
I-2B		Flexibility	2	*I-5B*		2	2	2	2	2	2	2	2	2	2	2
I-2C		Reliability	4	*I-5C*		2	2	2	2	2	2	2	2	1	1	2
I-2D		Apparent equity.	4	*I-5D*		4	3	4	4	4	4	4	4	4	4	4
I-3	Actual Water Delivery Service at the most downstream point in the system operated by a paid employee			*I-3*	Final deliveries	2.41	2.82	2.41	2.41	2.82	2.41	2.41	2.41	2.12	2.35	2.41
I-3A		Number of fields downstream of this point	1	*I-3A*		1	4	1	1	4	1	1	1	4	4	1
I-3B		Measurement of volumes	4	*I-3B*		1	3	1	1	3	1	1	1	1	1	1
I-3C		Flexibility	4	*I-3C*		2	2	2	2	2	2	2	2	2	2	2
I-3D		Reliability	4	*I-3D*		3	2	3	3	2	3	3	3	2	2	3
I-3E		Apparent equity.	4	*I-3E*		4	4	4	4	4	4	4	4	3	4	4
I-4	Stated Water Delivery Service at the most downstream point in the system operated by a paid employee			*I-7*	Project Office Questions	2.24	1.76	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24
I-4A		Number of fields downstream of this point	1	*I-7A*		2	2	2	2	2	2	2	2	2	2	2
I-4B		Measurement of volumes	4	*I-7B*		1	0	1	1	1	1	1	1	1	1	1
I-4C		Flexibility	4	*I-7C*		2	2	2	2	2	2	2	2	2	2	2
I-4D		Reliability	4	*I-7D*		2	2	2	2	2	2	2	2	2	2	2
I-4E		Apparent equity.	4	*I-7E*		4	3	4	4	4	4	4	4	4	4	4
I-5	Actual Water Delivery Service by the Main Canals to the			*I-4*	Main Canal	3.00	3.00	3.00	3.00	0.00	0.00	0.00	0.00	0.00	2.56	3.00
I-5A		Flexibility	1	*I-4A*		1	1	1	1	0	0	0	0	0	1	1
I-5B		Reliability	1	*I-4B*		4	4	4	4	0	0	0	0	0	3	4
I-5C		Equity	1	*I-4C*		4	4	4	4	0	0	0	0	0	3	4
I-5D		Control of flow rates to the submain as stated	2	*I-4D*		3	3	3	3	0	0	0	0	0	3	3
I-6	Stated Water Delivery Service by the Main Canals to the Second Level Canals			*I-8*	Project Office Questions	2.78	1.89	2.78	2.78	2.78	2.78	2.78	2.78	1.89	1.89	2.78
I-6A		Flexibility	1	*I-8A*		1	1	1	1	1	1	1	1	1	1	1
I-6B		Reliability	1	*I-8B*		4	3	4	4	4	4	4	4	3	3	4
I-6C		Equity	1	*I-8C*		3	3	3	3	3	3	3	3	3	3	3
I-6D		Control of flow rates to the submain as stated	2	*I-8D*		3	1	3	3	3	3	3	3	1	1	3
I-7	Social "Order" in the Canal System operated by paid employees			*I-9*	Final deliveries	3.50	4.00	3.50	3.50	4.00	3.50	3.50	3.50	3.25	4.00	3.50
I-7A		Degree to which deliveries are NOT taken when not allowed, or at flow rates greater than allowed	2	*I-9A*		4	4	4	4	4	4	4	4	4	4	4
I-7B		Noticeable non-existence of unauthorized turnouts from canals.	1	*I-9B*		4	4	4	4	4	4	4	4	4	4	4
I-7C		Lack of vandalism of structures.	1	*I-9C*		2	4	2	2	4	2	2	2	1	4	2
MAIN CANAL										**No main canal**						
I-8	Cross regulator hardware (Main Canal)			*I-l0*	Main Canal	1.71	2.86	2.86	2.57	n.a.	n.a.	n.a.	n.a.	n.a.	1.86	2.86
I-8A		Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets.	1	*I-10A*		4	4	4	4	n.a.	n.a.	n.a.	n.a.	n.a.	3	4
I-8B		Level of maintenance of the cross regulators.	1	*I-10C*		2	2	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	2	2
I-8C		Lack of water level fluctuation	3	*I-10D*		2	2	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	0	2
I-8D		Travel time of a flow rate change throughout this canal level	2	*I-10E*		0	4	4	3	n.a.	n.a.	n.a.	n.a.	n.a.	4	4
I-9	Turnouts from the Main Canal			*I-12*	Main Canal	2.33	2.33	2.33	2.33	n.a.	n.a.	n.a.	n.a.	n.a.	3.00	2.33
I-9A		Ease of turnout operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to meet the targets.	1	*I-12A*		3	3	3	3	n.a.	n.a.	n.a.	n.a.	n.a.	3	3
I-9B		Level of maintenance	1	*I-12C*		2	2	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	2	2
I-9C		Flow rate capacities	1	*I-12D*		2	2	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	4	2
I-l0	Regulating Reservoirs in the Main Canal **(Note: No regulating reservoir in these systems)**			*I-13*	Main Canal	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
I-10A		Suitability of the number of location(s)	2	*I-13A*		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		
I-10B		Effectiveness of operation	2	*I-13B*		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		
I-10C		Suitability of the storage/buffer capacities	1	*I-13C*		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		
I-10D		Maintenance	1	*I-13D*		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		
I-11	Communications for the Main Canal			*I-14*	Main Canal	2.27	2.27	2.27	2.27	n.a.	n.a.	n.a.	n.a.	n.a.	2.18	2.27
I-11A		Frequency of communications with the next higher level? (hr)	2	*I-14A*		1	1	1	1	n.a.	n.a.	n.a.	n.a.	n.a.	1	1
I-11B		Frequency of communications by operators or supervisors with their customers	2	*I-14B*		2	2	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	2	2
I-11C		Dependability of voice communications by phone or radio.	3	*I-14C*		4	4	4	4	n.a.	n.a.	n.a.	n.a.	n.a.	4	4
I-11D		Frequency of visits by upper level supervisors to the field.	1	*I-14D*		3	3	3	3	n.a.	n.a.	n.a.	n.a.	n.a.	3	3
I-11E		Existence and frequency of remote monitoring (either automatic or manual) at key spill points, including the end of the canal	1	*I-14E*		0	0	0	0	n.a.	n.a.	n.a.	n.a.	n.a.	1	0
I-11F		Availability of roads along the canal	2	*I-14F*		2	2	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	1	2
I-12	General Conditions for the Main Canal			*I-15*	Main Canal	1.80	1.80	1.20	1.20	n.a.	n.a.	n.a.	n.a.	n.a.	2.20	1.80
I-12A		General level of maintenance of the canal floor and canal banks	1	*I-15A*		2	2	1	1	n.a.	n.a.	n.a.	n.a.	n.a.	2	2
I-12B		General lack of undesired seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired).	1	*I-15B*		3	3	1	1	n.a.	n.a.	n.a.	n.a.	n.a.	2	3
I-12C		Availability of proper equipment and staff to adequately maintain this canal	2	*I-15C*		1	1	1	1	n.a.	n.a.	n.a.	n.a.	n.a.	2	1
I-12D		Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment)	1	*I-15D*		2	2	2	2	n.a.	n.a.	n.a.	n.a.	n.a.	3	2

C.6.6. Summary of internal assessment (continue)

Indicator Label	Primary Indicator Name	Sub-Indicator Name	Weighting Factor	Old Indicator Label (FAO Water Reports 19)	Worksheet Location	Value (0-4)										
						Irrigation System										
						Large	Medium			Small						
						Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton
MAIN CANAL										No main canal						
I-13	Operation of the Main Canal			*I-16*	Main Canal	2.66	2.66	2.14	2.14	n.a.	n.a.	n.a.	n.a.	n.a.	2.14	2.66
I-13A		How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times.	2	*I-16A*		4	4	2.7	2.7	n.a.	n.a.	n.a.	n.a.	n.a.	3	4
I-13B		Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	1	*I-16B*		1	1.3	1.3	1.3	n.a.	n.a.	n.a.	n.a.	n.a.	1	1
I-13C		Clarity and correctness of instructions to operators.	1	*I-16C*		4	4	4	4	n.a.	n.a.	n.a.	n.a.	n.a.	4	4
I-13D		How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	1	*I-16D*		0	0	0	0	n.a.	n.a.	n.a.	n.a.	n.a.	0	0
SECOND LEVEL CANALS																
I-14	Cross regulator hardware (Second Level Canals)			*I-l0*	Second Level Canals	2.00	2.86	2.00	2.00	2.71	2.00	2.00	2.00	1.86	3.57	1.43
I-14A		Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets.	1	*I-10A*		4	4	4	4	3	4	4	4	3	3	4
I-14B		Level of maintenance of the cross regulators.	1	*I-10C*		2	2	2	2	2	2	2	2	2	2	2
I-14C		Lack of water level fluctuation	3	*I-10D*		0	2	0	0	2	0	0	0	0	4	0
I-14D		Travel time of a flow rate change throughout this canal level	2	*I-10E*		4	4	4	4	4	4	4	4	4	4	2
I-15	Turnouts from the Second Level Canals			*I-12*	Second Level Canals	2	2.33	2.33	2.33	3	2.33	2.33	2.33	2.33	3.00	2.33
I-15A		Ease of turnout operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to meet the targets.	1	*I-12A*		3	3	3	3	3	3	3	3	3	3	3
I-15B		Level of maintenance	1	*I-12C*		2	2	2	2	2	2	2	2	2	2	2
I-15C		Flow rate capacities	1	*I-12D*		2	2	2	2	4	2	2	2	2	4	2
I-16	Regulating Reservoirs in the Second Level Canals **(Note: No regulating reservoir in these systems)**			*I-13*	Second Level Canals	n.a.	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a	n.a
I-16A		Suitability of the number of location(s)	2	*I-13A*		n.a.	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
I-16B		Effectiveness of operation	2	*I-13B*		n.a.	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
I-16C		Suitability of the storage/buffer capacities	1	*I-13C*		n.a.	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
I-16D		Maintenance	1	*I-13D*		n.a.	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
I-17	Communications for the Second Level Canals			*I-l20*	Second Level Canals	2.27	2.55	2.27	2.27	2.09	2.27	2.27	2.27	2.09	2.09	2.27
I-17A		Frequency of communications with the next higher level? (hr)	2	*I-20A*		1	2	1	1	1	1	1	1	1	1	1
I-17B		Frequency of communications by operators or supervisors with their customers	2	*I-20B*		2	3	2	2	2	2	2	2	2	2	2
I-17C		Dependability of voice communications by phone or radio.	3	*I-20C*		4	4	4	4	4	4	4	4	4	4	4
I-17D		Frequency of visits by upper level supervisors to the field.	1	*I-20D*		2	2	2	2	3	2	2	2	2	3	2
I-17E		Existence and frequency of remote monitoring (either automatic or manual) at key spill points, including the end of the canal	1	*I-20E*		1	0	1	1	0	1	1	1	1	0	1
I-17F		Availability of roads along the canal	2	*I-21F*		2	2	2	2	1	2	2	2	1	1	2
I-18	General Conditions for the Second Level Canals			*I-21*	Second Level Canals	1.20	1.80	1.80	1.80	2.20	1.80	1.80	1.80	2.00	2.40	1.80
I-18A		General level of maintenance of the canal floor and canal banks	1	*I-21B*		2	2	2	2	2	2	2	2	2	2	2
I-18B		General lack of undesired seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired).	1	*I-21C*		2	3	2	2	2	2	2	2	1	3	2
I-18C		Availability of proper equipment and staff to adequately maintain this canal	2	*I-21D*		1	1	1	1	2	1	1	1	2	2	1
I-18D		Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment)	1	*I-21E*		0	2	3	3	3	3	3	3	3	3	3
I-19	Operation of the Second Level Canals			*I-22*	Second Level Canals	2.40	2.34	2.40	2.40	1.78	2.40	2.40	2.40	2.14	2.34	2.40
I-19A		How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times.	2	*I-22A*		3	2.7	2.7	2.7	1	3	3	3	3	3	3
I-19B		Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	1	*I-22B*		1	1.3	1.3	1.3	1	1	1	1	1	1	1
I-19C		Clarity and correctness of instructions to operators.	1	*I-22C*		4	4	4	4	4	4	4	4	4	4	4
I-19D		How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	1	*I-22D*		1	1	1.3	1.3	1	1	1	1	0	1	1

C.6.6. Summary of internal assessment (continue)

Indicator Label	Primary Indicator Name	Sub-Indicator Name	Weighting Factor	Old Indicator Label (FAO Water Reports 19)	Worksheet Location	Value (0-4) Irrigation System: Large – Way Pengubuan	Medium – Way Padang Ratu	Medium – Way Negara Ratu	Medium – Way Tipo Balak	Small – Way Muara Mas	Small – Way Muara Mas I	Small – Way Muara Mas II	Small – Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton
THIRD LEVEL CANALS							No 3rd level							No 3rd level		
I-20	Cross regulator hardware (Third Level Canals)				Third Level Canals	0.86	n.a.	2.00	2.00	2.00	2.00	2.00	2.00	n.a.	1.86	1.14
I-20A		Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets.	1			4	n.a.	4	4	4	4	4	4		3	4
I-20B		Level of maintenance of the cross regulators.	1			2	n.a.	2	2	2	2	2	2		2	2
I-20C		Lack of water level fluctuation	3			0	n.a.	0	0	0	0	0	0		0	0
I-20D		Travel time of a flow rate change throughout this canal level	2			0	n.a.	4	4	4	4	4	4		4	1
I-21	Turnouts from the Third Level Canals				Third Level Canals	2.67	n.a.	2.67	2.67	3	2.67	2.67	2.67	n.a.	3.00	2.67
I-21A		Ease of turnout operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to meet the targets.	1			4	n.a.	4	4	3	4	4	4		3	4
I-21B		Level of maintenance	1			2	n.a.	2	2	2	2	2	2		2	2
I-21C		Flow rate capacities	1			2	n.a.	2	2	4	2	2	2		4	2
I-22	Regulating Reservoirs in the Third Level Canals **(Note: No regulating reservoir in these systems)**				Third Level Canals	n.a.	n.a.	0.00	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
I-22A		Suitability of the number of location(s)	2			n.a.	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
I-22B		Effectiveness of operation	2			n.a.	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
I-22C		Suitability of the storage/buffer capacities	1			n.a.	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
I-22D		Maintenance	1			n.a.	n.a.	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
I-23	Communications for the Third Level Canals				Third Level Canals	2.09	n.a.	2.09	2.09	2.27	2.09	2.09	2.09	n.a.	2.18	2.09
I-23A		Frequency of communications with the next higher level? (hr)	2			1	n.a.	1	1	1	1	1	1		1	1
I-23B		Frequency of communications by operators or supervisors with their customers	2			2	n.a.	2	2	2	2	2	2		2	2
I-23C		Dependability of voice communications by phone or radio.	3			4	n.a.	4	4	4	4	4	4		4	4
I-23D		Frequency of visits by upper level supervisors to the field.	1			1	n.a.	1	1	4	1	1	1		3	1
I-23E		Existence and frequency of remote monitoring (either automatic or manual) at key spill points, including the end of the canal	1			2	n.a.	2	2	1	2	2	2		1	2
I-23F		Availability of roads along the canal	2			1	n.a.	1	1	1	1	1	1		1	1
I-24	General Conditions for the Third Level Canals				Third Level Canals	1.40	n.a.	1.40	1.40	2.20	1.40	1.40	1.40	n.a.	2.80	1.40
I-24A		General level of maintenance of the canal floor and canal banks	1			1	n.a.	1	1	2	1	1	1		3	1
I-24B		General lack of undesired seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired).	1			0	n.a.	0	0	2	0	0	0		2	0
I-24C		Availability of proper equipment and staff to adequately maintain this canal	2			1	n.a.	1	1	2	1	1	1		3	1
I-24D		Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment)	1			4	n.a.	4	4	3	4	4	4		3	4
I-25	Operation of the Third Level Canals				Third Level Canals	2.40	n.a.	2.40	2.40	2.88	2.40	2.40	2.40	n.a.	2.34	2.40
I-25A		How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times.	2			3	n.a.	2.7	2.7	3	3	3	3		3	3
I-25B		Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	1			1	n.a.	1.3	1.3	4	1	1	1		1	1
I-25C		Clarity and correctness of instructions to operators.	1			4	n.a.	4	4	4	4	4	4		4	4
I-25D		How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	1			1	n.a.	1.3	1.3	1	1	1	1		1	1
BUDGETS, EMPLOYEES, AND WUAs																
I-26	Budgets			*I-23*	Project Office Questions	0.40	0.40	0.40	0.40	1.20	0.40	0.40	0.40	0.40	0.40	0.40
I-26A		What percentage of the total project (including WUA) Operation and Maintenance (O&M) is collected as in-kind services, and/or water fees from water users?	2	*I-23A*		0	0	0	0	2	0	0	0	0	0	0
I-26B		Adequacy of the actual dollars and in-kind services that is available (from all sources) to sustain adequate Operation and Maintenance (O&M) with the present mode of operation.	2	*I-23B*		1	1	1	1	1	1	1	1	1	1	1
I-26C		Adequacy of spending on modernization of the water delivery operation/structures (as contrasted to rehabilitation or regular operation)	1	*I-23C*		0	0	0	0	0	0	0	0	0	0	0

C.6.6. Summary of internal assessment (continue)

Indicator Label	Primary Indicator Name	Sub-Indicator Name	Weighting Factor	Old Indicator Label (FAO Water Reports 19)	Worksheet Location	Value (0-4)										
						Irrigation System										
						Large	Medium			Small						
						Way Pengubuan	Way Padang Ratu	Way Negara Ratu	Way Tipo Balak	Way Muara Mas	Way Muara Mas I	Way Muara Mas II	Way Muara Mas III	Way Tipo Lunik	Way Ilihan Balak	Way Srikaton
BUDGETS, EMPLOYEES, AND WUAs																
I-27	Employees			*I-24*	Project Employees	1.5	1.50	1.50	1.50	1.93	1.50	1.50	1.50	1.35	1.80	1.50
I-27A		Frequency and adequacy of training of operators and middle managers (not secretaries and drivers). This should include employees at all levels of the distribution system, not only those who work in the office.	1	*I-24A*		2	2	2	2	4	2	2	2	2	2	2
I-27B		Availability of written performance rules	1	*I-24B*		1	1	1	1	3	1	1	1	3	3	1
I-27C		Power of employees to make decisions	3	*I-24C*		1	1	1	1	1	1	1	1	1	1	1
I-27D		Ability of the project to dismiss employees with cause.	2	*I-24D*		3	3	3	3	2	3	3	3	2	2	3
I-27E		Rewards for ememplary service	1	*I-24E*		2	2	2	2	1	2	2	2	2	2	2
I-27F		Relative salary of an operator compared to a day laborer **(Note: There are no day laborer)**	2	*I-24F*		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a	n.a	n.a	n.a	n.a
I-28	Water User Associations			*I-25*	WUA	3.23	3.23	3.23	3.23	3.08	3.23	3.23	3.23	2.92	2.92	3.23
I-28A		Percentage of all project users who have a functional, formal unit that participates in water distribution	3	*I-25A*		4	4	4	4	4	4	4	4	4	4	4
I-28B		Actual ability of the strong Water User Associations to influence real-time water deliveries to the WUA.	1	*I-25B*		4	4	4	4	4	4	4	4	3	3	4
I-28C		Ability of the WUA to rely on effective outside help for enforcement of its rules	1	*I-25C*		1	1	1	1	1	1	1	1	1	1	1
I-28D		Legal basis for the WUAs	1	*I-25D*		3	3	3	3	3	3	3	3	3	3	3
I-28E		Financial strength of WUAS	1	*I-25E*		3	3	3	3	2	3	3	3	2	2	3
I-29	Mobility and Size of Operations Staff	Operation staff mobility and efficiency, based on the ratio of operating staff to the number of turnouts.		*I-28*	Project Office Questions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
I-30	Computers for billing and record management	The extent to which computers are used for billing and record management		*I-30*	Project Office Questions	0	0.00	0.00	0.00	0	0	0	0	0	0	0
I-31	Computers for canal control	The extent to which computers (either central or on-site) are used for canal control		*I-31*	Project Office Questions	1	0.00	1.00	1.00	1	1	1	1	0	0	1
INDICATORS THAT WERE NOT PREVIOUSLY COMPUTED																
I-32	Ability of the present water delivery service to individual fields,			*I-26*	n/a	2	3.17	2.17	2.17	3.17	2.17	2.17	2.17	1.83	3.17	2.17
I-32A	Measurement and control of volumes to the field	4 - Excellent volumetric metering and control; 3.5 - Ability to measure flow rates reasonably well, but not volume. Flow is well controlled; 2.5 - Cannot measure flow, but can control flow rates well; 0 - Cannot control the flow rate, even though it can be measured.	1	*I-26A*	n/a	3	3.5	2.5	2.5	4	3	3	3	3	4	3
I-32B	Flexibility to the field	4 - Arranged delivery, with frequency, rate and duration promised. All can be varied upon request; 3 - Same as 4, but cannot vary the duration; 2 - 2 variables are fixed, but arranged schedule; 0 - Rotation	1	*I-26B*	n/a	0	2.0	0	0	2	0	0	0	0	2	0
I-32C	Reliability to the field	4 - Water always arrives as promised, including the appropriate volume; 3 - A few days of delay occasionally occur, but water is still very reliable in rate and duration; 0 - More than a few days delay.	1	*I-26C*	n/a	4	4.0	4	4	4	4	4	4	3	4	4
I-33	Changes required to be able to support pressurized irrigation			*I-27*	n/a	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	1.00	2.50	2.50
I-33A	Procedures, Management	4 - No changes in water ordering, staff training, or mobility; 3.5 - Improved training, only. The basic procedures/conditions are just fine, they just are not being implemented to their full extent; 3.0 - Minor changes in water ordering, mobility, training, incentive programs; 2.0 - Major changes in 1 of the above; 1 - Major changes in 2 of the above; 0 - Need to completely revamp or convert almost everything.	1	*I-27A*	Management	3	2.0	3	3	2	3	3	3	2	2	3
I-33B	Hardware	4 - No changes needed; 3.5 - Only need to repair some of the existing structures so that they are workable again.; 3.0 - Improved communications, repair of some existing structures, and a few key new structures (less than US$300/ha needed), OR…very little change to existing, but new structures are needed for water recirculation; 2 - Larger capital expenditures - $US 300 - $US 600/ha; 1 - Larger capital expenditures needed (up to $US 1500/ha); 0 - Almost complete reworking of the system is needed	1	*I-27B*	Hardware	2	3.0	2	2	3	2	2	2		3	2
I-34	Sophistication in receiving and using feedback information. This does not need to be automatic.	4 - Continuous feedback and continuous use of information to change inflows, with all key points monitored. Or, minimal feed back is necessary, such as with closed pipe systems.; 3 - Feedback several times a day and rapid use (within a few hours) of that information, at major points.; 2 - Feedback once/day from key points and appropriate use of information within a day; 1 - Weekly feedback and appropriate usage, or once/day feeback but poor usage of the information; 0 - No meaningful feedback, or else there is a lot of feedback but no usage.		*I-29*	n/a	2	1.0	2	2	1	2	2	2	1	1	2
SPECIAL INDICATORS THAT DO NOT HAVE A 0-4 RATING																
I-35	Turnout density	Number of water users downstream of employee-operated turnouts			*Final deliveries*	2800	>1,000	2000	125	278.00	450.00	175.00	300.00	575.00	600.00	600.00
I-36	Turnouts/ Operator	(Number of turnouts operated by paid employees)/(Paid Employees)			*Project Office*	1.67	0.41	0.78	1.05	0.60	1.35	0.83	0.83	1.22	0.56	1.79
I-37	Main Canal Chaos	(Actual/Stated) Overall Service by the Main Canal				1.08	1.59	1.08	1.08	0.00	0.00	0.00	0.00	0.00	1.35	1.08
I-38	Second Level Chaos	(Actual/Stated) Overall Service at the most downstream point operated by a paid employee				1.08	1.60	1.08	1.08	1.26	1.08	1.08	1.08	0.95	1.05	1.08
I-39	Field Level Chaos	(Actual/Stated) Overall Service to the Individual Ownership Units				0.83	1.21	0.83	0.83	1.00	0.83	0.83	0.83	1.16	1.00	0.83

C.6.7. RAP and Benchmarking worksheets for Way Pengubuan irrigation system

C.6.7.1. Input of water balance

Input rules:		A blank cell indicates a place for data input
		A shaded cell should not receive input. It is a default value or explanation cell
	3.00	Red letters indicate computed values
	4.00	Blue values indicate values that were transferred from elsewhere in the spreadsheet.

Project Name =	Way Pengubuan	
Water Year =	2009/2010	
Total Project area (command and non-command)	4,975.00	Hectares; gross, including roads, all fields, water bodies
Command area - area with irrig. facilities	3,501.00	Physical area in hectares, NOT including multiple cropping
Estimated conveyance efficiency for external water	65.00	Percent, %
Est. convey. effic. for internal project recirculation	0.00	Percent, %
Estimated seepage (deep perc.) for paddy rice	30.00	Percent, % of irrigation water delivered to fields (averaged over the irrigation season)
Estimated surface losses from paddy rice to drains	20.00	Percent (%) of irrigation water delivered to fields
Estimated field irrigation efficiency for other crops	65.00	Percent, %
Flow rate capacity of main canal(s) at diversion point(s)	3.60	Cubic Meters per Second (CMS)
Actual Peak flow rate into the main canal(s) at the diversion	3.50	Cubic Meters per Second (CMS)
Average ECe of the Irrigation Water	1.00	dS/m (same as mmho/cm)

This worksheet has 9 tables that require inputs FOR ONE YEAR, in addition to the cells above.

- Table 1 - Field Coefficients and Crop Threshold Ece
- Table 2 - Monthly ETo, mm
- Table 3 - Surface Water Entering Command Area Boundaries
- Table 4 - Internal Surface Irrigation Water Sources
- Table 5 - Hectares of Each Crop in the Command Area, by Month
- Table 6 - Groundwater Data
- Table 7 - Precipitation, effective precipitation, and deep percolation of precipitation
- Table 8 - Special agronomic requirements
- Table 9 - Crop Yields and Values

Table 1 - Field Coefficients and Crop Threshold ECe

		Threshold ECe	Field Coefficient, Kc (based on ETo)											
Crop #	Water year month -->		October	November	December	January	February	March	April	May	June	July	August	September
	Irrigated Crop Name	dS/m												
1.00	Paddy Rice #1 (Wet season - Rendeng)	3.00			1.10	1.08	1.08	0.50	0.00					
2.00	Paddy Rice #2 (Dry season - Gadu)	3.00								1.10	1.08	1.08	0.50	0.00
4.00	Corn (Planting season III)	1.80	1.01	0.99										0.55

Table 2 - Monthly ETo values

Month -->	October	November	December	January	February	March	April	May	June	July	August	September	Annual
Monthly ETo, mm. -->	173.70	157.80	144.60	149.40	155.70	158.10	156.60	151.80	137.70	152.10	154.50	175.20	1,867.20

Table 3 - Surface Water Entering the Command Area Boundaries (Million Cubic Meters - MCM) and which can be used for Irrigation

Month -->	October	November	December	January	February	March	April	May	June	July	August	September	Annual
Irrigation Water Entering from outside the command area through regular canals. The MCM should be the total MCM at the original diversion point.	3.50	3.27	5.37	10.50	9.80	10.50	8.64	8.64	4.90	5.13	4.20	4.43	78.89
Other Irrigation water inflows to Command Area from External Source #2 (Define below)													0.00
Other Irrigation water inflows to Command Area from External Source #3 (Define below)													0.00
Total Surface Irrigation Water Sources	3.50	3.27	5.37	10.50	9.80	10.50	8.64	8.64	4.90	5.13	4.20	4.43	78.89

Define the External Sources of Irrigation Surface Water

External Source #2:	None
External Source #3:	None

Table 4 - Internal Surface Irrigation Water Sources (Million Cubic Meters - MCM)

("non-canal" water could have originated from canals, but the volumes below are pumped or diverted from rivers, drains, lakes, etc.)

Month -->	October	November	December	January	February	March	April	May	June	July	August	September	Annual
Direct Farmer Usage of non-canal Water Inside the Command Area.													0.00
Project Authority Use of non-canal Surface Water Inside Command Area.													0.00
Recirculation inside Command Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5 - Hectares of Each Crop in the Command Area, by Month

(note - the blue numbers in the cells for each month are the Kc values that were entered earlier. An area must be entered in the blank cells for those Kc values to be used)

Crop #	Month of the Water Year-->	October	November	December	January	February	March	April	May	June	July	August	September	max. value
	Crop Name													
	Fields with no crop this month (computed value)	3,034.00	3,034.00	0.00	0.00	0.00	0.00	3,501.00	1,189.00	1,189.00	1,189.00	1,189.00	3,034.00	
	Paddy Rice #1 (Wet season - Rendeng)	0.00	0.00	1.10	1.08	1.08	0.50	0.00	0.00	0.00	0.00	0.00	0.00	
1.00	Paddy Rice #1 (Wet season - Rendeng)			3,501.00	3,501.00	3,501.00	3,501.00							3,501.00
	Paddy Rice #2 (Dry season - Gadu)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	1.08	1.08	0.50	0.00	
2.00	Paddy Rice #2 (Dry season - Gadu)								2,312.00	2,312.00	2,312.00	2,312.00		2,312.00
	Corn (Planting season III)	1.01	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	
4.00	Corn (Planting season III)	467.00	467.00										467.00	467.00
	Total Irrigated Cropland, Ha	467.00	467.00	3,501.00	3,501.00	3,501.00	3,501.00	0.00	2,312.00	2,312.00	2,312.00	2,312.00	467.00	6,280.00

C.6.7.1. Input of water balance (continue)

The Groundwater data below should be provided only if wells are used within the project area.

Table 6 Groundwater Data (MCM)

Month -->	October	November	December	January	February	March	April	May	June	July	August	September	Annual
Ground water pumped by farmers Inside the Command Area													0.00
Ground water pumped by the Project Authorities Inside the Command Area.													0.00
Ground water pumped from the Aquifer, But which remains outside the Command Area													0.00
Ground water pumped outside the Command Area and then brought into the command area.													0.00
Total ground water pumped outside Command Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Ground water pumped Inside the Command Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Reality Check on Groundwater Storage and Recharge:

A. Total reported annual pump withdrawals from the aquifer = 0.00 MCM

B. Estimation of seepage and deep percolation of irrigation water

Your previous estimate of conveyance efficiency of external water (%): 65.00 This estimate includes spills, seepage, and evaporation.

Your estimate of the % of external water that deep percolates during conveyance: 35.00 %

**Note: your deep percolation estimate cannot exceed: 35.00 %

Your previous est. of the convey. effic. of internal project well water (%): 0.00

Est. of field irrigation efficiency computed from your earlier values: 50.69 % (this is weighted between rice and other crops; you must complete Table 7 before a value is displayed)

Your estimate of the % of delivered water that deep percolates on-farm: 40.00 %

**Note: your deep percolation estimate cannot exceed: 49.31 %

Estimated surface water imports that deep percolate due to conveyance seepage 27.61 MCM

Estimated surface water imports that deep percolate on-farm 11.04 MCM

C. Estimate of pumped groundwater that is used for ET or special practices in the command area: 0.00 MCM

D. Recharge from surface canal water that originated outside the boundaries 38.66 MCM

E. Difference (C - D). If the value > 0.0, the aquifer is considered as an external water source -38.66 MCM - Estimated net Aquifer contribution

Rough estimate of Net Aquifer Contribution as an external source: 0.00 MCM

END of the GROUNDWATER INPUT SECTION

Table 7 - Precipitation, effective precipitation, and deep percolation of precipitation

This table requires 3 inputs for each month:

A. The gross millimeters of precipitation per month.

B. For each crop, an estimate of the PERCENT of the precipitation that is effective, by month.

Effective precipitation is defined for this worksheet as precipitation that is either

- Stored in the root zone of the crop for use as ET in subsequent months, or
- Is used as ET during that month.......it does NOT include deep percolation for salt removal

***All other precipitation either DEEP PERCOLATES, or RUNS OFF.

C. For each crop, an estimate of the millimeters of deep percolation of precipitation beyond the root zone, by month.

		Item	October	November	December	January	February	March	April	May	June	July	August	September
		Precipitation, mm	44.61	122.16	152.21	206.80	147.74	180.18	122.82	81.81	48.85	6.26	11.23	12.13
	Crop Name													
Crop #	Irrigated Crops													
		ETfield, mm	0.00	0.00	159.06	160.61	167.38	79.05	0.00	0.00	0.00	0.00	0.00	0.00
1.00	Paddy Rice #1 (Wet season - Rendeng)	% Effective precip	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
		Effective precip., mm	8.92	24.43	30.44	41.36	29.55	36.04	24.56	16.36	9.77	1.25	2.25	2.43
		Deep perc. of precip., mm.	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
		ETfield, mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	166.98	148.03	163.51	77.25	0.00
2.00	Paddy Rice #2 (Dry season - Gadu)	% Effective precip	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
		Effective precip., mm	8.92	24.43	30.44	41.36	29.55	36.04	24.56	16.36	9.77	1.25	2.25	2.43
		Deep perc. of precip., mm.	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
		ETfield, mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	Corn (Planting season III)	% Effective precip	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
		Effective precip., mm	8.92	24.43	30.44	41.36	29.55	36.04	24.56	16.36	9.77	1.25	2.25	2.43
		Deep perc. of precip., mm.	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
		ETfield, mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 8 - Special agronomic requirements (mm)

Some crops have special irrigation requirements at a specific time of the year.
For example, rice fields may need to be flooded prior to transplanting or planting.
Cotton fields may need to be "pre-irrigated" - that is, irrigated prior to planting.
These special requirements may require a much higher project irrigation water demand than what is expected if one just examines evapotranspiration requirements. However, they do NOT include any leaching requirements for salinity control.

**The units of the input values for Table 8 are millimeters. They should represent the gross millimeters needed IN ADDITION TO any ET requirements (minus effective rainfall). These should be "gross" values at the field, but should not include any conveyance losses that are necessary to transport the water to the field.

Insert mm. values for this year. There may be no entries in this table, depending upon the crops and practices.

Special Needs, mm. of Irrigation Water

	Irrigated Crop Description	October	November	December	January	February	March	April	May	June	July	August	September
1.00	Paddy Rice #1 (Wet season - Rendeng)												
2.00	Paddy Rice #2 (Dry season - Gadu)							100.00					
4.00	Corn (Planting season III)												

Table 9 - Crop Yields and Values

Exchange rate - $US/(local currency) : 0.00

	Irrigated Crop Name	Typical yield, metric tons/ha	Farmgate selling price, Local currency/ metric ton	hectares	Gross tonnage/yr	Value of agricultural production, $US/yr
1.00	Paddy Rice #1 (Wet season - Rendeng)	6.20	4,000,000.00	3,501.00	21,706.20	9,647,200.00
2.00	Paddy Rice #2 (Dry season - Gadu)	5.80	4,000,000.00	2,312.00	13,409.60	5,959,822.22
4.00	Corn (Planting season III)	7.50	1,800,000.00	467.00	3,502.50	700,500.00
					Total annual value ($US)	16,307,522.22

C.6.7.2. External indicator calculation

Item Description	Units	2009/2010	Value used
Stated efficiencies			
Stated conveyance efficiency of imported canal water (accounts for seepage and spills and tail end flows)	%	65	65
Weighted field irrigation efficiency from stated efficiencies	%	51	51
Areas			
Physical area of irrigated cropland in the command area (not including multiple cropping)	Ha	3,501	3,501
Irrigated crop area in the command area, including multiple cropping	Ha	6,280	6,280
Cropping intensity in the command area including double cropping	none	1.79	1.79
External sources of water for the command area			
Surface irrigation water inflow from outside the command area (gross at diversion and entry	MCM	79	79
Gross precipitation in the irrigated fields in the command area	MCM	40	40
Effective precipitation to irrigated fields (not including salinity removal)	MCM	14	14
Net aquifer withdrawl due to irrigation in the command area	MCM	0	0
Total external **water** supply for the project - including gross ppt. and net aquifer withdrawl, but excluding internal recirculation	MCM	119	119
Total external irrigation supply for the project	MCM	79	79
Internal water sources			
Internal surface water recirculation by farmer or project in command area	MCM	0	0
Gross groundwater pumped by farmers within command area	MCM	0	0
Groundwater pumped by Project Authorities and applied to the command area	MCM	0	0
Gross total annual volume of project authority irrigation supply.	MCM	79	79
Total groundwater pumped and dedicated to the command area	MCM	0	0
Groundwater pumped by Project Authorities and applied to the command area, minus net groundwater withdrawl (this is to avoid double counting. Also, all of net is applied to this term, although some might be applied to farmers)	MCM	0	0
Estimated total gross internal surface water + groundwater	MCM	0	0
Irrigation water delivered to users			
Internal authority water sources are stated to have a conveyance efficiency of:	%	0	0
Delivery of external surface irrigation water to users - using stated conveyance efficiency	MCM	51	51
All other irrigation water to users (surface recirculation plus all well pumping, with stated conveyance efficiencies, using 100% for farmer pumping and farmer surface diversions)	MCM	0	0
Total irrigation water deliveries to users (external surface irrigation water + internal diversions and pumping water sources), reduced for conveyance efficiencies	MCM	51	51
Total irrigation water (internal plus external) - just for intermed. value	MCM	79	79
Overall conveyance efficiency of project authority delivered water	%	65	65
Net field irrigation requirements			
ET of irrigated fields in the command area	MCM	35	35
ET of irrigation water in the command area (ET - effective precipitation)	MCM	20	20
Irrigation water needed for salinity control (net)	MCM	0	0
Irrigation water needed for special practices	MCM	2	2
Total NET irrigation water requirements (ET - eff ppt + salt control + special practices)	MCM	23	23
Other key values			
Flow rate capacity of main canal(s) at diversion point(s)	cms	3.6	4
Actual peak flow rate of the main canal(s) at diversion point(s) this year	cms	3.503	4
Peak NET irrigation requirement for field, including any special requirements	cms	1.5	2
Peak GROSS irrigation requirement, including all inefficiencies	cms	5.4	5
ANNUAL or One-Time External INDICATORS for the Command Area			
Peak liters/sec/ha of surface irrigation inflows to canal(s) this year	LPS/Ha	1.00	1.00
RWS Relative water supply for the irrigated part of the command area (Total external water supply)/(Field ET during growing seasons + water for salt control - Effective precipitation)	none	5.23	5.23
Annual Command Area Irrigation Efficiency [100 x (Crop ET + Leaching needs - Effective ppt)/(Surface irrigation diversions + Net groundwater)]	%	29	29
Field Irrigation Efficiency (computed) = [Crop ET-Effective ppt + LR water]/[Total Water Delivered to Users] x 100	%	44	44
RGCC - Relative Gross Canal Capacity = (Peak Monthly Net Irrigation Requirement)/(Main Canal Capacity)	none	0.43	0.43
RACF - Relative Actual Canal Flow = (Peak Monthly Net Irrigation Requirement)/(Peak Main Canal Flow Rate)	none	0.44	0.44
Gross annual tonnage of agricultural production by crop type	m Tons	see Table 9 on each INPUT worksheet (1-3)	
Total annual value of agricultural production	$ US	16,307,522	16,307,522

C.6.7.3. External indicator calculation

Project Name: Way Pengubuan
Date: 25th January 2011

General Project Conditions	
Average net farm size (ha)	0.50
Number of water users	2,800.00
Typical field size, ha	0.50
Number of offtakes (turnouts) that are physically operated by paid employees. These can be of any size.	
By employees of the government or umbrella organization	51.00
By employees of water user associations - within their boundaries	292.00
Land consolidation (or rectangular fields) exists on what % of the project area?	70.37%
Canal water supplies what drinking water to what % of the people living in the project area?	0.00
Ownership of land, % of total	
owned and operated by farmers	55.00
farmed by tenants on private ground	45.00
owned by government or cooperative	
percent rented land	
Check: This value should equal 100 after the question above is answered.	100
Field irrigation description	
% of land with sprinklers	0
% of land with drip	0
% of land with surface irrigation	100
Check: This value should equal 100 after the question above is answered.	100
Water Supply	
Water source (river, reservoir, wells - write in the answer)	River+dam
Live Storage Capacity of Reservoir, million cubic meters (MCM)	n.a.
Times/year the majority of system is shut down without water	0
Typical total annual duration of canal system shutdown, days	0
Provide an answer to the most applicable of the 2 questions below:	
1. What is the volume of gross irrigation water officially allocated to the project, per year, mcm	78.89
or, 2. What is the maximum flow rate officially allocated to the project, (cms)	3.503
On the average, what percentage of this allocation is provided? (%)	100
Ownership (Define by terms such as "country", "state", "project", or "farmer")	
Main canals	Central
Secondary canals	Central
3rd Level	WUA
Distributaries to individual fields	Farmers
Water	Country
Currency	
Name of currency used in the budgets below:	Rp
Exchange rate: (US Dollar)/(Local currency)	0.00
Umbrella Water User Association (WUA)	
Do the individual WUAs also belong to a larger, project-level WUA? (Yes/No)	Yes
If so, does the larger, project-level WUA operate the main canals? (Yes/No)	No
Project Budget - Does not include Water User Associations, unless a WUA operates the main canal(s)	
Annual Project Budget (average over the last 5 years)	
Total salaries (Local currency/year)	0
Improvement of structures, modernization (including salaries) - local currency/year	0
Maintenance (including salaries and external contracts) - local currency/yr	236,317,500
Rehabilitation (including salaries and external contracts) - local currency/yr	589,632,400
Other Operation (including salaries and external contracts) - local currency/yr	236,317,500
Administration and other (including salaries and external contracts) - local currency/yr	0
Total annual budget - sum of previous 5 items (Local currency/year)	**1,062,267,400**
Total annual expense for pumping energy (this should have been included in Operation, above) - local currency/yr	**0**
Sources of the Project Budget (average over the last 5 years), % from each source	
Country or State Government	0
Foreign	100
Fees from Water User Associations or Farmers (computed from later WUA data)	**13**
Check: This value should equal 100 after the "Country" and "Foreign" answers are given.	**113**

C.6.7.3. External indicator calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

Employees	
Professional, permanent employees (college degrees and well-trained technicians)	1.00
Professional employees that are temporary or contract - equivalent number	0.00
Non-professional, permanent employees	1.00
Non-professional employees that are temporary or contract - equivalent number	0.00
Total number of full time equivalent employees	2
Average years a typical professional employee works for the project (anticipated)	10
How many of the operation staff actually work in the field?	3
Salaries - include bonus and the equivalent costs of houses and other benefits provided.	
Professional, senior admin, (Local currency/year)	30,000,000.00
Professional, engineer (Local currency/year)	0.00
Non-professional - canal operators, (Local currency/year)	237,000,000.00
Day laborers, (Local currency/year)	0.00
What percentage of the total project (including WUA) Operation and Maintenance (O&M) is collected as in-kind services, and/or water fees from water users? (calculated value from WUA worksheet)	**86**
Calculated Indicator of O&M sources (automatic computation)	**3**
What percentage of the total budget (project and WUA) is spent on modernization of the water delivery operation/structures (as contrasted to rehabilitation or regular operation)?, %	**0**
Calculated Indicator of the modernization budget (automatic computation)	0
The question below will require knowledge of the budget, as well as a qualitative assessment of project activities that are seen in the field.	
What is the visitor's estimate of the adequacy (%) of the actual dollars and in-kind services that is available (from all sources) to sustain adequate Operation and Maintenance (O&M) with the present mode of operation? (Answer =[Available funds]/[Needed Funds] * 100), %	50
Calculated Indicator of O&M adequacy (automatic computation)	1
Project Operation	
Annual Operation Policies	
Does the project make an annual estimate of total deliveries? (Yes/No)	Yes
Is there a fixed advance official schedule of deliveries for the year? (Yes/No)	Yes
If yes, how well is it followed in the field (10=Excellent, 1=Not followed)	8.00
Does the project tell farmers what crops to plant? (Yes/No)	Yes
If yes, how well is it followed (10=Excellent, 1 = Not followed)	8.00
Do the project authorities limit the acreage that can be planted to various crops? (Yes/No)	No
If yes, how well is it followed (10=Excellent, 1=Not followed)	
Daily Operation Policies - as described in the office	
How often are main supply discharges re-calculated, days?	15.00
How are flow changes into the main canal (at the source) computed and adjusted?	
Sums of farmer orders (Yes/No)	Yes
Observation of general conditions (Yes/No)	Yes
Standard pre-determined schedule with slight modifications (Yes/No)	Yes
Standard pre-determined schedule with no modifications (Yes/No)	No
What daily or weekly INSTRUCTIONS for field persons does the office give?	
1. Main dam discharge flows (Yes/No)	Yes
Predicted by computer program? (Yes/No)	No
Later observation - How closely is this instruction followed in the field (10=Excellent, 1=Not followed)?	8.00
2. Cross regulator positions (Yes/No)	Yes
Predicted by computer program? (Yes/No)	No
Later observation - How closely is this instruction followed in the field (10=Excellent, 1=Not followed)?	8.00
3. Water levels in the canals (Yes/No)	Yes
Predicted by computer program? (Yes/No)	No
Later observation - How closely is this instruction followed in the field (10=Excellent, 1=Not followed)?	8.00
4. Flow rates at all offtakes? (Yes/No)	Yes
Predicted by computer program? (Yes/No)	No
Later observation - How closely is this instruction followed in the field (10=Excellent, 1=Not followed)?	8.00
Based on the later observations, describe the extent to which computers (either central or on-site) are used for canal control (assign a value of 0-4)	1.00
4 - Very effective usage. Real time control of all key structures with meaningful results	
3 - A few key structures are automated with computer controls.	
2 - Computers are effectively used to predict water flows, gate positions, daily diversions, or other values. Open loop control. Output is used in the field and is meaningful.	
1 - Computers are used to predict some key control factors, but they are quite ineffective or give erroneous results.	
0 - No computers are really used for canal operation.	

C.6.7.3. External indicator calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

To what extent are computers being used for billing and record management? (0-4)	0.00
4 - Used for almost all billing and records. Frequently updated and effective.	
3 - Used for about half of billing and record-keeping activities. Frequently updated and effective	
2 - Just beginning either billing or record keeping of turnout deliveries.	
1 - Computers are used effectively for some data management on the project (such as flows down canals, dam releases), but not for billing	
0 - No significant usage of computers for billing and record management	
****AS DESCRIBED IN THE OFFICE****	
Stated Water Delivery Service that the Main Canal Provides to its Subcanals	
Flexibility Index - Choose a value from 0-4, based on the scale below:	1.00
4 - Wide range of frequency, rate, and duration, but the schedule is arranged by the downstream subcanals several times daily, based on actual need.	
3 - Wide range of frequency, rate, and duration but arranged by the downstream canal once/day based on actual need.	
2 - Schedules are adjusted weekly by downstream operators	
1 - The schedules are dictated by the project office. Changes are made at least weekly.	
0 - The delivery schedule is unknown by the downstream operators, or changes are made less frequently than weekly.	
Reliability Index - Choose a value from 0-4, based on the scale below:	4.00
4 - Second Level canal operators know the flows and receive the flows within a few hours of the targeted time. No shortages during the year.	
3 - Second Level canal operators 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.	
2 - The flow changes arrive plus or minus 2 days, but are correct. Perhaps 4 weeks of some shortage throughout the year.	
1 - The flows arrive plus or minus 4 days, but are incorrect. Perhaps 7 weeks of some shortage throughout the year.	
0 - Unreliable frequency, rate, and duration more than 50% of the time and the volume is unknown.	
Equity Index - Choose a value from 0-4, based on the scale below:	3.00
4 - Points along the canal enjoy the same level of good service	
3 - 5% of the canal turnouts receive significantly poorer service than the average	
2 - 15% of the canal turnouts receive significantly poorer service than the average.	
1 - 25% of the canal turnouts receive singificantly poorer service than the average.	
0 - Worse than 25%, or there may not even be any consistent pattern.	
Control of flows to Second Level canals - Choose a value from 0-4, based on the scale below:	3.00
4 - Flows are known and controlled within 5%	
3 - Flows are known and are controlled within 10%	
2 - Flows are not known but are controlled within 10%	
1 - Flows are controlled within 20%	
0 - Flows have more variation than 20%	
Stated Water Delivery Service provided at the most downstream point operated by a paid employee.	
Number of fields downstream (0-4)	2.00
4 - 1 field	
3 - less than 3 fields	
2 - less than 6 fields	
1 - less than 10 fields	
0 - 10 or more fields	
Measurement of volumes delivered at this point (0-4)	1.00
4 - Excellent measurement and control devices, properly operated and recorded	
3 - Reasonable measurement and control devices, average operation	
2 - Useful but poor measurement of volumes and flow rates	
1 - Reasonable measurement of flows, but not of volumes	
0 - No measurement of volumes or flows	

C.6.7.3. External indicator calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

Flexibility (0-4)		2.00
	4 - Unlimited frequency, rate, and duration, but arranged by users within a few days	
	3 - Fixed frequency, rate or duration, but arranged.	
	2 - Dictated rotation, but it approximately matches the crop needs	
	1 - Rotation deliveries, but on a somewhat uncertain schedule	
	0 - No established rules	
Reliability (0-4)		2.00
	4 - Water always arrives with the frequency, rate, and duration promised. Volume is known.	
	3 - Very reliable in rate and duration, but occasionally there are a few days of delay. Volume is known	
	2 - Water arrives about when it is needed, and in the correct amounts. Volume is unknown.	
	1 - Volume is unknown, and deliveries are fairly unreliable - but less than 50% of the time.	
	0 - Unreliable frequency, rate, and duration more than 50% of the time, and volume delivered in unknown.	
Apparent Equity (0-4)		4.00
	4 - All points throughout the project and within tertiary units receive the same type of water delivery service	
	3 - Areas of the project receive the same amounts of water, but within an area service is somewhat inequitable.	
	2 - Areas of the project unintentionally receive somewhat different amounts of water, but within an area it is equitable.	
	1 - There are medium inequities both between areas and within areas.	
	0 - There are differences of more than 50% throughout the project on a fairly wide-spread basis.	
Stated Water Delivery Service received by individual units (fields or farms).		
Measurement of volumes to the individual units (0-4)		1.00
	4 - Excellent measurement and control devices, properly operated and recorded	
	3 - Reasonable measurement and control devices, average operation	
	2 - Useful but poor measurement of volumes and flow rates	
	1 - Reasonable measurement of flows, but not of volumes	
	0 - No measurement of volumes or flows	
Flexibility to the individual units (0-4)		2.00
	4 - Unlimited frequency, rate, and duration, but arranged by users within a few days	
	3 - Fixed frequency, rate or duration, but arranged.	
	2 - Dictated rotation, but it approximately matches the crop needs	
	1 - Rotation deliveries, but on a somewhat uncertain schedule	
	0 - No established rules	
Reliability to the individual units (0-4)		2.00
	4 - Water always arrives with the frequency, rate, and duration promised. Volume is known.	
	3 - Very reliable in rate and duration, but occasionally there are a few days of delay. Volume is known	
	2 - Water arrives about when it is needed, and in the correct amounts. Volume is unknown.	
	1 - Volume is unknown, and deliveries are fairly unreliable - but less than 50% of the time.	
	0 - Unreliable frequency, rate, and duration more than 50% of the time, and volume delivered in unknown.	
Apparent Equity (0-4)		4.00
	4 - All fields throughout the project and within tertiary units receive the same type of water delivery service	
	3 - Areas of the project receive the same amounts of water, but within an area service is somewhat inequitable.	
	2 - Areas of the project unintentionally receive somewhat different amounts of water, but within an area it is equitable.	
	1 - There are medium inequities both between areas and within areas.	
	0 - There are differences of more than 50% throughout the project on a fairly wide-spread basis.	
Computed ratio of (number of turnouts)/(number of paid employees) - uses WUA sheet information		1.7
Computed index of operation staff mobility and efficiency		0
Drainage, and Salinity Information		
Average salinity of the irrigation water, dS/m (computed average of the 3 years of INPUT data)		1
Average salinity of the drainage water that leaves the project, dS/m		n.a.
Average annual depth to the shallow water table, m		n.a.
Change in the shallow water table depth over the last 5 years, m (+ is up)		n.a.
Chemical Oxygen Demand (COD) of the irrigation water, average mgm/L		n.a.
Chemical Oxygen Demand (COD) of the drainage water, average mgm/L		n.a.
Biological load (BOD) of the irrigation water, average mgm/L		n.a.
Biological load (BOD) of the drainage water, average mgm/L		n.a.

C.6.7.4. Project employee calculation

Project Name: Way Pengubuan
Date: 25th January 2011

This sheet must be completed after visiting all levels of the project. The answers only refer to paid employees.

Various Indicators Regarding Project Employees	
Frequency and adequacy of training of operators and middle managers (not secretaries and drivers). This should include employees at all levels of the distribution system, not only those who work in the office.	2.00
4 - Adequate training at all levels. Employees are very aware of the capabilities of themselves and of their equipment. Employees clearly have a service mentality. Employees are hired with good backgrounds or are trained at the time of employment, and afterwards.	
3 - Managers appear to have excellent training, both upon entering employment and continuing afterwards. But some important knowledge has not been passed down to the operators.	
2 - Training exists at all levels as needed, but evidently training does not go deep enough, because employees at all levels seem to be missing some important ideas. Many employees have never had adequate training - including poor pre-employment backgrounds.	
1 - Only minimal training exists. There is inattention to qualifications upon hiring.	
0 - Virtually no training exists before or after hiring.	
Availability of written performance rules	1.00
4 - Each employee has a written job description that spells out his/her job and specifies how he/she will be evaluated. Evaluations are annual, and results are discussed with the employee.	
3 - There is a general written job description in the office. There is an annual evaluation of performance, but it is not rigorous.	
2 - There is an evaluation, but no detailed job description, nor is there a description of evaluation procedures.	
1 - There is a written job description, but no meaningful evaluation procedure.	
0 - No written job description, and no formal evaluation procedure.	
Power of employees to make decisions	1.00
4 - Employees are oficially encouraged to think and act on their own, and they do it in a positive manner.	
3 - Employees are not officially encouraged to think and act on their own, but they do it anyway in a positive manner.	
2 - Employees are encouraged to think and act on their own, but they do not seem to have much initiative.	
1 - Employees are not supposed to do any significant tasks without prior authorization. However, if they do take the initiative they are not punished.	
0 - Employees are not supposed to do any signficant tasks without prior authorization. They think they will be reprimande if they do something on their own initiative.	
Ability of the project to dismiss employees with cause.	3.00
4 - it is easy to fire or lay off employees. There is a short process. Employees are aware of this and know of other employees being fired or laid off when it was necessary.	
3 - Employees can be fired if the case is well documented. It is a long process. Employees are aware of other employees being fired when it was necessary.	
2 - Firing only happens occasionally due to laziness or serious problems. It is not common. Employees believe that it would be very unusual unless a person was VERY lazy for a long time.	
1 - Firing rarely occurs, and never due to laziness. It is extremely difficult to lay off excess personnel.	
0 - Employees are virtually never fired, even if they should be. The system appears to be plagued with many people who are not necessary or who should be dismissed but are not.	
Rewards for ememplary service	2.00
4 - There is a well designed program that follows a structured process. Rewards occur at least annually to a significant number of individuals. Promotions are given for meritorious service, and bonuses or extra benefits are given to those who are at the top of their grade.	
3 - No program, but people who do a good job are frequently promoted. Promotion is based on merit.	
2 - Promotion is based on time in service, some some extra benefits are given for exemplary service. This is more than just a piece of paper.	
1 - There are seldom awards, but occasionally it happens. The awards are primarily paper with little or no cash or financial benefit.	
0 - Nothing exists.	
Relative salary of the canal operators, as compared to a typical day laborer. This is a computed value.	n.a.
Index of the relative salary of an operator compared to a day laborer (computed value)	n.a.

C.6.7.5. Water User Association calculation

Project Name: Way Pengubuan
Date: 25th January 2011

Water User Associations - WUAs - General description	
Percentage of project area for which WUAS meet the following descriptions:	
None - No WUAs exist in any form	
WUAs exist on paper, but have no meaningful activities	
WUAs exist on paper, but have no significant activities except for holding occasional meetings	
WUAs exist, but are quite weak	
WUAs exist, with medium strength	100
Strong WUAs with laws, enforcement, full collection of costs, new investment, etc.	
Total (must equal 100)	**100**
Typical WUA size, ha	175
Typical WUA age, years	15
Functions of a typical WUA (Yes/No answers)	
Distribution of water in its area	Yes
Maintenance of canals	Yes, from third level canals
Construction of facilities in its area	Yes, from third level canals
Collection of water fees	Yes
Collection of other fees	Yes
Farmer cooperative - agronomic purposes	Yes
Technical advice to farmers	No
Are there written rules in the WUA regarding proper behavior of farmers and employees?	No
Number of fines levied by a typical active WUA in the past year	None
Governing Board of WUA - select the answer that most closely matches average conditiions)	
Elected by all farmers (1 vote/farmer) - Yes/No	Yes
Elected by all farmers, but votes are weighted by farm size - Yes/No	No
Appointed - Yes/No	No
Is a government employee on the Board - Yes/No	No
Water User Association (WUA) Budget - These are TOTALs of all WUAs in the project.	
This does NOT include an Umbrella WUA - its budgets should be included in the earlier Project Office Questionnaire worksheet	
Sum of all Annual WUA Budgets (average over the last 5 years) - Local currency/yr	
Total salaries	699,425,000
Improvement of structures and modernization (including salaries)	
Maintenance (including salaries and external contracts)	279,770,000
Rehabilitation (including salaries and external contracts)	
Other Operation (including salaries and external contracts)	0
Administration (including salaries and external contracts)	279,770,000
Funds sent away to the project offices or government (Note: to GP3A)	139,885,000
Total of all WUA Budgets (sum of previous 6 items)	**699,425,000**
Sources of WUA Budgets (average over the last 5 years), Percentage from each source	
Country or State Government	
Foreign	
Fees from Farmers	100
Total (must equal 100)	**100**
Employees (totals for all WUAs in project)	
Professional, permanent employees (college degrees and well-trained technicians)	
Professional employees that are temporary or contract - equivalent number	
Non-professional, permanent employees	
Non-professional employees that are temporary or contract - equivalent number	204
Total number of full time equivalent employees	**204**
Average years a typical professional employee works for a WUA (anticipated)	5
How many of the operation staff actually work in the field?	120
Salaries - These should include the equivalent worth of benefits, housing, etc. that are provided.	
Professional, senior admin, (Local currency/year)	279,770,000
Professional, engineer (Local currency/year)	
Non-prof. - canal operators, (Local currency/year)	
Day laborers, (Local currency/year)	419,655,000
Water Charges	
How are water charges collected? - select one of the 3 choices below	3.00
1. None collected, and none are assessed	
2. None collected, although policy says charges are to be collected	
3. They are collected	
What Percentage of water charges are recovered/collected?, %	100.00
What group collects the water charges? (Choose 1, 2, or 3)	2.00
1. From individual users by the government or central organization	
2. From individual users by a WUA	
3. Other	
Basis of water charge and amount of the charge	
If by area, (Local currency)/hectare/year	400,000.00
If by crop, the maximum rate in (Local currency)/crop/year (not per season)	
If per irrigation, specify the (Local currency)/irrigation	
If volumetric, (Local currency)/cubic meter	

C.6.7.5. Water User Association calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

If water charges are described as "volumetric", which one of the following describes the term?	
a. The volume delivered to each farmer, each irrigation, is measured	
b. The volume is estimated based on total volume applied to an area of many farms	
Is there a special charge for private well usage? (Yes/No)	No
If so, what is charge? (Local currency)	
Describe the "unit" that is charged for:	
If so, what Percentage of these charges are collected?	
Estimated total annual water charges collected from farmers throughout the whole project, (Local currency)/year - not including in-kind fees	1,398,850,000.00
What annual value of in-kind services or contributions are provided by water users above point of ownership (equivalent local currency) for the total project?	
a. Labor (Local currency value)	336,000,000.00
b. Crop (Local currency value)	
c. Construction materials (Local currency value)	
d. Other (Local currency value)	
Total in-kind	**336,000,000**
Frequency of in-kind services (Number of times per year)	6
What Percentage of farmers participate in the in-kind services?	100
Various indices for Water User Associations (use the information above to answer these questions)	
Percentage of all project users who have a functional, formal unit that participates in water distribution	**100**
Automatically calculated index value (0-4)	**4**
Actual ability of the strong Water User Associations to influence real-time water deliveries to the WUA. (Note: This only applies to the strong WUAs. If there are no strong WUAs in the project, the answer is "0".)	4.00
4 - Within the capacity of the supply canal, changes are made according to the WUA request within 1 day of advance notice as a standard practice.	
3 - Changes can be made according to the WUA request with a one week advance notice - any flow rate, duration, or frequency that is physically possible.	
2 - Changes can be made according to the WUA request with a one week advance notice, but the changes are limited (less than what is probably physically possible).	
1 - The WUAs have no realistic voice in ordering, except for occasional changes. Perhaps they have a formal meeting a few times a year and express their desires.	
0 - No one listens to them.	
Ability of the WUA to rely on effective outside help for enforcement of its rules (Note: If there are no WUAs in the project, the answer is "0".)	1.00
4 - No problem. Just call up local authorities. The local authorities come out right away and effectively prosecute wrong-doers.	
3 - The local authorities will come and are moderately successful with prosecutions. Corruption is not a problem.	
2 - Sometimes, for very serious cases, the authorities will come. But they are not very effective or helpful.	
1 - Although some enabling laws have been written by the government, it is up to the WUA to enforce those laws. There is no help with enforcement from outside the WUA.	
0 - There are no enabling laws, and no outside assistance with enforcement. Everything depends on the WUA.	
Legal basis for the WUAs (Note: If there are no WUAs in the project, the answer is "0".)	3.00
4 - WUAs are recognized and formed under law. They have legal powers to tax, hold money, dismiss employees, condemn land, and own structures. The law is real and the enabling legislation is upheld in courts.	
3 - The WUAs are recognized by law. There is good judicial backup. However, the powers are limited. The government still holds most of the power that could belong to the WUA.	
2 - The WUAs are recognized by law. Many rules have been laid out in enabling legislation. Supposedly, the WUA has power, but in reality there is no support from either the judicial or executive systems to support it.	
1 - Although the government has the WUAs "on the books", in reality there are few if any true powers related to water. The WUAs were formed mainly to the bidding of the government, such as collecting fees.	
0 - WUAs are not even on the state or federal government books.	
Financial strength of WUAS (Note: If there are no WUAs in the project, the answer is "0".)	3.00
4 - Completely and sufficiently self-sustaining. They have the power to tax, charge for water, and obtain loans.	
3 - Completely and sufficiently financed, but much of the financing comes from the government in terms of maintenance, operation, grants, etc.	
2 - Underfinanced, but not badly. Conditions are poor but are maintained and replaced well enough to be functional. No modernization improvements are made.	
1 - Inadequate, but enough funds to replace and maintain key structures. Insufficient funds to do much of the basic maintenance needed..	
0 - Woefully inadequate. Only enough funds or in-kind services are available to do absolutely essential tasks. Funds are insufficient to maintain and replace essential equipment.	

C.6.7.6. Main canal calculation

Project Name: Way Pengubuan
Date: 25th January 2011

General Project Conditions That Require Field Visits to be Described	
General condition of project drains (10=Excellent, 1=Horrible)	7
Does there appear to be an adequate density of drains? (10=very adequate, 1=completely lacking where needed)	10
What is the ratio of yields at different areas of the project (head/tail) duringthe wet season?	1.0
What is the ratio of yields at different areas of the project (head/tail) during the dry season?	0.9
Silt level in canals (1=high; 10=low)	7
Source of silt	Deforestation at upper region
Main Canal	
Control of Flows Into Main Canals	
Type of flow control device	Gate
Type of flow measurement device	Romijn
Probably accuracy of Flow control AND measurement, +/- %	15 - 20
Main Canal Characteristics	
Total length of Main Canals, km	11.144
Length of longest main canal, km	1.395
Approximate canal invert slope, %	0.02600
Do uncontrolled drain flows enter the canal? (Yes/No)	No
Percentage of a typical canal cross section that is filled with silt	10
Total number of spill points for a typical main canal	n.a.
Water travel time (hours) from start to first deliveries	0.24
Longest water travel time for a change to reach a delivery point of this canal level from the source or from a buffer reservoir (hours) - i.e., water travel time to the most downstream delivery	7.31
Has seepage been measured well?	No
Have spills been measured well?	No
Number of wells feeding into the canal	None
How effectively are they used for regulation? (10=Excellent, 1=Horrible)	
Lining type (percentage of all main canals)	
Masonry, %	0
Concrete, %	100
Other type of lining, %	0
Unlined, %	0
The value to the right should equal 100 once the data above is entered	**100**
General level of maintenance of the canal floor and canal banks (assign a value of 0-4)	2
4 - Excellent.	
3 - Good. The canal appears to be functional, but it does not look very neat.	
2 - Routine maintenance is not good enough to prevent some decrease in performance of the canal.	
1 - Decreased performance is evident in at least 30% of the canal.	
0 - Almost no meaningful maintenance. Major items and sections are in disrepair.	
General lack of <u>undesired</u> seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired). Assign a value of 0-4	3
4 - Very little seepage (less than 4%)	
3 - 4-8% of what enters this canal.	
2 - 9 - 15% along this canal	
1 - 16-25% along this canal.	
0 - Extremely high levels of undesired seepage. Provides severe limitations to deliveries.	
Availability of proper equipment and staff to adequately maintain this canal (0-4)	1
4 - Excellent maintenance equipment and organization of people.	
3 - Equipment and number of people are reasonable to do the job, but there are some organizational problems.	
2 - Most maintenance equipment functions, and the staff is large enough to reach critical items in a week or so. Other items often wait a year or more for maintenance.	
1 - 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.	
0 - Almost no adequate and working maintenance equipment is available, nor is there good mobilization of people.	
Main Canal Cross Regulators	
Condition of cross regulators (10=Excellent, 1=Horrible)	7
Type of cross regulator (describe)	Division structure/division with offtake structures
Do operators live at each cross regulator site? (Yes/No)	Yes
Can the ones that exist operate as needed? (10=Excellent, 1=Horrible)	8
Are they operated as theoretically intended?(10=Excellent, 1=Horrible)	8
Number of cross regulators/km	0.74
Are there large overflows at cross regulator sides?	No
Unintended weekly maximum controlled water surface variation in an average gate, cm	10
In months with water, what is the maximum number of days of no gate change?	15
What is the maximum time required for an operator to reach a regulator, hours?	0.5
How frequently (hrs) will an operator move a gate if required or instructed?	72
How frequently (days) are gates typically operated?	15
Officially, can the gate operator make gate adjustments without upper approval?	Yes
In reality, do gate operators make adjustments without upper approval?	Yes, but rarely
If the operators make their own decisions, how good are their decisions (10=Excellent, 1=Horrible)	8
Minutes required for an operator to make a significant setting change on the gate	30

C.6.7.6. Main canal calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

Internal Indicators for Main Canal Cross Regulator Hardware	
Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met. Rather, this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets. Assign a value of 0-4 based on the descriptions below	4
4 - Very easy to operate. Hardware moves easily and quickly, or hardware has automatic features that work well. Water levels or flows could be controlled easily if desired. Current targets can be met with less than 2 manual changes per day.	
3 - Easy and quick to physically operate, but requires many manual interventions per structure per day to meet target.	
2 - Cumbersome to operate, but physically possible. Requires more than 5 manual changes per structure per day to meet target, but is difficult or dangerous to operate.	
1 - Cumbersome, difficult, or dangerous to operate. In some cases it is almost physically impossible to meet objectives.	
0 - Communications and hardware are very inadequate to meet the requirements. Almost impossible to operate as intended.	
Level of maintenance of the cross regulators. (0-4)	2
4 - Excellent preventative maintenance. Broken items are typically fixed within a few days, except in very unusual circumstances.	
3 - Decent preventative maintenance. Broken items are fixed within 2 weeks. Reasonable equipment is available for maintenance operations.	
2 - Routine maintenance is only done on critical items. Broken items are noticeable throughout the project, but not serious.	
1 - Even routine maintenance is lacking in many cases. Many broken items are noticeable, sometimes on important structures.	
0 - Large-scale damage has occurred due to deferred maintenance. Little or no maintenance equipment is in working order.	
Maximum unintended weekly fluctuation of target water levels in the canal, expressed as a percentage of the average water level drop across a turnout. For example, if the water level in the canal varies by 40 cm (highest to lowest level at a point), and the average change in water level across a turnout is 50 cm, the percentage variation is 90%. This is calculated automatically from the other data.	**20**
Computed index regarding water level fluctuation (0-4)	**2**
Computed index regarding the travel time of a flow rate change throughout this canal level (0-4)	**0**
Main Canal Cross Regulator Personnel	
For whom do the operators work?	Government
Typical education level of operator (years of school)	12
What is the option for firing an operator? (describe)	Lazyness, serious problem
Do incentives exist for exemplary work?(10=high, 1=none)	3
Do incentives exist for average work?(10=high, 1=none)	3
Are operators encouraged to think and act on their own?(10=Definitely yes; 1=No)	7
Is there a formal performance review process annually?	Yes
If so, is it written down & understood by employees?	Yes
Number of persons fired in last 10 yrs for incompetence	None
Main Canal Communications/Transportation	
How often do operators communicate with the next higher level? (hr)	24
Computed Index of communications frequency (0-4)	**1**
How often do operators or supervisors of this level communicate with the next lower level? (hr)	24
Computed Index of communications frequency (0-4)	**2**
How frequently do supervisors physically visit this level of canal and talk with operators? (days)	3
Computed index of visiting frequency (0-4)	**3**
Dependability of voice communications by the operators (by phone or radio) (0-4)	4
4 - Excellent - lines work all the time.	
3 - Very good. Lines work at least 95% of the time	
2 - Poor at many of the sites. However, there is a good line of communication within 30 minutes of travel by the operator	
1 - No direct line is available to operators, but they are within 30 minutes travel time to some line and that line of communication almost always works.	
0 - No direct line is available to the operators, but they are within 30 minutes travel time to some line. However, even that line often does not work.	
Existence and frequency of remote monitoring (either automatic or manual) at key **spill** points, including the end of the canal. (0-4)	0
4 - Excellent. At all key points, feedback is provided at least every 2 hours.	
3 - Excellent coverage. However, data are recorded continuously on-site and feedback is only once per day.	
2 - Data is recorded several times per day and stored on-site. Feedback is once per week.	
1 - Only a few sites are covered. Feedback occurs weekly.	
0 - Monthly or less frequent feedback of a few sites	
Availability of roads along the canal (0-4)	2
4 - Very good access for automobiles on at least one side in all but extreme weather. Equipment access on the second side.	
3 - Good access for automobiles on at least one side in all but extreme weather. Limited access in some areas on the second side.	
2 - Rough but accessible road on one side of the canal. No access on the second side.	
1 - All of the canal can be easily traversed on one side with a motorcycle, but maintenance equipment access is very limited.	
0 - No apparent maintained access on either side of the road, for very long sections of this canal.	
How is communication done? (explain)	By mobile phone, at operator cost
What is the transportation of mobile personnel?	Motorcycle
How many automatic remote monitoring sites are there?	None
Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment) - hours	2
Computed index of travel time for maintenance (0-4).	2
Travel time (hours) needed to reach the office of the main canal, from the office of the supplier	1

C.6.7.6. Main canal calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

Main Canal Off-Takes (Turnouts)	
Percentage of the offtake flows that are taken from unofficial offtakes	0
Magnitude of a typical significant offtake flow rate, cms	0.23
Number of significant offtakes/km	0.74
Typical change in water surface elevations across an off-take (main turnout), cm	50
Can they physically operate as needed? (10=Excellent, 1=Horrible)	8
Are they physically operated as theoretically intended? (10=Excellent, 1=Horrible)	8
How well can the offtakes be supplied when the canal flow rates are low? (10=Excellent, 1=Horrible)	8
Personnel from what level operate the offtakes? (1=this level; 2=lower; 3=both)	1
How frequently is the offtake examined by personnel? (hours)	24
Officially, how frequently should offtakes be adjusted? (days)	15
Officially, can offtake operators make flow rate adjustments without upper approval? (Yes/No)	Yes
In reality, do offtake operators make flow rate adjustments without upper approval? (Yes/No)	Yes, but rarely
Scheduling of Flows From Main Canal Offtakes	
What % of the time is the flow OFFICIALLY scheduled as follows:	
Proportional flow	
Rotation	
Schedule computed by higher level - no lower level input	
Schedule computed by higher level - some lower level input	100
Schedule by operator based on judgement of supply and d/s needs	
Schedule actively matches real-time lower level requests	
The value to the right should equal 100 once the data above is entered	**100**
What % of the time is the flow ACTUALLY scheduled as follows:	
Proportional flow	
Rotation	50
Schedule computed by higher level - no lower level input	
Schedule computed by higher level - some lower level input	50
Schedule by operator based on judgement of supply and d/s needs	
Schedule actively matches real-time lower level requests	
The value to the right should equal 100 once the data above is entered	**100**
Control of Flows From Main Canal Offtakes	
Official type of flow control device	Gate
Common name	Romijn Gate
Official type of flow measurement device	Gate
Common name?	Romijn Gate
Actual flow control/measurement	Gate
Probable accuracy of Q control/meas., +/-%	10 to 15
Turnout Indicators (Main Canal)	
Ease of turnout (to the next lower level) operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to me	3
4 - Very easy to operate. Hardware moves easily and quickly, or hardware has automatic features that work well. Water divisions or flows could be controlled easily if desired. Current targets can be met with less than 2 manual changes per day.	
3 - Easy and quick to physically operate. Flow rate or target measurement devices are reasonable but not excellent.	
2 - Cumbersome to operate, but physically possible. Flow rate measurement devices or techniques appear to be poor, along with poor calibration.	
1 - Cumbersome, difficult, or dangerous to operate, and in some cases almost physically impossible to meet objectives.	
0 - Communications and hardware are very inadequate to meet the requirements. Almost impossible to operate as intended.	
Level of maintenance of the turnouts that supply the next lower level.(0-4)	2
4 - Excellent preventative maintenance. Broken items are typically fixed within a few days, except in very unusual circumstances.	
3 - Decent preventative maintenance. Broken items are fixed within 2 weeks. Reasonable equipment is available for maintenance operations.	
2 - Routine maintenance is only done on critical items. Broken items are noticeable throughout the project, but not serious.	
1 - Even routine maintenance is lacking in many cases. Many broken items are noticeable, sometimes on important structures.	
0 - Large-scale damage has occurred due to deferred maintenance. Little or no maintenance equipment is in working order.	
Flow rate capacities of the Second Level Canal turnouts (to the next lower level) (0-4)	2
4 - No problems passing the maximum desired flow rates.	
2 - Minor problems	
0 - Serious problems - many structures are under-designed.	

C.6.7.6. Main canal calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

NO REGULATING RESRVOIR IN THIS CANAL	
Regulating Reservoir Indicators (Main Canal)	
Suitability of the number of location(s) (0-4)	n.a.
4 - Properly located and of sufficient quantity.	
2 - There is 1 regulating reservoir but more are needed or the location is wrong.	
0 - None.	
Effectiveness of operation (0-4)	n.a.
4 - Excellent.	
2 - They are used, but well below their potential.	
0 - There are none, they are not used, or are used incorrectly.	
Suitability of the storage/buffer capacities (0-4)	n.a.
4 - Excellent.	
2 - Helpful, but not large enough.	
0 - There are none, or they are so small that they give almost no benefit.	
Maintenance (0-4)	n.a.
4 - Excellent.	
2 - Not too good.	
0 - None, or very bad siltation and weed growth so that the effectiveness is reduced.	
Operation (Main Canal)	
How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times. Assign a value of 0-4	4
4 - If there is an excess or deficit (spill or deficit at the tail ends), the headworks responds within 12 hours.	
2.7 - Headworks responds to real-time feedback observations within 24 hours	
1.3 - Headworks responds within 3 days.	
0 - Headworks responds in a time of greater than 3 days.	
Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	1.3
4 - Excellent. Information passes from the lower level to this level in a timely and reliable manner, and the system then responds.	
2.7 -Good. Reliable procedure. Updated at least once every 2 days, and the system responds.	
1.3 - The schedule is updated at least weekly with meaningful data. Changes are actually made based on downstream requirements.	
0 - Perhaps the schedule is updated weekly, but with data that is not very meaningful. Corresponding changes may not actually be made.	
Clarity and correctness of instructions to operators.	4
4 - Instructions are very clear and very correct.	
2.7 - Instructions are clear, but lacking in sufficient detail.	
1.3 - Instructions are unclear, but are generally correct.	
0 - Instructions are incorrect, whether they are clear or not.	
How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	0
4 - Once/day	
2.7 - Once/2 days	
1.3 - Once per week	
0 - Once per month or less often	
Capacity "bottlenecks" in the Main Canal	
Describe any flow rate restrictions in the Main Canal, including their location and hydraulic nature (this is different than most	
ACTUAL Service that the Main Canal Provides to its Subcanals	
Flexibility Index - Choose a value from 0-4, based on the scale below:	1
4 - Wide range of frequency, rate, and duration, but the schedule is arranged by the downstream subcanals several times daily, based on actual need.	
3 - Wide range of frequency, rate, and duration but arranged by the downstream canal once/day based on actual need.	
2 - Schedules are adjusted weekly by downstream operators	
1 - The schedules are dictated by the project office. Changes are made at least weekly.	
0 - The delivery schedule is unknown by the downstream operators, or changes are made less frequently than weekly.	
Reliability Index - Choose a value from 0-4, based on the scale below:	4
4 - 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.	
3 - 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.	
2 - The flow changes arrive plus or minus 2 days, but are correct. Perhaps 4 weeks of some shortage throughout the year.	
1 - The flows arrive plus or minus 4 days, but are incorrect. Perhaps 7 weeks of some shortage throughout the year.	
0 - Unreliable frequency, rate, and duration more than 50% of the time and the volume is unknown.	
Equity Index - Choose a value from 0-4, based on the scale below:	4
4 - Points along the canal enjoy the same level of good service	
3 - 5% of the canal turnouts receive significantly poorer service than the average	
2 - 15% of the canal turnouts receive significantly poorer service than the average.	
1 - 25% of the canal turnouts receive singificantly poorer service than the average.	
0 - Worse than 25%, or there may not even be any consistent pattern.	
Control of flows to customers of the next lower level - Choose a value from 0-4, based on the scale below:	3
4 - Flows are known and controlled within 5%	
3 - Flows are known and are controlled within 10%	
2 - Flows are not known but are controlled within 10%	
1 - Flows are controlled within 20%	
0 - Flows are controlled within 25%	

C.6.7.7. Second level canal calculation

Project Name: Way Pengubuan
Date: 25th January 2011

Second Level Canal	
Control of Flows Into Second Level Canals	
Type of flow control device	Gate
Type of flow measurement device	Gate
Probably accuracy of Flow control AND measurement, +/- %	80.00
Second Level Canal Characteristics	
Total length of Second Level Canals, km	65.01
Length of longest Second Level Canal, km	2.29
Approximate canal invert slope, %	0.01600
Do uncontrolled drain flows enter the canal? (Yes/No)	No
Percentage of a typical canal cross section that is filled with silt	30.00
Total number of spill points for a typical Second Level Canal	n.a.
Water travel time (hours) from start to first deliveries	0.76
Longest water travel time for a change to reach a delivery point of this canal level from the source or from a buffer reservoir (hours) - i.e., water travel time to the most downstream delivery	6.50
Has seepage been measured well?	No
Have spills been measured well?	No
Number of wells feeding into the canal	None
How effectively are they used for regulation? (10=Excellent, 1=Horrible)	
Lining type (percentage of all Second Level Canals)	
Masonry, %	
Concrete, %	100.00
Other type of lining, %	
Unlined, %	
The value to the right should equal 100 once the data above is entered	**100**
General level of maintenance of the canal floor and canal banks (assign a value of 0-4)	2.00
4 - Excellent.	
3 - Good. The canal appears to be functional, but it does not look very neat.	
2 - Routine maintenance is not good enough to prevent some decrease in performance of the canal.	
1 - Decreased performance is evident in at least 30% of the canal.	
0 - Almost no meaningful maintenance. Major items and sections are in disrepair.	
General lack of undesired seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired). Assign a value of 0-4	2.00
4 - Very little seepage (less than 4%)	
3 - 4-8% of what enters this canal.	
2 - 9 - 15% along this canal	
1 - 16-25% along this canal.	
0 - Extremely high levels of undesired seepage. Provides severe limitations to deliveries.	
Availability of proper equipment and staff to adequately maintain this canal (0-4)	1.00
4 - Excellent maintenance equipment and organization of people.	
3 - Equipment and number of people are reasonable to do the job, but there are some organizational problems.	
2 - Most maintenance equipment functions, and the staff is large enough to reach critical items in a week or so. Other items often wait a year or more for maintenance.	
1 - 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.	
0 - Almost no adequate and working maintenance equipment is available, nor is there good mobilization of people.	
Second Level Canal Cross Regulators	
Condition of cross regulators (10=Excellent, 1=Horrible)	6.00
Type of cross regulator (describe)	Romijn
Do operators live at each cross regulator site? (Yes/No)	No
Can the ones that exist operate as needed? (10=Excellent, 1=Horrible)	8.00
Are they operated as theoretically intended?(10=Excellent, 1=Horrible)	8.00
Number of cross regulators/km	0.78
Are there large overflows at cross regulator sides?	No
Unintended weekly maximum controlled water surface variation in an average gate, cm	30.00
In months with water, what is the maximum number of days of no gate change?	15.00
What is the maximum time required for an operator to reach a regulator, hours?	0.50
How frequently (hrs) will an operator move a gate if required or instructed?	24.00
How frequently (days) are gates typically operated?	15.00
Officially, can the gate operator make gate adjustments without upper approval?	Yes, in emergency
In reality, do gate operators make adjustments without upper approval?	Rarely
If the operators make their own decisions, how good are their decisions (10=Excellent, 1=Horrible)	8.00
Minutes required for an operator to make a significant setting change on the gate	30.00

C.6.7.7. Second level canal calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

Internal Indicators for Second Level Canal Cross Regulator Hardware	
Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met. Rather, this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets. Assign a value 0 - 4	4.00
4 - Very easy to operate. Hardware moves easily and quickly, or hardware has automatic features that work well. Water levels or flows could be controlled easily if desired. Current targets can be met with less than 2 manual changes per day.	
3 - Easy and quick to physically operate, but requires many manual interventions per structure per day to meet target.	
2 - Cumbersome to operate, but physically possible. Requires more than 5 manual changes per structure per day to meet target, but is difficult or dangerous to operate.	
1 - Cumbersome, difficult, or dangerous to operate. In some cases it is almost physically impossible to meet objectives.	
0 - Communications and hardware are very inadequate to meet the requirements. Almost impossible to operate as intended.	
Level of maintenance of the cross regulators. (0-4)	2.00
4 - Excellent preventative maintenance. Broken items are typically fixed within a few days, except in very unusual circumstances.	
3 - Decent preventative maintenance. Broken items are fixed within 2 weeks. Reasonable equipment is available for maintenance operations.	
2 - Routine maintenance is only done on critical items. Broken items are noticeable throughout the project, but not serious.	
1 - Even routine maintenance is lacking in many cases. Many broken items are noticeable, sometimes on important structures.	
0 - Large-scale damage has occurred due to deferred maintenance. Little or no maintenance equipment is in working order.	
Maximum unintended weekly fluctuation of target water levels in the canal, expressed as a percentage of the average water level drop across a turnout. For example, if the water level in the canal varies by 40 cm (highest to lowest level at a point), and	100
Computed index regarding water level fluctuation (0-4)	0
Computed index regarding the travel time of a flow rate change throughout this canal level (0-4)	4
Second Level Canal Cross Regulator Personnel	
For whom do the operators work?	Government
Typical education level of operator (years of school)	12.00
What is the option for firing an operator? (describe)	Lazyness, serious offences
Do incentives exist for exemplary work?(10=high, 1=none)	5.00
Do incentives exist for average work?(10=high, 1=none)	3.00
Are operators encouraged to think and act on their own?(10=Definitely yes; 1=No)	5.00
Is there a formal performance review process annually?	Yes
If so, is it written down & understood by employees?	Yes
Number of persons fired in last 10 yrs for incompetence	None
Second Level Canal Communications/Transportation	
How often do operators communicate with the next higher level? (hr)	24.00
Computed Index of communications frequency (0-4)	1
How often do operators or supervisors of this level communicate with the next lower level? (hr)	24
Computed Index of communications frequency (0-4)	2
How frequently do supervisors physically visit this level of canal and talk with operators? (days)	7
Computed index of visiting frequency (0-4)	2
Dependability of voice communications by the operators (by phone or radio) (0-4)	4.00
4 - Excellent - lines work all the time.	
3 - Very good. Lines work at least 95% of the time	
2 - Poor at many of the sites. However, there is a good line of communication within 30 minutes of travel by the operator	
1 - No direct line is available to operators, but they are within 30 minutes travel time to some line and that line of communication almost always works.	
0 - No direct line is available to the operators, but they are within 30 minutes travel time to some line. However, even that line often does not work.	
Existence and frequency of remote monitoring (either automatic or manual) at key **spill** points, including the end of the canal. (0-4)	1.00
4 - Excellent. At all key points, feedback is provided at least every 2 hours.	
3 - Excellent coverage. However, data are recorded continuously on-site and feedback is only once per day.	
2 - Data is recorded several times per day and stored on-site. Feedback is once per week.	
1 - Only a few sites are covered. Feedback occurs weekly.	
0 - Monthly or less frequent feedback of a few sites	
Availability of roads along the canal (0-4)	2.00
4 - Very good access for automobiles on at least one side in all but extreme weather. Equipment access on the second side.	
3 - Good access for automobiles on at least one side in all but extreme weather. Limited access in some areas on the second side.	
2 - Rough but accessible road on one side of the canal. No access on the second side.	
1 - All of the canal can be easily traversed on one side with a motorcycle, but maintenance equipment access is very limited.	
0 - No apparent maintained access on either side of the road, for very long sections of this canal.	
How is communication done? (explain)	By mobile phone at operator cost and by handy talkie
What is the transportation of mobile personnel?	Motorcycle
How many automatic remote monitoring sites are there?	None
Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment) - hours	1.5
Computed index of travel time for maintenance (0-4).	0
Travel time (hours) needed to reach the office of the Second Level Canal, from the office of the supplier	1.00

C.6.7.7. Second level canal calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

Second Level Canal Off-Takes (Turnouts)	
Percentage of the offtake flows that are taken from unofficial offtakes	0.00
Magnitude of a typical significant offtake flow rate, cms	0.1
Number of significant offtakes/km	0.7
Typical change in water surface elevations across an off-take (main turnout), cm	30.00
Can they physically operate as needed? (10=Excellent, 1=Horrible)	8.00
Are they physically operated as theoretically intended? (10=Excellent, 1=Horrible)	8.00
How well can the offtakes be supplied when the canal flow rates are low? (10=Excellent, 1=Horrible)	8.00
Personnel from what level operate the offtakes? (1=this level; 2=lower; 3=both)	1.00
How frequently is the offtake examined by personnel? (hours)	24.00
Officially, how frequently should offtakes be adjusted? (days)	15.00
Officially, can offtake operators make flow rate adjustments without upper approval? (Yes/No)	Yes, in emergency
In reality, do offtake operators make flow rate adjustments without upper approval? (Yes/No)	Yes, but rarely
Scheduling of Flows From Second Level Canal Offtakes	
What % of the time is the flow OFFICIALLY scheduled as follows:	
Proportional flow	
Rotation	50.00
Schedule computed by higher level - no lower level input	
Schedule computed by higher level - some lower level input	50.00
Schedule by operator based on judgement of supply and d/s needs	
Schedule actively matches real-time lower level requests	
The value to the right should equal 100 once the data above is entered	**100**
What % of the time is the flow ACTUALLY scheduled as follows:	
Proportional flow	
Rotation	50.00
Schedule computed by higher level - no lower level input	
Schedule computed by higher level - some lower level input	50.00
Schedule by operator based on judgement of supply and d/s needs	
Schedule actively matches real-time lower level requests	
The value to the right should equal 100 once the data above is entered	**100**
Control of Flows From Second Level Canal Offtakes	
Official type of flow control device	Gate
Common name	Romijn
Official type of flow measurement device	Gate
Common name?	Romijn
Actual flow control/measurement	Romijn
Probable accuracy of Q control/meas., +/-%	80.00
Turnout Indicators (Second Level Canal)	
Ease of turnout (to the next lower level) operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to me	3
4 - Very easy to operate. Hardware moves easily and quickly, or hardware has automatic features that work well. Water divisions or flows could be controlled easily if desired. Current targets can be met with less than 2 manual changes per day.	
3 - Easy and quick to physically operate. Flow rate or target measurement devices are reasonable but not excellent.	
2 - Cumbersome to operate, but physically possible. Flow rate measurement devices or techniques appear to be poor, along with poor calibration.	
1 - Cumbersome, difficult, or dangerous to operate, and in some cases almost physically impossible to meet objectives.	
0 - Communications and hardware are very inadequate to meet the requirements. Almost impossible to operate as intended.	
Level of maintenance of the turnouts that supply the next lower level.(0-4)	2
4 - Excellent preventative maintenance. Broken items are typically fixed within a few days, except in very unusual circumstances.	
3 - Decent preventative maintenance. Broken items are fixed within 2 weeks. Reasonable equipment is available for maintenance operations.	
2 - Routine maintenance is only done on critical items. Broken items are noticeable throughout the project, but not serious.	
1 - Even routine maintenance is lacking in many cases. Many broken items are noticeable, sometimes on important structures.	
0 - Large-scale damage has occurred due to deferred maintenance. Little or no maintenance equipment is in working order.	
Flow rate capacities of the Second Level Canal turnouts (to the next lower level) (0-4)	2
4 - No problems passing the maximum desired flow rates.	
2 - Minor problems	
0 - Serious problems - many structures are under-designed.	
No regulating reservoar in these canals	
Regulating Reservoir Indicators (Second Level Canal)	
Suitability of the number of location(s) (0-4)	
4 - Properly located and of sufficient quantity.	
2 - There is 1 regulating reservoir but more are needed or the location is wrong.	
0 - None.	

C.6.7.7. Second level canal calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

Effectiveness of operation (0-4)	
4 - Excellent.	
2 - They are used, but well below their potential.	
0 - There are none, they are not used, or are used incorrectly.	
Suitability of the storage/buffer capacities (0-4)	
4 - Excellent.	
2 - Helpful, but not large enough.	
0 - There are none, or they are so small that they give almost no benefit.	
Maintenance (0-4)	
4 - Excellent.	
2 - Not too good.	
0 - None, or very bad siltation and weed growth so that the effectiveness is reduced.	
Operation (Second Level Canal)	
How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times. Assign a value of 0-4	2.70
4 - If there is an excess or deficit (spill or deficit at the tail ends), the headworks responds within 12 hours.	
2.7 - Headworks responds to real-time feedback observations within 24 hours	
1.3 - Headworks responds within 3 days.	
0 - Headworks responds in a time of greater than 3 days.	
Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	1.30
4 - Excellent. Information passes from the lower level to this level in a timely and reliable manner, and the system then responds.	
2.7 -Good. Reliable procedure. Updated at least once every 2 days, and the	
1.3 - The schedule is updated at least weekly with meaningful data. Changes are actually made based on downstream requirements.	
0 - Perhaps the schedule is updated weekly, but with data that is not very meaningful. Corresponding changes may not actually be made.	
Clarity and correctness of instructions to operators.	4.00
4 - Instructions are very clear and very correct.	
2.7 - Instructions are clear, but lacking in sufficient detail.	
1.3 - Instructions are unclear, but are generally correct.	
0 - Instructions are incorrect, whether they are clear or not.	
How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	1.30
4 - Once/day	
2.7 - Once/2 days	
1.3 - Once per week	
0 - Once per month or less often	
Capacity "bottlenecks" in the Second Level Canal	
Describe any flow rate restrictions in the Second Level Canal, including their location and hydraulic nature (this is different than	
ACTUAL Service that the Second Level Canal Provides to its Subcanals	
Flexibility Index - Choose a value from 0-4, based on the scale below:	1.00
4 - Wide range of frequency, rate, and duration, but the schedule is arranged by the downstream subcanals several times daily, based on actual need.	
3 - Wide range of frequency, rate, and duration but arranged by the downstream canal once/day based on actual need.	
2 - Schedules are adjusted weekly by downstream operators	
1 - The schedules are dictated by the project office. Changes are made at least weekly.	
0 - The delivery schedule is unknown by the downstream operators, or changes are made less frequently than weekly.	
Reliability Index - Choose a value from 0-4, based on the scale below:	3.00
4 - 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.	
3 - 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.	
2 - The flow changes arrive plus or minus 2 days, but are correct. Perhaps 4 weeks of some shortage throughout the year.	
1 - The flows arrive plus or minus 4 days, but are incorrect. Perhaps 7 weeks of some shortage throughout the year.	
0 - Unreliable frequency, rate, and duration more than 50% of the time and the volume is unknown.	
Equity Index - Choose a value from 0-4, based on the scale below:	3.00
4 - Points along the canal enjoy the same level of good service	
3 - 5% of the canal turnouts receive significantly poorer service than the average	
2 - 15% of the canal turnouts receive significantly poorer service than the average.	
1 - 25% of the canal turnouts receive singificantly poorer service than the average.	
0 - Worse than 25%, or there may not even be any consistent pattern.	
Control of flows to customers of the next lower level - Choose a value from 0-4, based on the scale below:	3.00
4 - Flows are known and controlled within 5%	
3 - Flows are known and are controlled within 10%	
2 - Flows are not known but are controlled within 10%	
1 - Flows are controlled within 20%	
0 - Flows are controlled within 25%	

C.6.7.8. Third level canal calculation

Project Name: Way Pengubuan
Date: 25th January 2011

Third and Fourth Level Canal	
Control of Flows Into Third Level Canals	
Type of flow control device	Gate
Type of flow measurement device	Gate
Probably accuracy of Flow control AND measurement, +/- %	80.00
Third Level Canal Characteristics	
Total length of Third Level Canals, km	270.95
Length of longest Third Level Canal, km	0.60
Approximate canal invert slope, %	0.13040
Do uncontrolled drain flows enter the canal? (Yes/No)	No
Percentage of a typical canal cross section that is filled with silt	50.00
Total number of spill points for a typical Third Level Canal	n.a.
Water travel time (hours) from start to first deliveries	0.67
Longest water travel time for a change to reach a delivery point of this canal level from the source or from a buffer reservoir (hours) - i.e., water travel time to the most downstream delivery	7.5
Has seepage been measured well?	No
Have spills been measured well?	No
Number of wells feeding into the canal	None
How effectively are they used for regulation? (10=Excellent, 1=Horrible)	
Lining type (percentage of all Third Level Canals)	
Masonry, %	
Concrete, %	20.00
Other type of lining, %	
Unlined, %	80.00
The value to the right should equal 100 once the data above is entered	**100**
General level of maintenance of the canal floor and canal banks (assign a value of 0-4)	1.00
4 - Excellent.	
3 - Good. The canal appears to be functional, but it does not look very neat.	
2 - Routine maintenance is not good enough to prevent some decrease in performance of the canal.	
1 - Decreased performance is evident in at least 30% of the canal.	
0 - Almost no meaningful maintenance. Major items and sections are in disrepair.	
General lack of undesired seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired). Assign a value of 0-4	0.00
4 - Very little seepage (less than 4%)	
3 - 4-8% of what enters this canal.	
2 - 9 - 15% along this canal	
1 - 16-25% along this canal.	
0 - Extremely high levels of undesired seepage. Provides severe limitations to deliveries.	
Availability of proper equipment and staff to adequately maintain this canal (0-4)	1.00
4 - Excellent maintenance equipment and organization of people.	
3 - Equipment and number of people are reasonable to do the job, but there are some organizational problems.	
2 - Most maintenance equipment functions, and the staff is large enough to reach critical items in a week or so. Other items often wait a year or more for maintenance.	
1 - 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.	
0 - Almost no adequate and working maintenance equipment is available, nor is there good mobilization of people.	
Third Level Canal Cross Regulators	
Condition of cross regulators (10=Excellent, 1=Horrible)	5.00
Type of cross regulator (describe)	Gate
Do operators live at each cross regulator site? (Yes/No)	Yes
Can the ones that exist operate as needed? (10=Excellent, 1=Horrible)	8.00
Are they operated as theoretically intended?(10=Excellent, 1=Horrible)	8.00
Number of cross regulators/km	1.07
Are there large overflows at cross regulator sides?	No
Unintended weekly maximum controlled water surface variation in an average gate, cm	30.00
In months with water, what is the maximum number of days of no gate change?	15.00
What is the maximum time required for an operator to reach a regulator, hours?	0.50
How frequently (hrs) will an operator move a gate if required or instructed?	12.00
How frequently (days) are gates typically operated?	15.00
Officially, can the gate operator make gate adjustments without upper approval?	Yes, in emergency
In reality, do gate operators make adjustments without upper approval?	Yes, but rarely
If the operators make their own decisions, how good are their decisions (10=Excellent, 1=Horrible)	8.00
Minutes required for an operator to make a significant setting change on the gate	30.00

C.6.7.8. Third level canal calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

Internal Indicators for Third Level Canal Cross Regulator Hardware	
Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met. Rather, this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets. Assign a v	4.00
4 - Very easy to operate. Hardware moves easily and quickly, or hardware has automatic features that work well. Water levels or flows could be controlled easily if desired. Current targets can be met with less than 2 manual changes per day.	
3 - Easy and quick to physically operate, but requires many manual interventions per structure per day to meet target.	
2 - Cumbersome to operate, but physically possible. Requires more than 5 manual changes per structure per day to meet target, but is difficult or dangerous to operate.	
1 - Cumbersome, difficult, or dangerous to operate. In some cases it is almost physically impossible to meet objectives.	
0 - Communications and hardware are very inadequate to meet the requirements. Almost impossible to operate as intended.	
Level of maintenance of the cross regulators. (0-4)	2.00
4 - Excellent preventative maintenance. Broken items are typically fixed within a few days, except in very unusual circumstances.	
3 - Decent preventative maintenance. Broken items are fixed within 2 weeks. Reasonable equipment is available for maintenance operations.	
2 - Routine maintenance is only done on critical items. Broken items are noticeable throughout the project, but not serious.	
1 - Even routine maintenance is lacking in many cases. Many broken items are noticeable, sometimes on important structures.	
0 - Large-scale damage has occurred due to deferred maintenance. Little or no maintenance equipment is in working order.	
Maximum unintended weekly fluctuation of target water levels in the canal, expressed as a percentage of the average water level drop across a turnout. For example, if the water level in the canal varies by 40 cm (highest to lowest level at a point), and	**100**
Computed index regarding water level fluctuation (0-4)	**0**
Computed index regarding the travel time of a flow rate change throughout this canal level (0-4)	**0**
Third Level Canal Cross Regulator Personnel	
For whom do the operators work?	WUA
Typical education level of operator (years of school)	9.00
What is the option for firing an operator? (describe)	Laziness
Do incentives exist for exemplary work?(10=high, 1=none)	1.00
Do incentives exist for average work?(10=high, 1=none)	1.00
Are operators encouraged to think and act on their own?(10=Definitely yes; 1=No)	1.00
Is there a formal performance review process annually?	No
If so, is it written down & understood by employees?	
Number of persons fired in last 10 yrs for incompetence	None
Third Level Canal Communications/Transportation	
How often do operators communicate with the next higher level? (hr)	24.00
Computed Index of communications frequency (0-4)	**1**
How often do operators or supervisors of this level communicate with the next lower level? (hr)	24
Computed Index of communications frequency (0-4)	**2**
How frequently do supervisors physically visit this level of canal and talk with operators? (days)	24
Computed index of visiting frequency (0-4)	**1**
Dependability of voice communications by the operators (by phone or radio) (0-4)	4.00
4 - Excellent - lines work all the time.	
3 - Very good. Lines work at least 95% of the time	
2 - Poor at many of the sites. However, there is a good line of communication within 30 minutes of travel by the operator	
1 - No direct line is available to operators, but they are within 30 minutes travel time to some line and that line of communication almost always works.	
0 - No direct line is available to the operators, but they are within 30 minutes travel time to some line. However, even that line often does not work.	
Existence and frequency of remote monitoring (either automatic or manual) at key **spill** points, including the end of the canal. (0-4)	2.00
4 - Excellent. At all key points, feedback is provided at least every 2 hours.	
3 - Excellent coverage. However, data are recorded continuously on-site and feedback is only once per day.	
2 - Data is recorded several times per day and stored on-site. Feedback is once per week.	
1 - Only a few sites are covered. Feedback occurs weekly.	
0 - Monthly or less frequent feedback of a few sites	
Availability of roads along the canal (0-4)	1.00
4 - Very good access for automobiles on at least one side in all but extreme weather. Equipment access on the second side.	
3 - Good access for automobiles on at least one side in all but extreme weather. Limited access in some areas on the second side.	
2 - Rough but accessible road on one side of the canal. No access on the second side.	
1 - All of the canal can be easily traversed on one side with a motorcycle, but maintenance equipment access is very limited.	
0 - No apparent maintained access on either side of the road, for very long sections of this canal.	
How is communication done? (explain)	By mobile phone at operator cost
What is the transportation of mobile personnel?	Motorcycle
How many automatic remote monitoring sites are there?	None
Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment) - hours	0.50
Computed index of travel time for maintenance (0-4).	**4**
Travel time (hours) needed to reach the office of the Third Level Canal, from the office of the supplier	1.00

C.6.7.8. Third level canal calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

Third Level Canal Off-Takes (Turnouts)	
Percentage of the offtake flows that are taken from unofficial offtakes	None
Magnitude of a typical significant offtake flow rate, cms	0.08
Number of significant offtakes/km	1.07
Typical change in water surface elevations across an off-take (main turnout), cm	30.00
Can they physically operate as needed? (10=Excellent, 1=Horrible)	8.00
Are they physically operated as theoretically intended? (10=Excellent, 1=Horrible)	8.00
How well can the offtakes be supplied when the canal flow rates are low? (10=Excellent, 1=Horrible)	5.00
Personnel from what level operate the offtakes? (1=this level; 2=lower; 3=both)	1.00
How frequently is the offtake examined by personnel? (hours)	24.00
Officially, how frequently should offtakes be adjusted? (days)	15.00
Officially, can offtake operators make flow rate adjustments without upper approval? (Yes/No)	Yes, in emergency
In reality, do offtake operators make flow rate adjustments without upper approval? (Yes/No)	Yes, but rarely
Scheduling of Flows From Third Level Canal Offtakes	
What % of the time is the flow OFFICIALLY scheduled as follows:	
Proportional flow	
Rotation	50.00
Schedule computed by higher level - no lower level input	
Schedule computed by higher level - some lower level input	50.00
Schedule by operator based on judgement of supply and d/s needs	
Schedule actively matches real-time lower level requests	
The value to the right should equal 100 once the data above is entered	**100**
What % of the time is the flow ACTUALLY scheduled as follows:	
Proportional flow	
Rotation	50.00
Schedule computed by higher level - no lower level input	
Schedule computed by higher level - some lower level input	50.00
Schedule by operator based on judgement of supply and d/s needs	
Schedule actively matches real-time lower level requests	
The value to the right should equal 100 once the data above is entered	**100**
Control of Flows From Third Level Canal Offtakes	
Official type of flow control device	Gate
Common name	Romijn
Official type of flow measurement device	Gate
Common name?	Romijn
Actual flow control/measurement	Romijn
Probable accuracy of Q control/meas., +/-%	80.00
Turnout Indicators (Third Level Canal)	
Ease of turnout (to the next lower level) operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to me	4.00
4 - Very easy to operate. Hardware moves easily and quickly, or hardware has automatic features that work well. Water divisions or flows could be controlled easily if desired. Current targets can be met with less than 2 manual changes per day.	
3 - Easy and quick to physically operate. Flow rate or target measurement devices are reasonable but not excellent.	
2 - Cumbersome to operate, but physically possible. Flow rate measurement devices or techniques appear to be poor, along with poor calibration.	
1 - Cumbersome, difficult, or dangerous to operate, and in some cases almost physically impossible to meet objectives.	
0 - Communications and hardware are very inadequate to meet the requirements. Almost impossible to operate as intended.	
Level of maintenance of the turnouts that supply the next lower level.(0-4)	2.00
4 - Excellent preventative maintenance. Broken items are typically fixed within a few days, except in very unusual circumstances.	
3 - Decent preventative maintenance. Broken items are fixed within 2 weeks. Reasonable equipment is available for maintenance operations.	
2 - Routine maintenance is only done on critical items. Broken items are noticeable throughout the project, but not serious.	
1 - Even routine maintenance is lacking in many cases. Many broken items are noticeable, sometimes on important structures.	
0 - Large-scale damage has occurred due to deferred maintenance. Little or no maintenance equipment is in working order.	
Flow rate capacities of the Third Level Canal turnouts (to the next lower level) (0-4)	2.00
4 - No problems passing the maximum desired flow rates.	
2 - Minor problems	
0 - Serious problems - many structures are under-designed.	
No regulating reservoir in these canals.	
Regulating Reservoir Indicators (Third Level Canal)	
Suitability of the number of location(s) (0-4)	
4 - Properly located and of sufficient quantity.	
2 - There is 1 regulating reservoir but more are needed or the location is wrong.	
0 - None.	

C.6.7.8. Third level canal calculation (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

Effectiveness of operation (0-4)	
4 - Excellent.	
2 - They are used, but well below their potential.	
0 - There are none, they are not used, or are used incorrectly.	
Suitability of the storage/buffer capacities (0-4)	
4 - Excellent.	
2 - Helpful, but not large enough.	
0 - There are none, or they are so small that they give almost no benefit.	
Maintenance (0-4)	
4 - Excellent.	
2 - Not too good.	
0 - None, or very bad siltation and weed growth so that the effectiveness is reduced.	
<u>Operation (Third Level Canal)</u>	
How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times. Assign a value of 0-4	2.70
4 - If there is an excess or deficit (spill or deficit at the tail ends), the headworks responds within 12 hours.	
2.7 - Headworks responds to real-time feedback observations within 24 hours	
1.3 - Headworks responds within 3 days.	
0 - Headworks responds in a time of greater than 3 days.	
Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	1.30
4 - Excellent. Information passes from the lower level to this level in a timely and reliable manner, and the system then responds.	
2.7 -Good. Reliable procedure. Updated at least once every 2 days, and the system responds.	
1.3 - The schedule is updated at least weekly with meaningful data. Changes are actually made based on downstream requirements.	
0 - Perhaps the schedule is updated weekly, but with data that is not very meaningful. Corresponding changes may not actually be made.	
Clarity and correctness of instructions to operators.	4.00
4 - Instructions are very clear and very correct.	
2.7 - Instructions are clear, but lacking in sufficient detail.	
1.3 - Instructions are unclear, but are generally correct.	
0 - Instructions are incorrect, whether they are clear or not.	
How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	1.30
4 - Once/day	
2.7 - Once/2 days	
1.3 - Once per week	
0 - Once per month or less often	
Capacity "bottlenecks" in the Third Level Canal	
Describe any flow rate restrictions in the Third Level Canal, including their location and hydraulic nature (this is different	
<u>ACTUAL Service that the Third Level Canal Provides to its Subcanals</u>	
Flexibility Index - Choose a value from 0-4, based on the scale below:	2.00
4 - Wide range of frequency, rate, and duration, but the schedule is arranged by the downstream subcanals several times daily, based on actual need.	
3 - Wide range of frequency, rate, and duration but arranged by the downstream canal once/day based on actual need.	
2 - Schedules are adjusted weekly by <u>downstream</u> operators	
1 - The schedules are dictated by the project office. Changes are made at least weekly.	
0 - The delivery schedule is unknown by the downstream operators, <u>or</u> changes are made less frequently than weekly.	
Reliability Index - Choose a value from 0-4, based on the scale below:	3.00
4 - 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.	
3 - 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.	
2 - The flow changes arrive plus or minus 2 days, but are correct. Perhaps 4 weeks of some shortage throughout the year.	
1 - The flows arrive plus or minus 4 days, but are incorrect. Perhaps 7 weeks of some shortage throughout the year.	
0 - Unreliable frequency, rate, and duration more than 50% of the time and the volume is unknown.	
Equity Index - Choose a value from 0-4, based on the scale below:	3.00
4 - Points along the canal enjoy the same level of good service	
3 - 5% of the canal turnouts receive significantly poorer service than the average	
2 - 15% of the canal turnouts receive significantly poorer service than the average.	
1 - 25% of the canal turnouts receive singificantly poorer service than the average.	
0 - Worse than 25%, or there may not even be any consistent pattern.	
Control of flows to customers of the next lower level - Choose a value from 0-4, based on the scale below:	3.00
4 - Flows are known and controlled within 5%	
3 - Flows are known and are controlled within 10%	
2 - Flows are not known but are controlled within 10%	
1 - Flows are controlled within 20%	
0 - Flows are controlled within 25%	

C.6.7.9. Final deliveries

Project Name: Way Pengubuan
Date: 25th January 2011

Point of Management Change (downstream of which the Paid Employees do not operate turnouts)	
Hectares downstream of that point (typical)	78
Number of water users downstream of that point (typical)	2800
Actual Service provided at the most downstream point operated by a paid employee.	
Number of fields downstream of this point (select from below, 0-4)	1.00
4 - 1 field	
3 - less than 3 fields	
2 - less than 6 fields	
1 - less than 10 fields	
0 - 10 or more fields	
Measurement of volumes delivered at this point (0-4)	1.00
4 - Excellent measurement and control devices, properly operated and recorded	
3 - Reasonable measurement and control devices, average operation	
2 - Useful but poor measurement of volumes and flow rates	
1 - Reasonable measurement of flows, but not of volumes	
0 - No measurement of volumes or flows	
Flexibility (0-4)	2.00
4 - Unlimited frequency, rate, and duration, but arranged by users within a few days	
3 - Fixed frequency, rate or duration, but arranged.	
2 - Dictated rotation, but it approximately matches the crop needs	
1 - Rotation deliveries, but on a somewhat uncertain schedule	
0 - No established rules	
Reliability (0-4)	3.00
4 - Water always arrives with the frequency, rate, and duration promised. Volume is known.	
3 - Very reliable in rate and duration, but occasionally there are a few days of delay. Volume is known	
2 - Water arrives about when it is needed, and in the correct amounts. Volume is unknown.	
1 - Volume is unknown, and deliveries are fairly unreliable - but less than 50% of the time.	
0 - Unreliable frequency, rate, and duration more than 50% of the time, and volume delivered in unknown.	
Apparent Equity (0-4)	4.00
4 - All points throughout the project and within tertiary units receive the same type of water delivery service	
3 - Areas of the project receive the same amounts of water, but within an area service is somewhat inequitable.	
2 - Areas of the project unintentionally receive somewhat different amounts of water, but within an area it is equitable.	
1 - There are medium inequities both between areas and within areas.	
0 - There are differences of more than 50% throughout the project on a fairly wide-spread basis.	
Final Water Distribution to Individual Ownership Units (e.g., field or farm)	
What percentage of the final distribution of water to individual fields is made by these people?	
No one (%)	
Individual farmer or farm irrigator (%)	
WUA volunteer (%)	
WUA employee (%)	100.00
Project-level employee (%)	
Check: The value on the right should equal 100% if the question above is answered properly	**100**

C.6.7.9. Final deliveries (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

If farmers must cooperate, how many farmers must cooperate to make the final distribution of water to fields?	n.a.
What percentage of the final distribution is done through:	
Small unlined distributary canals (%)	80
Larger unlined canals (%)	
Field-through-field conveyance (%)	
Pipelines (%)	
Lined canals (%)	20
Check: The value on the right should equal 100% if the question above is answered properly	**100**
General condition of final conveyance (10=Excellent, 1=Horrible)	8.00
Ability to measure flow rate to individual fields/farm (10=Excellent, 1=Horrible)	8.00
Ability to measure volume to individual fields/farm (10=Excellent, 1=Horrible)	1.00
FLEXIBILITY to final field/farm	
Are there written arrangements/policies for FREQUENCY of water delivery? (Yes/No)	Yes
How closely are they followed? (10=Excellent, 1=Horrible)	8.00
Are actual practices better than official policies?(10=Yes, 1=No)	5.00
Are there written arrangements/policies for RATE of water delivery? (Yes/No)	Yes
How closely are they followed? (10=Excellent, 1=Horrible)	8.00
Are actual practices better than official policies?(10=Yes, 1=No)	5.00
Are there written arrangements/policies for DURATION of water delivery? (Yes/No)	Yes
How closely are they followed? (10=Excellent, 1=Horrible)	8.00
Are actual practices better than official policies?(10=Yes, 1=No)	5.00
What percentage of the time do farmers actually receive water as:?	
Continuous flow - no adjustments (%)	
Continuous flow - some adjustments (%)	
Fixed rotation - well defined schedule that is followed (%)	100.00
Fixed rotation - well defined schedule that is often not followed (%)	
Rotation - variable but known schedule (%)	
Rotation - variable and unknown schedule (%)	
Arranged (but not part of a rotation) (%)	
Check: The value on the right should equal 100% if the question above is answered properly	**100**
Advance days notice required if water deliveries are arranged	1.00
EQUITY	
Is there an effective legal mechanism to ensure that individual farmers receive water with equity? (Yes/No)	Yes
Actual Service received by individual units (field or farms).	
Measurement of volumes to the individual units (0-4)	0.00
4 - Excellent measurement and control devices, properly operated and recorded	
3 - Reasonable measurement and control devices, average operation	
2 - Useful but poor measurement of volumes and flow rates	
1 - Reasonable measurement of flows, but not of volumes	
0 - No measurement of volumes or flows	
Flexibility to the individual units (0-4)	2.00
4 - Unlimited frequency, rate, and duration, but arranged by users within a few days	
3 - Fixed frequency, rate or duration, but arranged.	
2 - Dictated rotation, but it approximately matches the crop needs	
1 - Rotation deliveries, but on a somewhat uncertain schedule	
0 - No established rules	

C.6.7.9. Final deliveries (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

Reliability to the individual units (0-4)	2.00
4 - Water always arrives with the frequency, rate, and duration promised. Volume is known.	
3 - Very reliable in rate and duration, but occasionally there are a few days of delay. Volume is known	
2 - Water arrives about when it is needed, and in the correct amounts. Volume is unknown.	
1 - Volume is unknown, and deliveries are fairly unreliable - but less than 50% of the time.	
0 - Unreliable frequency, rate, and duration more than 50% of the time, and volume delivered in unknown.	
Apparent Equity to individual units (0-4)	3.00
4 - All fields throughout the project and within tertiary units receive the same type of water delivery service	
3 - Areas of the project receive the same amounts of water, but within an area the water delivery service is somewhat inequitable.	
2 - Areas of the project unintentionally receive somewhat different amounts of water (unintentionally), but within an area the water delivery service is equitable.	
1 - There are medium inequities both between areas and within areas.	
0 - There are differences of more than 50% throughout the project on a fairly wide-spread basis.	
Perceptions by Visiting Team	
Sense of lack of conflict between users (10=no conflicts, 1=huge problems)	9.00
Sense of lack of conflict between users and the government/project (10=no conflicts, 1=huge problems)	10.00
Ability to convert to modern field irrigation systems (10=easy; 1=almost impossible with the level of service provided)	5.00
"Order" Indicators - Evidence of orderly behavior throughout the canals that are operated by paid employees.	
Degree to which deliveries are NOT taken when not allowed, or NOT taken at flow rates greater than allowed (0-4)	4.00
4 - No noticeable evidence of farmers or WUAs taking deliveries when not allowed, or at flow rates greater than allowed.	
3 - Between 0 and 5% of deliveries are taken when not allowed or at flow rates greater than allowed.	
2 - Between 5 and 15% of deliveries are taken when not allowed or at flow rates greater than allowed.	
1 - Between 15 and 30% of deliveries are taken when not allowed or at flow rates greater than allowed.	
0 - Greater than 30% of deliveries are taken when not allowed or at flow rates greater than allowed.	
Noticeable non-existence of unauthorized turnouts from canals (0-4).	4.00
4 - No noticeable evidence of farmers or WUAs having unauthorized turnout locations.	
3 - Between 0 and 3% of deliveries are taken from unauthorized locations.	
2 - Between 3 and 6% of deliveries are taken from unauthorized locations.	
1 - Between 6 and 10% of deliveries are taken from unauthorized locations.	
0 - Greater than 10% of deliveries are taken from unauthorized locations.	
Lack of vandalism of structures (0-4).	2.00
4 - No noticeable evidence of vandalism of structures.	
3 - Between 0 and 3% of structures are vandalized.	
2 - Between 3 and 6% of structures are vandalized.	
1 - Between 6 and 10% of structures are vandalized.	
0 - More than 10% of structures are vandalized.	

C.6.7.10. Internal indicators calculation

Project Name: Way Pengubuan
Date: 25th January 2011

Points for understanding this Indicator Summary

1. This spreadsheet only applies to INTERNAL indicators. A separate spreadsheet is used for EXTERNAL indicators
2. The majority of the values on this worksheet are automatically transferred from previous worksheets in this spreadsheet.
3. Some of the indicator values on this worksheet must be assigned by the user.
4. The organization of this worksheet is as follows:
    a. The alpha-numeric label for each indicator is found in Column A
    b. The Primary Indicator name is given in Column B
    c. The Sub-Indicator is described in Column C
    d. The assigned value for each Sub-Indicator is found in Column D. Also, computed values for each Primary
    e. The weight assigned to each Sub-Indicator is given in Column E.
    f. The original indicator labels, as found in FAO Water Reports 19, are given here.
    g. The worksheet in which the original data were entered is given.

Indicator Label	Primary Indicator Name	Sub-Indicator Name	Value (0-4)	Weighting Factor	Old Indicator Label (FAO Water Reports 19)	Worksheet Location	weight x value	sum of weighting factors
	SERVICE and SOCIAL ORDER							
I-1	**Actual** Water Delivery Service to Individual Ownership Units (e.g., field or farm)		2.2		*I-1*	Final deliveries	24	11.0
I-1A		Measurement of volumes	0.0	1.0	*I-1A*		0	
I-1B		Flexibility	2.0	2.0	*I-1B*		4	
I-1C		Reliability	2.0	4.0	*I-1C*		8	
I-1D		Apparent equity.	3.0	4.0	*I-1D*		12	
I-2	**Stated** Water Delivery Service to Individual Ownership Units (e.g., field or farm)		2.6		*I-5*	Project Office Questions	29	11.0
I-2A		Measurement of volumes	1.0	1.0	*I-5A*		1	
I-2B		Flexibility	2.0	2.0	*I-5B*		4	
I-2C		Reliability	2.0	4.0	*I-5C*		8	
I-2D		Apparent equity.	4.0	4.0	*I-5D*		16	
I-3	**Actual** Water Delivery Service at the most downstream point in the system operated by a paid employee		2.4		*I-3*	Final deliveries	41	17.0
I-3A		Number of fields downstream of this point	1.0	1.0	*I-3A*		1	
I-3B		Measurement of volumes	1.0	4.0	*I-3B*		4	
I-3C		Flexibility	2.0	4.0	*I-3C*		8	
I-3D		Reliability	3.0	4.0	*I-3D*		12	
I-3E		Apparent equity.	4.0	4.0	*I-3E*		16	
I-4	**Stated** Water Delivery Service at the most downstream point in the system operated by a paid employee		2.2		*I-7*	Project Office Questions	38	17.0
I-4A		Number of fields downstream of this point	2.0	1.0	*I-7A*		2	
I-4B		Measurement of volumes	1.0	4.0	*I-7B*		4	
I-4C		Flexibility	2.0	4.0	*I-7C*		8	
I-4D		Reliability	2.0	4.0	*I-7D*		8	
I-4E		Apparent equity.	4.0	4.0	*I-7E*		16	
I-5	**Actual** Water Delivery Service by the Main Canals to the Second Level Canals		3.0		*I-4*	Main Canal	13.5	4.5
I-5A		Flexibility	1.0	1.0	*I-4A*		1	
I-5B		Reliability	4.0	1.0	*I-4B*		4	
I-5C		Equity	4.0	1.0	*I-4C*		4	
I-5D		Control of flow rates to the submain as stated	3.0	1.5	*I-4D*		4.5	
I-6	**Stated** Water Delivery Service by the Main Canals to the Second Level Canals		2.8		*I-8*	Project Office Questions	12.5	4.5
I-6A		Flexibility	1.0	1.0	*I-8A*		1	
I-6B		Reliability	4.0	1.0	*I-8B*		4	
I-6C		Equity	3.0	1.0	*I-8C*		3	
I-6D		Control of flow rates to the submain as stated	3.0	1.5	*I-8D*		4.5	
I-7	Social "Order" in the Canal System operated by paid employees		3.5		*I-9*	Final deliveries	14	4.0
I-7A		Degree to which deliveries are **NOT** taken when not allowed, or at flow rates greater than allowed	4.0	2.0	*I-9A*		8	
I-7B		Noticeable **non**-existence of unauthorized turnouts from canals.	4.0	1.0	*I-9B*		4	
I-7C		Lack of vandalism of structures.	2.0	1.0	*I-9C*		2	
	MAIN CANAL							
I-8	Cross regulator hardware (Main Canal)		1.7		*I-l0*	Main Canal	12	7.0
I-8A		Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets.	4.0	1.0	*I-10A*		4	
I-8B		Level of maintenance of the cross regulators.	2.0	1.0	*I-10C*		2	
I-8C		Lack of water level fluctuation	2.0	3.0	*I-10D*		6	
I-8D		Travel time of a flow rate change throughout this canal level	0.0	2.0	*I-10E*		0	

C.6.7.10. Internal indicators calculation (continued)

Indicator Label	Primary Indicator Name	Sub-Indicator Name	Value (0-4)	Weighting Factor	Old Indicator Label (FAO Water Reports 19)	Worksheet Location	weight x value	sum of weighting factors
I-9	Turnouts from the Main Canal		2.3		*I-12*	Main Canal	7	3.0
I-9A		Ease of turnout operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to meet the targets.	3.0	1.0	*I-12A*		3	
I-9B		Level of maintenance	2.0	1.0	*I-12C*		2	
I-9C		Flow rate capacities	2.0	1.0	*I-12D*		2	
I-10	Regulating Reservoirs in the Main Canal		n.a.		*I-13*	Main Canal	n.a.	0.0
I-10A		Suitability of the number of location(s)	n.a.	2.0	*I-13A*		n.a.	
I-10B		Effectiveness of operation	n.a.	2.0	*I-13B*		n.a.	
I-10C		Suitability of the storage/buffer capacities	n.a.	1.0	*I-13C*		n.a.	
I-10D		Maintenance	n.a.	1.0	*I-13D*		n.a.	
I-11	Communications for the Main Canal		2.3		*I-14*	Main Canal	25	11.0
I-11A		Frequency of communications with the next higher level? (hr)	1.0	2.0	*I-14A*		2	
I-11B		Frequency of communications by operators or supervisors with their customers	2.0	2.0	*I-14B*		4	
I-11C		Dependability of voice communications by phone or radio.	4.0	3.0	*I-14C*		12	
I-11D		Frequency of visits by upper level supervisors to the field.	3.0	1.0	*I-14D*		3	
I-11E		Existence and frequency of remote monitoring (either automatic or manual) at key **spill** points, including the end of the canal	0.0	1.0	*I-14E*		0	
I-11F		Availability of roads along the canal	2.0	2.0	*I-14F*		4	
I-12	General Conditions for the Main Canal		1.8		*I-15*	Main Canal	9	5.0
I-12A		General level of maintenance of the canal floor and canal banks	2.0	1.0	*I-15A*		2	
I-12B		General lack of undesired seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired).	3.0	1.0	*I-15B*		3	
I-12C		Availability of proper equipment and staff to adequately maintain this canal	1.0	2.0	*I-15C*		2	
I-12D		Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment)	2.0	1.0	*I-15D*		2	
I-13	Operation of the Main Canal		2.7		*I-16*	Main Canal	13.3	5.0
I-13A		How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times.	4.0	2.0	*I-16A*		8	
I-13B		Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	1.3	1.0	*I-16B*		1.3	
I-13C		Clarity and correctness of instructions to operators.	4.0	1.0	*I-16C*		4	
I-13D		How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	0.0	1.0	*I-16D*		0	
		SECOND LEVEL CANAL						
I-14	Cross regulator hardware (Second Level Canals)		0.0		*I-10*	Second Level Canals	0	7.0
I-14A		Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets.	0.0	1.0	*I-10A*		0	
I-14B		Level of maintenance of the cross regulators.	0.0	1.0	*I-10C*		0	
I-14C		Lack of water level fluctuation	0.0	3.0	*I-10D*		0	
I-14D		Travel time of a flow rate change throughout this canal level	0.0	2.0	*I-10E*		0	
I-15	Turnouts from the Second Level Canals		0.0		*I-12*	Second Level Canals	0	3.0
I-15A		Ease of turnout operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to meet the targets.	0.0	1.0	*I-12A*		0	
I-15B		Level of maintenance	0.0	1.0	*I-12C*		0	
I-15C		Flow rate capacities	0.0	1.0	*I-12D*		0	
I-16	Regulating Reservoirs in the Second Level Canals	**NO REGULATING RESERVOIR IN THIS CANALS**	0.0		*I-13*	Second Level Canals	0	6.0
I-16A		Suitability of the number of location(s)	0.0	2.0	*I-13A*		0	
I-16B		Effectiveness of operation	0.0	2.0	*I-13B*		0	
I-16C		Suitability of the storage/buffer capacities	0.0	1.0	*I-13C*		0	
I-16D		Maintenance	0.0	1.0	*I-13D*		0	
I-17	Communications for the Second Level Canals		0.0		*I-20*	Second Level Canals	0	11.0
I-17A		Frequency of communications with the next higher level? (hr)	0.0	2.0	*I-20A*		0	
I-17B		Frequency of communications by operators or supervisors with their customers	0.0	2.0	*I-20B*		0	
I-17C		Dependability of voice communications by phone or radio.	0.0	3.0	*I-20C*		0	
I-17D		Frequency of visits by upper level supervisors to the field.	0.0	1.0	*I-20D*		0	
I-17E		Existence and frequency of remote monitoring (either automatic or manual) at key **spill** points, including the end of the canal	0.0	1.0	*I-20E*		0	
I-17F		Availability of roads along the canal	0.0	2.0	*I-21F*		0	

C.6.7.10. Internal indicators calculation (continued)

Indicator Label	Primary Indicator Name	Sub-Indicator Name	Value (0-4)	Weighting Factor	*Old Indicator Label (FAO Water Reports 19)*	*Worksheet Location*	weight x value	sum of weighting factors
I-18	General Conditions for the Second Level Canals		0.0		*I-21*	Second Level Canals	0	5.0
I-18A		General level of maintenance of the canal floor and canal banks	0.0	1.0	*I-21B*		0	
I-18B		General lack of undesired seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired).	0.0	1.0	*I-21C*		0	
I-18C		Availability of proper equipment and staff to adequately maintain this canal	0.0	2.0	*I-21D*		0	
I-18D		Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment)	0.0	1.0	*I-21E*		0	
I-19	Operation of the Second Level Canals		0.0		*I-22*	Second Level Canals	0	5.0
I-19A		How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times.	0.0	2.0	*I-22A*		0	
I-19B		Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	0.0	1.0	*I-22B*		0	
I-19C		Clarity and correctness of instructions to operators.	0.0	1.0	*I-22C*		0	
I-19D		How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	0.0	1.0	*I-22D*		0	
		THIRD LEVEL CANAL						
I-20	Cross regulator hardware (Third Level Canals)		0.0			Third Level Canals	0	7.0
I-20A		Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets.	0.0	1.0			0	
I-20B		Level of maintenance of the cross regulators.	0.0	1.0			0	
I-20C		Lack of water level fluctuation	0.0	3.0			0	
I-20D		Travel time of a flow rate change throughout this canal level	0.0	2.0			0	
I-21		Turnouts from the Third Level Canals	0.0			Third Level Canals	0	3
I-21A		Ease of turnout operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to meet the targets.	0.0	1.0			0	
I-21B		Level of maintenance	0.0	1.0			0	
I-21C		Flow rate capacities	0.0	1.0			0	
I-22	Regulating Reservoirs in the Third Level Canals	**NO REGULATING RESERVOIR IN THIS CANALS**	0.0			Third Level Canals	0	6.0
I-22A		Suitability of the number of location(s)	0.0	2.0			0	
I-22B		Effectiveness of operation	0.0	2.0			0	
I-22C		Suitability of the storage/buffer capacities	0.0	1.0			0	
I-22D		Maintenance	0.0	1.0			0	
I-23	Communications for the Third Level Canals		0.0			Third Level Canals	0	11.0
I-23A		Frequency of communications with the next higher level? (hr)	0.0	2.0			0	
I-23B		Frequency of communications by operators or supervisors with their customers	0.0	2.0			0	
I-23C		Dependability of voice communications by phone or radio.	0.0	3.0			0	
I-23D		Frequency of visits by upper level supervisors to the field.	0.0	1.0			0	
I-23E		Existence and frequency of remote monitoring (either automatic or manual) at key **spill** points, including the end of the canal	0.0	1.0			0	
I-23F		Availability of roads along the canal	0.0	2.0			0	
I-24		General Conditions for the Third Level Canals	0.0			Third Level Canals	0	5.0
I-24A		General level of maintenance of the canal floor and canal banks	0.0	1.0			0	
I-24B		General lack of undesired seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired).	0.0	1.0			0	
I-24C		Availability of proper equipment and staff to adequately maintain this canal	0.0	2.0			0	
I-24D		Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment)	0.0	1.0			0	
I-25		Operation of the Third Level Canals	0.0			Third Level Canals	0	5.0
I-25A		How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times.	0.0	2.0			0	
I-25B		Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	0.0	1.0			0	
I-25C		Clarity and correctness of instructions to operators.	0.0	1.0			0	
I-25D		How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	0.0	1.0			0	

C.6.7.10. Internal indicators calculation (continued)

Indicator Label	Primary Indicator Name	Sub-Indicator Name	Value (0-4)	Weighting Factor	Old Indicator Label (FAO Water Reports 19)	Worksheet Location	weight x value	sum of weighting factors
		BUDGETS, EMPLOYEE, AND WUAs						
I-26	Budgets		1.6		I-23	Project Office Questions	8	5.0
I-26A		What percentage of the total project (including WUA) Operation and Maintenance (O&M) is collected as in-kind services, and/or water fees from water users?	3.0	2.0	I-23A		6	
I-26B		Adequacy of the actual dollars and in-kind services that is available (from all sources) to sustain adequate Operation and Maintenance (O&M) with the present mode of operation.	1.0	2.0	I-23B		2	
I-26C		Adequacy of spending on modernization of the water delivery operation/structures (as contrasted to rehabilitation or regular operation)	0.0	1.0	I-23C		0	
I-27	Employees		1.4		I-24	Project Employees	13.5	9.5
I-27A		Frequency and adequacy of training of operators and middle managers (not secretaries and drivers). This should include employees at all levels of the distribution system, not only those who work in the office.	2.0	1.0	I-24A		2	
I-27B		Availability of written performance rules	1.0	1.0	I-24B		1	
I-27C		Power of employees to make decisions	1.0	2.5	I-24C		2.5	
I-27D		Ability of the project to dismiss employees with cause.	3.0	2.0	I-24D		6	
I-27E		Rewards for exemplary service	2.0	1.0	I-24E		2	
I-27F		Relative salary of an operator compared to a day laborer **(NO DAY LABORER)**	n.a.	2.0	I-24F		n.a.	
I-28	Water User Associations		3.2		I-25	WUA	21	6.5
I-28A		Percentage of all project users who have a functional, formal unit that participates in water distribution	4.0	2.5	I-25A		10	
I-28B		Actual ability of the strong Water User Associations to influence real-time water deliveries to the WUA.	4.0	1.0	I-25B		4	
I-28C		Ability of the WUA to rely on effective outside help for enforcement of its rules	1.0	1.0	I-25C		1	
I-28D		Legal basis for the WUAs	3.0	1.0	I-25D		3	
I-28E		Financial strength of WUAS	3.0	1.0	I-25E		3	
I-29	Mobility and Size of Operations Staff	Operation staff mobility and efficiency, based on the ratio of operating staff to the number of turnouts.	0.0		I-28	Project Office Questions		
I-30	Computers for billing and record management	The extent to which computers are used for billing and record management	0.0		I-30	Project Office Questions		
I-31	Computers for canal control	The extent to which computers (either central or on-site) are used for canal control	1.0		I-31	Project Office Questions		
INDICATORS THAT WERE NOT PREVIOUSLY		**THESE INDICATORS REQUIRE THE INPUT OF VALUES (0-4) IN EACH OF THE BOXES**						
I-32	Ability of the present water delivery service to individual fields, to support pressurized irrigation methods		2.2		I-26	n/a	6.5	3
I-32A	Measurement and control of volumes to the field	4 - Excellent volumetric metering and control; 3.5 - Ability to measure flow rates reasonably well, but not volume. Flow is well controlled; 2.5 - Cannot measure flow, but can control flow rates well; 0 - Cannot control the flow rate, even though it can be measured.	2.50	1.0	I-26A	n/a	2.5	
I-32B	Flexibility to the field	4 - Arranged delivery, with frequency, rate and duration promised. All can be varied upon request; 3 - Same as 4, but cannot vary the duration; 2 - 2 variables are fixed, but arranged schedule; 0 - Rotation	0.00	1.0	I-26B	n/a	0	
I-32C	Reliability to the field	4 - Water always arrives as promised, including the appropriate volume; 3 - A few days of delay occasionally occur, but water is still very reliable in rate and duration; 0 - More than a few days delay.	4.00	1.0	I-26C	n/a	4	
I-33	Changes required to be able to support pressurized irrigation methods		2.5		I-27	n/a	5	2
I-33A	Procedures, Management	4 - No changes in water ordering, staff training, or mobility; 3.5 - Improved training, only. The basic procedures/conditions are just fine, they just are not being implemented to their full extent; 3.0 - Minor changes in water ordering, mobility, training, incentive programs; 2.0 - Major changes in 1 of the above; 1 - Major changes in 2 of the above; 0 - Need to completely revamp or convert almost everything.	3.00	1.0	I-27A	Management	3	
I-33B	Hardware	4 - No changes needed; 3.5 - Only need to repair some of the existing structures so that they are workable again.; 3.0 - Improved communications, repair of some existing structures, and a few key new structures (less than US$300/ha needed), OR…very little change to existing, but new structures are needed for water recirculation; 2 - Larger capital expenditures - $US 300 - $US 600/ha; 1 - Larger capital expenditures needed (up to $US 1500/ha); 0 - Almost complete reworking of the system is needed	2.00	1.0	I-27B	Hardware	2	
I-34	Sophistication in receiving and using feedback information. This does not need to be automatic.	4 - Continuous feedback and continuous use of information to change inflows, with all key points monitored. Or, minimal feed back is necessary, such as with closed pipe systems.; 3 - Feedback several times a day and rapid use (within a few hours) of that information, at major points.; 2 - Feedback once/day from key points and appropriate use of information within a day; 1 - Weekly feedback and appropriate usage, or once/day feeback but poor usage of the information; 0 - No meaningful feedback, or else there is a lot of feedback but no usage.	2.00		I-29	n/a		
		SPECIAL INDICATORS THAT DO NOT HAVE A 0-4 RATING SCALE						
I-35	Turnout density	Number of water users downstream of employee-operated turnouts	0			*Final deliveries*		
I-36	Turnouts/Operator	(Number of turnouts operated by paid employees)/(Paid Employees)	0.0			*Project Office*		
I-37	Main Canal Chaos	(Actual/Stated) Overall Service by the Main Canal	1.08					
I-38	Second Level Chaos	(Actual/Stated) Overall Service at the most downstream point operated by a paid employee	1.08					
I-39	Field Level Chaos	(Actual/Stated) Overall Service to the Individual Ownership Units	0.83					

C.6.7.11. IPTRID indicators calculations

Project Name: Way Pengubuan
Date: 25th January 2011

*** The following are data items that have been defined by the IPTRID Secretariat in the publicatio**
"Guidelines for Benchmarking Performance in the Irrigation and Drainage Sector", December 2(

* "DI 12" refers to "Data Item No. 12" of the IPTRID Guidelines

* "RAP 9" refers to a Data Item that was collected or computed in Worksheet 4.External Indicators, but

* These values have been imported from other worksheets

	Value	Description
DI 1	**51.28**	Availability of water (surface plus ground) to users - using stated conveyance efficiency for surface water and assumed efficiencies for ground water, MCM (includes all farmer pumping)
DI 2	**78.89**	Surface irrigation water inflow from outside the command area (gross at diversion and entry points), MCM
	0.00	Net groundwater imported into the project, MCM
	78.89	Total irrigation water supply (surface plus groundwater) brought into the project boundaries, MCM.
DI 3	**3,501.00**	Physical area of cropland in the command area (not including multiple cropping), ha
DI 4	**6,280.00**	Irrigated crop area in the command area, including multiple cropping, ha
	22,533.33	Annual external irrigation supply per unit command area (m^3/ha)
	12,561.97	Annual irrigation supply per unit irrigated area (including multiple cropping) - (m^3/ha)
DI 5	**118.69**	Total external water supply - including gross precipitation and net aquifer withdrawl, but excluding internal recirculation, MCM
DI 8	**3.60**	Flow rate capacity of main canal(s) at diversion point(s), cms
DI 9	**5.37**	Peak gross irrigation requirement, including all inefficiencies, cms
DI 10	**78.89**	Gross annual volume of irrigation water entitlement, MCM
DI 10	**3.50**	Gross maximum flow rate entitlement of the project, cms
DI 10a	**100.00**	Average percentage of the entitlement that is received, %
DI 12	**192,761.11**	Gross revenue collected from water users, including in-kind services. $US
DI 13	**180,200.82**	Total management, operation and maintenance cost of project. $US
DI 14	**57,343.06**	Total annual (Project + WUA) expenditure on system maintenance, $US
	206.00	Total number of Project and WUA employees
DI 15	**77,713.89**	Total cost of personnel in the project and WUAs, $US
DI 16	**123.00**	Total number of Project and WUA employees who work in the field
DI 17	**192,761.11**	Gross revenue that is due from the water users, $US
DI 18	**see note below**	Gross annual agricultural production, tons
DI 19	**16,307,522.22**	Total annual value of agricultural production at the farm gate, $US
DI 20	**34.67**	Total annual volume of water consumed as ET on the fields (ET) - MCM
DI 21	**1.00**	Average irrigation water salinity, dS/m
DI 21	**0.00**	Average drainage water salinity, dS/m
DI 22	**0.00**	Biological load (BOD) of the irrigation water, average mgm/l
DI 22	**0.00**	Biological load (BOD) of the drainage water, average mgm/l
DI 23	**0.00**	Chemical Oxygen Demand (COD) of the irrigation water, average mgm/l
DI 23	**0.00**	Chemical Oxygen Demand (COD) of the drainage water, average mgm/l
DI 24	**0.00**	Change in water table depth over the last 5 years, m
DI 25	**0.00**	Average annual depth to the water table, m
DI26	**Requires in-depth computations**	Differences in the volume of incoming salt and outgoing salts
RAP 9	**0.00**	Total annual NET groundwater pumping, MCM
RAP 20	**20.39**	Crop ET - Effective Rainfall, MCM
RAP 31	**44.27**	Average Field Irrigation Efficiency, % (computed from ET and Gross)
RAP 15	**0.00**	Estimated conveyance efficiency for pumped internal aquifer water, %

Values for DI 18 must be extracted from Table 9 on each INPUT-Year"X" worksheet

C.6.7.11. IPTRID indicators calculations (continued)

Project Name: Way Pengubuan
Date: 25th January 2011

IPTRID Indicators (computed from the values above)

**Note - IPTRID indicators may not equal the RAP indicators of the same name because the RAP

	225,333.33	Annual irrigation water delivery per unit command area (m^3/ha)
	12,561.97	Annual irrigation water delivery per unit irrigated area (m^3/ha)
	65.00	Conveyance system water delivery efficiency, % (as stated)
	3.42	Annual relative water supply ***does not include rice deep perc.***
	3.87	Annual relative irrigation supply ***does not include rice deep perc.***
	100.00	Security of entitlement supply, % received
	1.07	Cost recovery ratio
	0.30	Maintenance cost to revenue ratio
	51.47	Total MOM cost per unit area (US$/ha)
	377.25	Total cost per employee (US$/person)
	1.00	Revenue collection performance
	0.03	Staff per unit area (Persons/ha)
	1.67	(Number of turnouts operated by staff)/(total field staff persons)
		Total revenue per unit volume of water delivered by project authorities (US$/$m^3$)
	0.00	Total MOM cost per unit volume of water delivered by the project authorities (US$/$m^3$)
	16,307,522.22	Total annual value of agricultural production (US$)
	4,657.96	Output per unit command area (US$/ha)
	2,596.74	Output per unit irrigated area, including multiple cropping (US$/ha)
	0.21	Output per unit irrigation supply that is imported into the project boundaries (US$/$m^3$)
	0.14	Output per unit of total water (including precipitation) into the project (US$/$m^3$)
	0.47	Output per unit water consumed (US$/$m^3$)

C.6.7.12. World Bank indicators calculations

Project Name: Way Pengubuan
Date: 25th January 2011

1	Water Year of the data	2009/2010	Confidence Interval (CI) (%)
	WATER BALANCE INDICATORS		
2	Total annual volume of irrigation water available at the user level (MCM)	51.28	100
3	Total annual volume of irrigation supply into the 3-D boundaries of the command area (MCM)	78.89	100
4	Total annual volume of irrigation water managed by authorities (including internal well and recirculation pumps operated by authorities) (MCM) (can include recirculated water; but does not include any drainage or groundwater that is pumped by farmers)	78.89	100
5	Total annual volume of water supply (MCM)	118.69	100
	Total annual volume of irrigation water delivered to users by project authorities (M	51.28	100
6	Total annual volume of ground water pumped within/to command area (MCM)	0.00	100
7	Total annual volume of field ET in irrigated fields (MCM)	34.67	100
8	Total annual volume of (ET - effective precipitation) (MCM)	20.39	100
	Peak net irrigation water requirement (CMS)	1.55	100
9	Total command area of the system (ha)	3,501.00	100
10	Irrigated area, including multiple cropping (ha)	6,280.00	100
11	Annual irrigation supply per unit command area (m3/ha)	22,533.33	100
12	Annual irrigation supply per unit irrigated area (m3/ha)	12,561.97	100
13	Conveyance efficiency of project-delivered water, % (weighted for internal and external, using values stated by project authorities)	65.00	100
14	Estimated conveyance efficiency for project groundwater, %	0.00	100
15	Annual Relative Water Supply (RWS)	3.42	100
16	Annual Relative Irrigation Supply (RIS)	3.87	100
17	Water delivery capacity	2.33	100
18	Security of entitlement supply, %	100.00	100
19	Average Field Irrigation Efficiency, %	44.27	100
20	Command area Irrigation Efficiency, %	28.78	100
	FINANCIAL INDICATORS		
21	Cost recovery ratio	1.07	100
22	Maintenance cost to revenue ratio	0.30	100
23	Total MOM cost per unit area (US$/ha)	51.47	100
24	Total cost per staff person employed (US$/person)	377.25	100
25	Revenue collection performance	1.00	100
26	Staff persons per unit irrigated area (Persons/ha)	0.03	100
27	Number of turnouts per field operator	1.67	100
28	Average revenue per cubic meter of irrigation water delivered to water users by the project authorities (US$/m3)	0.00	100
29	Total MOM cost per cubic meter of irrigation water delivered to water users by the project authorities (US$/m3)	0.00	100
	AGRICULTURAL PRODUCTIVITY AND ECONOMIC INDICATORS		
30	Total annual value of agricultural production (US$)	16,307,522.22	100
31	Output per unit command area (US$/ha)	4,657.96	100
32	Output per unit irrigated area, including multiple cropping (US$/ha)	2,596.74	100
33	Output per unit irrigation supply (US$/m3)	0.21	100
34	Output per unit water supply (US$/m3)	0.14	100
35	Output per unit of field ET (US$/m3)	0.47	100
	ENVIRONMENTAL INDICATORS		
36	Water quality: Average salinity of the irrigation supply (dS/m)	1.00	100
37	Water quality: Average salinity of the drainage water (dS/m)	0.00	100
38	Water quality, Biological: Average BOD of the irrigation supply (mgm/liter)	0.00	100
39	Water quality, Biological: Average BOD of the drainage water (mgm/liter)	0.00	100
40	Water quality, Chemical: Average COD of the irrigation supply (mgm/liter)	0.00	100
41	Water quality, Chemical: Average COD of the drainage water (mgm/liter)	0.00	100
42	Average depth to the shallow water table (m)	0.00	100
43	Change in shallow water table depth over last 5 years (m) (+ is up)	0.00	100
	OTHER		
44	Percent of O&M expenses that are used for pumping (%)	0.00	100

C.7. Irrigation system performance summary

Performance Indicators	Performance			
	Value		Advantages	Disadvantages
Farmer & WUA				
a. Farmer	Fair	Satisfied with the current irrigation services, but they want better service and infrastructure in the future.	Generally male of reproductive age.	Average landplot ownership of 0.5 ha. No obvious water problem, farmers still less appreciate the value of water.
b. WUAs	Good	Beetween 2.92 - 3.23 (average of 3.16) out of 4.	Government regulates the uniformity of WUAs' organisations and elements of the institutional tradition still to be facilitated. Have the authority of O&M of irrigation at tertiary level. All farmers are members of the WUAs due to strong socio-cultural ties. No offences due to strong socio-cultural punishment against offence to the rules. 100% irrigation fee collection. Have the 5 comprehensiveness of legal requirements of organization to run as a business organisation.	From the completeness of the legality, WUAs' ages are generally young and the capability of WUAS board member to manage organisation are low. The function of *Ulu-ulu* and *Ili-ili* which merely only distribute irrigation water equitably, their potency can be maximized to conserve water for sustainability. Underfinanced, but not badly. At tertiary level, conditions are poor but are maintained and replaced well enough to be functional, no modernization improvements are made.
Rainfall vs Evapotranspiration				
a. Rainfall	Good	Rainfall is quite high, wet season 9 to 10 months in a year.	Do not need irrigation during wet season.	Most of the rainfall occurs during wet season. Need irrigation in semi dry and dry season.
b. Evapo-transpiration	Good	Eto exceeds annual precipitation.	Do not need irrigation during wet season.	Irrigation is required to achieve potential yields. Irrigation is needed for second cropping season and third cropping season (in some areas where irrigation water is adequate).
c. Surface and ground water	Good	n.a.	Surface water and ground water resources are potential. All irrigation water is distracted from rivers through weirs (in general). No ground water is utilised for irrigation.	Debit differences between the rainy and dry season are high, there is a shortage of water in the dry season and excess in the rainy season. The sustainability of irrigation water is threatened by the destruction of the hydrological functions of protected areas. There are increases in the level of water turbidity due to soil erosion.
Irrigation and drainage service				
a. Water balance	Good	*See Appendix C.6.5.1*	The total annual volume of irrigation water delivered to users by project authorities are well above the total annual volume of field ET in irrigated fields.	Higher water allowance compared to Java due to relatively porous of local soil conditions.
		100% (except Muara Mas)	No obvious water problem, current water supply is still able to satisfy user demand by 100% security of entitlement supply by almost all irrigation systems.	
		65%		Conveyance efficiency of project-delivered water is quite low.
		Between 16.13 - 72.98% (average of 47.76%)		Very low field irrigation efficiency.
		Between 10.48 - 47.44% (average of 31.05%)		Very low command area irrigation efficiency.

C.7. Irrigation system performance summary (continued)

Performance Indicators	Performance			
	Value		Advantages	Disadvantages
b. Service & social order	Good	Between 2.56 – 3.00 (average of 2.93) out of 4	AWDS at the main canal is good.	There was discontinuity (gradually decrease) in the AWDS at different levels in an irrigation system observed. Generally the managers overstated perception of the quality of WDS they provide at the individual landplot units and under stated the quality of their service at the main and second level canals, and at the most downstream point operated by paid employee. The WDS provides by paid employee is better than the WDS performs by WUAs.
c. Operation	Fair	2.4 out of 4 on average		Operation of main canal, secondary and tertiary channels are almost equal, since the staffs are simply following the standard procedure for the operation of irrigation networks and the WUAs are also directed by the staffs to follow this guidance.
Budget and employee				
a. Budget	Poor	Between 0.40 - 1.20 (average 0.47) out of 4 Between US$51.47 – 133.20/ha/year (US$96.42/ha/year on average)	Fees charged by the WUAs for tertiary O&M are established on seasonal basis according to the area irrigated.	Budget performances are low. MOM funds/hectare irrigated area is low and there is a wide disparity of fund provided by government. The fund from federal government are the highest, and the fund from provincial government are higher that the districts government. There is no direct financing mechanism to cover any of the cost of irrigation services provided by the government.
b. Management & staff	Poor	Between 1.35 - 1.93 (average 1.42) out of 4 Between 0.02 to 0.12 person/ ha (average 0.04 person/ha)	Daily O&M staffs have tried their best to serve the best water delivery service possible to the condition of the existing infrastructure and hardware, and operation and communication.	Employee performances are low. Staff person per unit irrigated area is low.
c. Computer for billing and record management	Poor	n.a.		No computer is used for billing and record management. Ability to measure rates reasonably well. No measurement on volume.
d. Computer for canal control	Poor	n.a.		No computer is used for canal control. The numbers of offtakes are small and there is required the addition of offtakes for better setting water distribution.
Asset condition				
a. Asset condition	Poor	On average, good in large system, moderate in medium system, and poor in small system.		The differences on MOM funds/hectare from the federal government, the provincial government and the districts government make the infrastructure condition of a large irrigation system is the best compared to medium and small irrigation system.
Agricultural productivity & economics				
a. Productivity	Fair	The average command area to irrigated area ratio is 0.73. The average cropping intensity is 2.03.	There is possibility to increase the ratio of command area to irrigated area and the cropping intensity of the case study irrigation system.	

C.7. Irrigation system performance summary (continued)

Performance Indicators	Performance			
	Value		Advantages	Disadvantages
b. Yields	Fair	Yields 5 – 6.2 tonnes/ha (wet season) and 4 – 5.8 tonnes/ha (dry season).	There is possibility to increase the yields by improving rice agriculture practices.	
c. Output per unit irrigation supply	Poor	Between US$367,589.29/m3 - US$163,395.50/m3 (average US$237,075.14/m3).	There is possibility to increase the output per unit irrigation supply.	
d. Output per unit water supply	Poor	Between US$0.24/m3 - US$0.10/m3 (average US$0.16/m3).	There is possibility to increase the output per unit water supply.	
e. Output per unit field ET	Poor	Between US$0.24/m3 - 0.48/m3 (average US$0.62/m3).	There is possibility to increase the output per unit field ET.	Between US$0.24/m3 - 0.48/m3 (average US$0.62/m3).
f. Farmer's income	Poor	Average net income of Rp1.000,00 (US$125.93) per 0.5 hectare.		Revenues are considered to be very low.
Financial				
a. Cost recovery ratio	Poor	Between 0.45 - 1.23 (average 0.75)		Cost recovery ratios were low.
b. Maintenance cost to revenue ratio	Poor	Between 0.21 – 0.48, except Ilihan Balak 1.05 (average 1.30 without Ilihan Balak)		Maintenance cost to revenue ratio is low, except Way Ilihan Balak. All available funds collected from water users are used only for emergency maintenance purposes to make the asset on tertiary level can be operated.
c. Average revenue/m^3 irrigation water	Poor	Between US$0.00220 to 0.00657/m3 (average US$0.00431/m3)		Average revenue/ m^3 are low. All revenue collected by WUAs are used for MOM of irrigation assets at tertiary level. No portion of the revenue is sent to the government.
d. Average MOM costs/m^3 irrigation water	Poor	Between US$0.00148 to 0.00594/ m3 (average US$0.00282/m3)		Total MOM costs/m^3 are low. Variation is caused by different project budget received by each irrigation system for the work such as improvement of structures, modernization, maintenance, rehabilitation and other operation in the recent five years.
Environment				
a. Water quality	Poor	On average DO = 4.05, BOD = 10.95, and COD = 32.16 mg/lt		Environmental aspect of irrigation systems in Indonesia has not received proper attention. Quality of irrigation water supply is critical (UNESCO requires of BOD 3 – 6 mg/lt and COD < 20 mg/lt). No assessment on water salinity (ECw) and total dissolved solids (TDS). (FAO requires ECw of 0 -3 dS/m and TDS of 0 – 2,000 mg/lt). No assessment on agricultural land or irrigation system.
b. Water table	n.a.	n.a.		No assessment on the average depth to the shallow water table (m) and change in shallow water table depth over last 5 years (+ is up) (m).
Other				
a. Ability to support pressurized irrigation method and to support recirculation of irrigation water	Fair	Between 1.83 - 3.17 (average 2.41) out of 4.	There is possibility to improve irrigation method to pressurized irrigation.	Improve procedures, management, and communications, repair of some existing structures or a little change to existing structures, and add new structures for water recirculation.

APPENDIX D

Details of Assessing the Irrigation Sustainability:

D.1. The Triple Bottom Line Assessment

D.2. Challenges of executing the physical and management improvements

D.3. SPSS – stakeholders' opinion survey

D.4. The viability assessment of physical and managerial interventions

D.1. The Triple Bottom Line Assessment

D.1.1. TBL assessment on profit – water balance, productivity and efficiency

Sustainability objective	Existing performance			Action needed
	TBL Rating	Issues	Its causes	
PROFIT				
a. Water balance, productivity and efficiency				
Maintain stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability: crop occupancy, irrigated area, groundwater rise/fall, and mapping the problematic areas (matching complex demands for water with constraints in supply and delivery).	√	Farmers still less appreciate the value of water. Eto exceeds annual precipitation, irrigation is required to achieve potential yields. Quality of irrigation water supply is critical: BOD = 10.95, and COD = 32.16 mg/lt (UNESCO requires of BOD 3 – 6 mg/lt and COD < 20 mg/lt). There are increases in the level of water turbidity due to soil erosion (FAO requires ECw of 0 -3 dS/m and TDS of 0 – 2,000 mg/lt).	No obvious water supply problem. Most of the rainfall occurs during wet season. River debit differences between the rainy and dry season are high. Higher water allowance due to relatively porous of local soil conditions. Quality and quantity of irrigation water is threatened by the destruction of the hydrological functions of protected areas and factories along the river that discharge their waste water without proper treatment. No assessment on water salinity (ECw) and total dissolved solids (TDS).	Increase farmers' awareness about global water crisis problem and the importance of using water efficiently. There is possibility to increase irrigated area by 33%, cropping intensity by 33% and yields by 50% per season with better rice farming method. Better irrigation is needed for second cropping season and third cropping season (in some areas where irrigation water is adequate). Modernisation of irrigation system to support pressurised irrigation and recirculate the irrigation water to improve water use efficiency. Clearer allocation of water rights could help reduce conflict and facilitate trading and compensation arrangement for reallocation and efficient water resource utilisation.
Increase the agricultural productivity.	√	The average command area to irrigated area ratio is 0.73. The average cropping intensity is 2.03. Yields 5 – 6.2 tonnes/ha (wet season) and 4 – 5.8 tonnes/ha (dry season).	Low conveyance efficiency, low irrigation efficiency, and no irrigation water circulation.	Better irrigation services. There is possibility to increase irrigated area by 33%, cropping intensity by 33% and yields by 50% per season with better rice farming method.
Maintain efficiency of irrigation water: application, distribution and conveyance (reducing the losses of the irrigation system).	√	Low conveyance efficiency of project-delivered water. Very low command area irrigation efficiency. Discontinuity in the AWDS at different levels in an irrigation system observed. Very low field irrigation efficiency.	Overstated/understated perception of the quality of WDS. The WDS provides by paid employee is better than the WDS performs by WUAs, needs to improve WUAs capability to increase efficiency at farm level.	Improvement of conveyance facilities and distribution system condition. Improve WUAs capability to increase efficiency at farm level. Improve farmers' knowledge on the global problems of irrigation water and land sustainability and the value of water.
Measure the water delivered accurately (pricing water).	√	Rate measurement is reasonably well. No measurement on volume.	No computer is used for billing and record management, and for canal control. The numbers of offtakes are small.	Required volume measurement device, automation device, and additional offtakes for better setting water distribution.

D.1.2. TBL assessment on profit – financial sustainability

Sustainability objective	Existing performance			Action needed
	TBL	Issues	Its causes	
PROFIT				
b. Financial sustainability				
Achieved financial and economic efficiency/profitability of irrigated agriculture (yields vs. water cost ratio, yields vs. water supply ratio, relative water cost).	√	Low output per unit irrigation supply. Low output per unit water supply. Low output per unit field ET. Low average revenue/m^3 irrigation water. Low average MOM costs/m^3 irrigation water.	Conveyance efficiency of project-delivered water is 65%. Average field irrigation efficiency is only 47.76%. Low value of irrigation water.	There is possibility to increase conveyance and field efficiency by improving the channels condition and modernise the irrigation system to pressurised method and recirculate the irrigation water. There is a need to increase the value of irrigation water by imposing a higher ISF, however there is a constraint in farmers' to afford such higher ISF.
Achieved financial viability (financial self-sufficiency, O&M fraction, fee collection performance).	√	Low cost recovery ratios.	Fees are charge on seasonal basis according to the area irrigated. 100% fee collection performance, but it is only enough to provides MOM of irrigation assets at tertiary level (generally only enough for emergency maintenance purposes to make the asset on tertiary level can be operated). No portion of the revenue is sent to the government (no direct financing mechanism to cover any of the cost of irrigation services provided by the government).	Turnover the authority of larger system/secondary level to WUAs (the government retain the authority to supervise water allocation to maintained upstream system do not deprive downstream during periods of shortage). Contracting the irrigation management where the O&M contractual approach might allow WUAs to hire their own technical specialists to operate larger schemes. (Need in-depth review on cost difference between WUAs/contracting approach and government manage (savings to government to enlighten the government burden on O&M cost).
Enhance the financial sustainability of existing water supply system.	√	There is constraints in legislation framework that allows irrigation systems to act as a business organisation that seeking revenue from farmers' water user.	Indonesia's constitutional framework establishes sole ownership and managerial responsibility of water resources by the national government. The government allows water use under special conditions and appropriate payment of a water tariff, while maintaining ownership and ultimate control. To address problems related to financial sustainability, it is needed special legislation framework that allows third party to involve in irrigation system management.	Management approaches to consider as suggested by experts: diversifying agriculture (agricultural productivity and profitability), water use rights and participation in basin management, WUAs as a business enterprise, contracting for irrigation management, farmer financing for irrigation development, and reengineering O&M.
Increase the value of the irrigation system through targeted investment in existing and new irrigation facilities (development/renewal/modernisation).	√	Generally, it is at least that irrigation could continue to maintain the canals and structures in good enough physical condition to provide the desired service is the least, however many agencies end up functioning on a contingency response basis.	Budget constraints are persistence in most irrigation and drainage systems to rehabilitate, reconstruct, repair, and renew asset.	Modernising irrigation system: applying pressurised irrigation method and recirculate the irrigation water to improve irrigation efficiency, improving channels condition and increasing the number of turnouts/offtakes to improve irrigation service and water distribution, and 3. Install volumetric measuring devices and expand the scope of irrigation service fee (ISF) by specifying water delivery service to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF to improve water use efficiency and to increase management, maintenance and operation (MOM) costs recoveries.
Enlightened government burden on O&M costs.	√	No portion of the revenue is sent to the government (no direct financing mechanism to cover any of the cost of irrigation services provided by the government). Financing irrigation system still relies heavily on government subsidy.	There is constraints in legislation framework that allows irrigation systems to act as a business organisation that seeking revenue from farmers' water user.	Review potential alternative approach to expand participatory in irrigation management and the cost difference between participatory options and government manage (savings to government to enlighten the government burden on O&M cost).

D.1.3. TBL assessment on profit – economic sustainability

Sustainability objective	Existing performance			Action needed
	TBL Rating	Issues	Its causes	
PROFIT				
c. Economic sustainability				
Achieved high level of good quality production.	√√	Moderate irrigated area ratio, moderate cropping intensity and yields.	Consistency in water delivery service. Conveyance efficiency of project-delivered water is 65%. Average field irrigation efficiency is only 47.76%.	There is possibility to increase the level of good quality production by improving water delivery service that can be achieved by the channels condition and modernise the irrigation system to pressurised method and recirculate the irrigation water. There is possibility to increase irrigated area by 33%, cropping intensity by 33% and yields by 50% per season with better rice farming method.
Achieved financial and economic efficiency (standardise gross value of output per hectare, standardise gross value of output per unit of water diverted).	√	Low output per unit irrigation supply. Low output per unit water supply. Low output per unit field ET. Low average revenue/m3 irrigation water.	Consistency in water delivery service. Conveyance efficiency of project-delivered water is 65%. Average field irrigation efficiency is only 47.76%. Low value of irrigation water.	There is possibility to increase the level of good quality production by improving water delivery service that can be achieved by improving the channels condition and modernise the irrigation system to pressurised method and recirculate the irrigation water. There is a need to increase the value of irrigation water by imposing a higher ISF, however there is a constraint in farmers' to afford such higher ISF.

D.1.4. TBL assessment on profit – asset sustainability

Sustainability objective	Existing performance			Action needed
	TBL Rating	Issues	Its causes	
PROFIT				
d. Asset sustainability				
Ensure continuing asset serviceability.	√	In general,the asset condition assessment results indicate that the assets condition of the irrigation system under the central government authority is sufficient, the systems under the jurisdiction of the provincial government are less good, and the systems under the authority of local governments (district/kabupaten) are in poor condition.	Low MOM funds/hectare receive from government and are used mainly for emergency maintenance purposes to make the asset can be operated. There are no asset management plan for a single irrigation system. All irrigation systems are following the rehabilitation, reconstruction, repair, and renewal of assets plan that set up by the central governement according to their priorities and the availability of fund which is usually relies heavily on overseas grant.	Increase MOM cost revenue by expanding the scope of irrigation service fee (ISF) (by specifying water delivery service and install suitable measuring structures within the systems). Irrigation system needs to organise WUAS to respond to the specific business opportunities such as fisheries, joint purchase of agricultural inputs, marketing crops, and electric power generation that are present in the system to generate income that subsequently to fund the he rehabilitation, reconstruction, repair, and renewal of assets of irrigation system.
Ensure asset integrity is safeguard.	√√	**No problem.** Less than 10% of noticeable evidence of vandalism of structures. No evidence of water are taken when not allowed, or at flow rates greater than allowed. No noticeable non-existence of unauthorized turnouts from canals.	**No problem.**	

D.1.5. TBL assessment on profit – busines management sustainability

Sustainability objective	Existing performance			Action needed
	TBL Rating	Issues	Its causes	
PROFIT				
e. Business management (irrigation system management)				
Achieved managerial ability to supply the required water to meet the crop water requirements (technical knowledge of the staffs).	√√	Existence and effectiveness of water ordering/delivery procedures to match actual demands are moderate.	The number of local staffs are insufficient since they have to serve 3 or 4 irrigation systems (small irrigation system). Frequency and adequacy of training of operators and middle managers (not secretaries and drivers). This should include employees at all levels of the distribution system, not only those who work in the office.	Improved procedures, management and communication. There is a need of computers extent (either central or on-site) for canal control.
Adapt to new technology to improve system performance by modernising irrigation system.	√	Asset rehabilitation, reconstruction, repair, and renewal are relied on government funding, mostly through overseas grants. In general, small irrigation system send up functioning on a contingency response basis – if something goes wrong it will get fixed, but until there is a crisis, no action is taken.	Frequency and adequacy of training of operators and middle managers (not secretaries and drivers). This should include employees at all levels of the distribution system, not only those who work in the office. Availability and adequacy of fund to invest to new technology to improve the present mode of operation.	Modernising irrigation system: applying pressurised irrigation method and recirculate the irrigation water to improve irrigation efficiency, improving channels condition and increasing the number of turnouts/offtakes to improve irrigation service and water distribution, and 3. Install volumetric measuring devices and expand the scope of irrigation service fee (ISF) by specifying water delivery service to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF to improve water use efficiency and to increase management, maintenance and operation (MOM) costs recoveries.
Adapt to new management approaches to improve system performance and sustainability.		Turnover irrigation management at tertiary level to WUAs has been successfully implemented, however it still is not enough to ensure the sustainability of irrigation in the future since the availability and the adequacy of government subsidy on the O&M and , reconstruction, repair, and renewal are decreasing. The irrigation system should seek approaches to increase its financial independency.	Compliance with legislative requirements.	Management approaches to consider as suggested by experts: diversifying agriculture (agricultural productivity and profitability), water use rights and participation in basin management, WUAs as a business enterprise, contracting for irrigation management, farmer financing for irrigation development, and reengineering O&M.
Ensure compliance with legislative requirements.	√√	**No problem.** Indonesia's constitutional framework establishes sole ownership and managerial responsibility of water resources by the national government. The government allows water use under special conditions and appropriate payment of a water tariff, while maintaining ownership and ultimate control. To address various problems and issues developing in irrigation management, the Indonesian government issued some policy, legislation, regulation presidential decree, presidential instructions, government regulations, and minister's decision.	**No problem.**	Special legislation framework is needed to allow third party to involve in irrigation system management.

D.1.6. TBL assessment on planet – water uses efficiency

Sustainability objective	Existing performance			Action needed
	TBL Rating	Issues	Its causes	
PLANET				
a. Water uses efficiency				
Enhance appreciation of farmers to the value of water.	√	Farmers still less appreciate the value of water, excess irrigation water easily is flowed to drainage system or river.	No obvious water problem and farmers accept whatever is offered by the nature. When there is no water in dry season, then they stop farming. No attemp to conquer the challenge and they still thinking it is the government responsibility to provide better irrigation service. Low value of irrigation water.	Maximise the role of Ulu-ulu and Ili-ili in efficient utilisation of water resources at the farm (field level) to conserve water for the water sustainability in the future. There is a need to increase the value of irrigation water by imposing a higher ISF, however there is a constraint in farmers' to afford such higher ISF.
Increase distribution system efficiencies.	√	Low conveyance efficiency, low irrigation efficiency, and no irrigation water circulation.	Low conveyance efficiency is caused by poor irrigation conveyance and distribution system. Existence and effectiveness of water ordering/delivery procedures to match actual demands are moderate.	Improving water delivery service that can be achieved by the improving channels condition and increasing the number of turnouts/offtakes. Maximise the role of Ulu-ulu and Ili-ili in efficient utilisation of water resources at the farm (field level) to conserve water for the water sustainability in the future.
Increase output of water uses (output per unit water supply)/litres of water used per dollar value of item produced.	√√	Low output per unit irrigation supply. Low output per unit water supply. Low output per unit field ET. Low average revenue/m3 irrigation water.	No obvious water problem and farmers accept whatever is offered by the nature. When there is no water in dry season, then they stop farming. No attemp to conquer the challenge and they still thinking it is the government responsibility to provide better irrigation service. Low value of irrigation water.	There is possibility to increase the level of good quality production by improving water delivery service that can be achieved by improving the channels condition and modernise the irrigation system to pressurised method and recirculate the irrigation water. Maximise the role of Ulu-ulu and Ili-ili in efficient utilisation of water resources at the farm (field level) to conserve water for the water sustainability in the future. There is a need to increase the value of irrigation water by imposing a higher ISF, however there is a constraint in farmers' to afford such higher ISF.

D.1.7. TBL assessment on planet – maintain hydraulic functions

Sustainability objective	Existing performance			Action needed
	TBL Rating	Issues	Its causes	
PLANET				
b. Achieve high level of environmental performance in systems and basin level				
Minimise negative environmental impacts of irrigation, especially the long-term cumulative negative such as:				
In the irrigation project: waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna.	√	**No data available.** No assessment on agricultural land or irrigation system.	Environmental aspect of irrigation systems in Indonesia has not received proper attention, because thefocus is still on how to improve performances in water balance, financial, agricultural productivity and economic. There are evidence of the increases in the level of water turbidity due to soil erosion.	WUAs can provide a structure for participation in basin water resource management, dealing with problems such as reallocation (clearer water use rights to irrigation system) and water quality. Clearer allocation of water rights could help reduce conflict and facilitate trading and compensation arrangement for reallocation and efficient water resource utilisation. Farmers in turned-over system do not have explicit water rights, though design of headworks is based on an indicative flow (debit). Therefore explicit water rights needs to be acquainted. WUAs needs to be provided with the information/data on hydrology, water quality, and meteorology. The environmental effects often impoverish tail-end farmers, and poor communities in the upper region who do not receive the benefits of irrigation are often deforest the mountains to feed their families. There should be a benefits sharing given to them to prevent them from deforesting the upper region. Increasing competion for water is bringing increasing pressure for reallocation of water from irrigation to other sectors. Industrial development often produces pollution which harms crops. Government must monitor and regulate against environmental degradation to prevent irrigation system from becoming overwhelmed by larger resource problems such as deforestation, soil erosion, unsustainable land use practice and water pollution.
Downstream of the project: reduced surface water availability, increased groundwater inflow, water logging, and polluted incoming water.	√	**No data available.** The assessment results of 3 majors rivers in the catchment area of irrigation system case studies shows the average monthly of DO, BOD, and COD exceed the threshold level regulated by UNESCO/WHO/UNEP WHO to be used for agricultural water supply and fisheries which is the COD <20 mg/l and BOD 3-6 mg /lt. No data available about the salinity assessment of the river water for irrigation, especially average irrigation water salinity (ECw) and total dissolved solids (TDS), which are important parameters of quality of irrigation water. FAO provides general guidelines regarding the usual range of ECw of 0 -3 dS/m and TDS of 0 – 2,000 mg/lt. The assessment results of 3 majors rivers in	Environmental aspect of irrigation systems in Indonesia has not received proper attention, because thefocus is still on how to improve performances in water balance, financial, agricultural productivity and economic. There is evidence on surface water declining. The polluted incoming water is caused by some industrial waste that exist along these rivers. From this information, it can be conclude that the above riversare in critical condition to meet the requirements to be used as irrigation water.	
Consider the net effects of the system to environment as follow:				
Quality and quantity of drainage water discharge into natural water course (or otherwise disposed of).	√	**No data available.**	Environmental aspect of irrigation systems in Indonesia has not received proper attention, because thefocus is still on how to improve performances in water balance, financial, agricultural productivity and economic.	WUAs can provide a structure for participation in basin water resource management, dealing with problems such as reallocation (clearer water use rights to irrigation system) and water quality. Government must monitor and regulate against environmental degradation to prevent irrigation system from becoming overwhelmed by larger resource problems such as deforestation, soil erosion, unsustainable land use practice and water pollution.
Health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury).	√	**No data available.**	Environmental aspect of irrigation systems in Indonesia has not received proper attention, because thefocus is still on how to improve performances in water balance, financial, agricultural productivity and economic.	
Direct effects of management practices (e.g. de-silting).	√	**No data available.**	Environmental aspect of irrigation systems in Indonesia has not received proper attention, because thefocus is still on how to improve performances in water balance, financial, agricultural productivity and economic.	
Impact of irrigation on groundwater quality and level.	√	**No data available.**	Environmental aspect of irrigation systems in Indonesia has not received proper attention, because thefocus is still on how to improve performances in water balance, financial, agricultural productivity and economic.	
Impact of irrigation on groundwater quality and level.	√	**No data available.**	Environmental aspect of irrigation systems in Indonesia has not received proper attention, because thefocus is still on how to improve performances in water balance, financial, agricultural productivity and economic.	
Impact of irrigation on river health.	√	**No data available.**	Environmental aspect of irrigation systems in Indonesia has not received proper attention, because thefocus is still on how to improve performances in water balance, financial, agricultural productivity and economic.	

D.1.8. TBL assessment on planet – social aspect of environment

Sustainability objective	Existing performance			Action needed
	TBL Rating	Issues	Its causes	
PLANET				
c. Social aspect of environmental:				
The environmental effects often impoverish tail-end farmers.	√	**No data available.**	Environmental aspect of irrigation systems in Indonesia has not received proper attention, because thefocus is still on how to improve performances in water balance, financial, agricultural productivity and economic.	The environmental effects often impoverish tail-end farmers, and poor communities in the upper region who do not receive the benefits of irrigation are often deforest the mountains to feed their families. There should be a benefits sharing given to them to prevent them from deforesting the upper region.

D.1.9. TBL assessment on people – staff

Sustainability objective	Existing performance			Action needed
	TBL Rating	Issues	Its causes	
PEOPLE				
a. Staffs				
Have a motivated, empowered and well-skilled workforce with an achievement-oriented culture.	√√	Most staffs works based on the standard guidelines.	The number of local staffs are insufficient since they have to serve 3 or 4 irrigation systems (small irrigation system). Weak of written performance rules as well as rewards for exememplary performance or punishment for poor performance. Weak power of employees to make decisions, most decisions are made by higher management staffs. Adequacy of proper supporting equipment for staff.	Improve the motivation, power and skill of staffs so the staffs have an achievement-oriented attitude as well as improve the mobility and size of operations staff. Establish a written performance rules to recognise exememplary performance or poor performance, and written guidelines to empower stafss. There is a need to improve the extent of supporting equipment to improve staffs performance.

D.1.10. TBL assessment on people – farmers

Sustainability objective	Existing performance			Action needed
	TBL Rating	Issues	Its causes	
PEOPLE				
b. Customer/farmers				
Improve the level of customer satisfaction with government/ UPTD (local technical implementation unit) services.	√√	Survey shows farmers want better service and infrastructure of irrigation in the future. Although security of entitlement supply is almost 100%, but the Actual Water Delivery Service (AWDS) both to individual ownership units (e.g., field or farm), at the most downstream point in the system operated by a paid employee, and by the main canals to the second level canals are moderate (2.31, 2.45 and 2.93 out of 4 respectively).	Low conveyance efficiency is caused by poor irrigation conveyance and distribution system.	Improvement of conveyance facilities and distribution system condition. Improve existence and frequency of remote monitoring (either automatic or manual) at key spill points, including the end of the canal.
Build improved customer/ farmers relationships.	√√	Survey shows farmers want better communication with irrigation authority.	Communications for the main, second , and third level canals are sufficient (2.26, 2.25, and 2.12 out of 4 respectively), but the number of local staffs are insufficient since they have to serve 3 or 4 irrigation systems (small irrigation system).	Improve the motivation, power and skill of staffs so the staffs have an achievement-oriented attitude as well as improve the mobility and size of operations staff.

D.1.11. TBL assessment on people – WUAs

Sustainability objective	Existing performance			Action needed
	TBL Rating	Issues	Its causes	
PEOPLE				
c. WUAs				
a. Strengthen WUAs and WUAF technically, financially and legally (handover more responsibility on the farmers to care for the supply system and hand over of responsibility for the O&M irrigation infrastructure above the tertiary turnouts on large and medium scale irrigation system, or the management authority of small scale irrigation system smaller than 500 ha from the government to the WUAs). WUAs also responsible to the administration of water tariffs/irrigation service fee (ISF) to raise revenue from the water users to provide funds for operation and maintenance of irrigation infrastructure under its authority.				
Legal:				
Availability of appropriate policy/legislation/regulation and guidelines for planning and operating the system under WUAs.	√√	Despite WUAs have enough power to make irrigation water sharing arrangements from tertiary level to individual landplots run harmoniously and irrigation water charges run smoothly, however actually WUAs in general have relatively weak organisation and management.	Indonesia's constitutional framework establishes sole ownership and managerial responsibility of water resources by the national government. The government allows water use under special conditions and appropriate payment of a water tariff, while maintaining ownership and ultimate control. There is legislation constraints to expand WUAs authority to a higher level or larger systems.	Legal basis for the WUAs to to develop and grow as business enterprise, and eventually run their irrigated agriculture enterprise. Developing a program of business promotion and providing appropriate support services for WUAs to respond to business opportunities.
Institutional:				
WUAs organisational and institutional capacity to operate the system.	√	Despite WUAs have enough power to make irrigation water sharing arrangements from tertiary level to individual landplots run harmoniously and irrigation water charges run smoothly, however actually WUAs in general have relatively weak organisation and management.	Many of WUAs are not supported by complete legal documents.	Financial and managerial support such as: resource mobilitation, credit and subsidy: advisory assistance and credit may be required from government, bank or financial institution, and subsidies may be continued on a gradually declining basis. Financial and managerial training such as: accounting and general management skills, computing, financial management, personnel management and information system. Technical support and training: developing capability in water measurement, water distribution and drainage, maintenance, rehabilitation and modernisation of asset, and O&M audits.
Improve WUAs as a business organisation.	√	**No data available.** The policy to developed WUAs a business organisation are just implemented recently (2007). The success of the implementation of this policy is not yet examine.	**No data available.**	Strenghthen the legality of WUAs so they can make contract with third party or they can provide some services (from a range of activities from fisheries, joint purchase of agricultural inputs, marketing of crops, to electric power generation). These opportunities to generate income enable WUAs to perform their functions in an effective and efficient manner (achieved financial viability: financial self-sufficiency, O&M fraction, fee collection performance). Institutions and regulatory bases to enable appropriate links between WUAs and other organisations (including private sector organisations) to develop in relation to business. Pool WUAs resources to achieved economic of scale in running irrigated agricultural business. Improve WUAs capability so they could organise members to respond to the specific business opportunities that are present in a particular system. Improve WUAs managerial capability so they can facilitate members' access to support services in an effective and efficient manner.
Trust/confidence in WUAs.	√√	Farmers are value trust/confidence on WUAs high. WUAs have enough power to make irrigation water sharing arrangements from tertiary level to individual landplots run harmoniously and irrigation water charges run smoothly, however actually WUAs in general have relatively weak organisation and management.	There is constraints in technical and managerial capability of WUAs board members. Most board members are volunteers.	Financial and managerial training such as: accounting and general management skills, computing, financial management, personnel management and information system. Technical support and training: developing capability in water measurement, water distribution and drainage, maintenance, rehabilitation and modernisation of asset, and O&M audits.

D.1.12. TBL assessment on people – community

Sustainability objective	Existing performance			Action needed
	TBL Rating	Issues	Its causes	
PEOPLE				
c. Community				
Achieved social capacity (users stake in irrigation system):				
Water user rights and participation in basin management.	√	There is evidence that shortage of water during dry season is caused by the destruction of the hydrological functions of protected areas that is generated by deforestation of protected forest areas in upper regionand agricultural cultivation practice without conservation. More than 60% of protected forests have been converted into plantations by the browser. Reforestation cannot keep pace with deforestation. Consequently, this condition increases the level of water turbidity due to soil erosion and affects the availability of water resources for irrigation in the downstream.Only a few are already known to impact on the degradation of rivers and coastal morphology (discharge, sediment, coastal erosion, and siltation).	The environmental effects often impoverish tail-end farmers, and poor communities in the upper region who do not receive the benefits of irrigation are often deforest the mountains to feed their families. There should be a benefits sharing given to them to prevent them from deforesting the upper region.	WUAs can provide a structure for participation in basin water resource management, dealing with problems such as reallocation (clearer water use rights to irrigation system) and water quality. Clearer allocation of water rights could help reduce conflict and facilitate trading and compensation arrangement for reallocation and efficient water resource utilisation.
Poor communities in the upper region who do not receive the benefits of irrigation are often deforest the mountains to feed their families.				
There should be a benefits sharing given to them to prevent them from deforesting the upper region by implementing a dividend reinvestment projects that benefit local communities and the environment (to stop sedimentation and flood in lower region).	√	There is evidence that shortage of water during dry season is caused by the destruction of the hydrological functions of protected areas that is generated by deforestation of protected forest areas in upper regionand agricultural cultivation practice without conservation. More than 60% of protected forests have been converted into plantations by the browser. Reforestation cannot keep pace with deforestation. Consequently, this condition increases the level of water turbidity due to soil erosion and affects the availability of water resources for irrigation in the downstream.Only a few are already known to impact on the degradation of rivers and coastal morphology (discharge, sediment, coastal erosion, and siltation).	The environmental effects often impoverish tail-end farmers, and poor communities in the upper region who do not receive the benefits of irrigation are often deforest the mountains to feed their families. There should be a benefits sharing given to them to prevent them from deforesting the upper region.	WUAs can provide a structure for participation in basin water resource management, dealing with problems such as reallocation (clearer water use rights to irrigation system) and water quality. Clearer allocation of water rights could help reduce conflict and facilitate trading and compensation arrangement for reallocation and efficient water resource utilisation.

Note: TBL ratings,

Below compliance	√
Compliance	√√
Beyond compliance/Best practice	√√√

D.2. Challenges of executing the physical and management improvements

No.	Scenario	Indicators			Problem/Challenge
		People	Planet	Profit (to Government)	
1. Modernising irrigation systems:					
1.	Pressurised irrigation method and recirculate the irrigation water to improve irrigation efficiency	Accomplish a better services to farmers. Farmers have greater freedom in choosing the frequency, flow rate, time, and duration of irrigation water services.	Sustainability of irrigation land and water: Water uses efficiency: litres of water used per dollar value of item produced	Maintain stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability: crop occupancy, irrigated area, groundwater rise/fall, and mapping the problematic areas (matching complex demands for water with constraints in supply and delivery). Measure the water delivered accurately (pricing water). Maintain efficiency of irrigation water: application, distribution and conveyance (reducing the losses of the irrigation system).	Required substantial capital investment to change the open-channel-gravity-based irrigation into close-channel-pressurized irrigation, as well to change water use measurement device from flow rate measurement into volumetric measurment device.
2.	Improving channels condition and increasing the number of turnouts/offtakes	Improved irrigation service and water distribution	Sustainability of irrigation land and water: Water uses efficiency: litres of water used per dollar value of item produced	Maintain efficiency of irrigation water: application, distribution and conveyance (reducing the losses of the irrigation system).	Required quite substantial capital investment to up-grade the channel condition and add the number of turnout/offtakes.
3.	Install volumetric measuring devices and expand the scope of irrigation service fee (ISF) by specifying water delivery service to implement irrigation service fee (ISF) based on the volume of water used and raise the ISF to improve water use efficiency and to	Enhance appreciation of farmers to the value of water.	Sustainability of irrigation land and water: Water uses efficiency: litres of water used per dollar value of item produced	Enhance appreciation of farmers to the value of water. Enlighten the government burden on O&M cost/less dependence on government support.	Required quite substantial capital investment to up-grade the channel condition and add the number of turnout/offtakes. Formulated policy that put more strenghth of turnover and ISF, and more scope of local capabilities and circumstances. Institutional and legal basis to expand the scope and raise the ISF. Technical support and training: developing capability in water measurement, water distribution and drainage, maintenance, rehabilitation and modernisation of asset, and O&M audits. Public/water user farmers community acceptance, trust/confidence in WUAs.

D.2. Challenges of executing the physical and management improvements (continued)

No.	Scenario	Indicators: People	Indicators: Planet	Indicators: Profit (to Government)	Problem/Challenge
	2. Improving irrigation system management, procedures, and communication by improving participatory in irrigation management:				
1.	Diversifying agriculture (agricultural productivity and profitability)	Better farmers income more likely to achieve from horticultural crops. Farmers have greater freedom in choosing their own crops.	Horticultural crops require lower water than rice crops. Sustainability of irrigation land and water: Water uses efficiency: litres of water used per dollar value of item produced Land uses efficiency: land used per dollar value of item produced	If agriculture more profitable, then the farmers will be more interested in irrigation management.	Diversification makes irrigation management more complex and may need to be operated differently. Farmers need to coordinate their crop planning so that flooding of rice fields does not interfere with other crops which have less tolerance of flooding. Required greater reliability through improved main system operation or through more flexibility for farmers to locally distribute water according to their needs. Government intervere needed to maintain sel-sufficiency in rice production.
2.	WUAs as a business organisation	Facilitate and support members to run their irrigated agriculture enterprise. Opportunities to generate income for WUAs (from a range of activities from fisheries, joint purchase of agricultural inputs, marketing of crops, to electric power generation) to enable them to perform their functions in an effective and efficient manner (achieved financial viability: financial self-sufficiency, O&M fraction, fee collection performance). WUAs could organise members to respond to the specific business opportunities that are present in a particular system. Facilitate members' access to support services in an effective and efficient manner.	Pool their resources to achieved economic of scale in running irrigated agricultural business. Sustainability of irrigation land and water: Water uses efficiency: litres of water used per dollar value of item produced Land uses efficiency: land used per dollar value of item produced	Achieved financial and economic efficiency/profitability of irrigated agriculture (yields vs. water cost ratio, yields vs. water supply ratio, relative water cost). Cost difference between WUAs and government manage (savings to government to enlightened the government burden on O&M cost/less dependence on government support. Maintain stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability: crop occupancy, irrigated area, groundwater rise/fall, and mapping the problematic areas (matching complex demands for water with constraints in supply and delivery). Maintain efficiency of irrigation water: application, distribution and conveyance (reducing the losses of the irrigation system). Achieved high level of good quality production Achieved financial and economic efficiency (standardise gross value of output per hectare, standardise gross value of output per unit of water diverted)	Institutional and legal basis for WUA to develop and grow as business enterprise. Lack of institutions to strengthen the financial capacity of farmers and WUAs to mobilise and manage resources. Developing a program of business promotion and providing appropriate support services for WUAs to respond to business opportunities. Institutions and regulatory bases to enable appropriate links between WUAs and other organisations (including private sector organisations) to develop in relation to business. Financial and managerial support such as: resource mobilitation, credit and subsidy: advisory assistance and credit may be rquired from government, bank or financial institution, and subsidies may be continued on a gradually declining basis. Financial and managerial training such as: accounting and general management skills, computing, financial management, personnel management and information system. Technical support and training: developing capability in water measurement, water distribution and drainage, maintenance, rehabilitation and modernisation of asset, and O&M audits. Public/water user farmers community acceptance, trust/confidence in WUAs
3.	Turnover secondary/larger system to WUAs	Focus on how to best accomplis the key process of better services to farmers.	Sustainability of irrigation land and water: Water uses efficiency: litres of water used per dollar value of item produced Land uses efficiency: land used per dollar value of item produced	Shortage in staff, vehicles, communication equipment and operational budget constrain the ability of irrigation offices to provide services, make farmers are asked to assist with maintenance and operations of larger systems although it is not within the capacity of farmers to carry out. Less dependence on government support.	When the larger systems are turned over, the government must retain the authority to supervise water allocation to maintained upstream system do not deprive downstream during periods of shortage. Institutional and legal basis for WUA to develop and grow as business enterprise. Formulated policy that put more strenghth of turnover and ISF, and more scope of local capabilities and circumstances.

D.3. Stakeholders' opinion survey

D.3.1. SPSS – stakeholders' opinion survey

Institution	I.1		Total	I.2		Total	I.3		Total
	Pressurized irrigation	Channel condition		Pressurized irrigation	ISF scope		Channel condition	ISF scope	
The irrigation authority staffs/decision makers	0	14	14	13	1	14	14	0	14
Consultant	7	10	17	3	14	17	14	3	17
WUAs' chiefs	3	8	11	6	5	11	10	1	11
Total	10	32	42	22	20	42	38	4	42

Institution	II.1		Total	II.2		Total	II.3		Total
	Diversifying agriculture	WUAs as business		Diversifying agriculture	Turnover secondary		WUAs as	Turnover secondar	
The irrigation authority staffs/decision makers	0	14	14	10	4	14	14	0	14
Consultant	9	8	17	6	11	17	11	6	17
WUAs' chiefs	3	8	11	5	6	11	9	2	11
Total	12	30	42	21	21	42	34	8	42

Institution	III.1		Total	III.2		Total	III.3		Total
	Pressurized irrigation	Diversifying agriculture		Pressurized irrigation	WUAs as business		Pressuriz ed	Turnover secondar	
The irrigation authority staffs/decision makers	2	12	14	1	13	14	13	1	14
Consultant	7	10	17	3	14	17	6	11	17
WUAs' chiefs	3	8	11	1	10	11	7	4	11
Total	12	30	42	5	37	42	26	16	42

Institution	III.4		Total	III.5		Total	III.6		Total
	Channel condition	Diversifying agriculture		Channel condition	WUAs as business		Channel condition	Turnover secondar	
The irrigation authority staffs/decision makers	14	0	14	2	12	14	13	1	14
Consultant	16	1	17	14	3	17	9	8	17
WUAs' chiefs	11	0	11	4	7	11	8	3	11
Total	41	1	42	20	22	42	30	12	42

Institution	III.7		Total	III.8		Total	III.9		Total
	ISF scope	Diversifying agriculture		ISF scope	WUAs as business		ISF scope	Turnover secondar	
The irrigation authority staffs/decision makers	1	13	14	2	12	14	13	1	14
Consultant	14	3	17	13	4	17	8	9	17
WUAs' chiefs	3	8	11	5	6	11	8	3	11
Total	18	24	42	20	22	42	29	13	42

D.3.2. Simple pairwise comparison matrix result on opinion survey

Organisation	Alternatives	Paired alternatives															Number of times alernative dominates	Rank
		1-2	1-3	2-3	4-5	4-6	5-6	1-4	1-5	1-6	2-4	2-5	2-6	3-4	3-5	3-6		
Irrigation Authority/UPTD/ Bapeda	1. Pressurized irrigation + recirculation	0	13					2	1	13							29	IV
	2. Improve channel condition	14		14							14	2	13				57	II
	3. Install volumetric measuring devices & expand the scope of ISF		1	0										1	2	13	17	V
	4. Diversifying agriculture				0	10		12			0			13			35	III
	5. WUAs as bussiness organisation				14		14		13			12			12		65	I
	6. Expand the scope of WUAs authority					4	0			1			1			1	7	VI
	Total	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14		
Consultant	1. Pressurized irrigation + recirculation	7	3					7	3	6							26	VI
	2. Improve channel condition	10		14							16	14	9				63	I
	3. Install volumetric measuring devices & expand the scope of ISF		14	3										14	13	8	52	II
	4. Diversifying agriculture				9	6		10			1			3			29	V
	5. WUAs as bussiness organisation				8		11		14			3			4		40	IV
	6. Expand the scope of WUAs authority					11	6			11			8			9	45	III
	Total	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17		
WUAs	1. Pressurized irrigation + recirculation	3	6					3	1	7							20	V
	2. Improve channel condition	8		10							11	4	8				41	I
	3. Install volumetric measuring devices & expand the scope of ISF		5	1										3	5	8	22	IV
	4. Diversifying agriculture				3	5		8			0			8			24	III
	5. WUAs as bussiness organisation				8		9		10			7			6		40	II
	6. Expand the scope of WUAs authority					6	2			4			3			3	18	VI
	Total	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11		
Total	1. Pressurized irrigation + recirculation	10	22					12	5	26							75	V
	2. Improve channel condition	32		38							41	20	30				161	I
	3. Install volumetric measuring devices & expand the scope of ISF		20	4										18	20	29	91	III
	4. Diversifying agriculture				12	21		30			1			24			88	IV
	5. WUAs as bussiness organisation				30		34		37			22			22		145	II
	6. Expand the scope of WUAs authority					21	8			16			12			13	70	VI
	Total	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42		

D.4. The Viability Assessment

D.4.1. The viability assessment of physical approaches

D.4.1.1. Applying pressurized irrigation methods and recirculate the irrigation water to improve irrigation efficiency

Pressurised irrigation method, recirculate the irrigation water and install volumetric measurement devices to improve irrigation efficiency

Key Issue	Goal/ objective	Criteria	Statement	Score	Weight	Real score = score * weight
Technical and economic aspects	Technical viability	Suply reliability/ serviceability	Stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability	3	1.20	3.60
		Efficiency	Efficiency of irrigation water: application, distribution and conveyance, and reducing the losses of the irrigation system	3	1.20	3.60
		Operation and maintenance	Level of skill required to operate and maintain the pressurised irrigation and recirculate the irrigation water	3	1.20	3.60
		Utilise existing infrastructure	Potential to utilise existing infrastructure	2	1.20	2.40
		Upgradeability	Adapability to new technology and ability to be expanded to improve the system	3	1.20	3.60
	Technical sustainability	Future demand	Ability to cope with the increasing demand in the future	3	1.20	3.60
		Flexibility	Matching complex demands for water with constraints in supply and delivery	3	1.20	3.60
		Long-term operation and maintenance	Ensure continuing asset serviceability	3	1.20	3.60
	Economical viability	Investment cost	The cost of implementing the pressurised irrigation method and recirculate irrigation water	1	1.20	1.20
		O&M cost efficiency	Difference in the overall O&M cost of supplying closed-channel pressurised irrigation water and open-channel gravity irrigation	2	1.20	2.40
		Pricing irrigation water accurately	With the ability to measure irrigation water use accurately, the cost of irrigation water can be determined accurately	3	1.20	3.60
		Agricultural productivity	Improve agricultural productivity (annual value of agricultural production, output per unit irrigated area, output per unit water supply)	3	1.20	3.60
	Economical sustainability	Financial sustainability	Achieve financial self-sufficiency, O&M fraction, fee collection performance	3	1.20	3.60
Social, institutional, and legal aspects	Social viability	Complain/dissatisfaction*	Dissatisfaction on the existing open channel gravity irrigation method serviceability	2	1.20	2.40
		Acceptance	Acceptance of pressurised irrigation system by the farmers	2	1.20	2.40
		Trust/confidence	Farmers' trust and confidence in the ability of irrigation authority to provide pressurised irrigation	2	1.20	2.40
	Institutional viability	Local capacity	Availability of institutional capacity to operate the system	2	1.20	2.40
		Acceptance	Acceptance of the pressurised irrigation system by decision makers	2	1.20	2.40
	Legal viability	Legislation/regulation	Regulation/by-laws available to guide system planning and operation	2	1.20	2.40
Environmental, and public health and safety aspects	Environmental viability	In the irrigation project	Reduce waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna	3	1.20	3.60
		Downstream of the project	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water	3	1.20	3.60
		Irrigation water efficiency	Reduction in irrigation water use due to irrigation infrastructure improvements, accurate water use measurement, and appropriate price of water	3	1.20	3.60
	Public health and safety	Monitoring and controlling	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)	3	1.20	3.60
			Increase quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)	3	1.20	3.60
			Reduce the environmental effects often impoverish tail-end farmers.	3	1.20	3.60
		Education/awareness	The value of water (water footprint concept, virtual water concept, global environmental issues)	3	1.20	3.60
Total score						81.60

Score : 1 = low, 2 = moderate, 3 = high
1 = high, 2 = moderate, 3 = low*)

D.4.1.2. Improving channel conditions and increasing the number of turnouts/offtakes to improve irrigation service and water distribution

Improving channel condition and increasing the number of turnouts/offtakes to improve irrigation service and water distribution						
Key Issue	**Goal/ objective**	**Criteria**	**Statement**	**Score**	**Weight**	**Real score = score * weight**
Technical and economic aspects	Technical viability	Suply reliability/ serviceability	Stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability	3	4.80	14.40
		Efficiency	Efficiency of irrigation water: application, distribution and conveyance, and reducing the losses of the irrigation system	2	4.80	9.60
		Operation and maintenance	Level of skill required to operate and maintain the channels and turnouts/offtakes	3	4.80	14.40
		Utilise existing infrastructure	Potential to utilise existing infrastructure	3	4.80	14.40
		Upgradeability	Adapability to new technology and ability to be expanded to improve the system	2	4.80	9.60
	Technical sustainability	Future demand	Ability to cope with the increasing demand in the future	2	4.80	9.60
		Flexibility	Matching complex demands for water with constraints in supply and delivery	2	4.80	9.60
		Long-term operation and maintenance	Ensure continuing asset serviceability	2	4.80	9.60
	Economical viability	Investment cost	The cost of improving channels conditions and increasing the number of turnouts/offtakes	2	4.80	9.60
		O&M cost efficiency	Difference in the O&M cost by improving channels condition and increasing the number of turnouts/offtakes	2	4.80	9.60
		Pricing irrigation water accurately	By increasing the number of offtakes, it is easier to measure irrigation water use and the cost of irrigation water can be determined accordingly	2	4.80	9.60
		Agricultural productivity	Improve agricultural productivity (annual value of agricultural production, output per unit irrigated area, output per unit water supply)	2	4.80	9.60
	Economical sustainability	Financial sustainability	Achieve financial self-sufficiency, O&M fraction, fee collection performance	2	4.80	9.60
Social, institutional, and legal aspects	Social viability	Complain/dissatisfaction*	Dissatisfaction on the existing open channel gravity irrigation method serviceability	2	4.80	9.60
		Acceptance	Acceptance of improving channels conditions and increasing the number of turnouts/offtakes by the farmers	3	4.80	14.40
		Trust/confidence	Farmers' trust and confidence in the ability of irrigation authority to improving channels conditions and increasing the number of turnouts/offtakes	3	4.80	14.40
	Institutional viability	Local capacity	Availability of institutional capacity to operate the improvement	3	4.80	14.40
		Acceptance	Acceptance of improving channels conditions and increasing the number of turnouts/offtakes by decision makers	3	4.80	14.40
	Legal viability	Legislation/regulation	Regulation/by-laws available to guide system planning and operation	3	4.80	14.40
Environmental, and public health and safety aspects	Environmental viability	In the irrigation project	Reduce waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna	1	4.80	4.80
		Downstream of the project	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water	1	4.80	4.80
		Irrigation water efficiency	Reduction in irrigation water use due to irrigation infrastructure improvements, water use measurement, and appropriate price of water	2	4.80	9.60
	Public health and safety	Monitoring and controlling	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)	1	4.80	4.80
			Increase quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)	1	4.80	4.80
			Reduce the environmental effects often impoverish tail-end farmers.	1	4.80	4.80
		Education/awareness	The value of water (water footprint concept, virtual water concept, global environmental issues)	2	4.80	9.60
Total score						264.00

Score : 1 = low, 2 = moderate, 3 = high
1 = high, 2 = moderate, 3 =

D.4.1.3. Install volumetric measuring devices and expand the scope of irrigation service fee (ISF) to improve to improve water use efficiency

Install volumetric measuring devices and expand the scope of the irrigation service fee (ISF) & raise the ISF to increase management, maintenance and operation (MOM) costs recoveries						
Key Issue	**Goal/ objective**	**Criteria**	**Statement**	**Score**	**Weight**	**Real score = score * weight**
Technical and economic aspects	Technical viability	Suply reliability/ serviceability	Stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability	2	1.71	3.42
		Efficiency	Efficiency of irrigation water: application, distribution and conveyance, and reducing the losses of the irrigation system	3	1.71	5.13
		Operation and maintenance	Level of skill required to operate and maintain the volumetric measuring devices	3	1.71	5.13
		Utilise existing infrastructure	Potential to utilise existing infrastructure	3	1.71	5.13
		Upgradeability	Adapability to new technology and ability to be expanded to improve the system	3	1.71	5.13
	Technical sustainability	Future demand	Ability to cope with the increasing demand in the future	2	1.71	3.42
		Flexibility	Matching complex demands for water with constraints in supply and delivery	2	1.71	3.42
		Long-term operation and maintenance	Ensure continuing asset serviceability	3	1.71	5.13
	Economical viability	Investment cost	The cost of installing volumetric measuring devices	1	1.71	1.71
		O&M cost efficiency	Difference in the O&M cost of supplying irrigation water through volumetric and flow rate measuring devices	1	1.71	1.71
		Pricing irrigation water accurately	With the ability to measure irrigation water use accurately, the cost of irrigation water can be determined accurately	3	1.71	5.13
		Agricultural productivity	Improve agricultural productivity (annual value of agricultural production, output per unit irrigated area, output per unit water supply)	3	1.71	5.13
	Economical sustainability	Financial sustainability	Achieve financial self-sufficiency, O&M fraction, fee collection performance	2	1.71	3.42
Social, institutional, and legal aspects	Social viability	Complain/dissatisfaction*	Dissatisfaction on the existing open channel gravity irrigation method serviceability	2	1.71	3.42
		Acceptance	Acceptance of expanding the scope of the irrigation service fee (ISF), raising the ISF and installing volumetric measuring devices by the farmers	2	1.71	3.42
		Trust/confidence	Farmers' trust and confidence in the ability of irrigation authority to expand the scope of the irrigation service fee (ISF), raise the ISF and install volumetric measuring devices	2	1.71	3.42
	Institutional viability	Local capacity	Availability of institutional capacity to operate the improvement	3	1.71	5.13
		Acceptance	Acceptance of expanding the scope of the irrigation service fee (ISF), raising the ISF and installing volumetric measuring devices by decision makers	1	1.71	1.71
	Legal viability	Legislation/regulation	Regulation/by-laws available to guide system planning and operation	2	1.71	3.42
Environmental, and public health and safety aspects	Environmental viability	In the irrigation project	Reduce waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna	1	1.71	1.71
		Downstream of the project	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water	1	1.71	1.71
		Irrigation water efficiency	Reduction in irrigation water use due to accurate water use measurement, and appropriate price of water	3	1.71	5.13
	Public health and safety	Monitoring and controlling	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)	1	1.71	1.71
			Increase quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)	1	1.71	1.71
			Reduce the environmental effects often impoverish tail-end farmers.	2	1.71	3.42
		Education/awareness	The value of water (water footprint concept, virtual water concept, global environmental issues)	2	1.71	3.42
Total score						88.92

Score : 1 = low, 2 = moderate, 3 = high
1 = high, 2 = moderate, 3 = low*)

D.4.2. The viability assessment of managerial interventions

D.4.2.1. Diversifying agriculture and developing agricultural business

Diversifying agriculture and developing agricultural business						
Key Issue	**Goal/ objective**	**Criteria**	**Statement**	**Score**	**Weight**	**Real score = score * weight**
Technical and economic aspects	Technical viability	Suply reliability/ serviceability	Ability to satisfying and matching complex demands for water with constraints in supply and delivery	1	1.60	1.60
		Efficiency	Horticultural crops require lower water than rice crops	3	1.60	4.80
		Operation and maintenance	Level of skill required to operate the systems according to the varying water requirements	1	1.60	1.60
		Utilise existing infrastructure	Potential to utilise existing infrastructure	2	1.60	3.20
		Upgradeability/ adaptability	Farmers need to coordinate their crop planning so that flooding of rice fields does not interfere with other crops which have less tolerance of flooding	2	1.60	3.20
	Technical sustainability	Future demand	Ability to cope with the increasing demand in the future	1	1.60	1.60
		Flexibility	Farmers have greater freedom in choosing their own crops	3	1.60	4.80
		Long-term operation and maintenance	If agriculture more profitable, then the farmers will be more interested in irrigation	3	1.60	4.80
	Economical viability	Implementation cost	The cost of implementing the diversifying agriculture and developing agricultural business (disseminating, training and supporting, and providing water measurement devices to measure water accurately)	2	1.60	3.20
		O&M cost efficiency	Difference in the overall O&M cost of supplying water for monocultivation of rice and diversifying cultivation	2	1.60	3.20
		Pricing irrigation water accurately	The ability to satisfy and match complex demands for water requires measuring irrigation water use accurately, therefore the cost of irrigation water can be determined accurately	3	1.60	4.80
		Agricultural productivity	Better farmers income more likely to achieve from horticultural crops and and developing agricultural business	3	1.60	4.80
	Economical sustainability	Financial sustainability	Achieve financial self-sufficiency, O&M fraction, fee collection performance	3	1.60	4.80
Social, institutional, and legal aspects	Social viability	Complain/dissatisfaction*	Dissatisfaction on the existing monocultivation method	2	1.60	3.20
		Acceptance	Acceptance of diversifying agriculture by the farmers	2	1.60	3.20
		Trust/confidence	Farmers' trust and confidence in the ability of irrigation authority to satisfy complex water requirement demands	2	1.60	3.20
	Institutional viability	Local capacity	Availability of institutional capacity to operate the system in a different way to satisfy more complex water requirements	2	1.60	3.20
		Acceptance	Financial support such as: resource mobilitation, credit and subsidy (advisory assistance and credit may be required from government, bank or financial institution, and subsidies) in developing agricultural business	2	1.60	3.20
	Legal viability	Legislation/regulation	Institutional and legal basis for farmers to enable them to diversify agrriculture and develop agricultural business; and regulation/by-laws available to guide implementation in accordance to system planning and operation of the system	2	1.60	3.20
Environmental, and public health and safety aspects	Environmental viability	In the irrigation project	Reduce waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna	3	1.60	4.80
		Downstream of the project	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water	3	1.60	4.80
		Irrigation water efficiency	Reduction in irrigation water use due to accurate water use measurement, and appropriate price of water	3	1.60	4.80
	Public health and safety	Monitoring and controlling	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)	3	1.60	4.80
			Increase quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)	3	1.60	4.80
			Reduce the environmental effects often impoverish tail-end farmers.	3	1.60	4.80
		Education/awareness	The value of water (water footprint concept, virtual water concept, global environmental issues)	3	1.60	4.80
Total score						99.2

Score : 1 = low, 2 = moderate, 3 = high
1 = high, 2 = moderate, 3 =

D.4.2.2. WUAs as business organization/enterprises

WUAs as business organisation/enterprises						
Key Issue	Goal/ objective	Criteria	Statement	Score	Weight	Real score = score * weight
Technical and economic aspects	Technical viability	Suply reliability/ serviceability	Maintain stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability by mapping the problematic areas (matching for water with constraints in supply and delivery)	2	2.67	5.34
		Efficiency	Maintain efficiency of irrigation water by perform irrigation services (application, distribution and conveyance) in an efficient and effective manner and reducing the losses of the irrigation system	2	2.67	5.34
		Operation and maintenance	Level of skill required to provide irrigation services	2	2.67	5.34
		Utilise existing infrastructure	Potential to utilise existing infrastructure	3	2.67	8.01
		Upgradeability/ adaptability	Opportunities to generate income for WUAs (from a range of activities from fisheries, joint purchase of agricultural inputs, marketing of crops, to electric power generation),enable them to perform their functions in an effective and efficient manner and achieved financial viability (financial self-sufficiency, O&M fraction, fee collection performance)	3	2.67	8.01
	Technical sustainability	Future demand	WUAs could organise members to respond to the specific business opportunities that are present in a particular system and run their irrigated agriculture business organisation	3	2.67	8.01
		Flexibility	Facilitate members' access to support services in an effective and efficient manner	3	2.67	8.01
		Long-term operation and maintenance	Pool their resources to achieved economic of scale in running irrigated agricultural business making the utilisation of water and land for irrigation more efficiently and effectively	3	2.67	8.01
	Economical viability	Implementation cost	Providing a program of business promotion and appropriate technical, managerial and support services for WUAs to respond to business opportunities.	2	2.67	5.34
		O&M cost efficiency	Savings to government (enlightened the government burden on O&M cost/less dependence on government support)	2	2.67	5.34
		Pricing irrigation water accurately	The ability to satisfy demands for water requires measuring irrigation water use accurately, therefore the cost of irrigation water can be determined accurately	3	2.67	8.01
		Agricultural productivity	Achieved financial and economic efficiency (standardise gross value of output per hectare, standardise gross value of output per unit of water diverted)	3	2.67	8.01
	Economical sustainability	Financial sustainability	Achieve financial self-sufficiency, O&M fraction, fee collection performance	3	2.67	8.01
Social, institutional, and legal aspects	Social viability	Complain/dissatisfaction*	Dissatisfaction on the existing government manage irrigation system	2	2.67	5.34
		Acceptance	Acceptance of WUAs as a business organisation by the farmers	2	2.67	5.34
		Trust/confidence	Farmers' trust and confidence in the ability of WUAs to provide irrigation services	2	2.67	5.34
	Institutional viability	Local capacity	Technical capability in managing irrigation system and financial and managerial capability to manage the organisation	2	2.67	5.34
		Acceptance	Financial and managerial support such as: resource mobilitation, credit and subsidy (advisory assistance and credit may be required from government, bank or financial institution, and subsidies may be continued on a gradually declining basis)	2	2.67	5.34
	Legal viability	Legislation/regulation	Institutional and legal basis for WUA to develop and grow as business organisation, and develop links in relation to business between WUAs and other organisations	3	2.67	8.01
Environmental, and public health and safety aspects	Environmental viability	In the irrigation project	Reduce waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna	3	2.67	8.01
		Downstream of the project	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water	3	2.67	8.01
		Irrigation water efficiency	Reduction in irrigation water use due to accurate water use measurement, and appropriate price of water	3	2.67	8.01
	Public health and safety	Monitoring and controlling	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)	2	2.67	5.34
			Increase quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)	2	2.67	5.34
			Reduce the environmental effects often impoverish tail-end farmers.	2	2.67	5.34
		Education/awareness	The value of water (water footprint concept, virtual water concept, global environmental issues)	2	2.67	5.34
Total score						170.88

Score : 1 = low, 2 = moderate, 3 = high
1 = high, 2 = moderate, 3 = low*)

D.4.2.3. Turnover secondary level/larger system to WUAs

Turnover Secondary Level/Larger System to WUAs						
Key Issue	Goal/ objective	Criteria	Statement	Score	Weight	Real score = score * weight
Technical and economic aspects	Technical viability	Suply reliability/ serviceability	Maintain stability of water supply for satisfying 100% of crop irrigation requirements that crucial for productive sustainability by mapping the problematic areas (matching for water with constraints in supply and delivery)	2	1.14	2.28
		Efficiency	Maintain efficiency of irrigation water by perform irrigation services (application, distribution and conveyance) in an efficient and effective manner and reducing the losses of the irrigation system	2	1.14	2.28
		Operation and maintenance	Level of skill required to operate the systems according to the varying water requirements	2	1.14	2.28
		Utilise existing infrastructure	Potential to utilise existing infrastructure	3	1.14	3.42
		Upgradeability/ adaptability	Opportunities for WUAs to extend their participation in irrigation management and generate income in performing their functions in an effective and efficient manner (achieved financial viability: financial self-sufficiency, O&M fraction, fee collection performance)	2	1.14	2.28
	Technical sustainability	Future demand	Shortage in staff, vehicles, communication equipment and operational budget constrain the ability of irrigation offices to provide services, make farmers are asked to assist with maintenance and operations of larger systems although it is not within the capacity of farmers to carry out	3	1.14	3.42
		Flexibility	Flexibility of WUAs to determine services in an effective and efficient manner	3	1.14	3.42
		Long-term operation and maintenance	Achieved financial viability: financial self-sufficiency, O&M fraction, fee collection performance in provideing irrigation services efficiently and effectively	3	1.14	3.42
	Economical viability	Implementation cost	Providing appropriate technical, managerial and support services for WUAs to respond to business opportunities.	2	1.14	2.28
		O&M cost efficiency	Savings to government (enlightened the government burden on O&M cost/less dependence on government support)	2	1.14	2.28
		Pricing irrigation water accurately	The ability to satisfy demands for water requires measuring irrigation water use accurately, therefore the cost of irrigation water can be determined accurately	3	1.14	3.42
		Agricultural productivity	Achieved financial and economic efficiency (standardise gross value of output per hectare, standardise gross value of output per unit of water diverted)	3	1.14	3.42
	Economical sustainability	Financial sustainability	Achieve financial self-sufficiency, O&M fraction, fee collection performance	3	1.14	3.42
Social, institutional, and legal aspects	Social viability	Complain/dissatisfaction*	Dissatisfaction on the existing government manage irrigation system	2	1.14	2.28
		Acceptance	Acceptance of WUAs having extended authority by the farmers	2	1.14	2.28
		Trust/confidence	Farmers' trust and confidence in the ability of WUAs to provide equitably irrigation services	2	1.14	2.28
	Institutional viability	Local capacity	Technical capability in managing irrigation system and financial and managerial capability to manage the organisation	2	1.14	2.28
		Acceptance	Financial and managerial support such as resource mobilitation, credit and subsidy (advisory assistance and credit may be required from government, bank or financial institution, and subsidies may be continued on a gradually declining basis)	2	1.14	2.28
	Legal viability	Legislation/regulation	Institutional and legal basis for farmers to enable them to participate in a larger system and regulation/by-laws available to guide implementation in accordance to system	2	1.14	2.28
Environmental, and public health and safety aspects	Environmental viability	In the irrigation project	Reduce waterlogging, soil salination, pollution of drainage water, loss of natural habitats of flora and fauna	3	1.14	3.42
		Downstream of the project	Increase surface water availability, increased groundwater inflow, water logging, and polluted incoming water	3	1.14	3.42
		Irrigation water efficiency	Reduction in irrigation water use due to accurate water use measurement, and appropriate price of water	3	1.14	3.42
	Public health and safety	Monitoring and controlling	Increase health and safety aspects of public access to irrigation infrastructures (including water quality, contamination risks to downstream users and potential injury)	2	1.14	2.28
			Increase quality and quantity of drainage water discharge into natural water course (or otherwise disposed of)	2	1.14	2.28
			Reduce the environmental effects often impoverish tail-end farmers.	2	1.14	2.28
		Education/awareness	The value of water (water footprint concept, virtual water concept, global environmental issues)	2	1.14	2.28
Total score						70.68

APPENDIX E

Details of Asst Management Planning:

E.1. The important government regulations related to irrigation

E.2. Level of Service (LoS): irrigation and drainage and physical asset

E.1. The important government regulations related to irrigation

Legislation	Related to
Instruction of the President of the Republic of Indonesia No. 3 Year 1999	Updates on irrigation management policy
The Decree of the President of the Republic of Indonesia KEPPRES No. 123 Year 2001	Water resources management team coordination
The Decree of the President of the Republic of Indonesia KEPPRES No. 83 Year 2002	Amendment of Presidential Decree No. 123 Year 2001 on Water resources management team coordination
The Decree of the Minister of Public Works KEPMEN PU No. 390/KPTS/M/2007	Irrigation Management authority
The Decree of the Coordinator Minister of Economics No. KEP-14/M.EKON/12/2001	Direction on the water resources national policy
The Decree of the Minister of Finance of the Republic of Indonesia No. 298/KMK.02/2003	Guidelines for providing management fund of districts/cities irrigation
The Decree of the Minister of Internal Affairs No. 50 Year 2001	Guidelines for empowerment of farmers' Water User Associations (WUAs)
The Decree of the Minister of Settlement and Regional Infrastructure No. 529/KPTS/M/ 2001	Guidelines for turnover authority of management of irrigation to farmers' Water User Associations (WUAs)
The Decree of the President of the Republic of Indonesia KEPPRES No. 9 Year 1999	Establishment of coordination team for policy on river utilisation and maintenance of watershed conservation
The Decree of the President of the Republic of Indonesia KEPPRES No. 2 Year 1984	Guidelines for implementation of farmers' Water User Associations (WUAs) building
The Decree of the President of the Republic of Indonesia KEPPRES No. 6 Year 2009	Establishment of the National Water Resources Council
Ministerial Regulation PERMEN No. 11A/PRT/M/2006	Criteria and zoning of rivers
	Draft Guidelines for operation and maintenance of rivers and lakes
Minister of Public Works Regulation PERMEN No. 63/PRT/1993	Rivers demarcation line, river benefit area, river authority area, and former river
Minister of Public Works Regulation PERMEN No. 30 /PRT/M/2007	Guidelines for development and management of participatory in irrigation
Minister of Public Works Regulation PERMEN No. 31 /PRT/M/2007	Guidelines on Irrigation Commission
Minister of Public Works Regulation PERMEN No. 32 / PRT / M / 2007	Guidelines for operation and maintenance of irrigation networks
Minister of Public Works Regulation PERMEN No. 33 /PRT/M/2007	Guidelines for empowerment of WUAs/WUAFs (P3A/ GP3A/ IP3A)
Government Regulation PP No. 77 Year 2001	Irrigation
Government Regulation PP No. 82 TAHUN 2001	Water quality management and water pollution control
Government Regulation PP No. 2 Year 2006	The procedures of foreign loan procurement and / or foreign grant acceptance and delivery of foreign loan and / or grants
Government Regulation PP No. 20 Year 2006	Irrigation
Government Regulation PP No. 23 Year 1992	Irrigation
Government Regulation PP No. 35 Year 1991	Irrigation
Government Regulation PP No. 20 Year 1990	Water pollution control
Government Regulation PP No. 27 Year 1991	Swamp
Government Regulation PP No. 22 Year 1982	Water regulation system
Peraturan Presiden No.39 Year 2005	Government Work Plan Year 2006
The President of the Republic of Indonesia Regulation PERPRES No. 67-2005	Cooperation between the Government with business enterprises in infrastructure provision
The Decree of the President of the Republic of Indonesia KEPPRES No. 6 Year 2009	Establishment of the National Water Resources Council
The law of the Republic of Indonesia No. 7 Year 2004	Water resources
The law of the Republic of Indonesia No. 25 Year 2004	The system of national development planning
The law of the Republic of Indonesia No. 17 Year 2007	The National Long-Term Development Plan Year 2005-2025
The law of the Republic of Indonesia No. 23 Year 1997	Environmental management
The law of the Republic of Indonesia No. 26 Year 2007	Spatial planning
The law of the Republic of Indonesia No. 32 Year 2004	Local government
The law of the Republic of Indonesia No. 33 Year 2004	Financial balance between Central Government and Local Government
The law of the Republic of Indonesia No. 41 Year 1999	Forestry

E.2. Level of service

E.2.1. Tertiary level irrigation and drainage

Key performance measure	Level of service	Performance measure process	Performance target	Current performance
Irrigation				
The level of service				
Quality - Level of service (serviceability)	Provide efficient and safe irrigation water supply that complies irrigation water requirements	Opinion survey, RAP & Benchmarking performance assessment	90% of farmers are satisfied with the level of service	76.09%of farmers are satisfied with the current level of service
- Water			COD < 20 mg/l, BOD 3-6 mg /Lt ECw of 0 -3 dS/m and TDS of 0 – 2,000 mg/Lt	Incoming irrigation water from main rivers shows the average monthly of DO = 4.05, BOD = 10.95, and COD = 32.16
Quantity (supply adequacy, flow rate, arrival time, and equity)	Provide efficient and adequate irrigation water supply according to crop water demand in the semi dry and dry season (ability to satisfying and matching complex demands for irrigation water)	Opinion survey, RAP & Benchmarking performance assessment	3 times cropping season a year for all irrigation areas can be achieved	Average cropping intensity is 2.03
			Expanded the service area to the whole potential area	Average command area to irrigated area ratio is 0.73
			90% of farmers are satisfied with adequacy of water service	70% of farmers are satisfied with adequacy of water service
			90% of farmers are satisfied with the supply levels or flow rates fluctuation	82% of farmers are satisfied with the supply levels or flow rates fluctuation
			90% of farmers are satisfied with the water arrival time	67% of farmers are satisfied with the water arrival time
			90% of farmers are satisfied with the equity of water service	86% of farmers are satisfied with the equity of water service
Reliability				
Flexibility	Ensure adequate irrigation water to farmers in which frequency, timing, flow rate, duration available according to farmers' needs	Opinion survey, RAP & Benchmarking performance assessment	Farmers have greater freedom in choosing their own crops and irrigation services (to support diversifying agriculture and developing agricultural business)	Supplying water to paddy fields is according to discharge conditions of irrigation water: continuous flow, rotation or intermittent. It dictates by the local irrigation authority (UPTD).
Technical aspect of the level of service				
Quality a. Level of service - Water supply management (operation) - Maintenance	Completion of annual operation program Completion of annual maintenance program	Biweekly review against O&M program timeframe	90%	n.a.
b. Health & safety	Irrigation water supply conform to standards (DO, BOD, COD, TDS, and ECw)	Annual irrigation water quality monitoring program	90%	n.a.
Quantity (supply adequacy, flow rate, arrival time, and equity)	Ensure adequate quantity of water to farmers	Availability during semi dry or dry season (peak irrigation times)	90%, all irrigation system have 3 cropping seasons	Some irrigation system case studies only have 2 cropping
	Increase the length and the condition of drainage channel system	Annual expenditure program	100% tertiary level irrigation channels into concrete lining	Only 30% to 50% are concrete lining
	Increasing the number of turnouts/offtakes to improve irrigation service and water distribution		Increase the number of turnouts/offtakes by 30 to 50%	Ideal capacity of off-takes ranges from 50 lt/s to 250 lt/dt
Condition	Periodic visual assessment to determine condition	Visual inspection (asset survey)	100% inspected each yaer	n.a.
		Routine maintenance/clearing of irrigation channel	Overall average condition is at least minor functional shortcoming	Most of small irrigation systems asset condition are poor
Cost effectiveness (financial management)	Revenue (ISF collected)	Actual revenue (ISF collected) againsts estimation	100%	100%
		Review to increase ISF rate by 100%	100% O&M costs covered	50% O&M covered
		Review to increase provision of ISF to fund the tertiary O&M to	40% of ISF funds the tertiary O&M	20% of ISF funds the tertiary O&M
	Efficient O&M program	Achieved improve irrigation service and water distribution	Increased conveyance efficiency of project-delivered water by 90%	Conveyance efficiency of project-delivered water (weighted for internal and external, using values stated by project authorities) of 65%
	Capital expenditure program	3 monthly review on actual expenditure againsts budget	Increase the length and the condition of irrigation channel system	Only 30% to 50% are concrete lining
			Increasing the number of turnouts/offtakes to improve irrigation service and water distribution	Ideal capacity of off-takes ranges from 50 lt/s to 250 lt/dt (Increase the number of turnouts/offtakes by 30 to 50%)
	Cash reserves	Annual review - in accordance with 5 year projection	Projection to increase channel length and condition and increase the number of turnouts/offtakes	70% of farmers are satisfied with adequacy of water service

E.2.1. Tertiary level irrigation and drainage (continue)

Key performance measure	Level of service	Performance measure process	Performance target	Current performance
Drainage				
The level of service				
Quantity	Provide efficient method of collection and disposal of storm water	Opinion survey, RAP & Benchmarking performance assessment	Prevent drainage water is discharge into natural water course and if possible circulate it to increase water use efficiency	All drainage water is discharged into natural water course
Function	Ensure drainage sytem meets farmers expectations	Opinion survey, RAP & Benchmarking performance assessment	Increase the length and the condition of drainage channel system	Only Way pengubuan and Way Padang ratu have drainage system
	No overflows of drainage onto neighbouring landplots or public spaces or natural water course	Opinion survey, RAP & Benchmarking performance assessment		
Health & Safety	Ensure drainage system has low environment risk to the community (low contamination risks to downstream users)	Opinion survey, RAP & Benchmarking performance assessment	Prevent drainage water is discharge into natural water course and if possible circulate it to increase water use efficiency	Quality and quantity of drainage water discharge into natural water course has not received proper attention, because thefocus is still on how to improve performances in water balance, financial, agricultural productivity and economic
Technical aspect of the level of service				
Operation and maintenance	Completion of annual operation program	Biweekly review against O&M program timeframe	75%	n.a.
Cost effectiveness (financial management)	Revenue (ISF collected)	Actual revenue (ISF collected) againsts estimation	100%	100%
		Review to increase ISF rate by 100%	100% O&M costs covered	50% O&M covered
		Review to increase provision of ISF to fund the tertiary O&M to	40% of ISF funds the tertiary O&M	20% of ISF funds the tertiary O&M
	Capital expenditure program	3 monthly review on actual expenditure againsts budget	Increase the length and the condition of drainage channel system	Only Way pengubuan and Way Padang ratu have drainage system
	Cash reserves	Annual review - in accordance with 5 year projection	Projection to increase drainage channel length and condition	70% of farmers are satisfied with adequacy of water service
Condition	Periodic visual assessment to determine condition	Visual inspection (asset survey)	100% inspected each yaer	n.a.
		Routine clearing of drainage	Flood risk areas 50% pa, other areas 5% pa	n.a.
Function and accessibility	Ensure drainage sytem has appropriate design capacity	Number of landplot inundation events	100% inspected everytime floods occur	n.a.
	Ensure all landplots have acces to drainage facilities			
Safety	Irrigation water discharge conform to standards (low contamination risks to downstream users)	Annual irrigation discharge water quality monitoring program	90%	n.a.

E.2.2. Tertiary level irrigation assets

Key performance measure	Level of service	Performance measure process	Performance target	Current performance
Level of service				
Quality	Irrigation assets meet farmers expectations of quality	Opinion survey, RAP & Benchmarking performance assessment	> 75% farmers are satisfied with the canal condition	58.62% farmers are satisfied with the canal condition
			> 90% farmers are satisfied with the water control and distribution	71.26% farmers are satisfied with the water control and distribution
Function	Irrigation assets are available as required by the farmers user groups	Farmers complaints on assets faults	Improved asset condition	Tertiary and quartenary channels were earth lining: large and medium irrigation systems have fair conditions, and small irrigation systems are mostly in poor conditions and ceased to function
		Opinion survey, asset survey, and RAP & Benchmarking performance assessment		Hydraulic structures were in fair condition, however in some of small irrigation systems were in poor condition and seriously reduce its functionality
				Large irrigation system were equiped with sufficient, medium with a very standard and small with a lack of supplementary structures. In general, the supplementary structures were in fair condition in large and medium systems, but in some of small systems were in poor condition and seriously reduce its
				Operation and control facilities were manually operated gates: mostly in poor condition and seriously reduce its functionality
				Large irrigation system were equipped with a standard, medium systems with a lack, and small system with a limited management and general facilities. Management and general facilities commonly were in fair condition and quite feasible to support the activities of the systems.
Safety	Irrigation assets are safe and suitable for their intended use	Number of complaints caused by assets faults	Increase safety aspects (from potensial injury) of public access to irrigation infrastructure	n.a.
		Opinion survey, RAP & Benchmarking performance assessment		
Technical aspect of the level of service				
Cost effectiveness (financial management)	Revenue (ISF collected)	Actual revenue (ISF collected) againsts estimation	100%	100%
		Review to increase ISF rate by 100%	100% O&M costs covered	50% O&M covered
		Review to increase provision of ISF to fund the tertiary O&M to	40% of ISF funds the tertiary O&M	20% of ISF funds the tertiary O&M
	Efficient O&M program	Achieved improve irrigation service and water distribution	Increased conveyance efficiency of project-delivered water by 90%	Conveyance efficiency of project-delivered water (weighted for internal and external, using values stated by project authorities) of 65%
	Efficient capital expenditure program	3 monthly review on actual expenditure againsts budget	Increase the length and the condition of irrigation channel system	Only 30% to 50% are concrete lining
			Increasing the number of turnouts/offtakes to improve irrigation service and water distribution	Ideal capacity of off-takes ranges from 50 lt/s to 250 lt/dt (Increase the number of turnouts/offtakes by 30 to 50%)
			Increase average field irrigation efficiency by 75%	Average field irrigation efficiency of 48%
	Cash reserves	Annual review - in accordance with 5 year projection	Projection to increase channel length and condition and increase the number of turnouts/offtakes	70% of farmers are satisfied with adequacy of water service
Function	Response to urgent (asset failure) maintenance requests	Within 1 weeks	95% addressed	n.a.
	Response to routine (asset failure) maintenance requests (outside of the above categories)	Within 1 month	90% addressed	n.a.
Condition	Asset condition is maintained to an acceptable level in line with the level of service relevance	Routine condition inspection	Overall average condition is at least minor functional shortcoming	
Accessibility	Access to a suitable irrigation networks and assets for farmers	Annual assessment	90% of farmers are satisfied with the equity of water service	86% of farmers are satisfied with the equity of water service
Safety	Response to urgent (safety risk, critical hazard) maintenance requests	Within 1 hour	95% addressed	n.a.